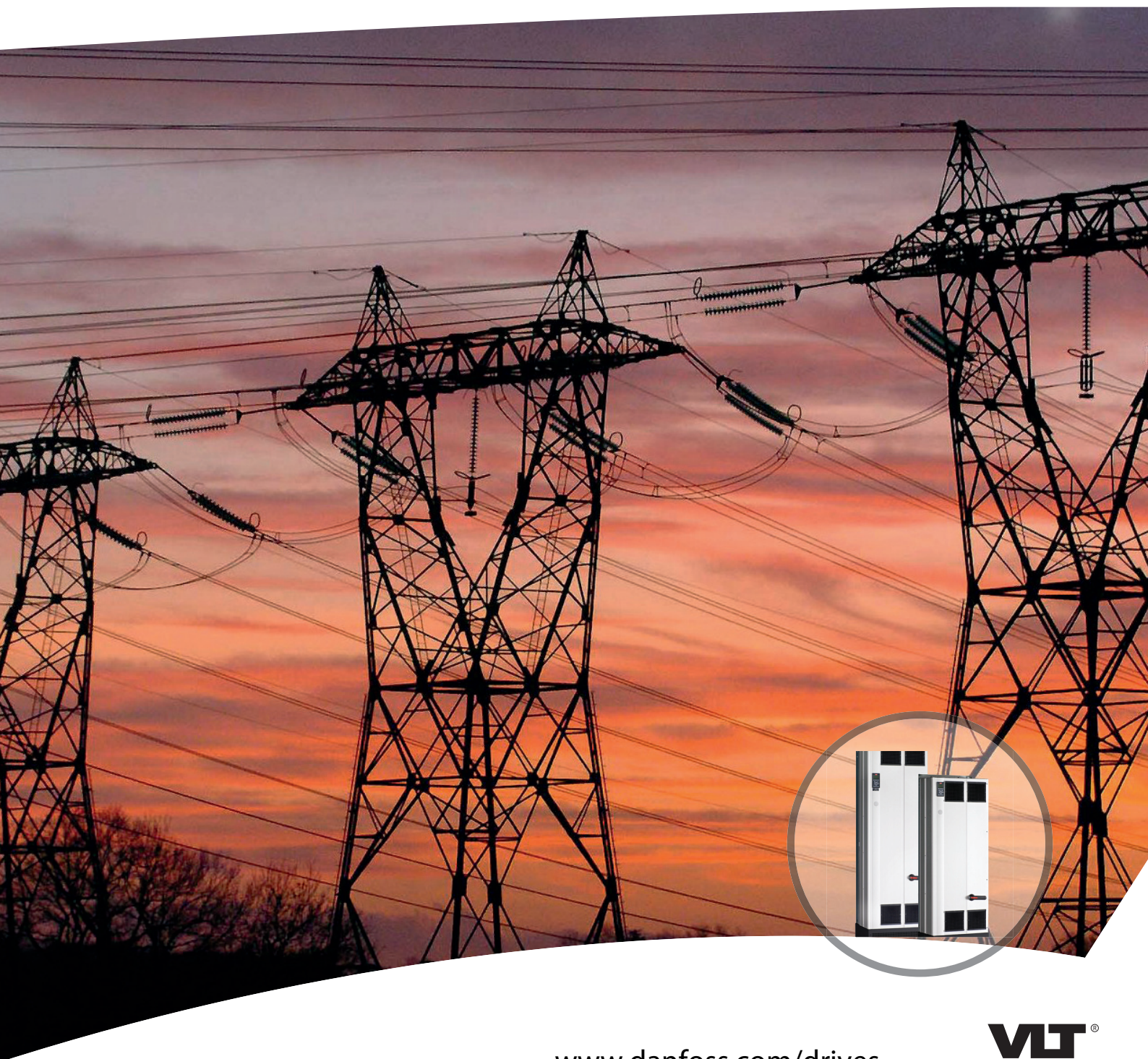


MAKING MODERN LIVING POSSIBLE



Operating Instructions

VLT® Active Filter AAF006



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1

1 Introduction

1.1 Purpose of the Manual

These operating instructions provide information for safe installation and commissioning of the filter.

The operating instructions are intended for use by qualified personnel.

Read and follow the operating instructions to use the filter properly, and pay particular attention to the safety instructions and general warnings. Keep these operating instructions available with the filter at all times.

VLT® is a registered trademark.

1.2 Additional Resources

Resources available to understand advanced active filter functions and programming:

- The *VLT® Advanced Active Filter Service Manual* provides information on troubleshooting and testing for field service technicians, as well as disassembly and assembly instructions.

1.3 Product Overview

1.3.1 Working Principle

The VLT® Advanced Active Filter is used for harmonic current mitigation and reactive current compensation. The unit can integrate with various systems and applications as a centrally installed filter or be combined with a VLT® frequency converter as a packaged low harmonic drive solution.

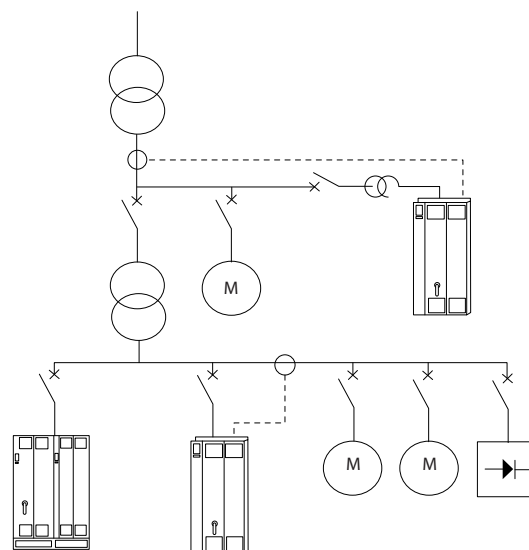


Illustration 1.1 Multiple Working Environments

The active shunt filter monitors all 3-phase line currents and processes the measured current signal via a digital signal processor system. The filter then compensates by actively imposing signals in counter phase to the unwanted elements of the current (harmonic distortion).

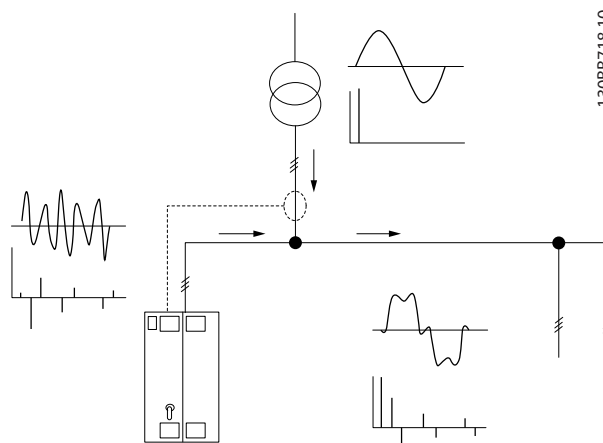


Illustration 1.2 Active Filter Principles

The filter sets different IGBT switches in real time feeding a DC voltage into the grid, which creates counter phase signals. A built-in LCL filter smooths the compensated current waveform, ensuring that the IGBT switching frequency and DC component is not imposed to the grid. The filter operates on generator or transformer supply and can reduce individual motor loads, non-linear loads, or

mixed loads. Non-linear loads (diode feed loads) must hold AC coils to protect against overcurrent of the input diodes.

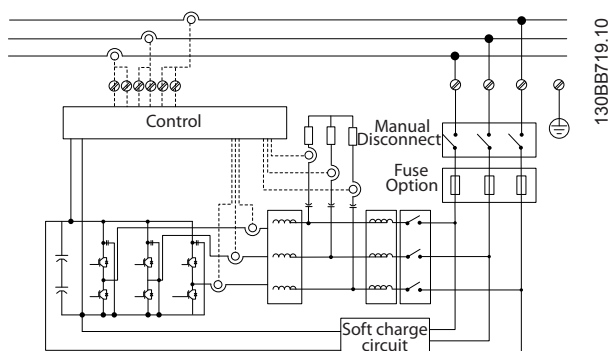


Illustration 1.3 Block Diagram

The filter allows either overall or selective harmonic compensation modes. In overall compensation mode, all harmonics are reduced. In this mode, the filter balances the load to reduce uneven load distribution among the 3 phases. The steady state performance allows compensation of harmonics to the 40th order, but the ultra-quick current injection allows the filter to compensate flicker and other quick and short-term phenomena. In selective mode, the user can program acceptable individual harmonic levels between 5th and 25th order. In selective mode, the filter does not reduce harmonics in twos and threes, and does not support phase load balancing and flicker reduction. See *parameter 300-00 Harmonic Cancellation Mode*.

Program the filter priority as either reactive current or harmonic compensation. If harmonic compensation is first priority, the filter uses the current needed for harmonic reduction and uses energy for reactive current correction only if there is excess. The filter automatically and continuously assigns energy between first and second priority to provide the highest possible mitigation of both reactive and harmonic compensation. The power factor is optimised continuously and the supply transformer is used to its maximum capacity. See *parameter 300-01 Compensation Priority*.

The active filter has an optional RFI filter for Class A1 equal to category C2.

1.3.2 IEEE519 Compliance

The active filter is designed to meet IEEE519 recommendation for $I_{sc}/I_l > 20$ for even individual harmonic levels. The filter has a progressive switching frequency that creates a wide frequency spread, giving lower individual harmonic levels above the 50th harmonic level.

1.4 Ordering Information

1.4.1 Filter Configurator

Use the ordering number system to design an active filter according to the application requirements. For the VLT® Active Filter AAF 006 Series, it is possible to order standard filters and filters with integral options by sending a type code string describing the product to the local Danfoss sales office. For example: AAF006A190T4E21HXXGCXXXSXXXXXAXBXCFXXDX

This section describes each character in the type code. In the example, a standard 190 A active filter in an enclosure with IP21 protection rating is selected for a 380–480 V net. The internet-based configurator configures the right filter for the right application and generates a type code string. The configurator automatically generates an 8-digit sales number to be delivered to the local sales office. It is also possible to establish a project list with several products and send it to a Danfoss sales representative. The configurator can be found at www.danfoss.com/BusinessAreas/DrivesSolutions/.

1.4.2 Ordering Form Type Code

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

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Illustration 1.4 Type Code Example

		Possible choice
Product groups	1-3	AAF
Series	4-6	006
Current rating	7-10	A190: 190 A A250: 250 A A310: 310 A A400: 400 A
Phases	11	T: 3 Phases
Mains Voltage	12	4: 380–480 V AC
Enclosure	13-15	E21: IP21/Nema Type1 E54: IP54/Nema Type 12 E2M: IP21/Nema Type 1 with mains shield E5M: IP54/Nema Type 12 with mains shield
RFI filter	16-17	HX: No RFI filter H4: RFI filter, Class A1 (optional)
Display (LCP)	19	G: Graphical Local Control Panel (LCP)
Coating PCB	20	C: Coated PCB
Mains option	21	X: No mains option 3: Mains disconnect and fuse 7: Fuse
Adaptation A	22	Reserved
Adaptation B	23	Reserved
Software release	24-27	Reserved
Software language	28	Reserved
A options	29-30	AX: No A option
B options	31-32	BX: No B option
C-option configuration	33-37	CFxxx: CO-option occupied with active filter control card

D options	38-39	DO: 24 V back-up DX: No options
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Table 1.1 Type Code Definitions

176F3535	Backwall cooling kit for D14 (IP54)
176F3537	Backwall cooling kit for E1 (IP54)

Table 1.2 Optional Kits

2 Safety

2.1 Safety Symbols

The following symbols are used in this document:

⚠ WARNING

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

⚠ CAUTION

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

NOTICE

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

2.2 Qualified Personnel

Correct and reliable transport, storage, installation, operation and maintenance are required for the trouble-free and safe operation of the active filter. Only qualified personnel are allowed to install or operate this equipment.

Qualified personnel is defined as trained staff, who are authorised to install, commission, and maintain equipment, systems and circuits in accordance with pertinent laws and regulations. Additionally, the personnel must be familiar with the instructions and safety measures described in this document.

2.3 Safety Precautions

⚠ WARNING

HIGH VOLTAGE

Active filters contain high voltage when connected to AC mains input. Failure to perform installation, start-up, and maintenance by qualified personnel can result in death or serious injury.

⚠ WARNING

DISCHARGE TIME

The active filter contains DC-link capacitors, which can remain charged even when the filter is not powered. Failure to wait the specified time after power has been removed before performing service or repair work can result in death or serious injury.

Voltage [V]	Output Current [A]	Minimum waiting time (minutes)
380–480	190–400	20
High voltage can be present even when the warning indicator lights are off.		

Table 2.1 Discharge Time

⚠ WARNING

LEAKAGE CURRENT HAZARD

Leakage currents exceed 3.5 mA. Failure to ground the filter properly can result in death or serious injury.

- Ensure correct grounding of the equipment by a certified electrical installer.

⚠ WARNING

EQUIPMENT HAZARD

Contact with rotating shafts and electrical equipment can result in death or serious injury.

- Ensure that only trained and qualified personnel perform installation, start up, and maintenance.
- Ensure that electrical work conforms to national and local electrical codes.
- Follow the procedures in this document.

⚠ CAUTION

INTERNAL FAILURE HAZARD

An internal failure in the filter can result in serious injury when the filter is not properly closed.

- Before applying power, ensure all safety covers are in place and securely fastened.

3

3 Mechanical Installation

3.1 Pre-installation

3.1.1 Planning the Installation Site

NOTICE

Due to the size and clearance requirements of the active filter, it is important to pre-plan installation. Failure to do so may result in additional work during and after installation.

Select the best possible operation site by considering the following:

- Ambient temperature conditions.
- Altitude at installation point.
- Installation and compensation method.
- Cooling.
- Position of the active filter.
- CT installation point and possibility to reuse existing CTs.
- Cable routing and EMI conditions.
- Ensure the power source supplies the correct voltage and frequency.
- If the unit is without built-in fuses, ensure that the external fuses are rated correctly.

3.1.2 Receiving the Active Filter

When receiving the unit, ensure that the packaging is intact, and note any damage that may have occurred during transport. In case of damage, immediately contact the shipping company to claim the damage.

NOTICE

Damaged packaging can indicate rough transportation which may have caused interior failures in the unit. Claim damages even if the exterior of the unit seems intact.

3.1.3 Transportation and Unpacking

Place the active filter as close as possible to its final installation site before unpacking it. Keep the filter on the pallet and boxed as long as possible to avoid damage.

3.1.4 Lifting

Always lift the unit in the dedicated lifting eyes. Use a bar to avoid bending the lifting holes.

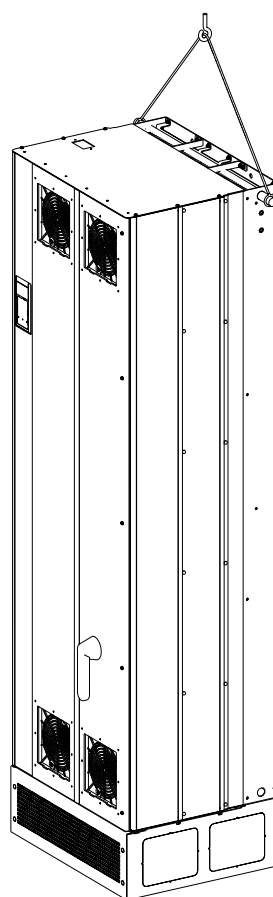


Illustration 3.1 Recommended Lifting Method for AAF 006, Enclosure Sizes D14 and E1

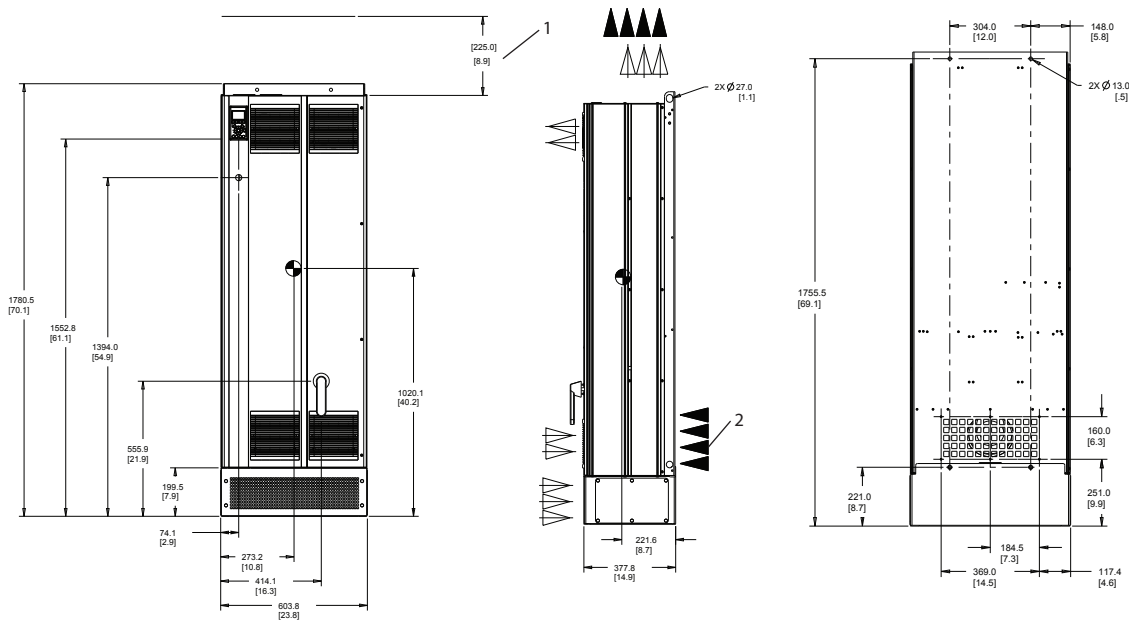
NOTICE

The lifting bar must be able to handle the weight of the unit. See *chapter 3.1.5 Mechanical Dimensions* for weights. Maximum diameter for the bar is 25 mm (1 inch). The angle from the top of the unit to the lifting cable should be $\geq 60^\circ$.

NOTICE

The plinth is required to allow airflow to the unit to provide proper cooling.

3.1.5 Mechanical Dimensions



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Illustration 3.2 AAF006 190 A, Enclosure Size D13

1	Minimum clearance from the ceiling	2	Backwall cooling option
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Table 3.1 Legend to *Illustration 3.2* and *Illustration 3.3*

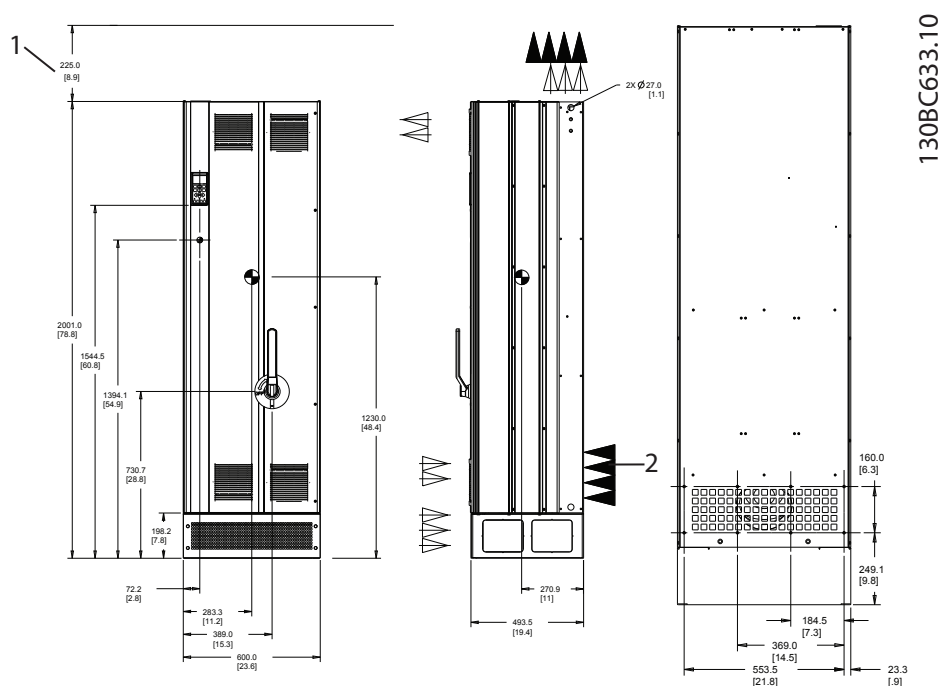


Illustration 3.3 AAF006 250-400 A, Enclosure Size E1

Enclosure		D14	E1
Enclosure protection	IP	21/54	21/54
	NEMA	Type 1/12	Type 1/12
Nominal current rate		190 A	250 A, 310 A, 400 A
Shipping dimensions	Height (mm/in.)	750/29.5	864/34
	Width (mm/in.)	737/29	737/29
	Depth (mm/in.)	1943/76.5	2203/86.7
	Weight (kg/lbs.)	283/623.9	500/1102.3
Unit dimensions	Height (mm/in.)	1780/70	2000/78.7
	Width (mm/in.)	600/23.6	600/23.6
	Depth (mm/in.)	380/14.9	494/19.4
	Maximum-Weight (kg/lbs.)	238/524.7	453/998.7

Table 3.2 Mechanical Dimensions

3.2 Mechanical Installation

Before installing the active filter, examine the mechanical drawings in *chapter 3.1.5 Mechanical Dimensions* to become familiar with the space demands.

3.2.1 Tools Needed

To perform the mechanical installation, the following tools are needed:

- Drill with a 10 or 12 mm drill bit.
- Tape measure.
- Screw driver.
- Wrench with 7–17 mm metric sockets.
- Wrench extensions.
- Sheet metal punch for conduits or cable glands.
- Lifting bar to lift the unit (rod or tube maximum Ø 25 mm/0.9 in., able to lift minimum 1000 kg/2205 lbs.).
- Crane or other lifting aid to place the unit in position.
- Torx T50 tool.

3.2.2 Clearance Requirements

Space

Ensure proper space above and below the unit to allow airflow and cable access. In addition, ensure adequate space in front of the unit for the door to open (*Illustration 3.4, Illustration 3.5*).

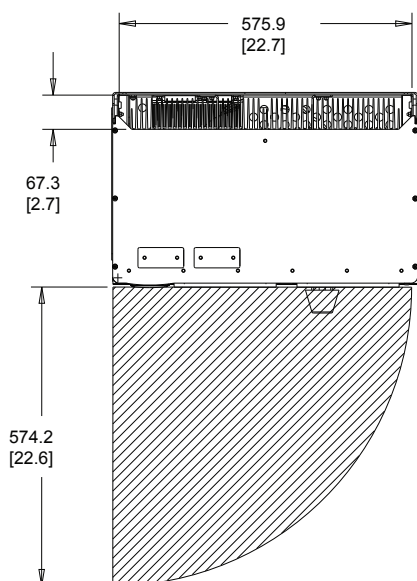


Illustration 3.4 Door Clearance IP21/IP54 Enclosure Type, Size D14

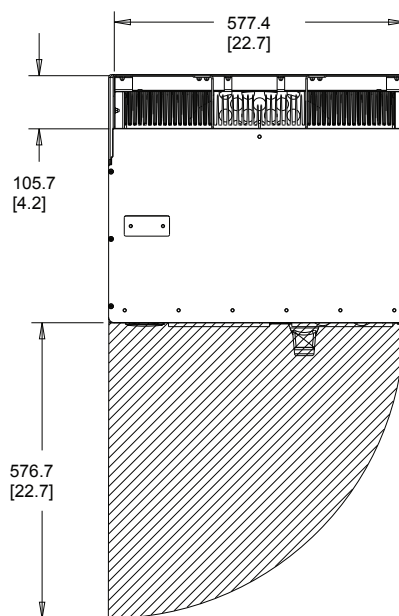


Illustration 3.5 Door Clearance, IP21/IP54 Enclosure Type, Size E1

Wire access

Ensure that proper cable access including the necessary bending allowance.

NOTICE

Power cables are heavy and difficult to bend. To make installation easier, consider the optimum position of the unit before delivery.

NOTICE

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

3.2.3 Power Terminal Locations

Consider the position of the terminals when designing for cable access. See *Illustration 3.6*, *Illustration 3.7*, *Illustration 3.8*, and *Illustration 3.9*

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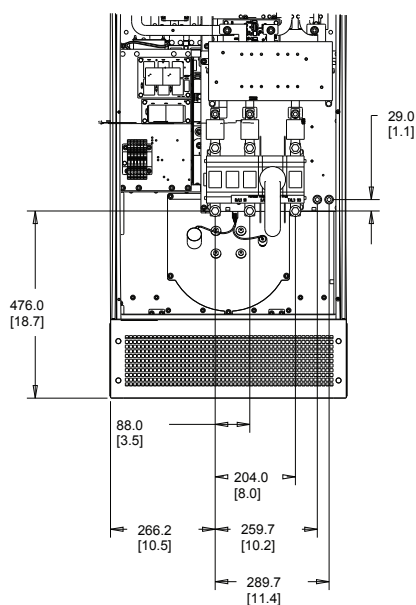


Illustration 3.6 Terminal Location of D14 with Disconnect

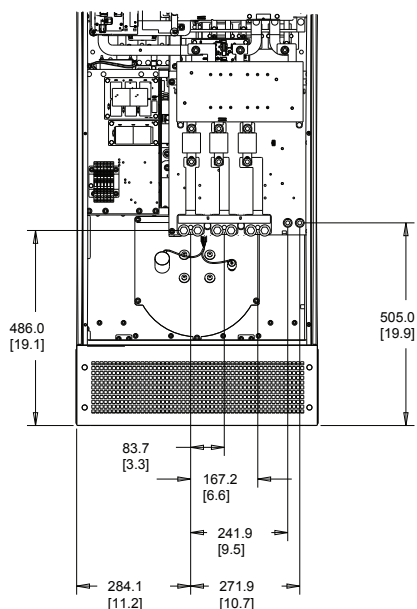


Illustration 3.7 Terminal Location of D14 without Disconnect

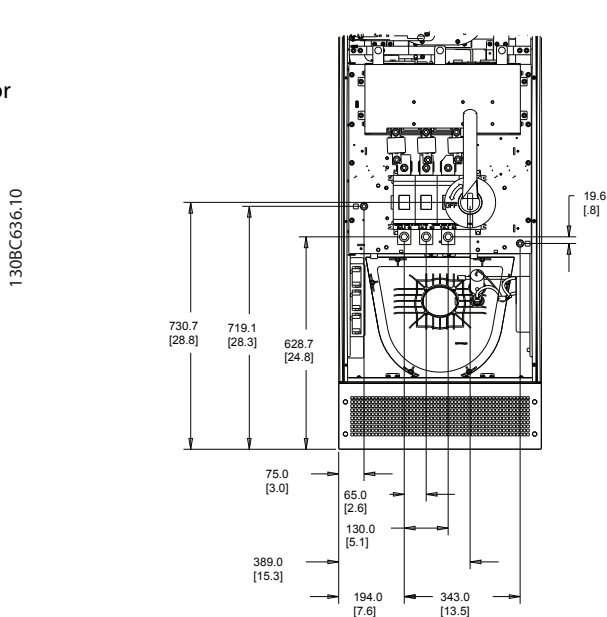


Illustration 3.8 Terminal Location of E1 with Disconnect

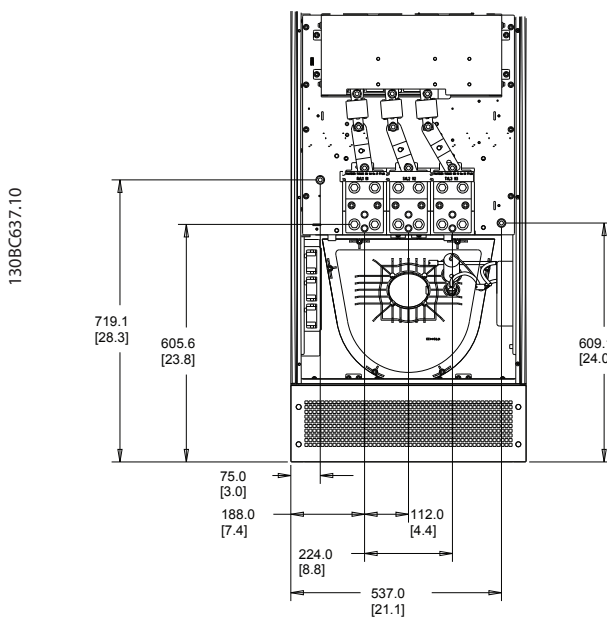


Illustration 3.9 Terminal Location of E1 without Disconnect

NOTICE

Each terminal allows up to 4 cables with cable lugs or use of a standard box lug. Ground is connected to the relevant termination point in the unit.

3.2.4 Cooling and Airflow

There are different ways to cool the active filter:

- Use the cooling ducts in the top and bottom of the unit
- Take air into the back of the unit
- Combine top, bottom, and back airflow

Back cooling

The active filter has a back channel cooling system where 85% of all heat is ducted via an IP54 segregated back channel. This reduces the needed airflow inside the enclosure and ensures less moisture and dust across vital components.

The back channel air is normally ventilated via the plinth inlet and ducted out the top of the enclosure. The design of the back channel can also take air from the control room and duct it back out again. This is supported to ease stress on the control room air conditioner and conserve energy. To support a backwall inlet, the unit air inlet has to be blocked via an optional cover and the air outlet ducted via an optional top duct.

NOTICE

The active filter fan runs for the following reasons:

- Active filter running.
- Specific heat sink temperature exceeded (power size dependent).
- Specific power card ambient temperature exceeded (power size dependent).
- Specific control card ambient temperature exceeded.

Once the fan is started, it runs for a minimum of 10 minutes.

External ducts

If additional duct work is added externally to the enclosure, the pressure drop in the ducting must be calculated. Use *Illustration 3.10* and *Illustration 3.11* to derate the unit according to the pressure drop.

