ENGINEERING TOMORROW

Operating Guide

Advanced Active Filter AAF 007

drives.danfoss.com | VLT®

Contents

1 Introduction

1.1 Purpose of the Manual

This operating guide provides information for safe installation and commissioning of the filter.

The operating guide is intended for use by qualified personnel only.

To ensure proper use of the filter, read and follow the operating guide, and pay particular attention to the safety instructions and general warnings. Always keep this operating guide available with the filter.

1.2 Additional Resources

Additional resources are available to help understand the features, and safely install and operate the products:

- The safety guide, which provides important safety information related to installing the filters.
- The installation guide, which covers the mechanical and electrical installation of the filters.
- The latest version of product documentation and other supplementary publications, drawings, and guides are available at www.danfoss.com.

1.3 Planning and Design Support Materials

Danfoss provides access to a consolidated product environment that can support throughout the product life cycle.

Manuals

The Advanced Active Filter AAF 007 series installation guide, safety guide, and operating guide are available for download at www.danfoss.com.

Software

MyDrive® Suite provides tools for support of planning and commissioning the AAF 007. MyDrive® Suite is available for download at suite.mydrive.danfoss.com.

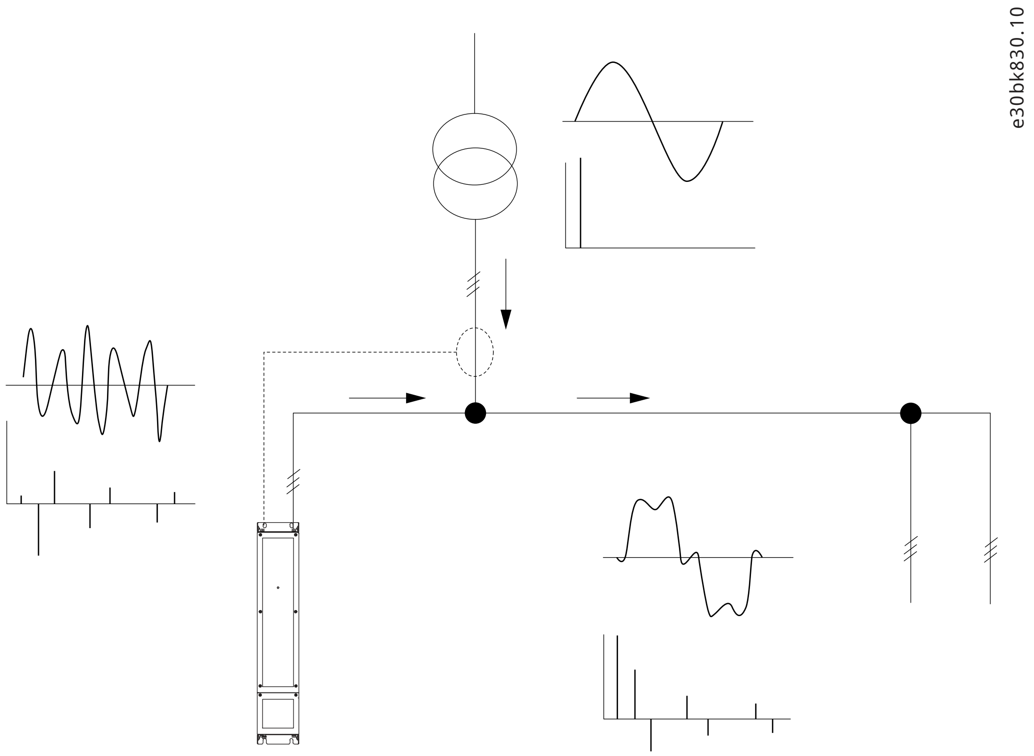
Configurator

The product configurator helps selecting the right product. When the process has been completed, the tool provides a list of relevant documentation and accessories. Find the configurator here store.danfoss.com.