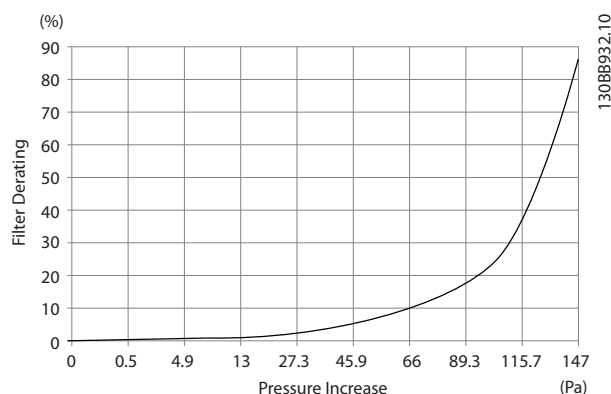


Illustration 3.10 Enclosure Size D, Derating vs. Pressure Change

Air Flow: 450 cfm (765 m³/h)

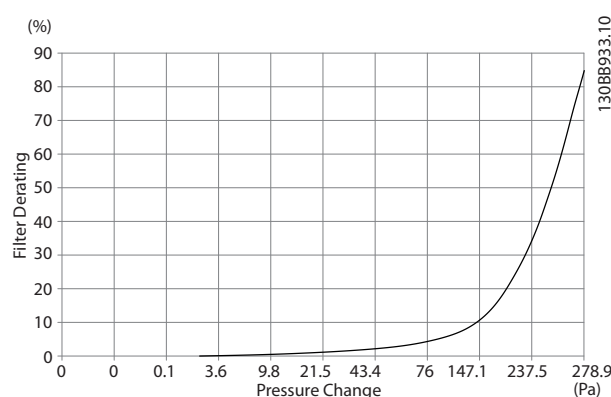


Illustration 3.11 Enclosure Size E, Derating vs. Pressure Change

Air Flow: 725 cfm (1230 m³/h)

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

Cables are connected through the gland plate from the bottom. Remove the plate and plan where to place the entry for the glands or conduits. *Illustration 3.12* and *Illustration 3.13* show the gland plate openings in bottom views.

NOTICE

The gland plate ensures the specified protection degree, and enables proper cooling of the unit. If the gland plate is not mounted, the unit may trip on *Alarm 69, Pwr. Card Temp.*

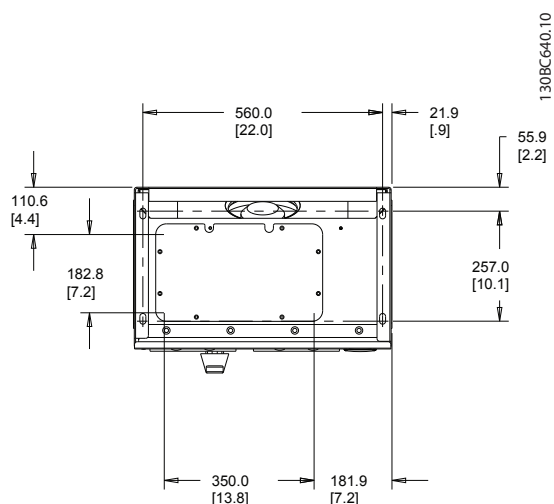


Illustration 3.12 Enclosure Size D14, Bottom View

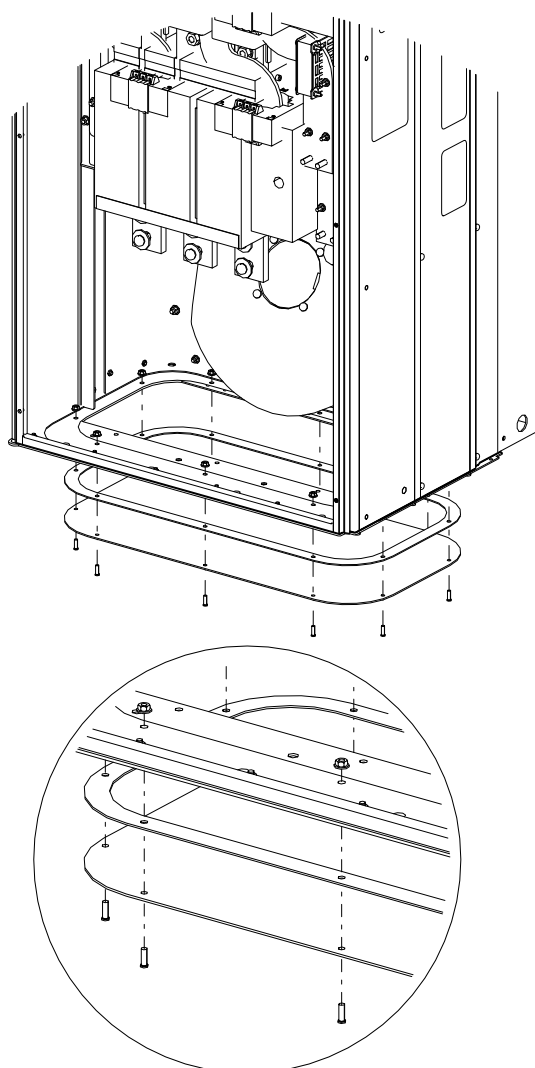


Illustration 3.14 Mounting of Base Plate, E1

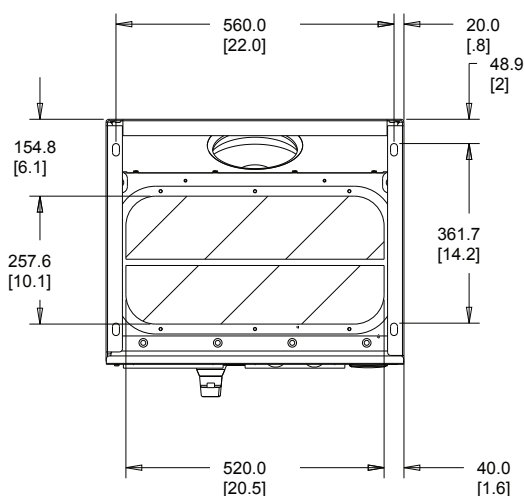


Illustration 3.13 Enclosure Size E1, Bottom View

The base plate of the enclosure size E can be mounted from either inside or outside of the enclosure, allowing flexibility in the installation process. If mounted from the bottom, the glands and cables can be mounted before the unit is placed on the pedestal.

4 Electrical Installation

4.1 Safety Instructions

See *chapter 2 Safety* for general safety instructions.

CAUTION

SHOCK HAZARD

The active filter can cause a DC current in the PE conductor.

- When a residual current-operated protective device (RCD) is used for protection against electrical shock, only an RCD of Type B is permitted on the supply side.

Failure to follow the recommendation means the RCD may not provide the intended protection.

4.2 Electrical Installation

4.2.1 Power Connections

Cabling and fusing

NOTICE

All cabling must comply with national and local regulations on cable cross-sections and ambient temperature. UL applications require 75 °C copper conductors. 75° and 90 °C copper conductors are thermally acceptable for use in non-UL applications.

The power cable connections are situated as shown in *Illustration 4.1*. The mains connection is fitted to the mains switch if this is included. Dimension the cable cross-section in accordance with the filter current rating, including skin and proximity effects, derating, and local legislation.

Connect mains to terminals 91, 92 and 93. Connect ground to the terminal on the immediate right of terminal 93.

Terminal number	Function
91, 92, 93	Mains R/L1, S/L2, T/L3
94	Ground

Table 4.1 Mains and Ground Connections

The conductor predominantly carries currents of high frequencies so the distribution of current is not evenly dispersed throughout the cross-section of the conductor. This is due to 2 independent effects known as skin effect and proximity effect. Both require derating and, consequently, the mains cable of the active filter is rated at a higher current than the filter rating itself.

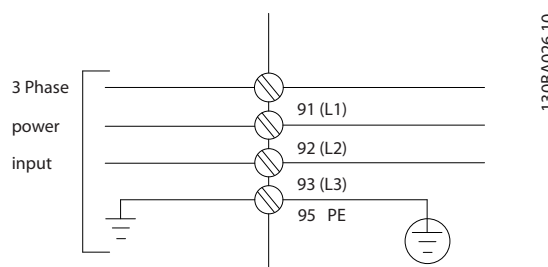


Illustration 4.1 Mains Connection Diagram

NOTICE

It is insufficient to rate the power cable for the filter current rating alone due to skin and proximity effects.

The required derating is calculated as 2 separate factors:

- The skin factor depends on frequency of current, cable material, and cable dimensions.
- The proximity factor depends on the number of conductors, diameters and distance between the individual cables.

The proximity effect is depending on the number of conductors, diameters and distance between the individual cables.

The optimised mains cable is:

- Copper wires.
- Single conductors.
- Bus bars.

Copper affects skin less than aluminum, and bus bars have a larger surface area than cables, reducing the skin effect factor. Proximity effects of single conductors are negligible.

The cable specifications in *Table 4.2* take both skin and proximity effects into account:

Filter	Minimum CU wire mm ² (AWG)	Equivalent RMS cable for CU	Minimum ALU wire mm ² (AWG)	Equivalent RMS current for ALU	Maximum wire mm ² (AWG)
190 A	70 mm ² (2/0)	225 A	95 mm ² (3/0)	240 A	2*150 mm ² (2*300 MCM)
250 A	120 mm ² (4/0)	295 A	150 mm ² (300 MCM)	315 A	4x240 mm ² (4x500 MCM)
310 A	240 mm ² (500 MCM)	365 A	2*95 mm ² (2*3/0)	390 A	4x240 mm ² (4x500 MCM)
400 A	2*95 mm ² (2*3/0)	470 A	2*150 mm ² (2*300 MCM)	500 A	4x240 mm ² (8x900 MCM)

Table 4.2 Allowed Active Filter Mains Cable with Typical Cable Manufacturer Data

Due to the built-in LCL filter, the unit does not feed the main wire with high dU/dt signals. Doing so reduces the radiated emission through the mains cable. Cable screen/shielding can thus be omitted allowing the mains cables to be connected without considering EMC requirements.

The active filter can run at long cable runs. Cable length is limited by the voltage drop. It is advised to keep the cable lengths to less than 200 m.

Active filters have either built-in or customer-supplied fuses. See *chapter 4.2.11 Fuses* for fuse recommendations. Always ensure proper fusing according to local regulation.

4.2.2 Grounding

Consider the following basic issues when installing an active filter, to obtain electromagnetic compatibility (EMC):

- Safety grounding: The active filter has leakage current and must be grounded appropriately for safety reasons. Apply local safety regulations.
- High-frequency grounding: Keep the ground wire connections as short as possible.
- Use high-strand wire to reduce electrical interference.
- Do not use pigtails.

Connect the different ground systems at the lowest possible conductor impedance. Obtain the lowest possible conductor impedance by keeping the conductor as short as possible and using the greatest possible surface area. The metal cabinets of the different devices are mounted on the enclosure back plate using the lowest possible high frequency impedance. This avoids having different high frequency voltages for the individual devices and avoids the risk of radio interference currents running in connection cables that may be used between the devices. The radio interference is reduced. To obtain a low HF impedance, use the fastening bolts of the devices as a high-frequency connection to the back plate. Remove any insulating paint or similar substances from the fastening points.

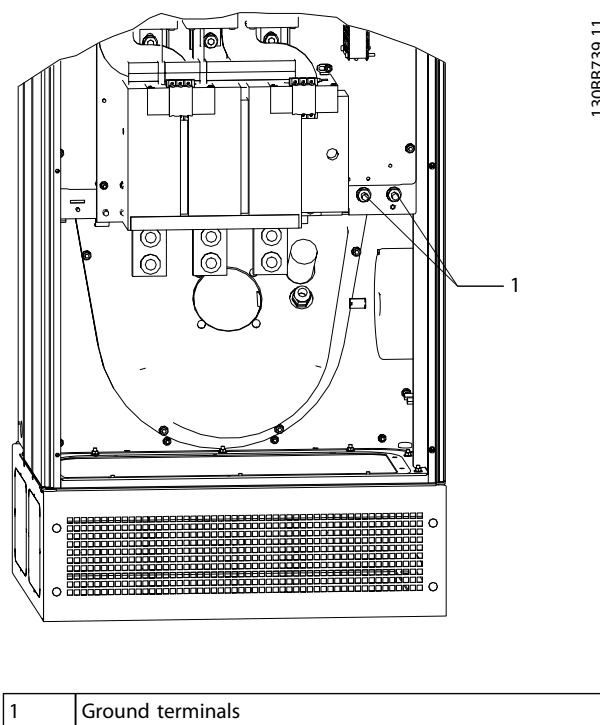
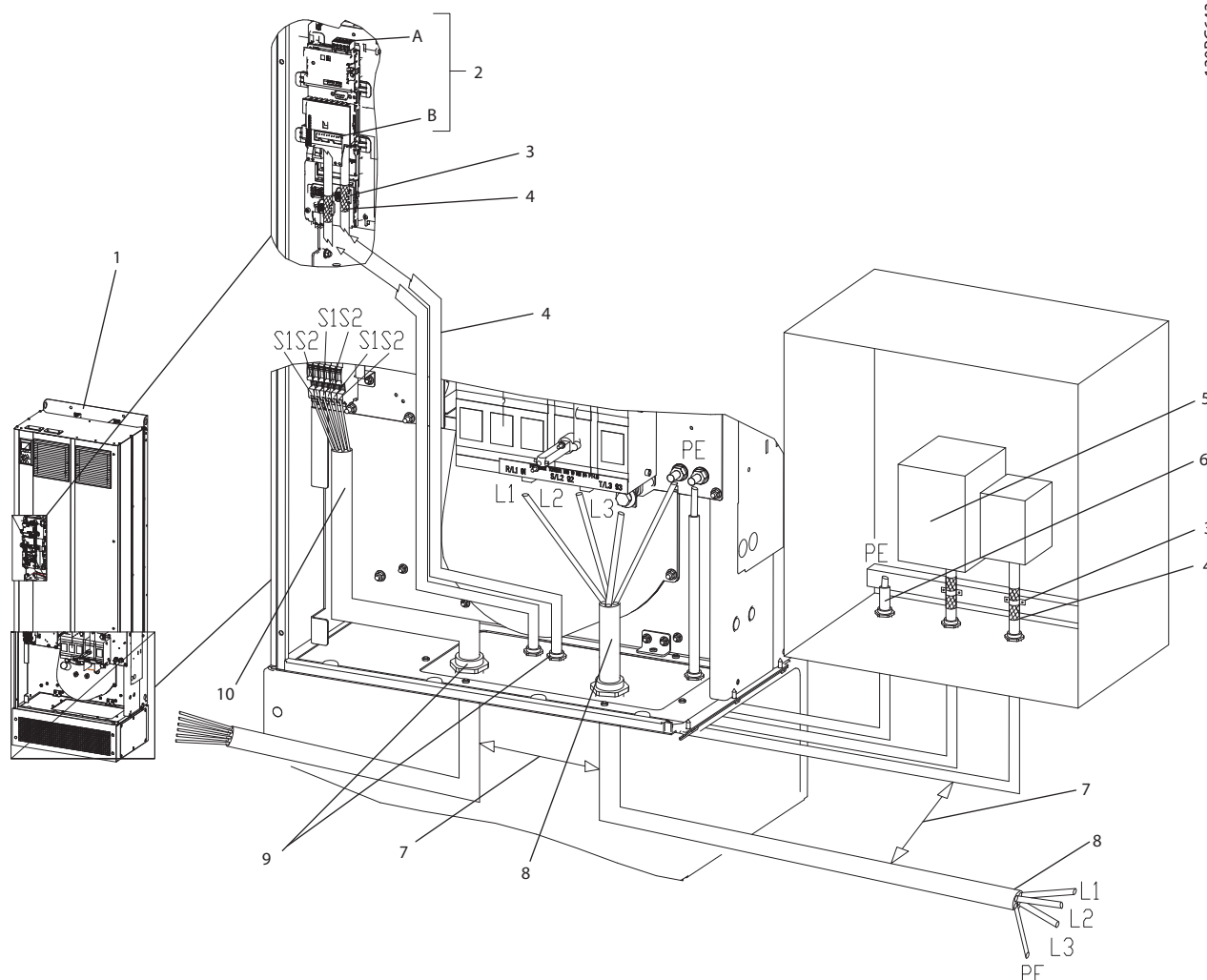


Illustration 4.2

4.2.3 EMC Interference



1	Advanced active filter (AAF)	6	Potential equalisation wire [minimum 16 mm ² /AWG 6]
2	Customer control termination points for options A and B	7	Clearance, minimum 200 mm (7.9 in)
3	Cable clamp	8	Mains, 3-phase and reinforced PE
4	Screened control wiring	9	Cable gland
5	Customer control input	10	External current transformer connections

Illustration 4.3 EMC-correct Installation

NOTICE

EMC INTERFERENCE

Use screened cables for control wiring. Separate AAF mains input cable from other cables and control wiring. Minimum 200 mm (7.9 in) clearance between mains and control cables is required. Maximise this clearance to minimise EMC emissions. Doing so reduces the risk of interference between the AAF and other electronic devices.

4.2.4 Extra Protection (RCD)

ELCB, RCD, GFCI relays or multiple protective groundings are often used as extra protection, or needed to provide compliance with local safety regulations. In case of a ground fault, a DC component may develop in the fault current. Observe local regulations when using ELCB relays. To reassure effective protection and unintended tripping of protective relays, all relays must be suitable for protection of 3-phase equipment with active current infeed and for a brief discharge during power-up. Use a relay type with adjustable trip amplitude and time characteristics. Select a current sensor with sensitivity of more than 200 mA and not less than 0.1 s operation time.

4.2.5 RFI Switch

Mains supply isolated from ground (IT mains)

If the active filter is supplied from an isolated mains source (IT mains, floating delta and grounded delta) or TT/TN-S mains with grounded leg, the RFI switch is recommended to be turned off (OFF) 1) via 14-50 RFI Filter on the unit. For further reference, see IEC 364-3. In OFF mode, the internal RFI capacities between the chassis and the intermediate circuit are cut off to avoid damage to the intermediate circuit. Refer to the application note *VLT® on IT mains*. It is important to use isolation monitors that are capable for use together with power electronics (IEC 61557-8).

NOTICE

Marine grids are typically IT type grids.

4.2.6 Torque

Correct torque is imperative for all electrical connections. Incorrect torque results in a bad electrical connection. Torque values are provided in *Table 4.3*.

Enclosure size	Torque	Bolt size
D	19 Nm (168 in.-lbs.)	M10
E	19 Nm (168 in.-lbs.)	M10

Table 4.3 Correct Torque Values

Use a torque wrench to ensure correct torque.

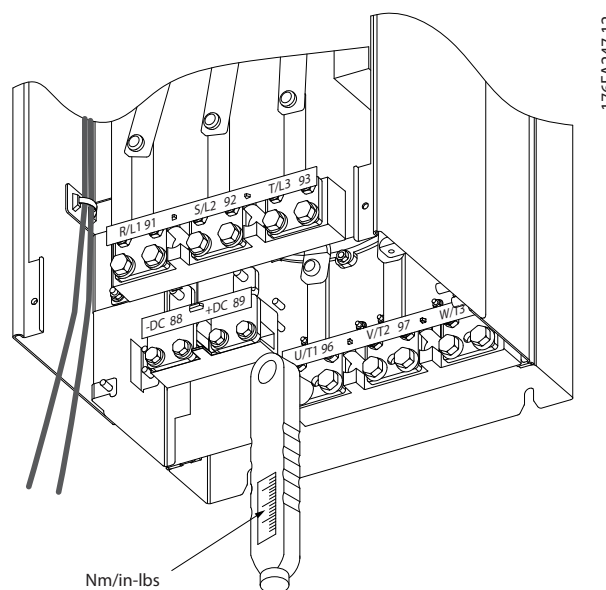


Illustration 4.4 Use a Torque Wrench to Tighten the Bolts

4.2.7 Current Transformer (CT)

The filter operates in close loop operation by receiving current signals for external current transformers. The received signal is processed and the filter reacts according to programmed actions.

CAUTION

Incorrect current transformer connection, installation or configuration leads to unintended and uncontrollable behaviour of the filter.

NOTICE

The current transformers are not part of the filter package and must be purchased separately.

CT specification

The active filter supports most CTs. The CTs must have the following specifications:

Technical specification of active filter, passive CT	
RMS	Maximum measured RMS current
Accuracy	0.5% or better (Class 0.5)
Secondary rated current	1A or 5A (5A is recommended) Set-up via hardware
Rated frequency	50/60 Hz
Rated power/burden	See <i>Table 4.5</i> (AAF burden equals 2 mΩ)

Table 4.4 CT Specifications

Rated power/ burden [VA]	5	7.5	10	15	30
Impedance of current CT [Ω]	≤ 0.15	≤ 0.25	≤ 0.35	≤ 0.55	≤ 1.15

Table 4.5 Rated Power/Burden

NOTICE

All other technical data such as dynamic rated current, maximal permitted operating voltage, thermal dimensioning of continuous current, thermal dimensioning of short-time current, overcurrent limit, isolation class, working temperature range etc. are specific values of the system and have to be defined during the project planning phase of the equipment.

RMS specification

The minimum RMS is determined by the total current that passes through the current transformer. It is important that the current sensor is not too small, leading to saturation of the sensor. Add 10% margin and pick the next following bigger standard RMS rate. Use current transformers that have an RMS rating close to the maximum current flowing through it to allow the highest possible accuracy of the measurement and so an ideal compensation.

CT burden

To ensure that the current transformer performs according to specifications, the rated burden should not be above the true current requirement of the active filter. The burden of the CT depends on the wire type and the cable length between the CT and the filter CT connection terminal. The filter itself contributes with 2 mΩ.

NOTICE

The accuracy of the CT is depending on wire type and length of the cable between filter and current transformer.

Calculate the required (minimum) CT burden as:

$$[VA] = 25 * [\Omega/M] * [M] + 1.25$$

[Ω/M] being the cable resistance in Ω/meter, [M] being the cable length in meters.

Table 4.6 shows the minimum CT burden for different wire gauge at wire length of 50 m and standard wire resistance value:

Wire Gauge [mm²/AWG]	Resistance [Ω/km]	Wire length [meters/feet]	Minimum CT burden [VA]
1.5/#16	13.3	50/164	>16.6
2.5/#14	8.2	50/164	>10.2
4/#12	5.1	50/164	> 6.3
6/#10	3.4	50/164	> 4.2
10/#8	2	50/164	> 2.5

Table 4.6 Minimum CT Burden

For a fixed CT burden, calculate the maximum allowed wire length as:

$$[M] = ([VA] - 1.25) / (25 * [\Omega/M])$$

Below the maximum wire length of CT with 2.5 mm² wires and resistor value equal 8.2 Ω/km:

Wire Gauge [mm²/ AWG]	Resistance [Ω/km]	Minimum CT burden [VA]	Wire length [meter/feet]
2.5/#14	8.2	5	<18/60
2.5/#14	8.2	7.5	<30/100
2.5/#14	8.2	10	<42/140
2.5/#14	8.2	15	<67/220
2.5/#14	8.2	30	<140/460

Table 4.7 Maximum CT Wire Length

Example

Calculation example for correct current transformer for an application with:

RMS=653 A, Distance between filter and CTs of 30 m.

RMS=653*1.1=719 A, CT RMS=750 A. Burden: 30 m@2.5 mm² wire => 25*0.0082*30+1.25=7.4=>7.5 [VA].

Current transformer installation

The unit only supports 3 CT installations. Install external CTs on all 3 phases to detect the harmonic content of the grid. The flow direction of the sensor is indicated by an arrow in most cases. The arrow points in the direction of the current flow and so towards the load. If the flow direction is programmed incorrectly, the polarity can be changed via active filter *parameter 300-25 CT Polarity*, which can program the polarity of the CTs in each of the 3 phases individually.

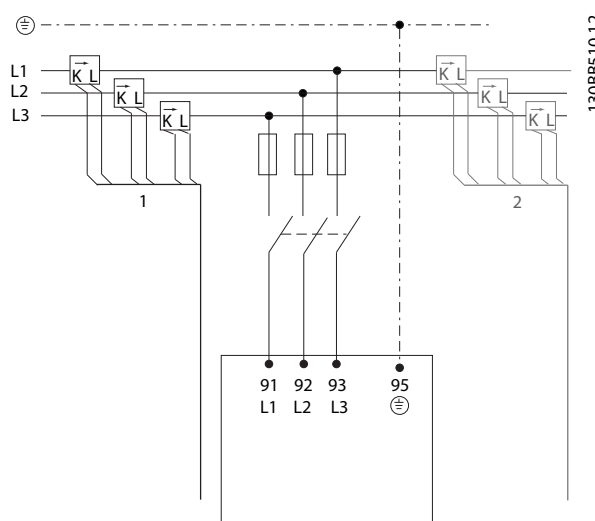


Illustration 4.5 CT Connections

1 or 5 A CT set-up

To allow for possible reuse of already present CT transformers, the active filter allows use of either 1 A or 5 A CTs. The filter is as standard set-up for 5 A CT feedback. If the CTs are 1 A, redirect the CT terminal plug from slot MK101, position 1, to MK108, position 2, on the AFC card. See *Illustration 4.6*.

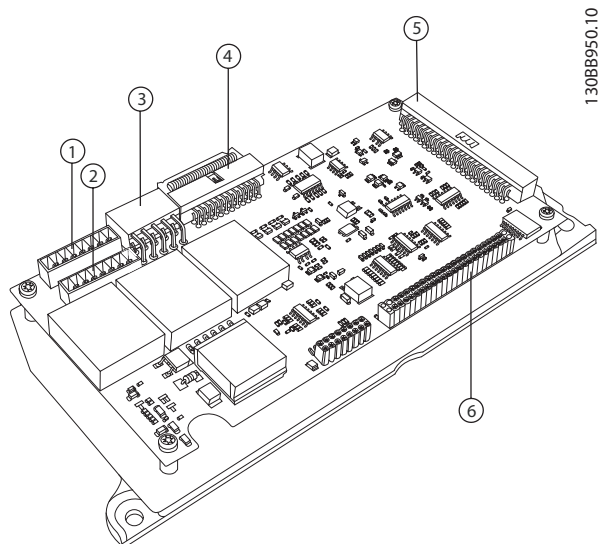


Illustration 4.6 AFC Card

Individual or group compensation

The compensation of the filter depends on the signal that is returned from the current transformers. The point of installation for these sensors is to determine the loads that are corrected.

Illustration 4.7 shows current transformers installed in front of the entire installation with the filter compensating all loads on the transformer. *Illustration 4.8* shows current transformers installed in front of distribution bus 2 and 1 frequency converter, so the filter only compensates for those.

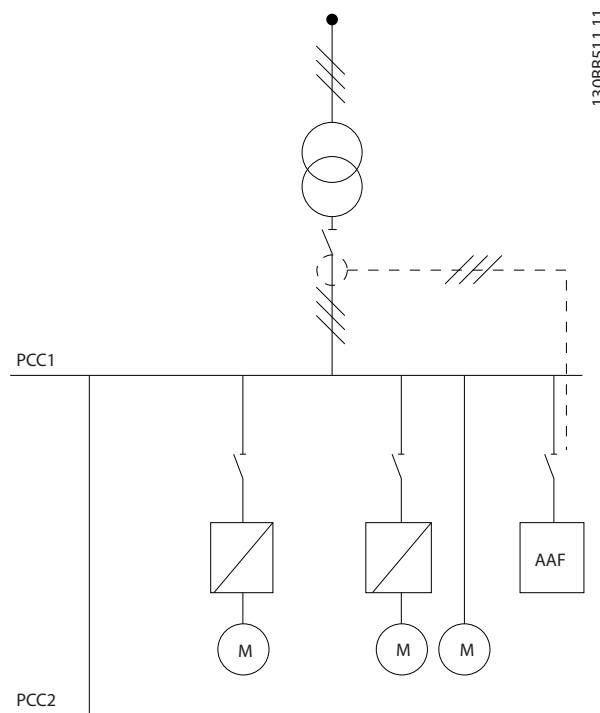


Illustration 4.7 CT on PCC Side

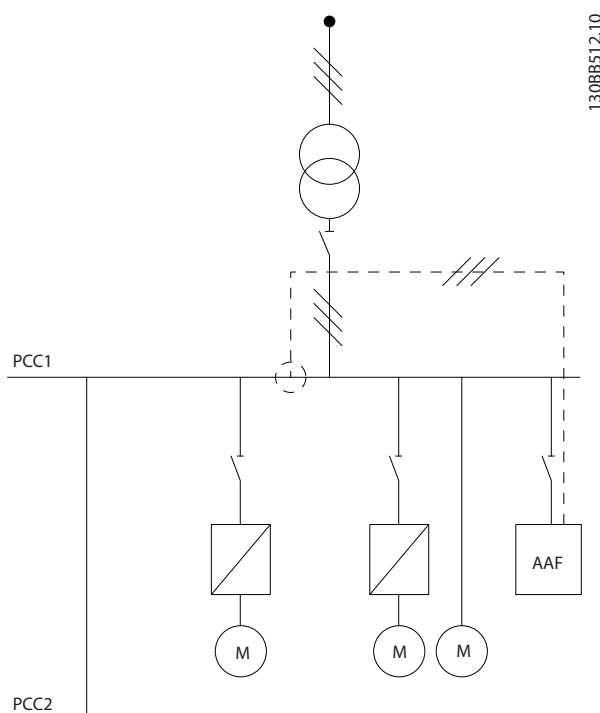


Illustration 4.8 CT on Load Side

If the CTs are installed on the secondary side of the transformer and so in front of the entire load, the filter compensates all loads simultaneously. See *Illustration 4.7*.

If, as in *Illustration 4.8*, the CTs are installed in front of only some of the loads, the filter does not compensate unwanted current deformation of the frequency converter and motor on the right hand side. If CTs are installed in front of a single load, the filter only compensates the 1 load and so form individual load compensation.

CTs can be installed on the source side (PCC–point of common coupling), or on the load side via *parameter 300-26 CT Placement*

NOTICE

The default setting is PCC side installation

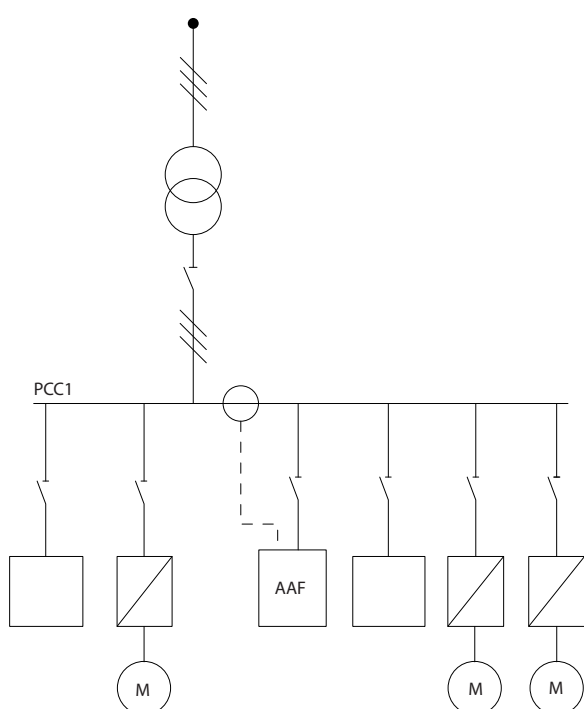


Illustration 4.9 Current Transformers Installed on Source (PCC) Side for Group Compensation

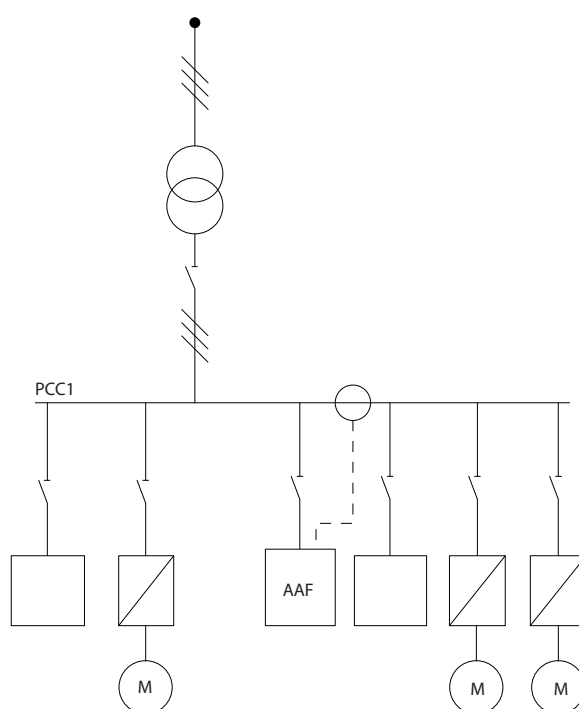


Illustration 4.10 Current Transformers Installed on Load Side for Group Compensation

If the current transformers are installed on the source (PCC) side, the filter expects a sinusoidal (corrected) signal feedback from the 3 sensors. If the sensors are installed on the load side, the received signal is subtracted from the ideal sine wave to calculate the necessary corrected current.

NOTICE

Erratic filter operation can be a result of incorrect current transformers connection point programming *parameter 300-26 CT Placement*.

4.2.8 Auto CT Detection

The active filter performs an auto detection of the installed CT. The CT auto detection can be conducted both while the system is running and when there is no load. The filter injects a prefixed current of known amplitude and phase angle and measures the returned CT input. The performance is conducted on each phase individually for several frequencies to check that phase sequence and RMS are set correctly.

The Auto CT detection is pending on the following conditions:

- Active filter bigger than 10% of CT RMS rate.
- CTs installed on source (PCC) side (auto CT not possible for load side CT installation).
- Only one CT per phase (not possible for summation CTs).
- CTs are part of below standard range:

						600	750
1000	1250	1500	2000	2500	3000	3500	4000

Table 4.8 Primary Rating [A]

Most restrictions on the CTs come from the installation, such as required cable length, temperature conditions, square section of conductors, standard or split core layout, etc. A broad range of different current transformers can be used independently of brand and type.

For specific CT requirements contact the local supplier or go to www.deif.com/

Secondary	Primary	Accuracy	Burden	Type	Description
5 or 1A	30–7500A	0.2–0.5-1	1.0–45 V A	ASR ASK EASR EASK	Measuring current transformer for cables and bus bars
5 or 1A	100–5000A	0.5–1	1.25–30 V A	KBU	Split core current transformer
5 or 1A	5 or 1A	0.5–1	15–30 V A	KSU/SUSK	Summation current transformer

Table 4.9 Standard CT Range from Deif: Fits Most Applications

4.2.9 Summation Transformers

Multiple current sources

Summation CTs are needed when the filter is to compensate current from several sources. This is often the case if a filter is installed in systems with generator back-up or where the filter is only to compensate a limited number of loads, for example, marine installations.

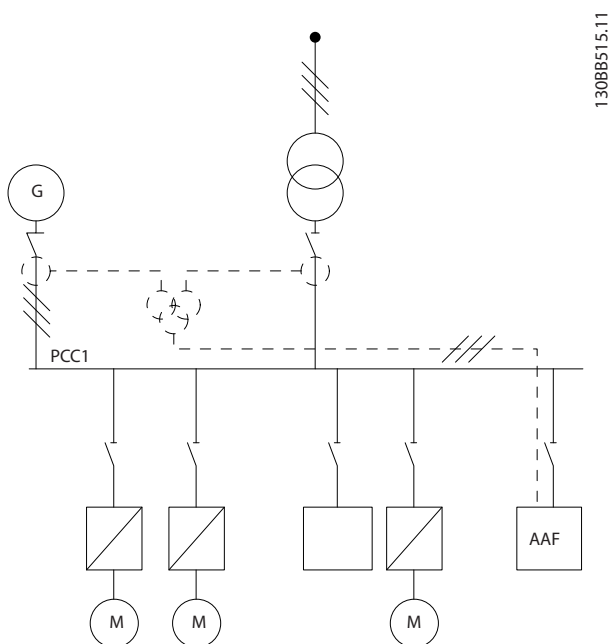


Illustration 4.11 Summation CTs on Generator Back-up Applications (PCC-side)

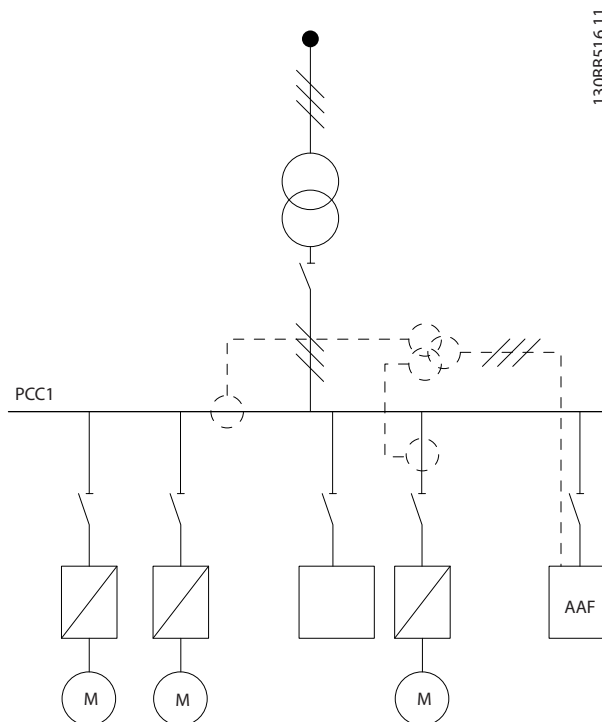


Illustration 4.12 Summation CTs Example for Individual Harmonic Compensation (Load Side)

Summation current transformers are available with multiple (2–5) inputs and a common output. For applications where summations CTs are used to add current from several sources, make sure that all CTs connected to the summation are from the same manufacturer and that the following aspects are the same:

- Polarity.
- Primary rating.
- RMS value.
- Accuracy (class 0.5).
- Location (PCC or load-side).
- Phase sequence.

NOTICE

Use summation CTs with great caution and always ensure correct phase sequence, current direction, primary and secondary rating. Incorrect installation causes problems with filter operation.

The current transformers burden calculation includes all wires in the installation and must be conducted for the longest total wire string when using summation CTs.

Total current [A]	Maximum individual harmonic compensation							
	I5	I7	I11	I13	I17	I19	I23	I25
190	133	95	61	53	38	34	30	27
250	175	125	80	70	50	45	40	35
310	217	155	99	87	62	56	50	43
400	280	200	128	112	80	72	64	56

Table 4.10 Maximum Individual Harmonic Compensation

4

4.2.10 Operating with Capacitor Banks

The active filter is able to run with capacitor banks as long as the resonance frequency of the capacitor bank is not in the operation range of the active filter.

NOTICE

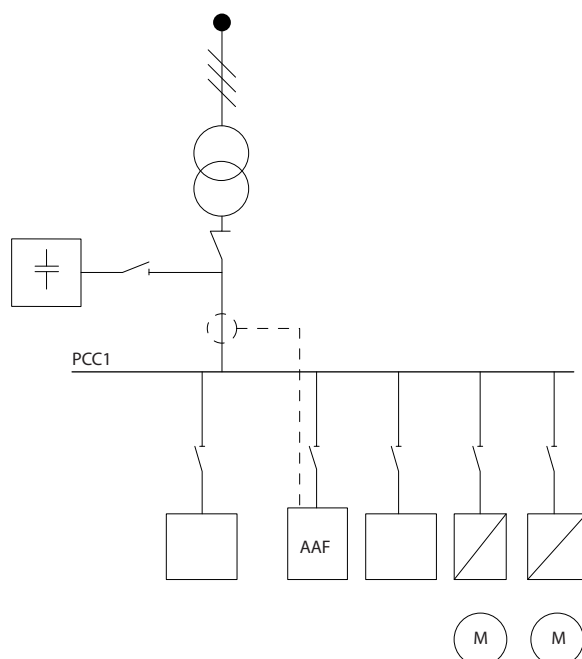
Always use de-tuned capacitor banks in installations with frequency converters and active filters to avoid resonance phenomena, unintended tripping or component breakdown.

For de-tuned capacitors, the resonance frequency capacitors should be tuned for an inter-harmonic number lower than the 3rd harmonic.

NOTICE

If installed with capacitor banks of any kind, the active filter must operate in selective compensation mode.

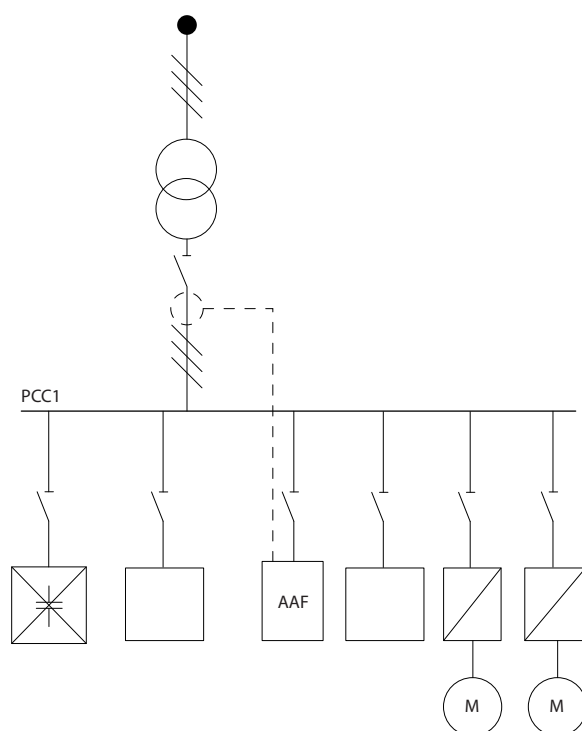
The capacitor bank should be installed upstream of the filter toward the transformer. If this is not possible, install the current transformers such that they do not measure both needed current compensation and the capacitor corrected current.



1308B517.11

Illustration 4.13 Capacitor bank mounted upstream. CTs do not measure capacitor current.

Illustration 4.13 shows recommended installation of the active filter and CT placement in installations containing capacitor banks.



1308B518.11

Illustration 4.14 Incorrect Installation

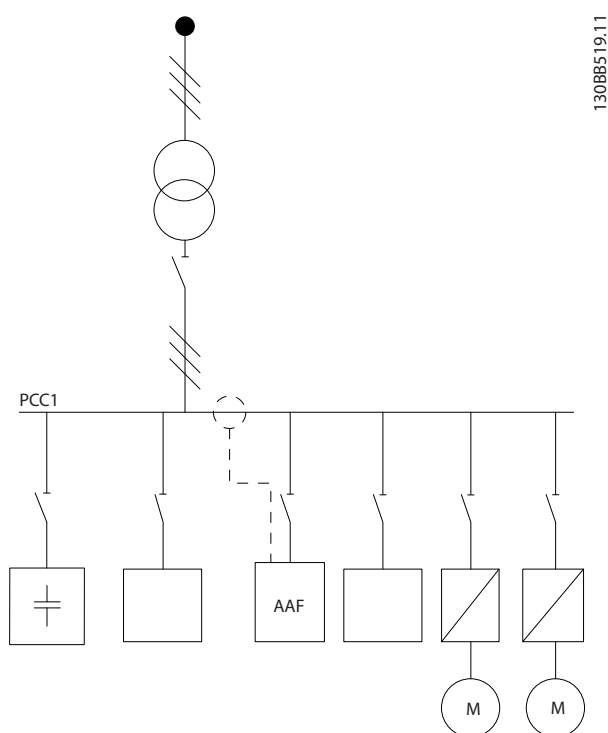


Illustration 4.15 CTs Do Not Measure Capacitor Current

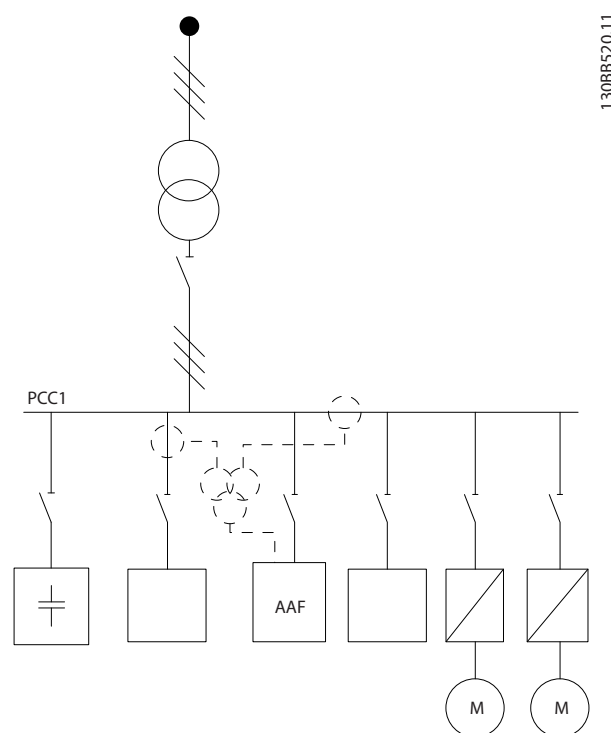


Illustration 4.16 Capacitor Bank Mounted on PCC with CTs Ensuring that Capacitor Corrected Current is not Measured.

For installations where the CT connection point can be moved, the configuration shown in *Illustration 4.15* is also possible. In some retrofit applications, summation CTs are needed to ensure that the capacitor current is not measured.

Summation CTs can also be used to subtract 2 signals from each other and so subtract the capacitor bank corrected current from the total current.

NOTICE

Use summation CTs with an accuracy of 0.5% or better.

4.2.11 Fuses

Branch circuit protection

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

Short circuit protection

Protect the active filter against short circuit to avoid electrical or fire hazard. Danfoss recommends using the fuses in *Table 4.11* and *Table 4.12* to protect service personnel and equipment in case of an internal failure in the device.

Overcurrent protection

The active filter is equipped with an internal overcurrent protection that avoids overload in normal running conditions. Overload protection is needed in case of internal failures to avoid fire hazard due to overheating of the cables in the installation. Use fuses or circuit breakers for overcurrent protection and comply with local and national regulations.

Mains fuses

Active Filter	Bussmann	Rating
AAF006, 190 A	170M3018	350 A, 700 V
AAF006, 250 A	170M4017	700 A, 700 V
AAF006, 310 A	170M4017	700 A, 700 V
AAF006, 400 A	170M6013	900 A, 700 V

Table 4.11 Recommended Mains Fuses

Supplemental fuses

Active Filter	Protection	Fuse	Rating
AAF006, 190–400A	SMPS	Bussmann KTK-4	4 A, 600 V
AAF006, 190–400A	Fan	Littelfuse KTK-15	15 A, 600 V
AAF006, 190–400A	Soft-charge resistor	Bussmann FNQ-R	1 A, 600 V
AAF006, 190–400A	CT	Bussmann FNQ-R	3 A, 600 V

Table 4.12 Recommended Supplemental Fuses

4.2.12 Mains Disconnectors

Enclosure size	Power & voltage	Type
D	A190 380–480 V	ABB OETL-NF200A
E	A250 380–480 V	ABB OETL-NF400A
E	A310 380–480 V	ABB OETL-NF400A
E	A400 380–480 V	ABB OETL-NF800A

Table 4.13 Mains Disconnect Part Numbers

4.2.13 Control and CT Cable Routing

Tie down all control wires to the designated control cable routing. Connect the shields properly to ensure optimum electrical immunity.

CT connection

Make connections on the terminal block below the active filter card. Place the cable in the path inside the filter and secure it with other control wires.

4.2.14 Control Wire Installation

All terminals to the control cables are located on the control or AFC board.

To connect the cable to the terminal:

1. Strip insulation 9–10 mm (0.4 in.)

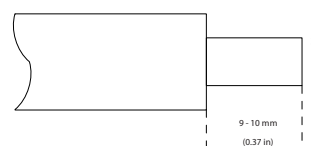


Illustration 4.17 Stripped Insulation

2. Insert a screwdriver (maximum 0.4x2.5 mm) in the square hole.

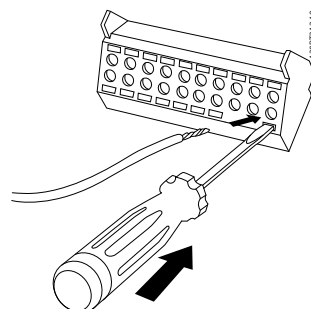


Illustration 4.18 Inserting the Cable

3. Insert the cable in the adjacent circular hole.

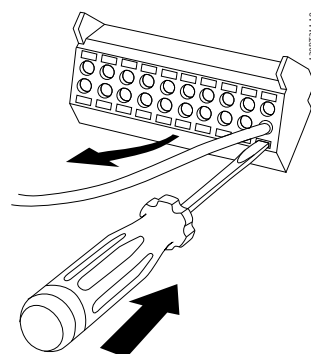


Illustration 4.19 Removing the Screwdriver

4. Remove the screwdriver. The cable is now mounted in the terminal.

To remove the cable from the terminal:

1. Insert a screwdriver (maximum 0.4x2.5 mm) in the square hole.
2. Pull out the cable.

4.2.15 Unscreened Control Wires

CAUTION

INDUCED VOLTAGE

Run input power and control wiring in separate metallic conduits or raceways for high-frequency noise isolation. Failure to isolate power and control wiring could result in less than optimum controls and associated equipment performance.

Isolate control wiring, including CT wires, from the high-voltage power wiring. When screened/armoured cable is not used, ensure that control wires are twisted pairs and keep the maximum possible distance between mains wire and control cables.

Long control cables and analog signals may result in 50/60 Hz ground loops due to noise from mains supply cables.

If ground loops occur, break the screen or insert a 100 nF capacitor between screen and chassis, if needed.

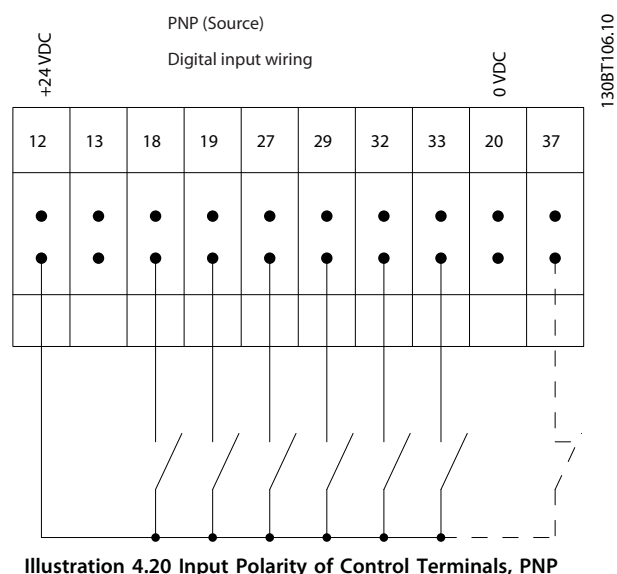


Illustration 4.20 Input Polarity of Control Terminals, PNP

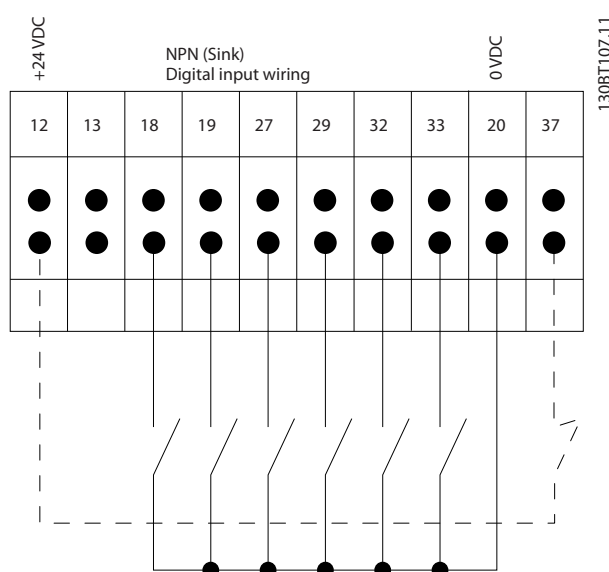


Illustration 4.21 Input Polarity of Control Terminals, NPN

NOTICE

To comply with EMC emission specifications, use screened/armoured cables. If using unscreened control cables, use ferrite cores to improve EMC performance.

Connect the shields in a proper way to ensure optimum electrical immunity.

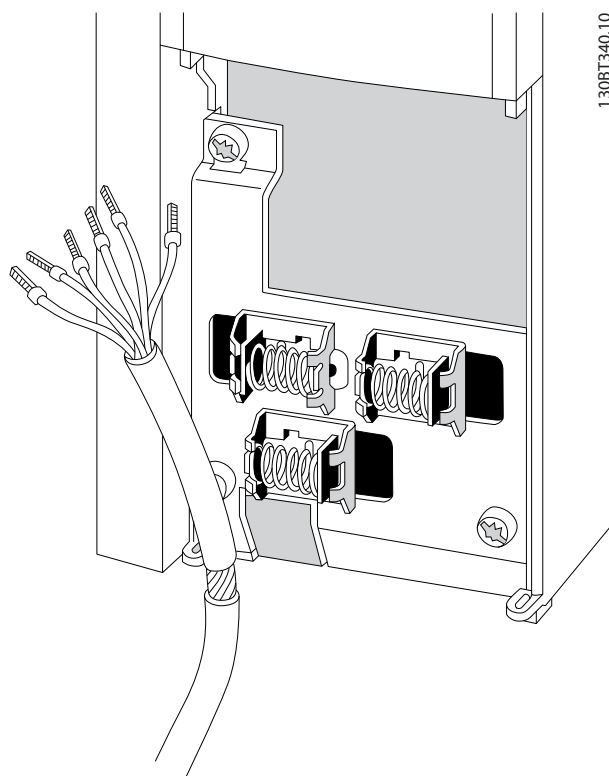


Illustration 4.22 Connecting Shielded Control Cables

4

4.2.16 Electrical Installation, Control Cables

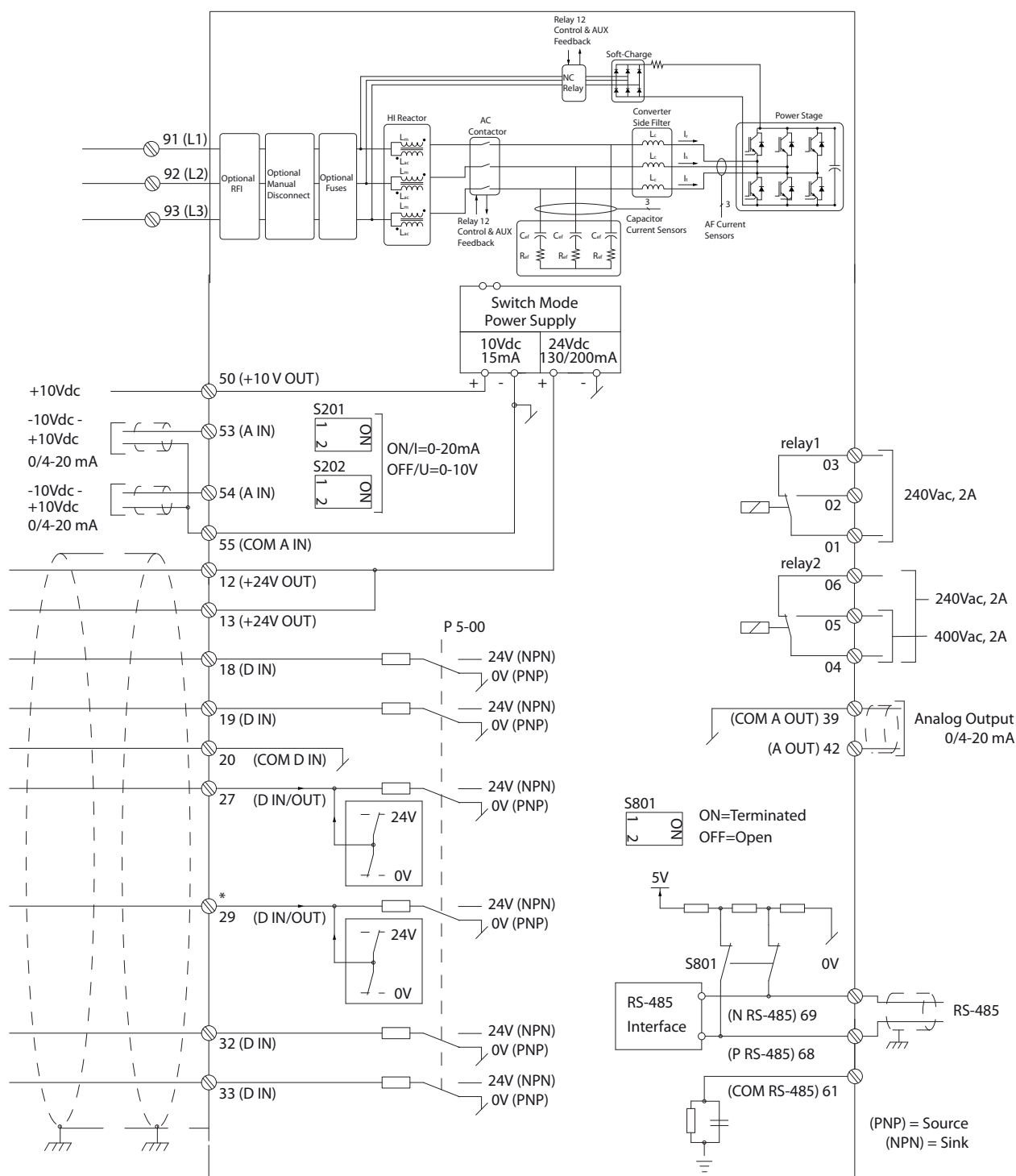


Illustration 4.23 Terminal Diagram

4.3 Installation Checklist

Before completing installation of the unit, inspect the entire installation as detailed in *Table 4.14*. Check and mark the items when completed.

Inspect for	Description	☑
Auxiliary equipment	• Ensure that all auxiliary equipment, such as switches, disconnects, or input fuses/circuit breakers are ready for operation. • Check function and installation of any sensors used for feedback to the active filter.	
Cable routing	• Ensure that power wiring and control wiring are separated, screened, or in 3 separate metallic conduits for high-frequency interference isolation.	
Control wiring	• Check for broken or damaged wires and loose connections. • Check that control wiring is isolated from power wiring for noise immunity. • Check the voltage source of the signals, if necessary. • The use of shielded cable or twisted pair is recommended. Ensure that the shield is terminated correctly.	
Cooling clearance	• Measure that top and bottom clearance is adequate to ensure proper air flow for cooling, see <i>chapter 3.2.4 Cooling and Airflow</i>.	
Ambient conditions	• Check that requirements for ambient conditions are met.	
Fusing and circuit breakers	• Check for proper fusing or circuit breakers. • Check that all fuses are inserted firmly and are in operational condition and that all circuit breakers are in the open position.	
Grounding	• Check for good ground connections that are tight and free of oxidation. • Grounding to conduit, or mounting the back panel to a metal surface, is not a suitable grounding.	
Input and output power wiring	• Check for loose connections. • Check that motor and mains are in separate conduit or separated screened cables.	
Panel interior	• Inspect that the unit interior is free of dirt, metal chips, moisture, and corrosion. • Check that the unit is mounted on an unpainted, metal surface.	
Switches	• Ensure that all switch and disconnect settings are in the proper positions.	
Vibration	• Check that the unit is mounted solidly, or that shock mounts are used, as necessary. • Check for an unusual amount of vibration.	

Table 4.14 Installation Check List

⚠ CAUTION

POTENTIAL HAZARD IN THE EVENT OF INTERNAL FAILURE

Risk of personal injury when the active filter is not properly closed.

- Before applying power, ensure all safety covers are in place and securely fastened.

5 User Interface

5.1 Local Control Panel Operation

5.1.1 Modes of Operation

There are 2 ways to operate the unit:

- Graphical Local Control Panel (GLCP)
- RS485 serial communication or USB, both for PC connection

5.1.2 How to Operate Graphical LCP (GLCP)

NOTICE

The active filter should be in *Auto* mode. Press [Auto On] on the filter LCP.

Graphical display:

The LCD display is backlit with a total of 6 alpha-numeric lines. All data is displayed on the LCP, which can show up to 5 operating variables while in *Status* mode.

Illustration 5.1 shows an example of the frequency converter LCP. The filter LCP looks identical but displays information related to the filter operation.

1. Display:
 - 1a **Status line:** Status messages displaying icons and graphics.
 - 1b **Line 1–2:** Operator data lines displaying data and variables the user defines. Add an extra line by pressing the [Status] key.
 - 1c **Status line:** Status messages displaying text.
2. Menu soft keys.
3. Indicator lights/navigation panel.
4. Operational keys.

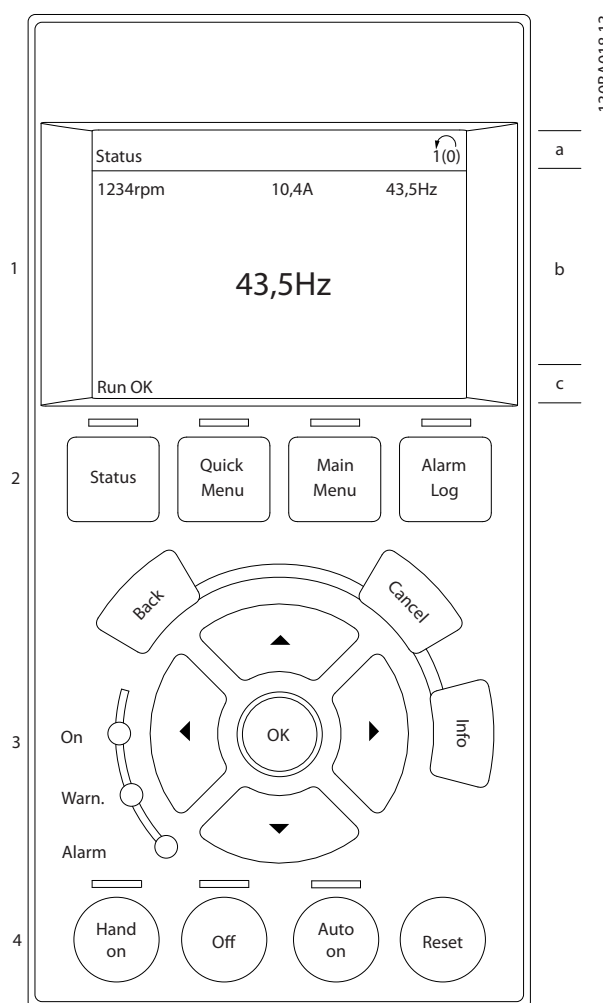


Illustration 5.1 Example LCP

The display is divided into 3 sections:

Top section (a)

Shows the status when in status mode or up to 2 variables when not in status mode and in the case of alarm/warning.

The number of the active set-up (selected as the active set-up in *parameter 0-10 Active Set-up*) is shown. When programming in another set-up than the active set-up, the number of the set-up being programmed appears to the right in brackets.

Middle section (b)

Shows up to 5 variables with related unit, regardless of status. In case of alarm/warning, the warning is shown instead of the variables.

It is possible to toggle among 3 status readout displays by pressing [Status].

Operating variables with different formatting are shown on each status screen.

Several values or measurements can be linked to each of the displayed operating variables. Define the values/measurements to be displayed via parameters 0-20, 0-21, 0-22, 0-23, and 0-24.

Each value/measurement readout parameter selected in parameters 0-20 to 0-24 has its own scale and number of digits after a possible decimal point. Larger numeric values are displayed with few digits after the decimal point.

Example: Current readout

5.25 A; 15.2 A 105 A.

Status display I

This readout state is standard after start-up or initialisation. Press [Info] to obtain information about the value/ measurement linked to the displayed operating variables (1.1, 1.2, 1.3, 2, and 3).

See the operating variables shown in the display in *Illustration 5.2*. 1.1, 1.2 and 1.3 are shown in small size. 2 and 3 are shown in medium size.

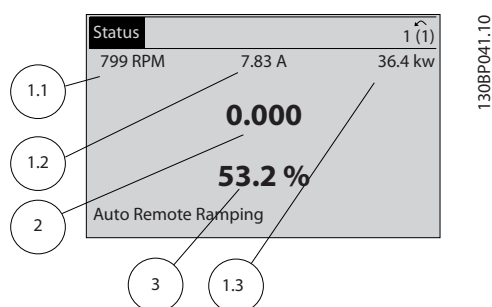


Illustration 5.2 Status Display I - Operating Variables

Status display II

See the operating variables (1.1, 1.2, 1.3, and 2) shown in the display in *Illustration 5.3*.

In the example, speed, motor current, motor power, and frequency are selected as variables in the first and second lines.

1.1, 1.2 and 1.3 are shown in small size. 2 is shown in large size.

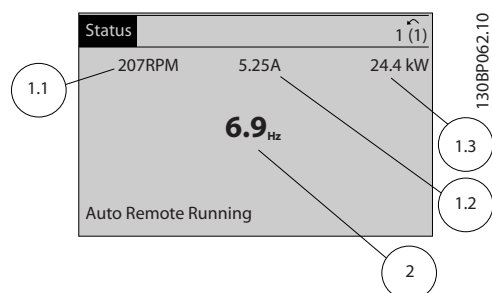


Illustration 5.3 Status Display II - Operating Variables

Bottom section

The bottom section always shows the state of the frequency converter in *Status* mode.

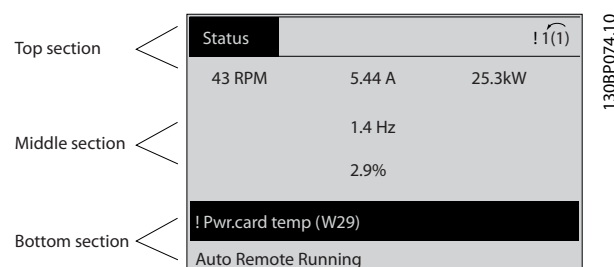


Illustration 5.4 Bottom Section Status Mode

Display contrast adjustment

Press [status] and [▲] for darker display

Press [Status] and [▼] for brighter display

Indicator lights (LEDs):

If certain threshold values are exceeded, the alarm and/or warning indicator lights are illuminated. A status and alarm text appear on the control panel.

The On indicator light is activated when the active filter receives power from:

- Mains voltage.
- A 24 V external supply.

Indicator lights (LEDs)

- Green LED/On: Control section is working.
- Yellow LED/Warn: Indicates a warning.
- Flashing Red LED/Alarm: Indicates an alarm.

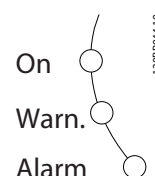


Illustration 5.5 LED Status Indicator Lights

LCP keys

Menu keys

The menu keys are divided into functions. The keys below the display and indicator lights are used for parameter set-up, including option of display indication during normal operation.



Illustration 5.6 Menu Keys

[Status]

Indicates the status of the active filter. Use [Status] for selecting display mode or reverting to display mode from:

- Quick menu.
- Main menu.
- Alarm mode.

Press the [Status] key to toggle single or double readout mode.

[Quick Menu]

The quick menu allows quick set-up of the frequency converter or the filter and programming of the most common functions.

The [Quick Menu] consists of:

- Q1: My personal menu.
- Q2: Quick set-up.
- Q5: Changes made.
- Q6: Loggings.

The active filter LCP displays information about operation such as THD of current, corrected current, injected current or Cos ϕ , and true power factor.

The Quick Menu parameters can be accessed immediately unless a password has been created via parameters 0-60, 0-61, 0-65 or 0-66.

It is possible to switch directly between *Quick Menu* mode and *Main Menu* mode.

[Main Menu]

The main menu is used for programming all parameters. The Main Menu parameters can be accessed immediately unless a password has been created via parameters 0-60, 0-61, 0-65 or 0-66.

It is possible to switch directly between *Main Menu* mode and *Quick Menu* mode.

A parameter shortcut can be carried out by pressing down [Main Menu] for 3 s. The parameter shortcut allows direct access to any parameter.

[Alarm Log]

The alarm log displays an alarm list of the 5 latest alarms (numbered A1-A5). To obtain more details about an alarm, press the navigation keys to navigate to the alarm number and press [OK]. Information is displayed about the condition of the frequency converter or filter before it enters the alarm mode.

[Back]

The back key reverts to the previous step or layer in the navigation structure.



Illustration 5.7 Back Key

[Cancel]

The last change or command is cancelled as long as the display has not been changed.



Illustration 5.8 Cancel Key

[Info]

The info key displays information about a command, parameter, or function in any display window. [Info] provides detailed information when needed. Exit *Info* mode by pressing either [Info], [Back], or [Cancel].



Illustration 5.9 Info Key

Navigation keys

The 4 navigation keys are used to navigate between the options available in [Quick Menu], [Main Menu], and [Alarm Log]. Move the cursor with the navigation keys.

[OK]

The OK key is used for selecting a parameter marked by the cursor and for enabling the change of a parameter.

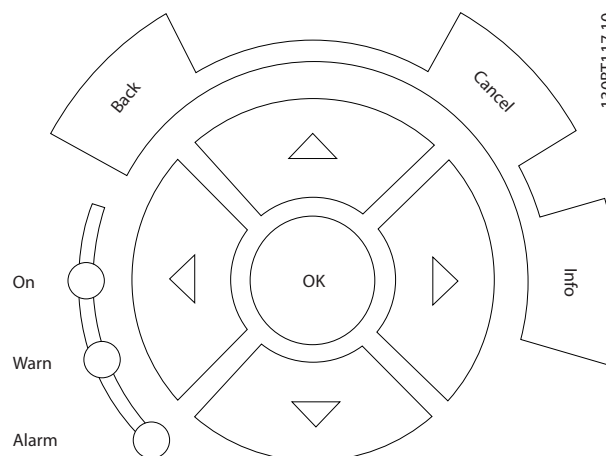


Illustration 5.10 Navigation Keys

Operation keys

For local control. Found at the bottom of the control panel.

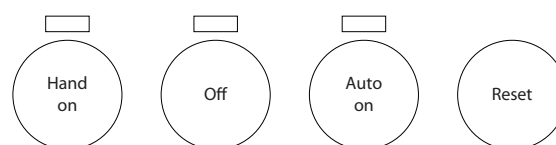


Illustration 5.11 Operation Keys

[Hand On]

Press [Hand On] to begin operation of the active filter via the LCP. The key can be [1] Enabled or [0] Disabled via 0-40 [Hand on] Key on LCP.

The following control signals are active when [Hand On] is pressed:

- [Hand On] - [Off] - [Auto On].
- Reset.
- Stop inverse.
- Set-up select bit 0; Set-up select bit 1.

NOTICE

External stop signals activated with control signals or a serial bus overrides a Start command via the LCP.

[Off]

The OFF key stops the active filter (when pressed on the filter LCP). The key can be [1] Enabled or [0] Disabled via parameter 0-41 [Off] Key on LCP. If no external stop function is selected, and the [Off] key is inactive, the active filter can only be stopped by disconnecting the mains supply.

[Auto On]

The Auto On key enables the active filter to be controlled via the control terminals and/or serial communication. When a start signal is applied on the control terminals and/or the bus, the active filter starts. The key can be [1] Enabled or [0] Disabled via parameter 0-42 [Auto on] Key on LCP.

NOTICE

An active HAND-OFF-AUTO signal via the digital inputs has higher priority than the control keys [Hand On] – [Auto On].

[Reset]

The Reset key is used for resetting the filter after an alarm (trip). The key can be [1] Enabled or [0] Disabled via parameter 0-43 [Reset] Key on LCP on the LCP.

Parameter shortcut

A parameter shortcut can be carried out by holding down [Main Menu] for 3 s. The parameter shortcut allows direct access to any parameter.

5.1.3 Changing Data

1. Press [Quick Menu] or [Main Menu].
2. Press [▲] and [▼] to find the parameter group to edit.
3. Press [OK].
4. Press [▲] and [▼] to find the parameter to edit.
5. Press [OK].

6. Press [▲] and [▼] to select the correct parameter setting. Or, to move to digits within a number, use [◀] and [▶]. The cursor indicates the digit selected to change. [▲] increases the value, [▼] decreases the value.
7. Press [Cancel] to ignore the change, or press [OK] to accept the change and enter a new setting.

5.1.4 Changing a Text Value

If the selected parameter is a text value, change the text value by pressing the [▲]/[▼] keys.

[▲] increases the value, and [▼] decreases the value. Place the cursor on the value to be saved and press [OK].

5.1.5 Changing a Group of Numeric Data Values

If the selected parameter represents a numeric data value, change the selected data value by pressing the [◀] and [▶] navigation keys as well as [▲] and [▼] keys. Press [◀] and [▶] to move the cursor horizontally.

Press [▲]/[▼] to change the data value. [▲] increases the data value, and [▼] decreases the data value. Place the cursor on the value to be saved and press [OK].

5.1.6 Changing of Data Value, Step-by-Step

Certain parameters can be changed step-by-step or infinitely variably. This method applies to parameter 300-10 Active Filter Nominal Voltage. The parameters are changed both as a group of numeric data values and as numeric data values infinitely variably.

5.1.7 Readout and Programming of Indexed Parameters

Parameters are indexed when placed in a rolling stack. 15-30 Alarm Log: Error Code to parameter 15-32 Alarm Log: Time contain a fault log that can be read out. Select a parameter, press [OK], and use [▲]/[▼] to scroll through the value log.

Use 3-10 Preset Reference as another example: Select the parameter, press [OK], and press [▲]/[▼] to scroll through the indexed values. To change the parameter value, select the indexed value and press [OK]. Change the value by using [▲]/[▼]. Press [OK] to accept the new setting. Press [Cancel] to abort. Press [Back] to leave the parameter.

5.1.8 Quick Transfer of Parameter Settings with the LCP

Once the set-up is complete, store (back up) the parameter settings in the LCP or on a PC via MCT 10 set-up software tool.

WARNING

Running the unit during these operations can cause unexpected operation. Stop the unit before performing any of these operations. Failure to do so can cause damage or injury..

Data storage in LCP

1. Go to 0-50 LCP Copy.
2. Press [OK].
3. Select [1] All to LCP.
4. Press [OK].

All parameter settings are now stored in the LCP indicated by the progress bar. When 100% is reached, press [OK].

The LCP can now be connected to another active filter and the parameter settings copied to this active filter.

Data transfer from LCP to the unit

1. Go to 0-50 LCP Copy.
2. Press [OK].
3. Select [2] All from LCP.
4. Press [OK].

The parameter settings stored in the LCP are now transferred to the active filter indicated by the progress bar. When 100% is reached, press [OK].

5.1.9 Initialisation to Default Settings

There are 2 ways to initialise the unit to default: Recommended initialisation and manual initialisation. Each method has a different impact.

5.1.9.1 Recommended Initialisation Method

Initialisation via 14-22 Operation Mode

1. Select 14-22 Operation Mode.
2. Press [OK].
3. Select Initialisation.
4. Press [OK].
5. Remove power to the unit and wait for the display to turn off.
6. Reconnect power to reset the unit.
7. Press [Reset].

14-22 Operation Mode initialises all except:

- Parameter 14-50 RFI Filter.
- 8-31 Address.
- 8-32 Baud Rate
- 8-35 Minimum Response Delay
- Parameter 8-36 Max Response Delay
- 8-37 Maximum Inter-Char Delay
- Parameter 15-00 Operating hours to parameter 15-05 Over Volt's
- Parameter 15-20 Historic Log: Event to parameter 15-22 Historic Log: Time
- 15-30 Alarm Log: Error Code to parameter 15-32 Alarm Log: Time

NOTICE

Parameters selected in 0-25 My Personal Menu, stay present with default factory setting.

5.1.9.2 Manual Initialisation Method

NOTICE

When carrying out manual initialisation, serial communication, RFI filter settings, and fault log settings are reset. Manual initialisation removes parameters selected in 0-25 My Personal Menu.

1. Disconnect from mains and wait until the display turns off.
2. Press [Status] - [Main Menu] - [OK] at the same time during power-up for graphical LCP .
3. Release the keys after 5 s.
4. The unit is now programmed according to default settings.

This parameter initialises all except:

- Parameter 15-00 Operating hours
- Parameter 15-03 Power Up's
- Parameter 15-04 Over Temp's
- Parameter 15-05 Over Volt's

5.1.10 RS485 Bus Connection

A frequency converter or active filter can be connected to a controller (or master) together with other loads using the RS485 standard interface. Terminal 68 is connected to the P signal (TX+, RX+), while terminal 69 is connected to the N signal (TX-, RX-).

To avoid potential equalising currents in the screen, ground the cable screen via terminal 61, which is connected to the frame via an RC-link.

Bus termination

Terminate the RS485 bus via a resistor network at both ends. If the unit is the first or the last device in the RS485 loop, set the switch S801 on the control card to ON.

5.1.11 Connection to a PC

To program the unit from a PC, install the PC-based configuration tool MCT 10 Set-up Software.

The PC is connected via a standard (host/device) USB cable to the unit, or via the RS485 interface.

NOTICE

The USB connection is galvanically isolated from the supply voltage (PELV) and other high-voltage terminals. The USB connection is connected to protective ground on the unit. Use only an isolated laptop as PC connection to the USB connector.

For control cable connections, see *chapter 4.2.16 Electrical Installation, Control Cables*.

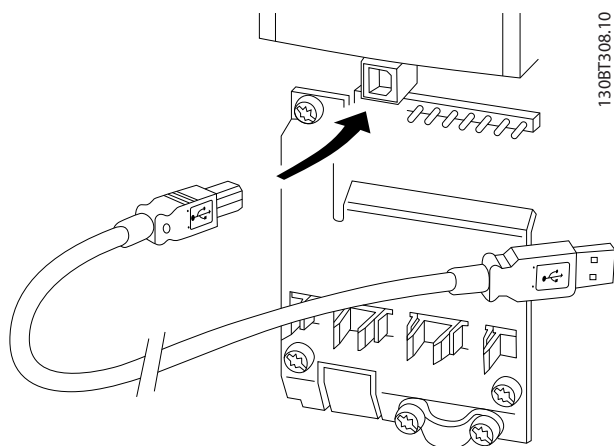


Illustration 5.12 Control Cable Connections

6 Applications and Basic Programming

6.1 Paralleling of Active Filters

6.1.1 Parameter Set-up

The factory settings for the active filter are selected for optimal operation for most applications with a minimum of programming needed. The filter is set in overall harmonic compensation mode with harmonic current priority. Selection of readouts and information to be displayed on the LCP status lines can be customised. In a few cases, the filter must be tuned specially for the given grid and load conditions.

The following steps are often sufficient to set up the filter and get proper operation:

- Program the external CTs:
 - Check that the CT location is correct in *parameter 300-26 CT Placement*.
 - Activate the Auto CT Detection in *parameter 300-29 Start Auto CT Detection*.
 - Confirm the found CT ratio, polarity, and sequence.
- Make sure that the filter is in auto mode (press [Auto On] on the LCP).

All digital input/output terminals are multifunctional. All terminals have factory default functions suitable for most applications but if other special functions are required, they must be programmed in parameter group 5-***Digital I/O Mode*.

6.1.2 Paralleling of Active Filters

The VLT® Active Filter is designed for installation in networks with other active infeed current suppliers and so operate in conjunction with other active filters, UPS's and AFE drives. There is no limitation to the allowable number of units. Four filters can be connected to the same CT input and run in a master/slave configuration. The master unit activates the individual slaves according to mitigation demand in a cascade network. This keeps the switching losses as low as possible and so improves the system efficiency. The master unit automatically allocates a new slave in case a unit is out due to service or has unintentionally tripped.

6.1.3 CT-wiring for Parallel Filter Connection

VLT active filter is designed to allow up to 4 units to run in parallel for a harmonic and reactive compensation extension to 4 times the individual filter rating. The parallel installed filters use the same current input and so only one external set of CTs have to be installed. In case additional filtration is needed, additional filters have to use separate current transformers installed up or down stream of the CT signal and injection point of the paralleled installation.

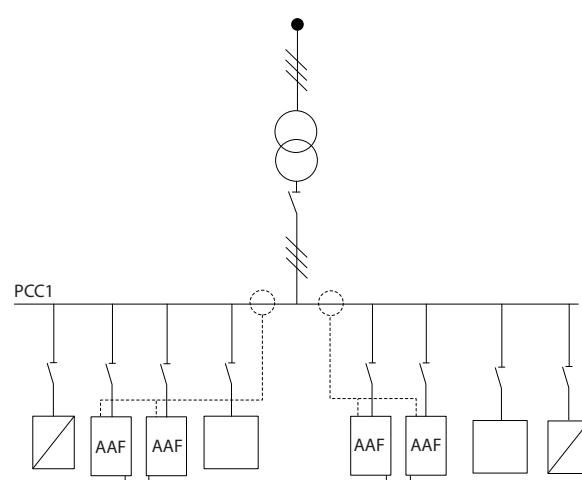


Illustration 6.1 2 Sets of AAFs in Master/Slave

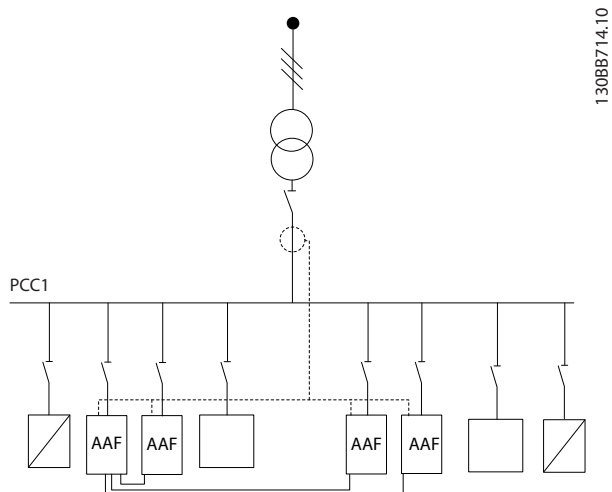


Illustration 6.2 4 AAFs in Master/Slave

The parallel connected filters must have the CT input signal wired in serial according to *Illustration 6.3*:

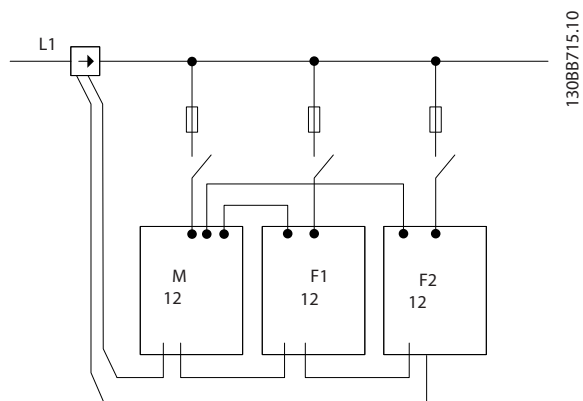


Illustration 6.3 Single-phase CT-connection Diagram for Master and Slave

CAUTION

Unshielded cables can lead to noise on the CT and result in incorrect harmonic filtration. Use shielded cables for correct EMC installation. Failure to do so can cause improper equipment function or damage.

The current transformers VA-limitation still have to be kept for filters in parallel, and so total wire lengths must be limited according to wire type and CT VA-rating.

$$[M] = \frac{([VA] - 1,25)}{(25 * [Q/M])}$$

See *chapter 4.2.1 Power Connections* for more details.

6.1.4 Control Wire Connection for Parallel Filter Run

In addition to the CT wiring, all slave units must be connected to the master via either digital or analog inputs. *Illustration 6.4* shows the necessary control wire connections:

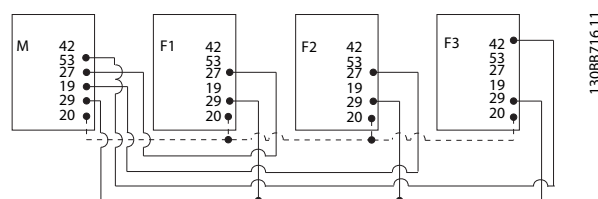


Illustration 6.4 Control Wire Connection of Slave units F1-F3 to Master M

Table 6.1 shows the necessary connections when fewer than 4 units are paralleled. The software set-up of digital and analog input/output is done automatically according to *Table 6.1*, based on software programming *parameter 300-40 Master Follower Selection* and *parameter 300-41 Follower ID*.

	Terminal connection at follower	Terminal connection at master
Follower 1 (F1)	27	27
Follower 2 (F2)	27	19
Follower 3 (F3)	42	53
All (parallel)	29	29
All (parallel)	20	20

Table 6.1 Master/follower Terminal Connections

Follower units will not work if control wires are not correctly connected. Connect control wiring as directed in *chapter 4 Electrical Installation*. Failure to do so can cause malfunction.

NOTICE

Use screened control wires for correct EMC installation.

6.1.5 Software Set-up of Parallel Filter Run

Running followers in different mitigation mode or with changed priorities individually compromises performance. Parallel-connected filters are thus always to be programmed with same compensation and priority mode. Ensure all CT settings have been set identically in all parallel connection units, and all have the same hardware secondary CT configuration.

The automatic CT detection is still effective for filters in a master/follower configuration but setting follower units manually is recommended. Use the following procedure for setting the CT values:

1. Program master unit *parameter 300-10 Active Filter Nominal Voltage*.
2. Program master unit *parameter 300-26 CT Placement*.
3. Perform an automatic CT detection on master unit *parameter 300-29 Start Auto CT Detection*.
4. Note the auto CT result and manually program each follower unit.
5. Ensure identical settings in *parameter 300-10 Active Filter Nominal Voltage* and *parameter 300-26 CT Placement* on each unit.

Alternatively, each follower unit can conduct an automatic CT detection after the master unit is turned off. Only run 1 auto CT detection at a time.

In addition to this CT setting, it is also necessary to set each unit to have its respective role in the cascade network. *Parameter 300-40 Master Follower Selection* is set to master or follower for each unit.

300-40 Master Follower Selection		
Option:		Function:
[0]	Master	If operating active filters in parallel, select whether this filter is a master or a follower active filter.
[1]	Follower	
[2] *	Not Paralleled	

NOTICE

Ensure that only 1 master is set in each group of parallel connected filters. Verify that no other unit is set to master.

After changing this parameter, additional parameters are accessible. For the master units, *300-42 Number of Follower AFs* has to be programmed for the number of followers connected.

300-41 Follower ID		
Range:		Function:
1*	[1 - 3]	Enter the unique ID of this follower. Verify that no other follower uses the same ID.

NOTICE

Parameter 300-41 Follower ID is not accessible unless *parameter 300-40 Master Follower Selection* is set to follower.

NOTICE

Each follower should have its own follower ID. Verify that no 2 followers have the same follower ID.

300-42 Num. of Follower AFs		
Range:		Function:
1*	[1 - 3]	Enter the total number of follower active filters. The master active filter only controls this number of followers.

NOTICE

Parameter 300-42 Num. of Follower AFs is not accessible unless *parameter 300-40 Master Follower Selection* is set to master.

Program each follower unit at *parameter 300-41 Follower ID* with a unique ID.

Before starting the units by pushing [Auto On], check that the following parameters all have been correctly programmed and have similar values for all units sharing 1 set of CTs:

- *Parameter 300-00 Harmonic Cancellation Mode.*
- *Parameter 300-20 CT Primary Rating.*
- *300-22 CT Nominal Voltage.*
- *Parameter 300-24 CT Sequence.*
- *Parameter 300-25 CT Polarity.*
- *Parameter 300-26 CT Placement.*
- *Parameter 300-30 Compensation Points.*
- *Parameter 300-35 Cosphi Reference.*

6.2 Programming

6.2.1 Quick Menu Mode

The LCP provides access to all parameters listed under the Quick Menus. Press [Quick Menu] to display the list of options in the quick menu.

Efficient parameter set-up for most applications

The parameters for most the applications are set up via the *Quick Menu*.

To set parameters through the [Quick Menu]:

1. Select [2] *Quick set-up* for selecting language, compensation mode, CT set-up, etc.
2. Select [1] *My personal menu* to set up the LCP readout parameters. If preset display is acceptable, this operation can be left out.

It is recommended to do the set-up in the order listed.

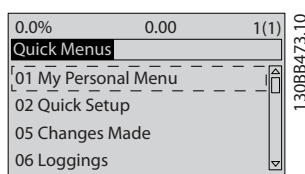


Illustration 6.5 Quick Menu View

If *No Operation* is selected in terminal 27, no connection to +24 V on terminal 27 is necessary to enable start.

If *Coast Inverse* is selected in Terminal 27, a connection to +24 V is necessary to enable start.

6.2.2 Q1 My Personal Menu

Parameters defined by the user can be stored in *Q1 My Personal Menu*. Select *My Personal Menu* to display only the parameters, which have been pre-selected and programmed as personal parameters. A large-scale active filter user may have pre-programmed important set-up values in the *My Personal Menu* to make on-site commissioning/fine-tuning simpler. These parameters are selected in *parameter 0-25 My Personal Menu*. Up to 20 different parameters can be defined in this menu.

Q1 My Personal Menu	
Parameter number and Name	Factory default
0-01 Language	English
0-20 Display Line 1.1 Small	Power Factor
0-21 Display Line 1.2 Small	THD of current
0-22 Display Line 1.3 Small	Mains current
0-23 Display Line 2 Large	Output current (corrected)
0-24 Display Line 3 Large	Mains frequency
15-51 Frequency Converter Serial Number	

Table 6.2 My Personal Menu Settings

6.2.3 Q2 Quick Setup

The parameters in *Q2 Quick Setup* are the basic parameters that are always needed to set up the active filter.

Q2 Quick Setup	
Parameter number and Name	Factory default
0-01 Language	English
300-22 CT Nominal Voltage	Same as AF
Parameter 300-29 Start Auto CT Detection	Off
Parameter 300-01 Compensation Priority	Harmonics
Parameter 300-00 Harmonic Cancellation Mode	Overall

Table 6.3 Quick Setup Settings

NOTICE

Set the nominal voltage and CT secondary rating and change *parameter 300-26 CT Placement* to PCC before starting the Auto CT detection. Auto CT detection is only possible if CTs are located at the point of common coupling.

6.2.4 Q5 Changes Made

Use *Q5 Changes Made* for fault finding.

Select *Q5 Changes Made* to get information about:

- The 10 most recent changes. Use ▲ and ▼ to scroll between the last 10 parameters changed.
- Changes made since default setting.

6.2.5 Q6 Loggings

Use *Q6 Loggings* for fault finding.

Select *Loggings* to get information about the display line readouts. The information is shown as graphs. Only display parameters selected in *0-20 Display Line 1.1 Small* and *0-24 Display Line 3 Large* can be viewed. It is possible to store up to 120 samples in the memory for later reference. Note that the parameters listed in *Table 6.4* for Q6 only serve as examples as they vary depending on the programming of the particular active filter.

Q6 Loggings	
0-20 Display Line 1.1 Small	Power Factor
0-21 Display Line 1.2 Small	THD of current
0-22 Display Line 1.3 Small	Mains Current
0-23 Display Line 2 Large	Output Current
0-24 Display Line 3 Large	Mains Frequency

Table 6.4 Loggings Parameter Examples

6.2.6 Main Menu Mode

The LCP provides access to the *Main Menu* mode. Select the *Main Menu* mode by pressing the [Main Menu] key. The resulting readout appears on the display of the LCP. Lines 2 through 5 on the display show a list of parameter groups that can be selected via the ▲ and ▼ keys.

Each parameter has a name and number that remain the same regardless of the programming mode. In the *Main Menu* mode, the parameters are divided into groups. The first digit of the parameter number (from the left) indicates the parameter group number. All parameters can be changed in the main menu. Option cards added to the unit enable additional parameters associated with the option device.

6.2.7 Parameter Selection

Select a parameter group with the navigation keys.
The following parameter groups are accessible:

Group	Title	Function
0-**-	Operation/Display	Parameters related to the fundamental functions of the filter, function of the LCP keys and configuration of the LCP display.
5-**-	Digital In/Out	Parameter group for configuring the digital inputs and outputs.
8-**-	Communication and Options	Parameter group for configuring communications and options.
14-**-	Special Functions	Parameter group for configuring special filter functions.
15-**-	Unit Information	Parameter group containing filter information such as operating data, hardware configuration, and software versions.
16-**-	Data Readouts	Parameter group for data readouts, e.g. actual references, voltages, control, alarm, warning, and status words.
300-**-	AF Settings	Parameter group for setting the active filter.
301-**-	AF Readouts	Parameter group for the filter readouts.

Table 6.5 Parameter Groups

After selecting a parameter group, select a parameter with the navigation keys.
The middle section on the LCP display shows the parameter number and name as well as the selected parameter value.

6.3 Description of Parameters

6.3.1 Main Menu

The main menu includes all available parameters in the VLT® Active Filter. All parameters are grouped by name indicating the function of the parameter group. All parameters are listed by name and number in this manual.

6.4 0-** Operation/Display

Parameters in this group are related to the fundamental functions of the active filter, function of the LCP keys, and configuration of the LCP display.

6.4.1 0-0* Basic Settings

0-01 Language		
Option:	Function:	
		Defines the language to be used in the display. The filter can be delivered with 4 different language packages. English and German are included in all packages. English cannot be erased or manipulated.
[0] *	English	Part of Language packages 1 - 4
[1]	Deutsch	Part of Language packages 1 - 4
[2]	Francais	Part of Language package 1
[3]	Dansk	Part of Language package 1
[4]	Spanish	Part of Language package 1
[5]	Italiano	Part of Language package 1
[6]	Svenska	Part of Language package 1
[7]	Nederlands	Part of Language package 1
[10]	Chinese	Part of Language package 2
[20]	Suomi	Part of Language package 1
[22]	English US	Part of Language package 4
[27]	Greek	Part of Language package 4
[28]	Bras.port	Part of Language package 4
[36]	Slovenian	Part of Language package 3
[39]	Korean	Part of Language package 2
[40]	Japanese	Part of Language package 2
[41]	Turkish	Part of Language package 4
[42]	Trad.Chinese	Part of Language package 2
[43]	Bulgarian	Part of Language package 3
[44]	Srpski	Part of Language package 3
[45]	Romanian	Part of Language package 3

0-01 Language		
Option:	Function:	
[46]	Magyar	Part of Language package 3
[47]	Czech	Part of Language package 3
[48]	Polski	Part of Language package 4
[49]	Russian	Part of Language package 3
[50]	Thai	Part of Language package 2
[51]	Bahasa Indonesia	Part of Language package 2
[52]	Hrvatski	

0-04 Operating State at Power-up (Hand)		
Option:	Function:	
		Selects the operating mode upon reconnection of the filter to mains voltage after power down in Hand (local) operation mode.
[0]	Resume	Restarts the filter maintaining the same start/stop settings (applied by [HAND ON/OFF]) as before the filter was powered down.
[1] *	Forced stop	Restarts the filter with a saved local reference, after mains voltage reappears and after pressing [HAND ON].

6.4.2 0-1* Set-up Operations

Define and control the individual parameter set-ups. The active filter has 4 parameter set-ups that can be programmed independently of one another, making it flexible.

The active set-up (the set-up in which the active filter is currently operating) can be selected in *parameter 0-10 Active Set-up* and is displayed on the LCP. Using multi set-up, it is possible to switch between set-ups with the active filter running or stopped, via digital input or serial communication commands. If it is necessary to change set-ups while running, ensure that *parameter 0-12 This Set-up Linked to* is programmed as required. Using *parameter 0-11 Edit Set-up*, it is possible to edit parameters within any of the set-ups while continuing the active filter operation in its active set-up, which can be a different set-up than the one being edited.

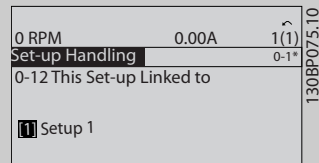
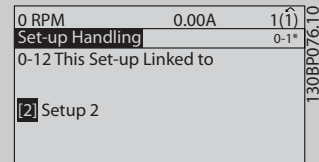
Use *parameter 0-51 Set-up Copy* to copy parameter settings between the set-ups enabling faster commissioning if similar parameter settings are required in different set-ups.

0-10 Active Set-up		
Option:	Function:	
		Select the set-up to control the filter functions.
[0]	Factory setup	Cannot be changed. It contains the factory data set, and can be used as a data source when returning the other set-ups to a known state.
[1] *	Set-up 1	[1] Set-up 1 to [4] Set-up 4 are the 4 separate parameter set-ups within which all parameters can be programmed.
[2]	Set-up 2	
[3]	Set-up 3	
[4]	Set-up 4	
[9]	Multi Set-up	Remote set-up selections using digital inputs and the serial communication port. This set-up uses the settings from <i>parameter 0-12 This Set-up Linked to</i> . Stop the filter before making changes to open- and closed loop functions

Use *parameter 0-51 Set-up Copy* to copy a set-up to one or all other set-ups. Stop the filter before switching between set-ups where parameters marked not changeable during operation have different values. To avoid conflicting settings of the same parameter within 2 different set-ups, link the set-ups together using *parameter 0-12 This Set-up Linked to*. Parameters which are not changeable during operation are marked FALSE in the parameter lists in *chapter 6.12 Parameter Lists*.

0-11 Edit Set-up		
Option:	Function:	
		Select the set-up to be edited (i.e. programmed) during operation; either the active set-up or one of the inactive set-ups.
[0]	Factory setup	Cannot be edited but it is useful as a data source to return the other set-ups to a known state.
[1] *	Set-up 1	[1] Set-up 1 to [4] Set-up 4 can be edited freely during operation, independently of the active set-up.
[2]	Set-up 2	
[3]	Set-up 3	
[4]	Set-up 4	
[9]	Active Set-up	Can also be edited during operation. Edit the selected set-up from a range of sources: LCP, FC, RS485, FC, USB, or up to 5 Fieldbus sites.

0-12 This Set-up Linked to		
Option:	Function:	
		To enable conflict-free changes from one set-up to another during operation, link set-ups containing parameters that are not changeable during operation. The link ensures synchronising of the <i>not changeable during operation</i>

0-12 This Set-up Linked to		
Option:	Function:	
	parameter values when moving from one set-up to another during operation. <i>Not changeable during operation</i> parameters can be identified by the label FALSE in the parameter lists in <i>chapter 6.12 Parameter Lists</i>. <i>Parameter 0-12 This Set-up Linked to</i> is used by [9] Multi set-up in <i>parameter 0-10 Active Set-up</i>. [9] Multi set-up is used to move from one set-up to another during operation (i.e. while the filter is running). Example: Use [9] Multi set-up to shift from Set-up 1 to Set-up 2 while the unit is running. Programme in Set-up 1 first, then ensure that Set-up 1 and Set-up 2 are synchronised (or linked). Synchronisation can be performed in 2 ways: 1. Change the edit set-up to [2] Set-up 2 in <i>parameter 0-11 Edit Set-up</i> and set <i>parameter 0-12 This Set-up Linked to</i> to [1] Set-up 1. This starts the linking (synchronising) process.	
		
	Illustration 6.6 Synchronisation Method 1	
	OR 1. While still in Set-up 1, copy Set-up 1 to Set-up 2. Then set <i>parameter 0-12 This Set-up Linked to</i> to [2] Set-up 2. This starts the linking process.	
		
	Illustration 6.7 Synchronisation Method 2	
	After the link is complete, <i>parameter 0-13 Readout: Linked Set-ups</i> reads {1,2} to indicate that all <i>not changeable during operation</i> parameters are now the same in Set-up 1 and Set-up 2. If there are changes to a <i>not changeable during operation</i> parameter, in Set-up 2, they are also changed automatically in	

0-12 This Set-up Linked to		
Option:	Function:	
		Set-up 1. A switch between Set-up 1 and Set-up 2 during operation is now possible.
[0] *	Not linked	
[1]	Set-up 1	
[2]	Set-up 2	
[3]	Set-up 3	
[4]	Set-up 4	

0-13 Readout: Linked Set-ups														
Range:		Function:												
0*	[0 - 255]	View a list of all the set-ups linked by means of 0-12 <i>This Set-up Linked to</i>. The parameter has one index for each parameter set-up. The parameter value displayed for each index represents which set-ups are linked to that parameter set-up. <table><tr><th>Index</th><th>LCP value</th></tr><tr><td>0</td><td>{0}</td></tr><tr><td>1</td><td>{1,2}</td></tr><tr><td>2</td><td>{1,2}</td></tr><tr><td>3</td><td>{3}</td></tr><tr><td>4</td><td>{4}</td></tr></table> Table 6.7 Example: Set-up 1 and Set-up 2 are linked	Index	LCP value	0	{0}	1	{1,2}	2	{1,2}	3	{3}	4	{4}
Index	LCP value													
0	{0}													
1	{1,2}													
2	{1,2}													
3	{3}													
4	{4}													

0-14 Readout: Edit Set-ups / Channel		
Range:	Function:	
0* [-2147483648 - 2147483647]	View the setting of <i>parameter 0-11 Edit Set-up</i> for each of the 4 different communication channels. When the number is displayed as a hex number, as it is in the LCP, each number represents 1 channel. Numbers 1-4 represent a set-up number; F means factory setting; and A means active set-up. The channels are, from right to left: LCP, FC bus, USB, HPFB1-5. Example: The number AAAAAA21h means the following: - The frequency converter selected Set-up 2 via a fieldbus channel. This selection is reflected in <i>parameter 0-11 Edit Set-up</i>. - A user selected Set-up 1 via the LCP. - All other channels are using the active set-up.	

6.4.3 0-2* LCP Display

Define the variables displayed in the LCP.

NOTICE

Refer to 0-37 *Display Text 1*, 0-38 *Display Text 2* and 0-39 *Display Text 3* for information on how to write display texts.

0-20 Display Line 1.1 Small		
Option:	Function:	
		Select a variable for display in line 1, left position.
[0]	None	No display value selected.
[1501]	Running Hours	Running hours meter of the unit.
[1600]	Control Word	Present control word
[1603]	Status Word	Present status word.
[1630]	DC Link Voltage	Intermediate circuit voltage in the unit.
[1634]	Heatsink Temp.	Present heat sink temperature of the unit. The cut-out limit is 95 ±5 °C; cutting back in occurs at 70 ±5 °C.
[1635]	Inverter Thermal	Percentage load of the inverters.
[1636]	Inv. Nom. Current	Nominal current of the unit.
[1637]	Inv. Max. Current	Maximum current of the unit.
[1639]	Control Card Temp.	Temperature of the control card.
[1660]	Digital Input	Signal states form the 6 digital terminals (18, 19, 27, 29, 32 and 33). There are 16 bits in total, but only 6 of them are used. Input 18 corresponds to the leftmost of the used bits. Signal low=0; Signal high=1.
[1666]	Digital Output [bin]	Binary value of all digital outputs.
[1671]	Relay Output [bin]	Binary value of the relay outputs.
[1680]	Fieldbus CTW 1	Control word (CTW) received from the bus master.
[1684]	Comm. Option STW	Extended Fieldbus communication option status word.
[1685]	FC Port CTW 1	Control word (CTW) received from the bus master.
[1690]	Alarm Word	One or more alarms in a hex code.
[1691]	Alarm Word 2	One or more alarms in a hex code.
[1692]	Warning Word	One or more warnings in a hex code.
[1693]	Warning Word 2	One or more warnings in a hex code.
[1694]	Ext. Status Word	One or more status conditions in a hex code.

0-20 Display Line 1.1 Small

Option:	Function:
[30100]	Output Current [A]
[30101]	Output Current [%]
[30102]	Fifth Output Current [A]
[30103]	Seventh Output Current [A]
[30104]	Eleventh Output Current [A]
[30105]	Thirteenth Output Current [A]
[30106]	Seventeenth Output Current [A]
[30107]	Nineteenth Output Current [A]
[30108]	Twenty-third Output Current [A]
[30109]	Twenty-fifth Output Current [A]
[30110]	THD of current [%]
[30112]	Power factor
[30113]	Cosphi
[30114]	Leftover Currents
[30120]	Mains Current [A]
[30121]	Mains Frequency
[30122]	Fund. Mains Current [A]

0-21 Display Line 1.2 Small

Option:	Function:
[0] *	None
	Select a variable for display in line 1, middle position. The options are the same as those listed for 0-20 Display Line 1.1 Small.

0-22 Display Line 1.3 Small

Select a variable for display in line 1, right position. The options are the same as those listed for 0-20 Display Line 1.1 Small.

0-23 Display Line 2 Large

Select a variable for display in line 2. The options are the same as listed for 0-20 Display Line 1.1 Small. The options are the same as those listed in 0-20 Display Line 1.1 Small.

0-24 Display Line 3 Large

Select a variable for display in line 3.

0-25 My Personal Menu

Range:	Function:
Size related* [0 - 9999]	Define up to 50 parameters to appear in the Q1 Personal Menu, accessible via the [Quick Menu] key on the LCP. The parameters are displayed in the Q1 Personal Menu in the order they are programmed into this array parameter. Delete parameters by setting the value to '0000'.

0-25 My Personal Menu

Range:	Function:
	For example, this can be used to provide quick, simple access to just 1 or up to 50 parameters which require changing on a regular basis (e.g. for plant maintenance reasons) or by an OEM to enable simple commissioning of their equipment.

6.4.4 0-4* LCP Keypad

Enable, disable and password protect individual keys on the LCP.

0-40 [Hand on] Key on LCP

Option:	Function:
[0]	Disabled
	No effect when [Hand on] is pressed. Select [0] Disabled to avoid accidental start of the frequency converter in Hand on mode.
[1] *	Enabled
[2]	Password
	Avoids unauthorised stop. If parameter 0-41 [Off] Key on LCP is included in the Quick Menu, then define the password in parameter 0-65 Quick Menu Password.

0-41 [Off] Key on LCP

Option:	Function:
[0]	Disabled
	Avoids accidental stop of the unit.
[1]	Enabled
[2]	Password
	Avoids unauthorised stop. If parameter 0-41 [Off] Key on LCP is included in the Quick Menu, then define the password in parameter 0-65 Quick Menu Password.

0-42 [Auto on] Key on LCP

Option:	Function:
[0]	Disabled
	Avoid accidental start of the unit in Auto mode.
[1]	Enabled
[2]	Password
	Avoids unauthorised start in Auto On mode. If parameter 0-42 [Auto on] Key on LCP is included in the Quick Menu, then define the password in parameter 0-65 Quick Menu Password.

0-43 [Reset] Key on LCP

Option:	Function:
[0]	Disabled
	No effect when [Reset] is pressed. Avoids accidental alarm reset.
[1]	Enabled
[2]	Password
	Avoids unauthorised resetting. If parameter 0-43 [Reset] Key on LCP is included in the Quick Menu, then define the password in parameter 0-65 Quick Menu Password.

0-43 [Reset] Key on LCP		
Option:		Function:
[7]	Enabled without OFF	
[8]	Password without OFF	

6.4.5 0-5* Copy/Save

Copy parameters from and to the LCP. Use these parameters for saving and copying set-ups from one unit to another.

0-50 LCP Copy		
Option:		Function:
[0] *	No copy	
[1]	All to LCP	
[2]	All from LCP	Copies all parameters in all set-ups from the LCP memory to the filter memory.
[3]	Size indep. from LCP	Copy only the parameters that are independent of the active filter size. The latter selection can be used to programme several filters with the same function without disturbing size-dependent data.

0-51 Set-up Copy		
Option:		Function:
[0] *	No copy	No function
[1]	Copy to set-up 1	Copies all parameters in the present programming set-up (defined in 0-11 Programming Set-up) to set-up 1.
[2]	Copy to set-up 2	Copies all parameters in the present programming set-up (defined in 0-11 Programming Set-up) to set-up 2.
[3]	Copy to set-up 3	Copies all parameters in the present programming set-up (defined in 0-11 Programming Set-up) to set-up 3.
[4]	Copy to set-up 4	Copies all parameters in the present programming set-up (defined in 0-11 Programming Set-up) to set-up 4.
[9]	Copy to all	Copies the parameters in the present set-up to each of the set-ups 1 to 4.

6.4.6 0-6* Password

0-60 Main Menu Password		
Range:	Function:	
100*	[-9999 - 9999]	Define the password for access to the Main Menu via the [Main Menu] key. If 0-61 Access to Main Menu w/o Password is set to [0] Full access, this parameter is ignored.

0-61 Access to Main Menu w/o Password		
Option:		Function:
[0] *	Full access	Disables password defined in parameter 0-60 Main Menu Password.
[1]	LCP: Read only	Prevent unauthorised editing of Main Menu parameters.
[2]	LCP: No access	Prevent unauthorised viewing and editing of Main Menu parameters.
[3]	Bus: Read only	Read-only functions for parameters on Fieldbus and/or FC standard bus.
[4]	Bus: No access	No access to parameters is allowed via Fieldbus and/or FC standard bus.
[5]	All: Read only	Read-only function for parameters on LCP, Fieldbus or FC standard bus.
[6]	All: No access	No access from LCP, Fieldbus or FC standard bus is allowed.

If [0] Full access is selected, parameter 0-60 Main Menu Password, 0-65 Personal Menu Password and 0-66 Access to Personal Menu w/o Password are ignored.

NOTICE

A more complex password protection is available for OEMs upon request.

0-65 Quick Menu Password		
Range:	Function:	
200*	[-9999 - 9999]	Define the password for access to the Quick Menu via the [Quick Menu] key. If parameter 0-66 Access to Quick Menu w/o Password is set to [0] Full access, this parameter is ignored.

0-66 Access to Quick Menu w/o Password		
If 0-61 Access to Main Menu w/o Password is set to [0] Full access then this parameter is ignored.		
Option:		Function:
[0] *	Full access	Disables the password defined in parameter 0-65 Quick Menu Password.
[1]	LCP: Read only	Prevents unauthorised editing of Quick Menu parameters.
[3]	Bus: Read only	Read only functions for Quick Menu parameters on Fieldbus and/or FC standard bus.
[5]	All: Read only	Read only function for Quick Menu parameters on LCP, Fieldbus or FC standard bus.

6.5 5-** Digital I/O Mode

6.5.1 5-0* Digital I/O Mode

Parameters for configuring the input and output using NPN and PNP.

5-00 Digital I/O Mode		
Option:	Function:	
		This parameter cannot be adjusted while the unit is running. Digital inputs and programmed digital outputs are pre-programmable for operation either in PNP or NPN systems.
[0] *	PNP	Action on positive directional pulses (↑). PNP systems are pulled down to GND.
[1]	NPN	Action on negative directional pulses (↓). NPN systems are pulled up to + 24 V, internally in the filter.

NOTICE

Once this parameter has been changed, it must be activated by performing a power cycle.

5-01 Terminal 27 Mode		
Option:	Function:	
		NOTICE This parameter cannot be adjusted while the unit is running.
[0] *	Input	Defines terminal 27 as a digital input.
[1]	Output	Defines terminal 27 as a digital output.

5-02 Terminal 29 Mode		
Option:	Function:	
[0] *	Input	Defines terminal 29 as a digital input.
[1]	Output	Defines terminal 29 as a digital output.

6.5.2 5-1* Digital Inputs

Parameters for configuring the input functions for the input terminals.

The digital inputs are used for selecting various functions in the filter. All digital inputs can be set to the following functions:

Digital input function	Select	Terminal
No operation	[0]	All term 32, 33
Reset	[1]	All
Stop inverse	[6]	All
Start	[8]	All term 18
Latched start	[9]	All
Set-up select bit 0	[23]	All
Set-up select bit 1	[24]	All
Pulse input Time Based	[32]	29, 33
Follower AF # 1 Run Feedback	[99]	All
Follower AF # 2 Run Feedback	[100]	All
Sleep	[101]	T18, T19, T27, T29

Table 6.8 Digital Input Functions

Functions dedicated to only one digital input are stated in the associated parameter.

5-10 Terminal 18 Digital Input		
Option:	Function:	
[0]	No operation	No reaction to signals transmitted to the terminal.
[1]	Reset	Resets filter after a trip/alarm. Not all alarms can be reset.
[6]	Stop inverse	Stop Inverted function. Generates a stop function when the selected terminal goes from logical level 1 to 0.
[8] *	Start	(Default Digital input 18): Select start for a start/stop command. Logic 1=start, logic 0=stop.
[9]	Latched Start	The filter starts, if a pulse is applied for minimum 2 ms. The filter stops when stop inverse is activated.
[23]	Set-up select bit 0	Select Set-up select bit 0 or Select Set-up select bit 1 to select one of the 4 set-ups. Set <i>parameter 0-10 Active Set-up</i> to [9] <i>Multi Set-up</i> .
[24]	Set-up select bit 1	(Default Digital input 32): Same as [23] <i>Set-up select bit 0</i> .
[32]	Master cmd pulse in	Time-based pulse input measures the duration between flanks. This gives a higher resolution at lower frequencies, but is not as precise at higher frequencies. This principle has a cut-off frequency, which makes it unsuited for encoders with very low resolutions (e.g. 30 PPR) at low speeds.
[99]	Follower AF #1 Run Feedback	Do not program this setting. It is done automatically for paralleling. See <i>parameter 300-40 Master Follower Selection</i> and <i>parameter 300-41 Follower ID</i> for more information about paralleling.

5-10 Terminal 18 Digital Input			
Option:		Function:	
[100]	Follower AF #2 Run Feedback	Do not program this setting. It is done automatically for paralleling. See <i>parameter 300-40 Master Follower Selection</i> and <i>parameter 300-41 Follower ID</i> for more information about paralleling.	
[101]	Sleep	The filter goes into sleep mode at light duty to save energy.	

5-11 Terminal 19 Digital Input			
Option:		Function:	
[0] *	No Operation	Functions are described under <i>5-1* Digital Inputs</i>	

5-12 Terminal 27 Digital Input			
Option:		Function:	
[0] *	No Operation	Functions are described under <i>5-1* Digital Inputs</i>	

5-13 Terminal 29 Digital Input			
Option:		Function:	
[0] *	No Operation	Functions are described under <i>5-1* Digital Inputs</i>	

5-16 Terminal X30/2 Digital Input			
Option:		Function:	
[0] *	No operation	Functions are described under <i>5-1* Digital Inputs</i>	

5-17 Terminal X30/3 Digital Input			
Option:		Function:	
[0] *	No operation	Functions are described under <i>5-1* Digital Inputs</i>	

5-18 Terminal X30/4 Digital Input			
Option:		Function:	
[0] *	No operation	Functions are described under <i>5-1* Digital Inputs</i>	

5-19 Terminal 37 Safe Torque Off (STO)			
Function	Number	PTC	Relay
No Function	[0]	-	-
Safe Torque Off (STO) Alarm	[1]*	-	safe torque off [A68]

Table 6.9 Overview of Functions, Alarms and Warnings

6.5.3 5-3* Digital Outputs

Parameters for configuring the output functions for the output terminals. The 2 solid-state digital outputs are common for terminals 27 and 29. Set the I/O function for terminal 27 in *parameter 5-01 Terminal 27 Mode*, and set the I/O function for terminal 29 in *parameter 5-02 Terminal*

29 Mode. These parameters cannot be adjusted while the unit is running.

5-30 Terminal 27 Digital Output			
Option:		Function:	
[0]	No operation	Default for all digital outputs and relay outputs.	
[1]	Control ready	The control card is ready. E.g.: Feedback from a unit where the control is supplied by an external 24 V (MCB 107) and the main power to the unit is not detected.	
[2]	Unit ready	The unit is ready for operation and applies a supply signal on the control board.	
[4]	Enable / no warning	Ready for operation. No start or stop command is been given (start/disable). No warnings are active.	
[5]	Running	The motor is running and shaft torque present.	
[9]	Alarm	An alarm activates the output. There are no warnings.	
[10]	Alarm or warning	An alarm or a warning activates the output.	
[12]	Current limit	The motor current is outside the range set in <i>4-18 Current Limit</i> . The active filter current is at the limit.	
[21]	Thermal warning	The thermal warning turns on when the temperature exceeds the limit in the active filter.	
[22]	Ready, no thermal W	The unit is ready for operation and there is no overtemperature warning.	
[24]	Ready, voltage OK	The unit is ready for operation and the mains voltage is within the specified voltage range.	
[26]	Bus OK	Active communication (no time-out) via the serial communication port.	
[55]	Pulse output		
[122]	No alarm		
[125]	Hand mode	Output is high when the unit is in <i>Hand on</i> mode (as indicated by the LED light above [Hand on]).	
[126]	Auto mode		
[152]	AF sleeping		

5-31 Terminal 29 Digital Output			
Option:		Function:	
[0] *	No operation	Functions are described under parameter group <i>5-3* Digital Outputs</i>	

6.6 8-** General Settings

6.6.1 8-0* General Settings

8-01 Control Site		
Option:	Function:	
	The setting in this parameter overrides the settings in 8-50 Coasting Select to 8-56 Preset Reference Select.	
[0]	Digital and ctrl.word	Control by using both digital input and control word.
[1]	Digital only	Control by using digital inputs only.
[2]	Controlword only	Control by using control word only.

8-02 Control Word Source		
This parameter cannot be adjusted while the motor is running. Select the source of the control word: One of 2 serial interfaces or 4 installed options. During initial power-up, the unit automatically sets this parameter to [3] Option A if it detects a valid Fieldbus option installed in slot A. If the option is removed, the unit detects a change in the configuration, sets <i>parameter 8-02 Control Word Source</i> back to default setting [1] FC RS485, and the unit then trips. If an option is installed after initial power-up, the setting of <i>parameter 8-02 Control Word Source</i> does not change but the unit trips and displays: Alarm 67 Option Changed. When retrofitting a bus option into a unit that did not have a bus option installed to begin with, move the control to bus based. This is done for safety reasons to avoid an accidental change.		
Option:	Function:	
[0]	None	
[1]	FC RS485	
[2]	FC USB	
[3]	Option A	
[4]	Option B	
[5]	Option C0	
[6]	Option C1	
[30]	External Can	

8-03 Control Word Timeout Time		
Range:	Function:	
1 s* [0.1 - 18000 s]	Enter the maximum time expected to pass between the reception of 2 consecutive telegrams. If this time is exceeded, it indicates that the telegram communication has stopped. The function selected in 8-04 Control Word Timeout Function is then carried out. A valid control word triggers the time-out counter.	

8-04 Control Word Timeout Function

Select the time-out function. The time-out function activates when the control word fails to be updated within the time period specified in *parameter 8-03 Control Word Timeout Time*.

Option:	Function:	
[0] *	Off	Resumes control via serial bus (fieldbus or standard) using the most recent control word.
[2]	Stop	Stops with auto restart when communication resumes.
[5]	Stop and trip	Stops, then resets the unit in order to restart: via the fieldbus, via [Reset] on the LCP or via a digital input.
[7]	Select setup 1	Changes the set-up upon reestablishment of communication following a control word time-out. If communication resumes causing the time-out situation to disappear, <i>parameter 8-05 End-of-Timeout Function</i> defines whether to resume the set-up used before the time-out or to retain the set-up endorsed by the time-out function.
[8]	Select setup 2	See [7] Select setup 1
[9]	Select setup 3	See [7] Select setup 1
[10]	Select setup 4	See [7] Select setup 1

NOTICE

The following configuration is required to change the set-up after a time-out:

Set *parameter 0-10 Active Set-up* to [9] Multi set-up and select the relevant link in *parameter 0-12 This Set-up Linked to*.

8-05 End-of-Timeout Function

Option:	Function:	
	Select the action after receiving a valid control word following a time-out. This parameter is active only when 8-04 Control Word Timeout Function is set to [Set-up 1-4].	
[0]	Hold set-up	Retains the set-up selected in 8-04 Control Word Timeout Function and displays a warning, until 8-06 Reset Control Timeout toggles. Then the unit resumes its original set-up.
[1] *	Resume set-up	Resumes the set-up active before the time-out.

8-06 Reset Control Word Timeout

This parameter is active only when [0] Hold set-up has been selected in *parameter 8-05 End-of-Timeout Function*.

Option:	Function:	
[0] *	Do not reset	Retains the set-up specified in 8-04 Control Word Timeout Function, following a control word time-out.
[1]	Do reset	Returns the unit to the original set-up following a control word time-out. The unit

8-06 Reset Control Word Timeout		
This parameter is active only when [0] Hold set-up has been selected in parameter 8-05 End-of-Timeout Function.		
Option:	Function:	
		performs the reset and then immediately reverts to the [0] Do not reset setting

6.6.2 8-3* FC Port Settings

8-30 Protocol		
Option:	Function:	
[0] *	FC	Communication according to the FC Protocol.
[1]	FC MC	Select the protocol for the FC (standard) port.
[2]	Modbus RTU	

8-31 Address		
Range:	Function:	
Size related*	[1 - 255]	Enter the address for the FC (standard) port. Valid range: 1-126.

8-32 FC Port Baud Rate		
Option:	Function:	
[0]	2400 Baud	Baud rate selection for the FC (standard) port.
[1]	4800 Baud	
[2]	9600 Baud	
[3]	19200 Baud	
[4]	38400 Baud	
[5]	57600 Baud	
[6]	76800 Baud	
[7]	115200 Baud	

8-35 Minimum Response Delay		
Range:	Function:	
10 ms*	[1 - 10000 ms]	Specify the minimum delay time between receiving a request and transmitting a response. This is used for overcoming modem turnaround delays.

8-36 Max Response Delay		
Range:	Function:	
Size related*	[11 - 10001 ms]	Specify the maximum permissible delay time between transmitting a request and receiving a response. If a response from the frequency converter is exceeding the time setting, then it is discarded.

8-37 Max Inter-Char Delay		
Range:	Function:	
Size related*	[0.00 - 35.00 ms]	Specify the maximum permissible time interval between receipt of 2 bytes. This

8-37 Max Inter-Char Delay		
Range:	Function:	
		parameter activates timeout if transmission is interrupted. This parameter is active only when parameter 8-30 Protocol is set to [1] FC MC protocol.

8-53 Start Select		
Option:	Function:	
		NOTICE This parameter is active only when parameter 8-01 Control Site is set to [0] Digital and control word. Select control of the unit start function via the terminals (digital input) and/or via the fieldbus.
[0]	Digital input	Activates a start command via a digital input.
[1]	Bus	Activates a start command via the serial communication port or Fieldbus option.
[2]	Logic AND	Activates a start command via the fieldbus/serial communication port, AND additionally via one of the digital inputs.
[3] *	Logic OR	Activates a start command via the fieldbus/serial communication port OR via one of the digital inputs.

8-55 Set-up Select		
Option:	Function:	
		NOTICE This parameter is active only when parameter 8-01 Control Site is set to [0] Digital and control word. Select control of the unit set-up selection via the terminals (digital input) and/or via the fieldbus.
[0]	Digital input	Activates the set-up selection via a digital input.
[1]	Bus	Activates the set-up selection via the serial communication port or fieldbus option.
[2]	Logic AND	Activates the set-up selection via the fieldbus/serial communication port, AND additionally via one of the digital inputs.
[3] *	Logic OR	Activate the set-up selection via the fieldbus/serial communication port OR via one of the digital inputs.

6.7 14-2* Trip Reset

Parameters for configuring auto reset handling, special trip handling and control card self-test or initialisation.

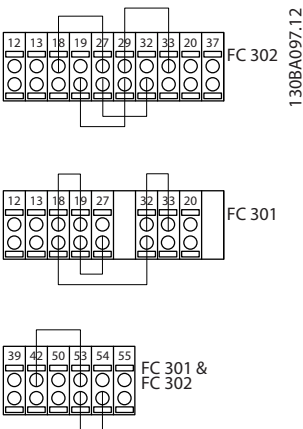
14-20 Reset Mode		
Option:		Function:
		Select the reset function after tripping. Once reset, the unit can be restarted.
[0] *	Manual reset	Select [0] <i>Manual reset</i> , to perform a reset via [RESET] or via the digital inputs.
[1]	Automatic reset x 1	Select [1]-[12] <i>Automatic reset x 1... x20</i> to perform between 1 and 20 automatic resets after tripping.
[2]	Automatic reset x 2	
[3]	Automatic reset x 3	
[4]	Automatic reset x 4	
[5]	Automatic reset x 5	
[6]	Automatic reset x 6	
[7]	Automatic reset x 7	
[8]	Automatic reset x 8	
[9]	Automatic reset x 9	
[10]	Automatic reset x 10	
[11]	Automatic reset x 15	
[12]	Automatic reset x 20	
[13]	Infinite auto reset	Select [13] <i>Infinite Automatic Reset</i> for continuous resetting after tripping.
[14]	Reset at power-up	

NOTICE

The filter may start without warning. If the specified number of automatic resets is reached within 10 minutes, the unit enters [0] *Manual Reset* mode. After the manual reset is performed, the setting of 14-20 *Reset Mode* reverts to the original selection. If the number of automatic resets is not reached within 10 minutes, or when a manual reset is performed, the internal automatic reset counter returns to 0.

14-21 Automatic Restart Time		
Range:		Function:
10 s*	[0 - 600 s]	Enter the time interval from trip to start of the automatic reset function. This parameter is active when 14-20 <i>Reset Mode</i> is set to [1] - [13] <i>Automatic reset</i> .

14-22 Operation Mode		
Option:		Function:
[0] *	Normal operation	Use this parameter to specify normal operation; to perform tests; or to initialise all parameters except <i>parameter 15-03 Power Up's</i> , <i>parameter 15-04 Over Temp's</i> and <i>parameter 15-05 Over Volt's</i> . This function is active only when the power is cycled to the unit.
[1]	Control card test	Select [1] <i>Control card test</i> to test the analog and digital inputs and outputs and the +10 V control voltage. The test requires a test connector with internal connections. Use the following procedure for the control card test: 1. Select [1] <i>Control card test</i>. 2. Disconnect the mains supply and wait for the indicator light in the display to go out. 3. Set switches S201 (A53) and S202 (A54)=ON/I. 4. Insert the test plug (see <i>Illustration 6.8</i>). 5. Connect to mains supply. 6. Carry out various tests. 7. The results are displayed on the LCP and the unit moves into an infinite loop. 8. <i>Parameter 14-22 Operation Mode</i> is automatically set to normal operation. Carry out a power cycle to start up in normal operation after a control card test. If the test is OK: LCP readout: Control Card OK. Disconnect the mains supply and remove the test plug. The green indicator light on the control card lights up. If the test fails: LCP readout: Control Card I/O failure. Replace the unit or control card. The red LED on the control card is turned on. Test plugs (connect the following terminals to each other): 18 - 27 - 32; 19 - 29 - 33; 42 - 53 - 54

14-22 Operation Mode		
Option:	Function:	
	 Illustration 6.8 Terminal Connections	
[2]	Initiali- sation	Select [2] <i>Initialisation</i> to reset all parameter values to default settings, except for <i>parameter 15-03 Power Up's</i> , <i>parameter 15-04 Over Temp's</i> , and <i>parameter 15-05 Over Volt's</i> . The unit resets during the next power-up. <i>Parameter 14-22 Operation Mode</i> also reverts to the default setting [0] <i>Normal operation</i> .
[3]	Boot mode	

14-29 Service Code		
Range:	Function:	
0*	[-2147483647 - 2147483647]	For internal service only.

14-50 RFI Filter		
Option:	Function:	
[0]	Off	Select [0] <i>Off</i> only if the unit is fed by an isolated mains source (IT mains). In this mode, the internal RFI filter capacitors between chassis and the mains RFI filter circuit are cut-out to reduce the ground capacity currents.
[1] *	On	Select [1] <i>On</i> to ensure that the unit complies with EMC standards.

14-54 Bus Partner		
Range:	Function:	
1*	[0 - 126]	

6.8 15-** Drive Information

6.8.1 15-0* Operating Data

15-00 Operating hours		
Range:		Function:
0 h*	[0 - 2147483647 h]	View how many hours the unit has run. The value is saved when the unit is turned off.

15-01 Running Hours		
Range:		Function:
0 h*	[0 - 2147483647 h]	View how many hours the filter has run. Reset the counter in <i>15-07 Reset Running Hours Counter</i> . The value is saved when the unit is turned off.

15-03 Power Up's		
Range:		Function:
0*	[0 - 2147483647]	View the number of times the unit has been powered up.

15-04 Over Temp's		
Range:		Function:
0*	[0 - 65535]	View the number of unit temperature faults that have occurred.

15-05 Over Volt's		
Range:		Function:
0*	[0 - 65535]	View the number of unit overvoltages that have occurred.

15-07 Reset Running Hours Counter		
Option:		Function:
[0] *	Do not reset	
[1]	Reset counter	Select [1] <i>Reset</i> and press [OK] to reset the running hours counter to zero (see <i>parameter 15-01 Running Hours</i>). This parameter cannot be selected via the serial port, RS485. Select [0] <i>Do not reset</i> if no reset of the running hours counter is desired.

6.8.2 15-1* Data Log Settings

The data log enables continuous logging of up to 4 data sources (*15-10 Logging Source*) at individual rates (*parameter 15-11 Logging Interval*). A trigger event (*15-12 Trigger Event*) and window (*15-14 Samples Before Trigger*) are used to start and stop the logging conditionally.

15-10 Logging Source		
Array [4]		
Option:		Function:
		Select which variables are to be logged.
[0] *	None	
[1600]	Control Word	
[1603]	Status Word	
[1630]	DC Link Voltage	
[1634]	Heatsink Temp.	
[1635]	Inverter Thermal	
[1660]	Digital Input	
[1666]	Digital Output [bin]	
[1690]	Alarm Word	
[1692]	Warning Word	
[1694]	Ext. Status Word	

15-11 Logging Interval		
Array [4]		
Range:		Function:
Size related*	[0.000 - 0.000]	Enter the interval in ms between each sampling of the variables to be logged.

15-12 Trigger Event		
Select the trigger event. When the trigger event occurs, a window is applied to freeze the log. The log then retains a specified percentage of samples before the occurrence of the trigger event (<i>parameter 15-14 Samples Before Trigger</i>).		
Option:		Function:
[0] *	False	
[1]	True	
[2]	Running	
[6]	Current limit	
[16]	Thermal warning	
[19]	Warning	
[20]	Alarm (trip)	
[21]	Alarm (trip lock)	
[33]	Digital input DI18	
[34]	Digital input DI19	
[35]	Digital input DI27	
[36]	Digital input DI29	

15-13 Logging Mode		
Option:		Function:
[0] *	Log always	Select [0] <i>Log always</i> for continuous logging.
[1]	Log once on trigger	Select [1] <i>Log once on trigger</i> to conditionally start and stop logging using <i>15-12 Trigger Event</i> and <i>15-14 Samples Before Trigger</i> .

15-14 Samples Before Trigger		
Range:		Function:
50*	[0 - 100]	Before a trigger event, enter the percentage of all samples which are to be retained in the log. See also <i>15-12 Trigger Event</i> and <i>parameter 15-13 Logging Mode</i> .

6.8.3 15-2* Historic Log

View up to 50 logged data items via the array parameters in this parameter group. For all parameters in the group, [0] is the most recent data and [49] the oldest data. Data is logged every time an *event* occurs. *Events* in this context are defined as a change in one of the following areas

- Digital input.
- Digital outputs.
- Warning word.
- Alarm word.
- Status word.
- Control word.
- Extended status word.

Events are logged with value, and time stamp in ms. The time interval between 2 events depends on how often *events* occur (maximum once every scan time). Data logging is continuous, but if an alarm occurs, the log is saved and the values can be viewed on the display. This feature is useful, for example when carrying out service following a trip. View the historic log contained in this parameter via the serial communication port or via the display.

15-20 Historic Log: Event		
Array [50]		
Range:		Function:
0*	[0 - 255]	View the event type of the logged events.

15-21 Historic Log: Value			
Array [50]			
Range:		Function:	
0*	[0 - 2147483647]	View the value of the logged event. Interpret the event values according to this table:	
		Digital input	Decimal value. See <i>parameter 16-60 Digital Input</i> for description after converting to binary value.

15-21 Historic Log: Value			
Array [50]			
Range:		Function:	
		Digital output (not monitored in this SW release)	Decimal value. See <i>parameter 16-66 Digital Output [bin]</i> for description after converting to binary value.
		Warning word	Decimal value. See <i>16-92 Warning Word</i> for description.
		Alarm word	Decimal value. See <i>16-90 Alarm Word</i> for description.
		Status word	Decimal value. See <i>parameter 16-03 Status Word</i> for description after converting to binary value.
		Control word	Decimal value. See <i>parameter 16-00 Control Word</i> for description.
		Extended status word	Decimal value. See <i>parameter 16-94 Ext. Status Word</i> for description.

15-22 Historic Log: Time		
Array [50]		
Range:		Function:
0 ms*	[0 - 2147483647 ms]	View the time at which the logged event occurred. Time is measured in ms since unit start. The maximum value corresponds to approximately 24 days, which means that the count restarts at 0 after this time period.

6.8.4 15-3* Alarm Log

Parameters in this group are array parameters, where up to 10 fault logs can be viewed. [0] is the most recent logged data, and [9] is the oldest. Error codes, values, and time stamp can be viewed for all logged data.

15-30 Fault Log: Error Code		
Array [10]		
Range:		Function:
0*	[0 - 255]	View the fault code and look up its meaning in <i>chapter 8.3 Active Filter Warning and Alarm Definitions</i> .

15-31 Alarm Log: Value		
Array [10]		
Range:	Function:	
0* [-32767 - 32767]	View an extra description of the error. This parameter is mostly used in combination with <i>alarm 38 internal fault</i> .	

15-32 Alarm Log: Time		
Array [10]		
Range:	Function:	
0 s* [0 - 2147483647 s]	View the time when the logged event occurred. Time is measured in seconds from unit start-up.	

6.8.5 15-4* Unit Identification

Parameters containing read-only information about the hardware and software configuration of the active filter.

15-40 FC Type		
Range:	Function:	
0* [0 - 6]	View the active filter type. The readout is identical to the type code, characters 1–6.	

15-41 Power Section		
Range:	Function:	
0* [0 - 20]	View the active filter type. The readout is identical to the type code, characters 7–10.	

15-42 Voltage		
Range:	Function:	
0* [0 - 20]	View the active filter type. The readout is identical to the type code, characters 11–12.	

15-43 Software Version		
Range:	Function:	
0* [0 - 5]	View the combined SW version (or 'package version') consisting of power SW and control SW.	

15-44 Ordered Typecode String		
Range:	Function:	
0* [0 - 40]	View the typecode string used for re-ordering the active filter in its original configuration.	

15-45 Actual Typecode String		
Range:	Function:	
0* [0 - 40]	View the actual type code string.	

15-46 Unit Ordering No		
Range:	Function:	
0 N/A* [0 - 0 N/A]	View the 8-digit ordering number used for re-ordering the active filter in its original configuration.	

15-47 Power Card Ordering No		
Range:	Function:	
0* [0 - 8]	View the power card ordering number.	

15-48 LCP Id No		
Range:	Function:	
0* [0 - 20]	View the LCP ID number.	

15-49 SW ID Control Card		
Range:	Function:	
0* [0 - 20]	View the control card software version number.	

15-50 SW ID Power Card		
Range:	Function:	
0* [0 - 20]	View the power card software version number.	

15-51 Unit Serial Number		
Range:	Function:	
0 N/A* [0 - 0 N/A]	View the active filter serial number.	

15-53 Power Card Serial Number		
Range:	Function:	
0* [0 - 19]	View the power card serial number.	

6.8.6 15-6* Option Ident.

This read-only parameter group contains information about the hardware and software configuration of the options installed in slots A, B, C0 and C1.

15-60 Option Mounted		
Array [8]		
Range:	Function:	
0* [0 - 30]	View the installed option type.	

15-61 Option SW Version		
Array [8]		
Range:	Function:	
0* [0 - 20]	View the installed option software version.	

15-62 Option Ordering No		
Array [8]		
Range:	Function:	
0* [0 - 8]	Shows the ordering number for the installed options.	

15-63 Option Serial No		
Array [8]		
Range:	Function:	
0* [0 - 18]	View the installed option serial number.	

15-70 Option in Slot A		
Range:		Function:
0*	[0 - 30]	View the type code string for the option installed in slot A, and a translation of the type code string. E.g. for type code string AX the translation is No option.
15-71 Slot A Option SW Version		
Range:		Function:
0*	[0 - 20]	View the software version for the option installed in slot A.
15-72 Option in Slot B		
Range:		Function:
0*	[0 - 30]	View the type code string for the option installed in slot B, and a translation of the type code string. E.g. for type code string BX the translation is No option.
15-73 Slot B Option SW Version		
Range:		Function:
0*	[0 - 20]	View the software version for the option installed in slot B.
15-74 Option in Slot C0/E0		
Range:		Function:
0*	[0 - 30]	View the type code string for the option installed in slot C, and a translation of the type code string. E.g. for type code string CXXXX the translation is No option.
15-75 Slot C0/E0 Option SW Version		
Range:		Function:
0*	[0 - 20]	View the software version for the option installed in slot C.
15-76 Option in Slot C1/E1		
Range:		Function:
0*	[0 - 30]	Shows the typecode string for the options (CXXXX if no option) and the translation i.e. No option.
15-77 Slot C1/E1 Option SW Version		
Range:		Function:
0*	[0 - 20]	Software version for the installed option in option slot C.

6.8.7 15-9* Parameter Info

15-92 Defined Parameters		
Array [1000]		
Range:		Function:
0*	[0 - 9999]	View a list of all defined parameters in the active filter. The list ends with 0.
15-93 Modified Parameters		
Array [1000]		
Range:		Function:
0*	[0 - 9999]	View a list of the parameters that have been changed from their default setting. The list ends with 0. Changes may not be visible until up to 30 s after implementation.
15-98 Unit Identification		
Range:		Function:
0 N/A*	[0 - 0 N/A]	
15-99 Parameter Metadata		
Array [30]		
Range:		Function:
0*	[0 - 9999]	This parameter contains data used by the MCT 10 Set-up Software.

6.9 16-** Data Readouts

16-00 Control Word		
Range:	Function:	
0* [0 - 65535]	View the control word sent from the unit via the serial communication port in hex code.	

16-03 Status Word		
Range:	Function:	
0* [0 - 65535]	View the status word sent from the unit via the serial communication port in hex code.	

16-30 DC Link Voltage		
Range:	Function:	
0 V* [0 - 10000 V]	View a measured value. The value is filtered with a 30 ms time constant.	

16-34 Heatsink Temp.		
Range:	Function:	
0 °C* [0 - 255 °C]	View the heat sink temperature. The cut-out limit is 90 ± 5 °C, and the filter cuts back in at 60 ± 5 °C.	

16-35 Inverter Thermal		
Range:	Function:	
0 %* [0 - 100 %]	View the percentage load on the inverter.	

16-36 Inv. Nom. Current		
Range:	Function:	
Size related* [0.01 - 10000 A]	View the inverter nominal current.	

16-37 Inv. Max. Current		
Range:	Function:	
Size related* [0.01 - 10000 A]	View the inverter maximum current.	

16-39 Control Card Temp.		
Range:	Function:	
0 °C* [0 - 100 °C]	View the temperature on the control card, stated in °C	

16-40 Logging Buffer Full		
Option:	Function:	
	View whether the logging buffer is full (see parameter group 15-1* Data Log Settings). The logging buffer is never full when setting parameter 15-13 Logging Mode to [0] Log always.	
[0] *	No	
[1]	Yes	

16-49 Current Fault Source		
Range:	Function:	
0* [0 - 8]	Value indicates source of current faults including short circuit, overcurrent, and phase imbalance (from left): 1-4 Inverter 5-8 Rectifier 0 No fault recorded	

6.9.1 16-6* Inputs and Outputs

16-60 Digital Input		
Range:	Function:	
0* [0 - 1023]	View the signal states from the active digital inputs. Example: Input 18 corresponds to bit no. 5, 0=no signal, 1=connected signal. Bit 6 works in the opposite way, on=0, off=1 (safe stop input).	
Bit 0	Digital input term. 33	
Bit 1	Digital input term. 32	
Bit 2	Digital input term. 29	
Bit 3	Digital input term. 27	
Bit 4	Digital input term. 19	
Bit 5	Digital input term. 18	
Bit 6	Digital input term. 37	
Bit 7	Digital input GP I/O term. X30/4	
Bit 8	Digital input GP I/O term. X30/3	
Bit 9	Digital input GP I/O term. X30/2	
Bit 10-63	Reserved for future terminals	

Table 6.10 Active Digital Inputs

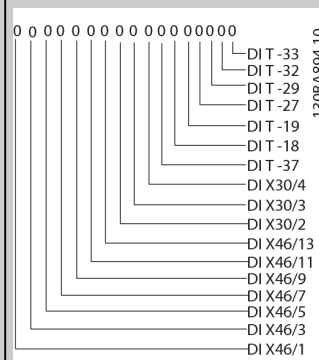


Illustration 6.9 Relay Settings

16-66 Digital Output [bin]		
Range:	Function:	
0* [0 - 15]	View the binary value of all digital outputs.	

16-71 Relay Output [bin]		
Range:	Function:	
0* [0 - 511]	View the settings of all relays.	
	Readout choice (Par. 16-71): Relay output (bin): 0 0 0 0 0 bin OptionB card relay 09 OptionB card relay 08 OptionB card relay 07 Power card relay 02 Power card relay 01 130BA195.10 Illustration 6.11 Relay Settings	

6.9.2 16-8* Fieldbus & FC Port

Parameters for reporting the bus references and control words.

16-80 Fieldbus CTW 1		
Range:	Function:	
0* [0 - 65535]	View the 2-byte control word (CTW) received from the bus master. Interpretation of the control word depends on the fieldbus option installed and the control word profile selected in <i>8-10 Control Profile</i> . For more information, refer to the relevant fieldbus manual.	

16-84 Comm. Option STW		
Range:	Function:	
0* [0 - 65535]	View the extended fieldbus comm. option status word. For more information, refer to the relevant fieldbus manual.	

16-85 FC Port CTW 1		
Range:	Function:	
0* [0 - 65535]	View the 2-byte control word (CTW) received from the bus master. Interpretation of the control word depends on the fieldbus option installed and the control word profile selected in <i>8-10 Control Profile</i> .	

6.9.3 16-9* Diagnosis Readouts

NOTICE

When using MCT 10 Set-up Software, the readout parameters can only be read online, i.e. as the actual status. This means that the status is not stored in the MCT 10 Set-up Software file.

16-90 Alarm Word		
Range:	Function:	
0* [0 - 4294967295]	View the alarm word sent via the serial communication port in hex code.	

16-91 Alarm Word 2		
Range:	Function:	
0* [0 - 4294967295]	View the alarm word sent via the serial communication port in hex code.	

16-92 Warning Word		
Range:	Function:	
0* [0 - 4294967295]	View the warning word sent via the serial communication port in hex code.	

16-93 Warning Word 2		
Range:	Function:	
0* [0 - 4294967295]	View the warning word sent via the serial communication port in hex code.	

16-94 Ext. Status Word		
Range:	Function:	
0* [0 - 4294967295]	Returns the extended warning word sent via the serial communication port in hex code.	

6.10 300-** AF Settings

NOTICE

Except for *parameter 300-10 Active Filter Nominal Voltage*, it is not recommended to change the settings in this parameter group.

300-00 Harmonic Cancellation Mode		
Option:	Function:	
[0] *	Overall	
[1]	Selective	
[2]	Parallel	Enter the harmonic compensation mode. [1] <i>Selective</i> provides precise compensation of the following harmonics: 5,7,11,13,17,19,23,25. [0] <i>Overall</i> provides compensation for additional harmonics, but with reduced precision in some cases.

300-01 Compensation Priority		
Option:	Function:	
[0] *	Harmonics	
[1]	Cosphi	Enter the compensation priority for the active filter. If cosphi compensation has priority, harmonics compensation is reduced in cases where a large amount of current is used to compensate cosphi. Similarly, if harmonics mitigation has priority, cosphi compensation might be reduced.

300-08 Lagging Reactive Current		
Option:	Function:	
[0]	Enable	Enable/disable lagging reactive current.
[1]	Disable	

300-10 Active Filter Nominal Voltage		
Range:	Function:	
Application dependent*	[Application dependant]	Enter the network voltage at the location where the active filter is installed. If using a step-down transformer, enter the transformer secondary side voltage.

300-20 CT Primary Rating		
Range:	Function:	
Application dependent*	[1 - 4000 A]	Enter the primary rating of the current transformers. For a 1000:5 current transformer, enter 1000. Alternatively, this value can be determined by performing an auto CT detection using <i>parameter 300-29 Start Auto CT Detection</i> .

300-24 CT Sequence		
Option:	Function:	
[0] *	L1, L2, L3	
[1]	L1, L3, L2	
[2]	L2, L1, L3	
[3]	L2, L3, L1	
[4]	L3, L1, L2	
[5]	L3, L2, L1	Enter the sequence of the current transformers. Alternatively, this value can be determined by performing an auto CT detection using <i>parameter 300-29 Start Auto CT Detection</i> .

300-25 CT Polarity		
Option:	Function:	
[0] *	Normal	
[1]	Inverse	Enter the polarity of the current transformers. Alternatively, this value can be determined by performing an auto CT detection using <i>parameter 300-29 Start Auto CT Detection</i> .

300-26 CT Placement		
Option:	Function:	
[0]	PCC	
[1] *	Load Current	Enter the placement of the current transformers. For a standalone active filter installation, the CTs are typically placed at a PCC.

300-27 Number of CTs per Phase		
Option:	Function:	
[1]	1	Number of current transformers per phase.
[2]	2	

300-29 Start Auto CT Detection		
Option:	Function:	
[0] *	Off	
[1]	Enable Auto CT Detection	When enabled, the auto CT detection determines the CT primary rating, CT sequence, and CT polarity. The user must enter CT secondary rating, CT nominal voltage and CT placement before starting the auto CT detection. Automatic CT detection cannot be performed on CTs placed at the load currents.

300-30 Compensation Points		
Range:	Function:	
0.0 A*	[0.0 - 8000.1 A]	Enter the maximum accepted distortion of the current in A. Change these values to customise the harmonic compensation. It is possible to change the compensation points for the following harmonics: 5,7,11,13,17,19,23,25. Selective mode provides compensation of individual harmonics with permitted residual levels on the supply mains. This parameter

300-30 Compensation Points		
Range:		Function:
		defines the permitted residual level into the supply of the following harmonics.

300-35 Cosphi Reference		
Range:		Function:
0.500*	[0.500 - 1.000]	Enter the reference for cosphi.

300-40 Master Follower Selection		
Option:		Function:
[0]	Master	If operating active filters in parallel, select whether this filter is a master or a follower active filter.
[1]	Follower	
[2] *	Not Paralleled	

NOTICE

Ensure that only 1 master is set in each group of parallel connected filters. Verify that no other unit is set to master.

After changing this parameter, additional parameters are accessible. For the master units, 300-42 Number of Follower AFs has to be programmed for the number of followers connected.

300-41 Follower ID		
Range:		Function:
1*	[1 - 3]	Enter the unique ID of this follower. Verify that no other follower uses the same ID.

NOTICE

Parameter 300-41 Follower ID is not accessible unless parameter 300-40 Master Follower Selection is set to follower.

NOTICE

Each follower should have its own follower ID. Verify that no 2 followers have the same follower ID.

300-42 Num. of Follower AFs		
Range:		Function:
1*	[1 - 3]	Enter the total number of follower active filters. The master active filter only controls this number of followers.

NOTICE

Parameter 300-42 Num. of Follower AFs is not accessible unless parameter 300-40 Master Follower Selection is set to master.

Program each follower unit at parameter 300-41 Follower ID with a unique ID.

300-50 Enable Sleep Mode		
Option:		Function:
		This parameter saves energy at light system load where harmonic distortion is insignificant and mitigation not needed. The filter automatically deactivates when not needed and reactivates when mitigation is called for. The filter still measures harmonics during sleep, but is not injecting currents. The filter is hard coded to have a minimum sleep time of 5 s to avoid contact bounce.
[0]	Disabled	Default filter does not use the sleep mode function.
[1]	Enabled	The filter enters sleep mode at light loads or if triggered from external.

300-51 Sleep Mode Trig Source		
Option:		Function:
[0] *	Mains current	The filter is active/inactive according to line current. Trigger values are set in parameter 300-52 Sleep Mode Wake Up Trigger and parameter 300-53 Sleep Mode Sleep Trigger
[1]	Digital Input	Filter sleep is triggered via an external signal provided to filter terminal 18.

300-52 Sleep Mode Wake Up Trigger		
Range:		Function:
Application dependent*	[Application dependant]	Only available when [0] Mains Current is selected in parameter 300-51 Sleep Mode Trig Source. The parameter sets the % current value of parameter 300-20 CT Primary Rating at which the filter awakes. 5 equals 5% of parameter 300-20 CT Primary Rating. If CTs are 1500 and this parameter is 5, this equals 5% of 1500 A=75 A wake-up current.

300-53 Sleep Mode Sleep Trigger		
Range:		Function:
80 %*	[0 - 90 %]	This value enters the % sleep-mode trigger value of parameter 300-52 Sleep Mode Wake Up Trigger. If the filter leaves sleep mode at 75 A and this parameter is set to 80, it enters sleep mode at 8% of 75 A=60 A. The filter is programmed to have minimum 5 s sleep time

6.10.1 300-6*

300-60 Fifth Harmonic Limit

Option: **Function:**

[0]	300-60	Mains current triggering point for waking up active filters in sleep mode.
-----	--------	--

300-61 Seventh Harmonic Limit

Option: **Function:**

[0]	300-61	Mains current triggering point for waking up active filters in sleep mode.
-----	--------	--

300-62 Eleventh Harmonic Limit

Option: **Function:**

[0]	300-62	Mains current triggering point for waking up active filters in sleep mode.
-----	--------	--

300-63 Thirteenth Harmonic Limit

Option: **Function:**

[0]	300-63	Mains current triggering point for waking up active filters in sleep mode.
-----	--------	--

300-64 Seventeenth Harmonic Limit

Option: **Function:**

[0]	300-64	Mains current triggering point for waking up active filters in sleep mode.
-----	--------	--

300-65 Nineteenth Harmonic Limit

Option: **Function:**

[0]	300-65	Mains current triggering point for waking up active filters in sleep mode.
-----	--------	--

300-66 Twenty-third Harmonic Limit

Option: **Function:**

[0]	300-66	Mains current triggering point for waking up active filters in sleep mode.
-----	--------	--

300-67 Twenty-fifth Harmonic Limit

Option: **Function:**

[0]	300-67	Mains current triggering point for waking up active filters in sleep mode.
-----	--------	--

6.11 301-** AF Readouts

301-00 Output Current [A]		
Range:		Function:
0.00 A*	[0.00 - 10000.00 A]	View the RMS output current of the unit.

301-01 Output Current [%]		
Range:		Function:
0.0 %*	[0.0 - 10000.0 %]	View the RMS output current of the unit, expressed as a percentage of the nominal current.

301-10 THD of Current [%]		
Range:		Function:
0 %*	[0 - 200 %]	View the total harmonic distortion of the current.

301-11 Estimated THD of Voltage [%]		
Range:		Function:
0 %*	[0 - 200 %]	View the total harmonic distortion of the voltage. This value is estimated because the active filter does not measure the mains voltage.

301-12 Power Factor		
Range:		Function:
0.00*	[0.00 - 2.00]	View the power factor after compensation by the active filter.

301-13 Cospfi		
Range:		Function:
0.00*	[-1.00 - 2.00]	View the displacement power factor, after compensation by the active filter. Positive numbers indicate a leading power factor, while negative numbers indicate a lagging power factor.

301-14 Leftover Currents		
Range:		Function:
0.0 A*	[0.0 - 8000.0 A]	View the harmonic currents left over after prioritised harmonic and cosphi compensation by the active filter.

301-20 Mains Current [A]		
Range:		Function:
0 A*	[0 - 65000 A]	View the total harmonic distortion of the current after compensation by the active filter.

301-21 Mains Frequency		
Range:		Function:
0 Hz*	[0 - 100 Hz]	View the total harmonic distortion of the voltage.

301-22 Fund. Mains Current [A]		
Range:		Function:
0 A*	[0 - 65000 A]	View the power factor, after compensation by the active filter.

6.12 Parameter Lists

6.12.1 Default Settings

Changes during operation:

True means that the parameter can be changed while the active filter is in operation, and *False* means that the unit must be stopped before a change can be made.

4-Set-up:

All set-up: The parameter can be set individually in each of the 4 set-ups, (1 single parameter can have 4 different data values).

1 set-up: Data value is the same in all set-ups.

SR:

Size-related.

N/A:

No default value available.

Conversion index:

This number refers to a conversion figure used when writing or reading with an active filter.

Conv. index	100	75	74	70	67	6	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6
Conv. factor	1	3600000	3600	60	1/60	1000000	100000	10000	1000	100	10	1	0.1	0.01	0.001	0.0001	0.00001	0.000001

Table 6.11 Conversion Index

Data type	Description	Type
2	Integer 8	Int8
3	Integer 16	Int16
4	Integer 32	Int32
5	Unsigned 8	UInt8
6	Unsigned 16	UInt16
7	Unsigned 32	UInt32
9	Visible string	VisStr
33	Normalised value 2 bytes	N2
35	Bit sequence of 16 boolean variables	V2
54	Time difference without date	TimD

Table 6.12 Data Type and Description

6.12.2 0-** Operation/Display

Par. No. #	Parameter description	Default value	4-set-up	Change during operation	Conversion index	Type
0-0* Basic Settings						
0-01	Language	[0] English	1 set-up	TRUE	-	UInt8
0-04	Operating state at power-up (hand)	[1] Forced stop	All set-ups	TRUE	-	UInt8
0-1* Set-up Operations						
0-10	Active set-up	[1] Set-up 1	1 set-up	TRUE	-	UInt8
0-11	Edit set-up	[1] Set-up 1	All set-ups	TRUE	-	UInt8
0-12	This set-up linked to	[0] Not linked	All set-ups	FALSE	-	UInt8
0-13	Readout: Linked set-ups	0 N/A	All set-ups	FALSE	0	UInt16
0-14	Readout: Edit set-ups/channel	0 N/A	All set-ups	TRUE	0	Int32
0-2* LCP Display						
0-20	Display Line 1.1 small	30112	All set-ups	TRUE	-	UInt16
0-21	Display Line 1.2 small	30110	All set-ups	TRUE	-	UInt16
0-22	Display Line 1.3 small	30120	All set-ups	TRUE	-	UInt16
0-23	Display Line 2 large	30100	All set-ups	TRUE	-	UInt16
0-24	Display Line 3 large	30121	All set-ups	TRUE	-	UInt16
0-25	My personal menu	ExpressionLimit	1 set-up	TRUE	0	UInt16
0-4* LCP Keypad						
0-40	[Hand on] key on LCP	[1] Enabled	All set-ups	TRUE	-	UInt8
0-41	[Off] key on LCP	[1] Enabled	All set-ups	TRUE	-	UInt8
0-42	[Auto on] key on LCP	[1] Enabled	All set-ups	TRUE	-	UInt8
0-43	[Reset] key on LCP	[1] Enabled	All set-ups	TRUE	-	UInt8
0-5* Copy/Save						
0-50	LCP copy	[0] No copy	All set-ups	FALSE	-	UInt8
0-51	Set-up copy	[0] No copy	All set-ups	FALSE	-	UInt8
0-6* Password						
0-60	Main menu password	100 N/A	1 set-up	TRUE	0	Int16
0-61	Access to main menu without password	[0] Full access	1 set-up	TRUE	-	UInt8
0-65	Quick menu password	200 N/A	1 set-up	TRUE	0	Int16
0-66	Access to quick menu without password	[0] Full access	1 set-up	TRUE	-	UInt8

6.12.3 5-** Digital In/Out

Par. No. #	Parameter description	Default value	4-set-up	Change during operation	Conversion index	Type
5-0* Digital I/O mode						
5-00	Digital I/O mode	[0] PNP	All set-ups	FALSE	-	UInt8
5-01	Terminal 27 mode	[0] Input	All set-ups	TRUE	-	UInt8
5-02	Terminal 29 mode	[0] Input	All set-ups	TRUE	-	UInt8
5-1* Digital Inputs						
5-10	Terminal 18 digital input	[8] Start	All set-ups	TRUE	-	UInt8
5-11	Terminal 19 digital input	[0] No operation	All set-ups	TRUE	-	UInt8
5-12	Terminal 27 digital input	[0] No operation	All set-ups	TRUE	-	UInt8
5-13	Terminal 29 digital input	[0] No operation	All set-ups	TRUE	-	UInt8
5-16	Terminal X30/2 digital input	[0] No operation	All set-ups	TRUE	-	UInt8
5-17	Terminal X30/3 digital input	[0] No operation	All set-ups	TRUE	-	UInt8
5-18	Terminal X30/4 digital input	[0] No operation	All set-ups	TRUE	-	UInt8
5-19	Terminal 37 Safe stop	[1] Safe Stop Alarm	1 set-up	TRUE	-	UInt8
5-3* Digital Outputs						
5-30	Terminal 27 Digital output	[0] No operation	All set-ups	TRUE	-	UInt8
5-31	Terminal 29 Digital output	[0] No operation	All set-ups	TRUE	-	UInt8
5-4* Relays						
5-40	Function relay	[0] No operation	All set-ups	TRUE	-	UInt8
5-41	On delay, relay	0.30 s	All set-ups	TRUE	-2	UInt16
5-42	Off delay, relay	0.30 s	All set-ups	TRUE	-2	UInt16

6.12.4 8-** Comm. and Options

Par. No. #	Parameter description	Default value	4-set-up	Change during operation	Conversion index	Type
8-0* General Settings						
8-01	Control site	[0] Digital and ctrl.word	All set-ups	TRUE	-	UInt8
8-02	Control word source	null	All set-ups	TRUE	-	UInt8
8-03	Control word timeout time	1.0 s	1 set-up	TRUE	-1	UInt32
8-04	Control word timeout function	[0] Off	1 set-up	TRUE	-	UInt8
8-05	End-of-timeout Function	[1] Resume set-up	1 set-up	TRUE	-	UInt8
8-06	Reset control word timeout	[0] Do not reset	All set-ups	TRUE	-	UInt8
8-3* FC Port Settings						
8-30	Protocol	[1] FC MC	1 set-up	TRUE	-	UInt8
8-31	Address	2 N/A	1 set-up	TRUE	0	UInt8
8-32	FC port baud rate	[2] 9600 Baud	1 set-up	TRUE	-	UInt8
8-35	Minimum response delay	10 ms	All set-ups	TRUE	-3	UInt16
8-36	Max response delay	5000 ms	1 set-up	TRUE	-3	UInt16
8-37	Max liter-char delay	25 ms	1 set-up	TRUE	-3	UInt16
8-5* Digital/Bus						
8-53	Start select	[3] Logic OR	All set-ups	TRUE	-	UInt8
8-55	Set-up select	[3] Logic OR	All set-ups	TRUE	-	UInt8

6.12.5 14-** Special Functions

Par. No. #	Parameter description	Default value	4-set-up	Change during operation	Conversion index	Type
14-2* Trip Reset						
14-20	Reset mode	[0] Manual reset	All set-ups	TRUE	-	UInt8
14-21	Automatic restart time	10 s	All set-ups	TRUE	0	UInt16
14-22	Operation mode	[0] Normal operation	All set-ups	TRUE	-	UInt8
14-23	Typecode setting	null	2 set-ups	FALSE	-	UInt8
14-28	Production settings	[0] No action	All set-ups	TRUE	-	UInt8
14-29	Service code	0 N/A	All set-ups	TRUE	0	Int32
14-5* Environment						
14-50	RFI filter	[1] On	1 set-up	FALSE	-	UInt8
14-53	Fan monitor	[1] Warning	All set-ups	TRUE	-	UInt8
14-54	Bus partner	1 N/A	2 set-ups	TRUE	0	UInt16

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6.12.6 15-** FC Information

Par. No. #	Parameter description	Default value	4-set-up	Change during operation	Conversion index	Type
15-0* Operating Data						
15-00	Operating hours	0 h	All set-ups	FALSE	74	UInt32
15-01	Running hours	0 h	All set-ups	FALSE	74	UInt32
15-03	Power up's	0 N/A	All set-ups	FALSE	0	UInt32
15-04	Over temp's	0 N/A	All set-ups	FALSE	0	UInt16
15-05	Over volt's	0 N/A	All set-ups	FALSE	0	UInt16
15-07	Reset running hours counter	[0] Do not reset	All set-ups	TRUE	-	UInt8
15-1* Data Log Settings						
15-10	Logging source	0	2 set-ups	TRUE	-	UInt16
15-11	Logging interval	ExpressionLimit	2 set-ups	TRUE	-3	TimD
15-12	Trigger event	[0] False	1 set-up	TRUE	-	UInt8
15-13	Logging mode	[0] Log always	2 set-ups	TRUE	-	UInt8
15-14	Samples before trigger	50 N/A	2 set-ups	TRUE	0	UInt8
15-2* Historic Log						
15-20	Historic log: Event	0 N/A	All set-ups	FALSE	0	UInt8
15-21	Historic log: Value	0 N/A	All set-ups	FALSE	0	UInt32
15-22	Historic log: Time	0 ms	All set-ups	FALSE	-3	UInt32
15-3* Fault Log						
15-30	Fault log: Error code	0 N/A	All set-ups	FALSE	0	UInt16
15-31	Fault log: Value	0 N/A	All set-ups	FALSE	0	Int16
15-32	Fault log: Time	0 s	All set-ups	FALSE	0	UInt32
15-4* Unit Identification						
15-40	FC type	0 N/A	All set-ups	FALSE	0	VisStr[6]
15-41	Power section	0 N/A	All set-ups	FALSE	0	VisStr[20]
15-42	Voltage	0 N/A	All set-ups	FALSE	0	VisStr[20]
15-43	Software version	0 N/A	All set-ups	FALSE	0	VisStr[5]
15-44	Ordered typecode string	0 N/A	All set-ups	FALSE	0	VisStr[40]
15-45	Actual typecode string	0 N/A	All set-ups	FALSE	0	VisStr[40]
15-46	Unit ordering number	0 N/A	All set-ups	FALSE	0	VisStr[8]
15-47	Power card ordering number	0 N/A	All set-ups	FALSE	0	VisStr[8]
15-48	LCP ID number	0 N/A	All set-ups	FALSE	0	VisStr[20]
15-49	SW ID control card	0 N/A	All set-ups	FALSE	0	VisStr[20]

Par. No. #	Parameter description	Default value	4-set-up	Change during operation	Conversion index	Type
15-50	SW ID power card	0 N/A	All set-ups	FALSE	0	VisStr[20]
15-51	Unit serial number	0 N/A	All set-ups	FALSE	0	VisStr[10]
15-53	Power card serial number	0 N/A	All set-ups	FALSE	0	VisStr[19]
15-6* Option Ident						
15-60	Option mounted	0 N/A	All set-ups	FALSE	0	VisStr[30]
15-61	Option SW version	0 N/A	All set-ups	FALSE	0	VisStr[20]
15-62	Option ordering number	0 N/A	All set-ups	FALSE	0	VisStr[8]
15-63	Option serial number	0 N/A	All set-ups	FALSE	0	VisStr[18]
15-70	Option in slot A	0 N/A	All set-ups	FALSE	0	VisStr[30]
15-71	Slot A option SW version	0 N/A	All set-ups	FALSE	0	VisStr[20]
15-72	Option in slot B	0 N/A	All set-ups	FALSE	0	VisStr[30]
15-73	Slot B option SW version	0 N/A	All set-ups	FALSE	0	VisStr[20]
15-74	Option in slot C0	0 N/A	All set-ups	FALSE	0	VisStr[30]
15-75	Slot C0 option SW version	0 N/A	All set-ups	FALSE	0	VisStr[20]
15-76	Option in slot C1	0 N/A	All set-ups	FALSE	0	VisStr[30]
15-77	Slot C1 option SW version	0 N/A	All set-ups	FALSE	0	VisStr[20]
15-9* Parameter Info						
15-92	Defined parameters	0 N/A	All set-ups	FALSE	0	UInt16
15-93	Modified parameters	0 N/A	All set-ups	FALSE	0	UInt16
15-98	Unit identification	0 N/A	All set-ups	FALSE	0	VisStr[40]
15-99	Parameter metadata	0 N/A	All set-ups	FALSE	0	UInt16

6.12.7 16-** Data Readouts

Par. No. #	Parameter description	Default value	4-set-up	Change during operation	Conversion index	Type
16-0* General Status						
16-00	Control word	0 N/A	All set-ups	FALSE	0	V2
16-03	Status word	0 N/A	All set-ups	FALSE	0	V2
16-3* AF Status						
16-30	DC link voltage	0 V	All set-ups	FALSE	0	Uint16
16-34	Heatsink temp.	0 °C	All set-ups	FALSE	100	Uint8
16-35	Inverter thermal	0 %	All set-ups	FALSE	0	Uint8
16-36	Inv. nom. current	ExpressionLimit	All set-ups	FALSE	-2	Uint32
16-37	Inv. max. current	ExpressionLimit	All set-ups	FALSE	-2	Uint32
16-39	Control card temp.	0 °C	All set-ups	FALSE	100	Uint8
16-40	Logging buffer full	[0] No	All set-ups	TRUE	-	Uint8
16-49	Current fault source	0 N/A	All set-ups	TRUE	0	Uint8
16-6* Inputs & Outputs						
16-60	Digital input	0 N/A	All set-ups	FALSE	0	Uint16
16-66	Digital output [bin]	0 N/A	All set-ups	FALSE	0	Int16
16-71	Relay output [bin]	0 N/A	All set-ups	FALSE	0	Int16
16-8* Fieldbus & FC Port						
16-80	Fieldbus CTW 1	0 N/A	All set-ups	FALSE	0	V2
16-84	Comm. option STW	0 N/A	All set-ups	FALSE	0	V2
16-85	FC port CTW 1	0 N/A	All set-ups	FALSE	0	V2
16-9* Diagnosis Readouts						
16-90	Alarm word	0 N/A	All set-ups	FALSE	0	Uint32
16-91	Alarm word 2	0 N/A	All set-ups	FALSE	0	Uint32
16-92	Warning word	0 N/A	All set-ups	FALSE	0	Uint32
16-93	Warning word 2	0 N/A	All set-ups	FALSE	0	Uint32
16-94	Ext. status word	0 N/A	All set-ups	FALSE	0	Uint32

6.12.8 300-** AF Settings

NOTICE

Except for *parameter 300-10 Active Filter Nominal Voltage*, it is not recommended to change the settings in this parameter group.

Par. No. #	Parameter description	Default value	4-set-up	Change during operation	Conversion index	Type
300-0* General Settings						
300-00	Harmonic cancellation mode	[0] Overall	All set-ups	TRUE	-	UInt8
300-01	Compensation priority	[0] Harmonics	All set-ups	TRUE	-	UInt8
300-08	Lagging reactive current	[0] Disabled	All set-ups			
300-1* Network Settings						
300-10	Active filter nominal voltage	ExpressionLimit	2 set-ups	FALSE	0	UInt32
300-2* CT Settings						
300-20	CT primary rating	ExpressionLimit	2 set-ups	FALSE	0	UInt32
300-22	CT nominal voltage	342 V	2 set-ups	FALSE	0	UInt32
300-24	CT sequence	[0] L1, L2, L3	2 set-ups	FALSE	-	UInt8
300-25	CT polarity	[0] Normal	2 set-ups	FALSE	-	UInt8
300-26	CT placement	[1] Load Current	2 set-ups	FALSE	-	UInt8
300-29	Start auto CT detection	[0] Off	All set-ups	FALSE	-	UInt8
300-3* Compensation						
300-30	Compensation points	0.0 A	All set-ups	TRUE	-1	UInt32
300-35	Cosphi reference	0.500 N/A	All set-ups	TRUE	-3	UInt16
300-4* Paralleling						
300-40	Master follower selection	[2] Not Paralleled	2 set-ups	FALSE	-	UInt8
300-41	Follower ID	1 N/A	2 set-ups	FALSE	0	UInt32
300-42	Number of follower AFs	1 N/A	2 set-ups	FALSE	0	UInt32
300-5* Sleep Mode						
300-50	Enable sleep mode	null	2 set-ups	TRUE	-	UInt8
300-51	Sleep mode trig source	[0] Mains current	All set-ups	TRUE	-	UInt8
300-52	Sleep mode wake up trigger	ExpressionLimit	All set-ups	TRUE	0	UInt32
300-53	Sleep mode sleep trigger	80 %	All set-ups	TRUE	0	UInt32

6.12.9 301-** AF Readouts

Par. No. #	Parameter description	Default value	4-set-up	Change during operation	Conversion index	Type
301-0* Output Currents						
301-00	Output current [A]	0.00 A	All set-ups	TRUE	-2	Int32
301-01	Output current [%]	0.0 %	All set-ups	TRUE	-1	Int32
301-1* Unit Performance						
301-10	THD of current [%]	0.0 %	All set-ups	TRUE	-1	UInt16
301-11	Estimated THD of voltage [%]	0.0 %	All set-ups			UInt16
301-12	Power factor	0.00 N/A	All set-ups	TRUE	-2	UInt16
301-13	Cosphi	0.00 N/A	All set-ups	TRUE	-2	Int16
301-14	Leftover currents	0.0 A	All set-ups	TRUE	-1	UInt32
301-2* Mains Status						
301-20	Mains current [A]	0 A	All set-ups	TRUE	0	Int32
301-21	Mains frequency	0 Hz	All set-ups	TRUE	0	UInt8
301-22	Fund. mains current [A]	0 A	All set-ups	TRUE	0	Int32

7 RS485 Installation and Set-up

7.1 Installation and Set-up

7.1.1 Overview

RS485 is a 2-wire bus interface compatible with multi-drop network topology. Nodes can be connected as a bus, or via drop cables from a common trunk line. A total of 32 nodes can be connected to one network segment. Network segments are divided by repeaters. Each repeater functions as a node within the segment in which it is installed. Each node connected within a given network must have a unique node address across all segments. Terminate each segment at both ends using either the termination switch (S801) of the unit, or a biased termination resistor network. Use screened twisted pair (STP) cable for bus cabling, and follow good common installation practice.

Low-impedance ground connection of the screen at every node is very important, including at high frequencies. This can be achieved by connecting a large surface of the screen-to-ground, for example with a cable clamp or a conductive cable gland. It may be necessary to apply potential-equalizing cables to maintain the same ground potential throughout the network, particularly in installations where there are long lengths of cable. To prevent impedance mismatch, use the same type of cable throughout the entire network.

Cable	Screened twisted pair (STP)
Impedance	120 Ω
Cable length	Maximum 1200 m (3937 ft.), including drop lines
Maximum	500 m (1640 ft.) station-to-station

Table 7.1 Cable Specifications

7.1.2 Network Connection

Connect the unit to the RS485 network as follows:

1. Connect signal wires to terminal 68 (P+) and terminal 69 (N-) on the main control board of the unit.
2. Connect the cable screen to the cable clamps.

NOTICE

Screened, twisted-pair cables are recommended to reduce noise between conductors.

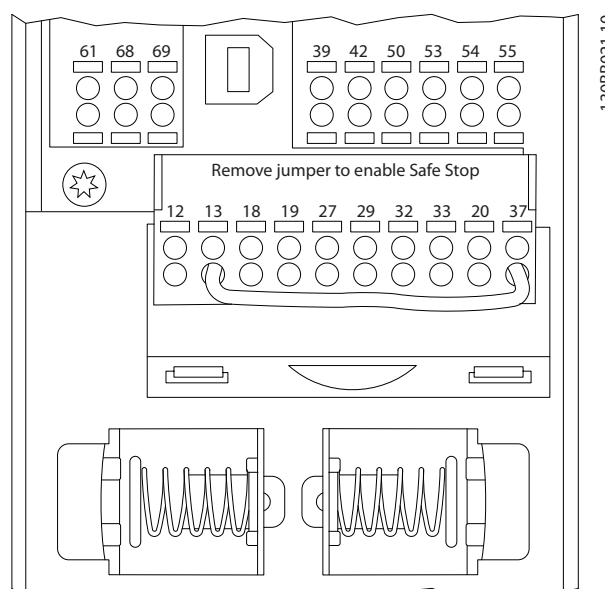


Illustration 7.1 Control Card Terminals

7.1.3 Bus Termination

Use the terminator DIP switch on the main control board of the unit to terminate the RS485 bus.

NOTICE

The factory setting for the switch is OFF.

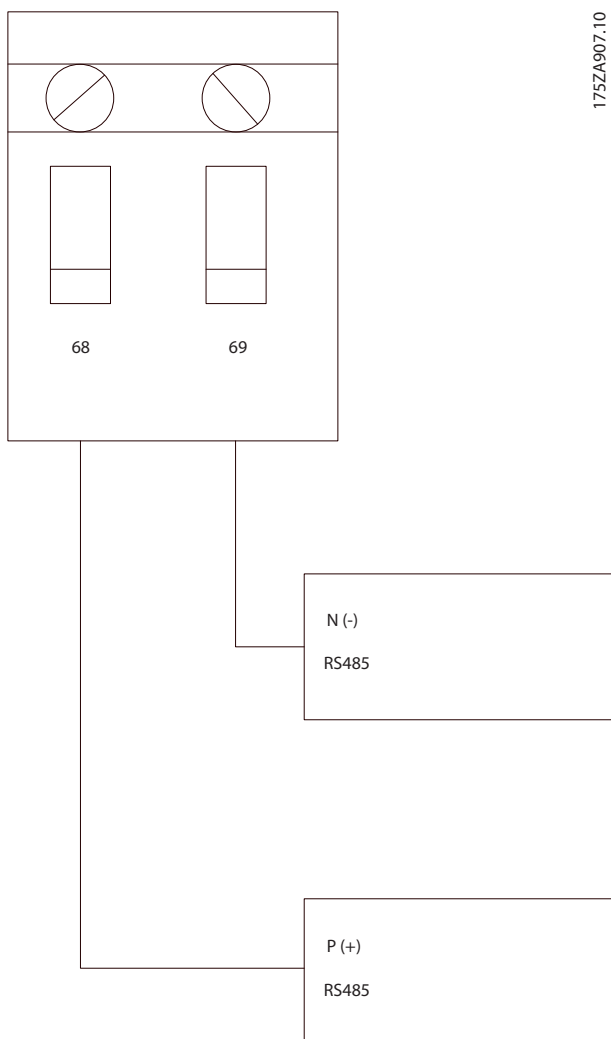


Illustration 7.2 Terminator Switch Factory Setting

7.1.4 EMC Precautions

The following EMC precautions are recommended in order to achieve interference-free operation of the RS485 network.

- Observe relevant national and local regulations regarding protective ground connection.
- Keep the RS485 communication cable away from noisy cables such as power lines and motor cables. Doing so reduces high frequency noise

transference. A distance of 200 mm (8 in) is the minimum, but keeping the greatest possible distance between cables is best, especially when cables run in parallel over long distances.

- When crossing cables is unavoidable, the RS485 cable must cross other power cables at a 90° angle

7.2 Network Configuration

Set the parameters in Table 7.2 to enable the FC protocol for the filter.

Parameter Number	Setting
Parameter 8-30 Protocol	FC
8-31 Address	1-126
Parameter 8-32 FC Port Baud Rate	2400-115200
8-33 Parity / Stop Bits	Even parity, 1 stop bit (default)

Table 7.2 Configuration Parameter Settings

7.3 FC Protocol Message Framing Structure

7.3.1 Content of a Character (byte)

Each character transferred begins with a start bit. Then 8 data bits are transferred, corresponding to a byte. Each character is secured via a parity bit. This bit is set at 1 when it reaches parity. Parity is when there is an equal number of 1s in the 8 data bits and the parity bit in total. A stop bit completes a character, thus consisting of 11 bits in all.



Illustration 7.3 Content of a Character

7.3.2 Telegram Structure

Each telegram begins with a start character (STX)=02 hex, followed by a byte denoting the telegram length (LGE) and a byte denoting the filter address (ADR). A number of data bytes (variable, depending on the type of telegram) follows. The telegram is completed by a data control byte (BCC).

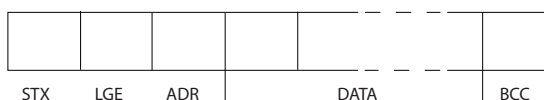


Illustration 7.4 Telegram Structure

7.3.3 Telegram Length (LGE)

The telegram length is the number of data bytes plus the address byte ADR and the data control byte BCC.

4 data bytes	$LGE=4+1+1=6$ bytes
12 data bytes	$LGE=12+1+1=14$ bytes
Telegrams containing texts	$10^{1)}+n$ bytes

Table 7.3 Length of Telegrams

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

7.3.4 Filter Address (ADR)

2 different address formats are used.

The address range of the filter is either 1–31 or 1–126.

1. Address format 1–31:

Bit 7=0 (address format 1–31 active).

Bit 6 is not used.

Bit 5=1: Broadcast, address bits (0–4) are not used.

Bit 5=0: No Broadcast.

Bit 0-4=Filter address 1–31.

2. Address format 1–126:

Bit 7=1 (address format 1–126 active).

Bit 0-6=Filter address 1–126.

Bit 0-6=0 Broadcast.

The slave returns the address byte unchanged to the master in the response telegram.

7.3.5 Data Control Byte (BCC)

The checksum is calculated as an XOR-function. Before the first byte in the telegram is received, the calculated checksum is 0.

7.3.6 The Data Field

The structure of data blocks depends on the type of telegram. There are 3 telegram types, and the type applies for both control telegrams (master⇒follower) and response telegrams (follower⇒master).

The 3 types of telegram are:

Process block (PCD)

The PCD is made up of a data block of 4 bytes (2 words) and contains:

- Control word and reference value (from master to follower).
- Status word and present output frequency (from follower to master).



Illustration 7.5 Process Block

Parameter block

The parameter block is used to transfer parameters between master and follower. The data block is made up of 12 bytes (6 words) and also contains the process block.

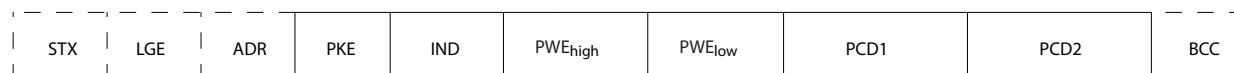
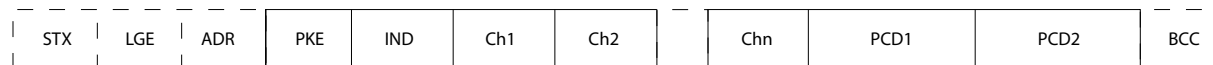


Illustration 7.6 Parameter Block

Text block

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



130BA270.10

Illustration 7.7 Text Block

7.3.7 The PKE Field

The PKE field contains 2 sub-fields:

- Parameter command and response AK
- Parameter number PNU

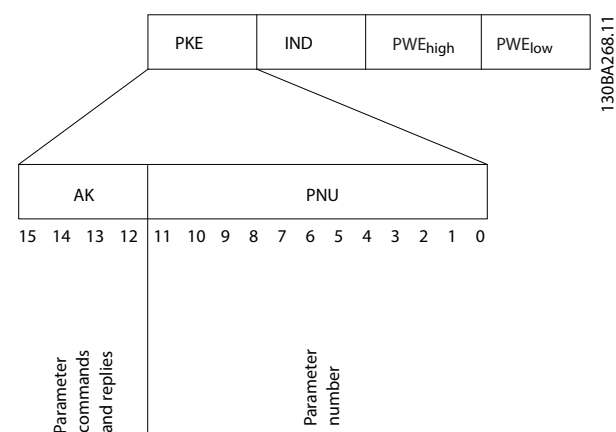


Illustration 7.8

Bits 12–15 transfer parameter commands from master to slave and return processed slave responses to the master.

Parameter commands master⇒slave				
Bit no.				Parameter command
15	14	13	12	
0	0	0	0	No command
0	0	0	1	Read parameter value
0	0	1	0	Write parameter value in RAM (word)
0	0	1	1	Write parameter value in RAM (double word)
1	1	0	1	Write parameter value in RAM and EEprom (double word)
1	1	1	0	Write parameter value in RAM and EEprom (word)
1	1	1	1	Read/write text

Table 7.4 Parameter Commands from Master to Slave

Response slave⇒master				
Bit no.				Response
15	14	13	12	
0	0	0	0	No response
0	0	0	1	Parameter value transferred (word)
0	0	1	0	Parameter value transferred (double word)
0	1	1	1	Command cannot be performed
1	1	1	1	Text transferred

Table 7.5 Parameter Response from Slave to Master

If the command cannot be performed, the slave sends this response:

0111 Command cannot be performed

- and issues the following fault report in the parameter value (PWE):

PWE low (hex)	Fault report
0	The parameter number used does not exist.
1	There is no write access to the defined parameter.
2	Data value exceeds the parameter limits.
3	The sub index used does not exist.
4	The parameter is not the array type.
5	The data type does not match the defined parameter.
11	Data change in the defined parameter is not possible in the unit's present mode. Certain parameters can only be changed when the motor is turned off.
82	There is no bus access to the defined parameter.
83	Data change is not possible because factory set-up is selected.

Table 7.6 Fault Definitions

7.3.8 Parameter Number (PNU)

Bits 0–1 transfer parameter numbers. The function of the relevant parameter is defined in the parameter description in the *Programming Guide*.

7.3.9 Index (IND)

The index is used with the parameter number to read/write-access parameters with an index, e.g. *15-30 Alarm Log: Error Code*. The index consists of 2 bytes, a low byte and a high byte.

Only the low byte is used as an index.

7.3.10 Parameter Value (PWE)

The parameter value block consists of 2 words (4 bytes), and the value depends on the defined command (AK). The master prompts for a parameter value when the PWE block contains no value. To change a parameter value (write), write the new value in the PWE block and send from the master to the follower.

When a follower responds to a parameter request (read command), the present parameter value in the PWE block is transferred and returned to the master. If a parameter contains not a numerical value, but several data options, e.g. *parameter 0-01 Language* where [0] is English, and [4] is Danish, select the data value by entering the value in the PWE block. Serial communication is only capable of reading parameters containing data type 9 (text string).

15-40 FC Type to *parameter 15-53 Power Card Serial Number* contain data type 9.

For example, read the unit size and mains voltage range in *15-40 FC Type*. When a text string is transferred (read), the length of the telegram is variable, and the texts are of different lengths. The telegram length is defined in the second byte of the telegram, LGE. When using text transfer, the index character indicates whether it is a read or a write command.

To read a text via the PWE block, set the parameter command (AK) to F hex. The index character high-byte must be 4.

Some parameters contain text that can be written to via the serial bus. To write a text via the PWE block, set the parameter command (AK) to 'F' hex. The index characters high-byte must be 5.

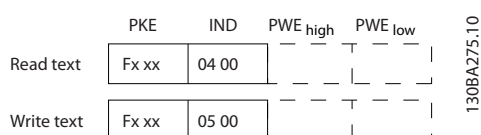


Illustration 7.9 Text via PWE Block

7.3.11 Supported Data Types

Unsigned means that there is no operational sign in the telegram.

Data types	Description
3	Integer 16
4	Integer 32
5	Unsigned 8
6	Unsigned 16
7	Unsigned 32
9	Text string
10	Byte string
13	Time difference
33	Reserved
35	Bit sequence

Table 7.7 Supported Data Types

7.3.12 Conversion

The various attributes of each parameter are displayed in factory setting. Parameter values are transferred as whole numbers only. Conversion factors are therefore used to transfer decimals.

A conversion factor of 0.1 means that the value transferred is multiplied by 0.1. The value 100 is therefore read as 10.0.

Examples:

0 s⇒conversion index 0

0.00 s⇒conversion index -2

0 ms⇒conversion index -3

0.00 ms⇒conversion index -5

Conversion index	Conversion factor
100	
75	
74	
67	
6	1000000
5	100000
4	10000
3	1000
2	100
1	10
0	1
-1	0.1
-2	0.01
-3	0.001
-4	0.0001
-5	0.00001
-6	0.000001
-7	0.0000001

Table 7.8 Conversion Table

7.3.13 Process Words (PCD)

The block of process words is divided into 2 blocks of 16 bits, which always occur in the defined sequence.

PCD 1	PCD 2
Control telegram (master⇒slave control word)	Reference value
Control telegram (slave⇒master) status word	Present output frequency

Table 7.9 Process Words (PCD)

7.4 How to Access Parameters in Modbus RTU

7.4.1 Parameter Handling

The PNU (Parameter Number) is translated from the register address contained in the Modbus read or write message. The parameter number is translated to Modbus as (10 x parameter number) DECIMAL.

7.4.2 Data Storage

The coil 65 decimal determines whether data written to the unit are stored in EEPROM and RAM (coil 65=1) or only in RAM (coil 65=0).

7.4.3 IND (Index)

Some parameters in the frequency converter are array parameters e.g. *3-10 Preset Reference*. Since the Modbus does not support arrays in the holding registers, the frequency converter has reserved the holding register 9 as pointer to the array. Before reading or writing an array parameter, set the holding register 9. Setting holding register to the value of 2 causes all following read/write to array parameters to be to the index 2.

7.4.4 Text Blocks

Parameters stored as text strings are accessed in the same way as the other parameters. The maximum text block size is 20 characters. If a read request for a parameter is for more characters than the parameter stores, the response is truncated. If the read request for a parameter is for fewer characters than the parameter stores, the response is space filled.

7.4.5 Conversion Factor

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

7.4.6 Parameter Values

Standard data types

Standard data types are int 16, int 32, uint 8, uint 16 and uint 32. They are stored as 4x registers (40001–4FFFF). The parameters are read using function 03 hex *Read Holding Registers*. Parameters are written using the function 6 hex *Preset Single Register* for 1 register (16 bits), and the function 10 hex *Preset Multiple Registers* for 2 registers (32 bits). Readable sizes range from 1 register (16 bits) up to 10 registers (20 characters).

Non-standard data types

Non-standard data types are text strings and are stored as 4x registers (40001–4FFFF). The parameters are read using function 03 hex *Read Holding Registers* and written using function 10 hex *Preset Multiple Registers*. Readable sizes range from 1 register (2 characters) up to 10 registers (20 characters).

8 Maintenance, Diagnostics and Troubleshooting

8.1 Maintenance and Service

Under normal operating conditions and load profiles, the active filter is maintenance-free throughout its designed lifetime. To prevent breakdown, danger, and damage, examine the filter at regular intervals depending on the operating conditions. Replace worn or damaged parts with original spare parts or standard parts. For service and support, refer to www.danfoss.com/contact/sales_and_services/.

8.2 Warning and Alarm Types

8.2.1 Warnings

A warning is issued when an alarm condition is impending or when an abnormal operating condition is present and may result in the active filter issuing an alarm. A warning clears by itself when the abnormal condition is removed.

8.2.2 Alarm Trip

An alarm is issued when the active filter is tripped, that is, the active filter suspends operation to prevent filter or system damage. After the fault condition is remedied, reset the active filter. It is then ready to start operation again.

A trip can be reset in any of 4 ways:

- Press [Reset] on the LCP.
- Digital reset input command.
- Serial communication reset input command.
- Auto reset.

8.2.3 Alarm Trip-lock

An alarm that causes the active filter to trip-lock requires that input power is cycled. The active filter logic continues to operate and monitors status. Remove input power to the active filter and correct the cause of the fault, then restore power. This action puts the active filter into a trip condition as described in *chapter 8.2.2 Alarm Trip* and may be reset in any of the 4 ways.

8.3 Active Filter Warning and Alarm Definitions

NOTICE

After a manual reset pressing [Reset], press [Auto On] or [Hand On] to restart the unit.

If an alarm cannot be reset, the reason may be that its cause has not been rectified, or the alarm is trip-locked (see also *Table 8.1*).

Alarms that are trip-locked offer additional protection, meaning that the mains supply must be switched off before the alarm can be reset. After being switched back on, the unit is no longer blocked and may be reset as described in *chapter 8.2.2 Alarm Trip* once the cause has been rectified.

Alarms that are not trip-locked can also be reset using the automatic reset function in *14-20 Reset Mode*. Automatic wake-up is possible during this type of reset.

If a warning and alarm is marked against a code in *Table 8.1*, either a warning occurs before an alarm, or the display for a given fault (warning or alarm) is configurable.

8

Number	Description	Warning	Alarm/Trip	Alarm/Trip Lock	Parameter Reference
1	10 Volts low	X			
2	Live zero error	(X)	(X)		6-01
4	Mains phase loss	X			
5	DC link voltage high	X			
6	DC link voltage low	X			
7	DC over voltage	X	X		
8	DC under voltage	X	X		
13	Over current	X	X	X	
14	Earth fault	X	X	X	
15	Hardware mismatch		X	X	
16	Short circuit		X	X	
17	Control word timeout	(X)	(X)		8-04
23	Internal fan fault	X			
24	External fan fault	X			14-53
29	Heatsink temp	X	X	X	
33	Inrush fault		X	X	
34	Fieldbus fault	X	X		
35	Option fault	X	X		
38	Internal fault				
39	Heatsink sensor		X	X	
40	Overload of digital output terminal 27	(X)			5-00, 5-01
41	Overload of digital output terminal 29	(X)			5-00, 5-02
46	Pwr. card supply		X	X	
47	24 V supply low	X	X	X	
48	1.8 V supply low		X	X	
65	Control board over-temperature	X	X	X	
66	Heat sink temperature low	X			
67	Option configuration has changed		X		
68	Safe torque off activated		X		
69	Pwr. card temp		X	X	
70	Illegal FC configuration			X	
72	Dangerous failure			X	
73	Safe torque off auto restart				
76	Power unit setup	X			

Number	Description	Warning	Alarm/Trip	Alarm/Trip Lock	Parameter Reference
79	Illegal PS config		X	X	
80	Unit initialised to default value		X		
250	New spare part			X	
251	New type code		X	X	
300	Mains cont. fault	X			
301	SC cont. fault	X			
302	Cap. over current	X	X		
303	Cap. earth fault	X	X		
304	DC over current	X	X		
305	Mains freq. limit		X		
306	Compensation Limit				
308	Resistor temp	X		X	
309	Mains earth fault	X	X		
311	Switch. freq. limit		X		
312	CT range		X		
314	Auto CT interrupt		X		
315	Auto CT error		X		
316	CT location error	X			
317	CT polarity error	X			
318	CT ratio error	X			

Table 8.1 Alarm/Warning Code List

A trip is the action when an alarm has appeared. The trip disables the active filter and can be reset by pressing [Reset] or resetting via a digital input (parameter group 5-1* *Digital Inputs [1] Reset*). The origin event that caused an alarm cannot damage the active filter or cause dangerous conditions. A trip lock is an action when an alarm occurs, which may cause damage to active filter or connected parts. A trip lock situation can only be reset by a power cycling.

Warning	yellow
Alarm	flashing red
Trip locked	yellow and red

Table 8.2 LED Indicator Lights

Alarm word and extended status word					
Bit	Hex	Dec	Alarm word	Warning word	Extended status word
0	00000001	1	Mains cont. fault	Reserved	Reserved
1	00000002	2	Heatsink temp	Heatsink temp	Auto CT running
2	00000004	4	Ground fault	Ground fault	Reserved
3	00000008	8	Ctrl.card temp	Ctrl.card temp	Reserved
4	00000010	16	Ctrl. word TO	Ctrl. word TO	Reserved
5	00000020	32	Over current	Over current	Reserved
6	00000040	64	SC cont. fault	Reserved	Reserved
7	00000080	128	Cap. over current	Cap. over current	Reserved
8	00000100	256	Cap. earth fault	Cap. earth fault	Reserved
9	00000200	512	Inverter overld.	Inverter overld.	Reserved
10	00000400	1024	DC under volt	DC under volt	Reserved
11	00000800	2048	DC over volt	DC over volt	Reserved
12	00001000	4096	Short circuit	DC voltage low	Reserved
13	00002000	8192	Inrush fault	DC voltage high	Reserved
14	00004000	16384	Mains ph. loss	Mains ph. loss	Reserved
15	00008000	32768	Auto CT error	Reserved	Reserved
16	00010000	65536	Reserved	Reserved	Reserved
17	00020000	131072	Internal fault	10 V low	Password Time Lock
18	00040000	262144	DC over current	DC over current	Password Protection
19	00080000	524288	Resistor temp	Resistor temp	Reserved
20	00100000	1048576	Mains earth fault	Mains earth fault	Reserved
21	00200000	2097152	Switch. freq. limit	Reserved	Reserved
22	00400000	4194304	Fieldbus fault	Fieldbus fault	Reserved
23	00800000	8388608	24 V supply low	24 V supply low	Reserved
24	01000000	16777216	CT range	Reserved	Reserved
25	02000000	33554432	1.8 V supply low	Reserved	Reserved
26	04000000	67108864	Reserved	Low temp	Reserved
27	08000000	134217728	Auto CT interrupt	Reserved	Reserved
28	10000000	268435456	Option change	Reserved	Reserved
29	20000000	536870912	Unit initialised	Unit initialised	Reserved
30	40000000	1073741824	Safe torque off	Safe torque off	Reserved
31	80000000	2147483648	Mains freq. limit	Extended status word	Reserved

Table 8.3 Description of Alarm Word, Warning Word and Extended Status Word

The alarm words, warning words and extended status words can be read out via serial bus or optional fieldbus for diagnosis. See also *parameter 16-90 Alarm Word*, *parameter 16-92 Warning Word* and *16-94 Ext. Status Word*. Reserved means that the bit is not guaranteed to be any particular value. Reserved bits should not be used for any purpose.

8.3.1 Fault Messages for Active Filter

WARNING 1, 10 volts low

The control card voltage is below 10 V from terminal 50. Remove some of the load from terminal 50, as the 10 V supply is overloaded. Max. 15 mA or minimum 590 Ω.

WARNING/ALARM 2, Live zero error

The signal on terminal 53 or 54 is less than 50% of the value set in parameters *6-10 Terminal 53 Low Voltage*, *6-12 Terminal 53 Low Current*, *6-20 Terminal 54 Low Voltage*, *6-22 Terminal 54 Low Current*.

WARNING 4, Mains phase loss

A phase is missing on the supply side, or the mains voltage imbalance is too high.

WARNING 5, DC-link voltage high

The DC-link voltage (DC) is higher than the high-voltage warning limit. The unit is still active.

WARNING 6, DC-link voltage low

The DC-link voltage (DC) is below the low-voltage warning limit. The unit is still active.

WARNING/ALARM 7, DC overvoltage

If the DC-link voltage exceeds the limit, the unit trips.

WARNING/ALARM 8, DC under voltage

If the DC-link voltage (DC) drops below the under voltage limit, the filter checks if a 24 V back-up supply is connected. If not, the filter trips. Check that the mains voltage matches the nameplate specification.

WARNING/ALARM 13, Overcurrent

The unit current limit has been exceeded.

ALARM 14, Ground fault

The sum current of the IGBT CTs does not equal zero. Check if the resistance of any phase-to-ground has a low value. Check both before and after mains contactor. Ensure IGBT current transducers, connection cables, and connectors are OK.

ALARM 15, Incomp. Hardware

A mounted option is incompatible with the present control card SW/HW.

ALARM 16, Short circuit

There is a short circuit in the output. Turn off the unit and correct the error.

WARNING/ALARM 17, Control word time-out

There is no communication to the unit.

The warning is only active when *8-04 Control Word Timeout Function* is not set to off.

Possible correction: Increase *parameter 8-03 Control Word Timeout Time*. Change *8-04 Control Word Timeout Function*

WARNING 23, Internal fan fault

Internal fans have failed due to defect hardware or fans not mounted.

WARNING 24, External fan fault

External fans have failed due to defective hardware or fans not mounted.

ALARM 29, Heat sink temp

The maximum temperature of the heat sink has been exceeded. The temperature fault is not reset until the temperature drops below a defined heat sink temperature.

ALARM 33, Inrush fault

Check whether a 24 V external DC supply has been connected.

WARNING/ALARM 34, Fieldbus communication fault

The fieldbus on the communication option card is not working.

WARNING/ALARM 35, Option Fault:

Contact Danfoss or supplier.

ALARM 38, Internal fault

Contact Danfoss or supplier.

ALARM 39, Heat sink sensor

No feedback from the heat sink temperature sensor.

WARNING 40, Overload of Digital Output Terminal 27

Check the load connected to terminal 27 or remove short circuit connection.

WARNING 41, Overload of Digital Output Terminal 29

Check the load connected to terminal 29 or remove short circuit connection.

ALARM 46, Power card supply

The supply on the power card is out of range.

WARNING 47, 24 V supply low

Contact Danfoss or supplier.

WARNING 48, 1.8 V supply low

Contact Danfoss or supplier.

WARNING/ALARM/TRIP 65, Control card overtemperature

Control card overtemperature: The cut-out temperature of the control card is 80 °C.

WARNING 66, Heat sink temperature low

This warning is based on the temperature sensor in the IGBT module.

Troubleshooting

The heat sink temperature measured as 0 °C could indicate that the temperature sensor is defective, causing the fan speed to increase to the maximum. If the sensor wire between the IGBT and the gate drive card is disconnected, this warning would result. Also, check the IGBT thermal sensor.

ALARM 67, Option module configuration has changed

One or more options have either been added or removed since the last power-down.

ALARM 68, Safe Torque Off (STO) activated

Safe Torque Off (STO) has been activated. To resume normal operation, apply 24 V DC to terminal 37, then send a reset signal (via bus, digital I/O, or by pressing [Reset]). See *5-19 Terminal 37 Safe Stop*.

ALARM 69, Power card temperature

The temperature sensor on the power card is either too hot or too cold.

ALARM 70, Illegal FC Configuration

Actual combination of control board and power board is illegal.

ALARM 79, Illegal power section configuration

The scaling card is the incorrect part number or not installed. Also MK102 connector on the power card could not be installed.

ALARM 80, Unit initialised to default value

Parameter settings are initialised to default settings after a manual reset.

ALARM 247, Power card temperature

Power card overtemperature. A report value indicates the source of the alarm (from left):

1–4 inverter

5–8 rectifier

ALARM 250, New spare part

The power or switch mode supply has been exchanged. The filter type code must be restored in the EEPROM. Select the correct type code in *14-23 Typecode Setting* according to the label on the unit. Remember to select *Save to EEPROM* to complete.

ALARM 251, New type code

The filter has a new type code.

ALARM 300, Mains Cont. Fault

The feedback from the mains contactor did not match the expected value within the allowed time frame. Contact Danfoss or supplier.

ALARM 301, SC Cont. Fault

The feedback from the soft charge contactor did not match the expected value within the allowed time frame. Contact Danfoss or supplier.

ALARM 302, Cap. Overcurrent

Excessive current was detected through the AC capacitors. Contact Danfoss or supplier.

ALARM 303, Cap. Ground Fault

A ground fault was detected through the AC capacitor currents. Contact Danfoss or supplier.

ALARM 304, DC Overcurrent

Excessive current through the DC-link capacitor bank was detected. Contact Danfoss or supplier.

ALARM 305, Mains Freq. Limit

The mains frequency was outside the limits. Verify that the mains frequency is within product specification.

ALARM 306, Compensation Limit

The needed compensation current exceeds unit capability. Unit is running at full compensation.

ALARM 308, Resistor temp

Excessive resistor heat sink temperature detected.

ALARM 309, Mains Ground Fault

A ground fault was detected in the mains currents. Check the mains for shorts and leakage current.

ALARM 310, RTDC Buffer Full

Contact Danfoss or supplier.

ALARM 311, Switch. Freq. Limit

The average switching frequency of the unit exceeded the limit. Verify that *parameter 300-10 Active Filter Nominal Voltage* and *300-22 CT Nominal Voltage* are set correctly. If so, contact Danfoss or supplier.

ALARM 312, CT Range

Current transformer measurement limitation was detected. Verify that the CTs used are an appropriate ratio.

ALARM 314, Auto CT Interrupt

Auto CT detection has been interrupted.

ALARM 315, Auto CT Error

An error was detected while performing auto CT detection. Contact Danfoss or supplier.

WARNING 316, CT Location Error

The auto CT function could not determine the correct locations of the CTs.

WARNING 317, CT Polarity Error

The auto CT function could not determine the correct polarity of the CTs.

WARNING 318, CT Ratio Error

The auto CT function could not determine the correct primary rating of the CTs.

9 Specifications

9.1 Power Rating

Grid conditions

Supply voltage	380–480 V, +5%/-10%
----------------	---------------------

Mains voltage low/mains drop-out:

During low mains voltage or a mains drop-out, the filter continues until the DC-link voltage drops below the minimum stop level, which corresponds to 15% below the filter lowest rated supply voltage. Full compensation cannot be expected at mains voltage lower than 10% below the filter lowest rated supply voltage. If mains voltage exceeds the filter highest rated voltage, the filter continues to work but harmonic mitigation performance is reduced. The filter does not cut out until main voltages exceed 580 V.

Supply frequency	50/60 Hz $\pm$ 5%
	3.0% of rated supply voltage

Maximum imbalance temporary between mains phases where mitigation performance is kept high.	Filter mitigates at higher mains imbalance but harmonic mitigation performance is reduced
---	---

	10% with kept mitigation performance
Maximum THDv pre-distortion	Reduced performance for higher pre-distortion levels

Harmonic mitigation performance

	Best performance <4%
THiD	Depending on filter vs. distortion ratio.
Individual harmonic mitigation ability:	Current maximum RMS [% of rated RMS current]
2nd	10%
4th	10%
5th	70%
7th	50%
8th	10%
10th	5%
11th	32%
13th	28%
14th	4%
16th	4%
17th	20%
19th	18%
20th	3%
22nd	3%
23rd	16%
25th	14%
Total current of harmonics	90%

The filter is performance tested to the 40th order

Reactive current compensation

Cos phi	Lagging and leading, depending on parameter settings
Cos phi	Controllable 1.0 to 0.5 lagging
Reactive current, % of filter current rating	100%

Cable lengths and cross-sections

Maximum grid cable length (direct internal connection)	Unlimited (determined by voltage drop)
Maximum cross-section to control terminals, rigid wire	1.5 mm ² /16 AWG (2 x 0.75 mm ²)
Maximum cross-section to control terminals, flexible cable	1 mm ² /18 AWG
Maximum cross-section to control terminals, cable with enclosed core	0.5 mm ² /20 AWG
Minimum cross-section to control terminals	0.25 mm ²

CT terminals specification

CT number	3 (one for each phase)
The AAF burden equals	2 mΩ
Secondary current rating	1 A or 5 A (hardware set-up)
Accuracy	Class 0.5 or better

Digital inputs

Programmable digital inputs	2 (4)
Terminal number	18, 19, 27 ¹⁾ , 29 ¹⁾
Logic	PNP or NPN
Voltage level	0-24-V DC
Voltage level, logic 0 PNP	<5 V DC
Voltage level, logic1 PNP	>10 V DC
Voltage level, logic 0 NPN	>19 V DC
Voltage level, logic 1 NPN	<14 V DC
Maximum voltage on input	28 V DC
Input resistance, R _i	approx. 4 kΩ

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

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

Control card, RS485 serial communication

Terminal number	68 (P, TX+, RX+), 69 (N, TX-, RX-)
Terminal number 61	Common for terminals 68 and 69

The RS485 serial communication circuit is functionally separated from other central circuits and galvanically isolated from the supply voltage (PELV).

Digital output

Programmable digital/pulse outputs	2
Terminal number	27, 29 ¹⁾
Voltage level at digital/frequency output	0-24 V
Maximum output current (sink or source)	40 mA

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

Control card, 24 V DC output

Terminal number	13
Maximum load	200 mA

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

Surroundings

Enclosure	IP21, IP54
Vibration test	1.0 g
Relative humidity	5% - 95% (IEC 721-3-3; class 3K3 (non-condensing) during operation
Aggressive environment (IEC 60068-2-43) H ₂ S test	class kD
Test method according to IEC 60068-2-43 H ₂ S (10 days)	
Ambient temperature	
- with derating	maximum 50 °C
- at full continuous output current	max. 40 °C
Minimum ambient temperature	-10 °C
Temperature during storage/transport	-25 to +65 °C
Maximum altitude above sea level without derating	1000 m
Maximum altitude above sea level with derating	3000 m
EMC standards, Emission	EN 61800-3-4
	EN 61000-6-1/2,
EMC standards, Immunity	EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6

Control card performance

Scan interval	5 ms
---------------	------

Control card, USB serial communication

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

Generic specifications

Maximum parallel filters	4 on same CT set
Filter efficiency	97%
Typical average switching frequency	3.0–4.5 kHz
Response time (reactive and harmonic)	<0.5 ms
Settling time - reactive current control	<20 ms
Settling time - harmonic current control	<20 ms
Overshoot – reactive current control	<10%
Overshoot – Harmonic current control	<10%

⚠ WARNING

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

Protection and features

- Temperature monitoring of the heat sink ensures that the active filter trips if the temperature reaches a predefined level. An overload temperature cannot be reset until the temperature of the heat sink is below the acceptable values.
- If a mains phase is missing, the active filter trips.
- The active filter has a short circuit protection current rate of 100 kA if properly fused
- Monitoring of the DC-link voltage ensures that the filter trips if the DC-link voltage is too low or too high.
- The active filter monitors the mains current as well as internal currents to reassure that current levels do not reach critical levels. If current exceeds a critical level, the filter trips.

Rated Current	Current	[A]	190	250	310	400
Losses	Watt	[kW]	5	7	9	11
Needed Airflow		M ³ /h	765	1230	1230	1230
Frame			D	E	E	F
Nominal	Reactive	[A]	190	250	310	400
Nominal	Harmonic	[A]	170	225	280	360
Maximum individual harmonic compensation in back channel	I ₅	[A]	119	158	196	252
Nominal/(maximum)	I ₇		85	113	140	180
	I ₁₁		54	72	90	115
	I ₁₃		48	63	78	101
	I ₁₇		34	45	56	72
	I ₁₉		31	41	50	65
	I ₂₃		27	36	45	58
	I ₂₅		24	32	39	50

Table 9.1

Note: Numbers are rounded to nearest amp

9.2 Derating for Altitude and Ambient Temperature

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

Below 1000 m altitude no derating is necessary, but above 1000 m the ambient temperature (T_{AMB}) or maximum output current (I_{OUT}) should be derated in accordance with *Illustration 9.1*.

An alternative is to lower the ambient temperature at high altitudes and thereby ensure 100% output current at high altitudes. As an example of how to read the graph, the situation at 2000 m is elaborated. At a temperature of 45 °C ($T_{AMB, MAX} - 3.3 K$), 91% of the rated output current is available. At a temperature of 41.7 °C, 100% of the rated output current is available.

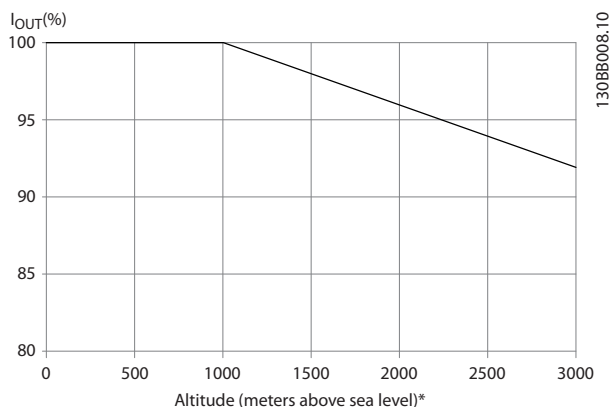


Illustration 9.1 Altitude Derating

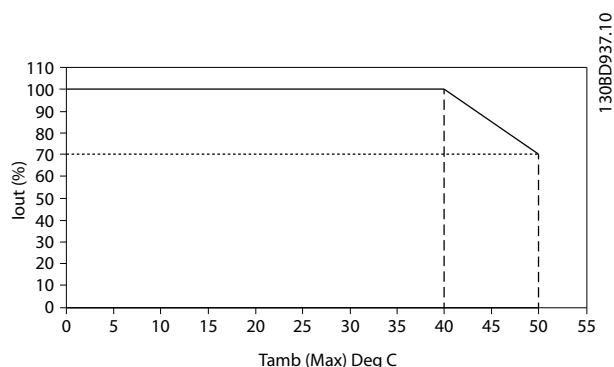


Illustration 9.2 Input/Output vs. Maximum Ambient Temperature

9.3 Acoustic Noise

	AAF190	AAF250, AAF310, and AAF400
DUT idle running (60 Hz) with no load with fans on	73	66.5
DUT running (60 Hz) with 100% load	78.7	69

Table 9.2 Acoustic Noise

10 Appendix

10.1 Abbreviations and Conventions

Abbreviation	Explanation
AC	Alternating current
AWG	American wire gauge
°C	Degrees celsius
DC	Direct current
EMC	Electromagnetic compatibility
IP	Ingress protection
I_{LIM}	Current limit
I_{INV}	Rated inverter output current
$I_{M,N}$	Nominal motor current
LCP	Local control panel
N.A.	Not applicable
PCB	Printed circuit board
PE	Protective earth
PELV	Protective extra low voltage

Table 10.1 Abbreviations

Conventions

Numbered lists indicate procedures.

Bullet lists indicate other information and description of illustrations.

Italicised text indicates:

- Cross-reference
- Link
- Footnote
- Parameter name, parameter group name, parameter option
- All dimensions in mm [in]

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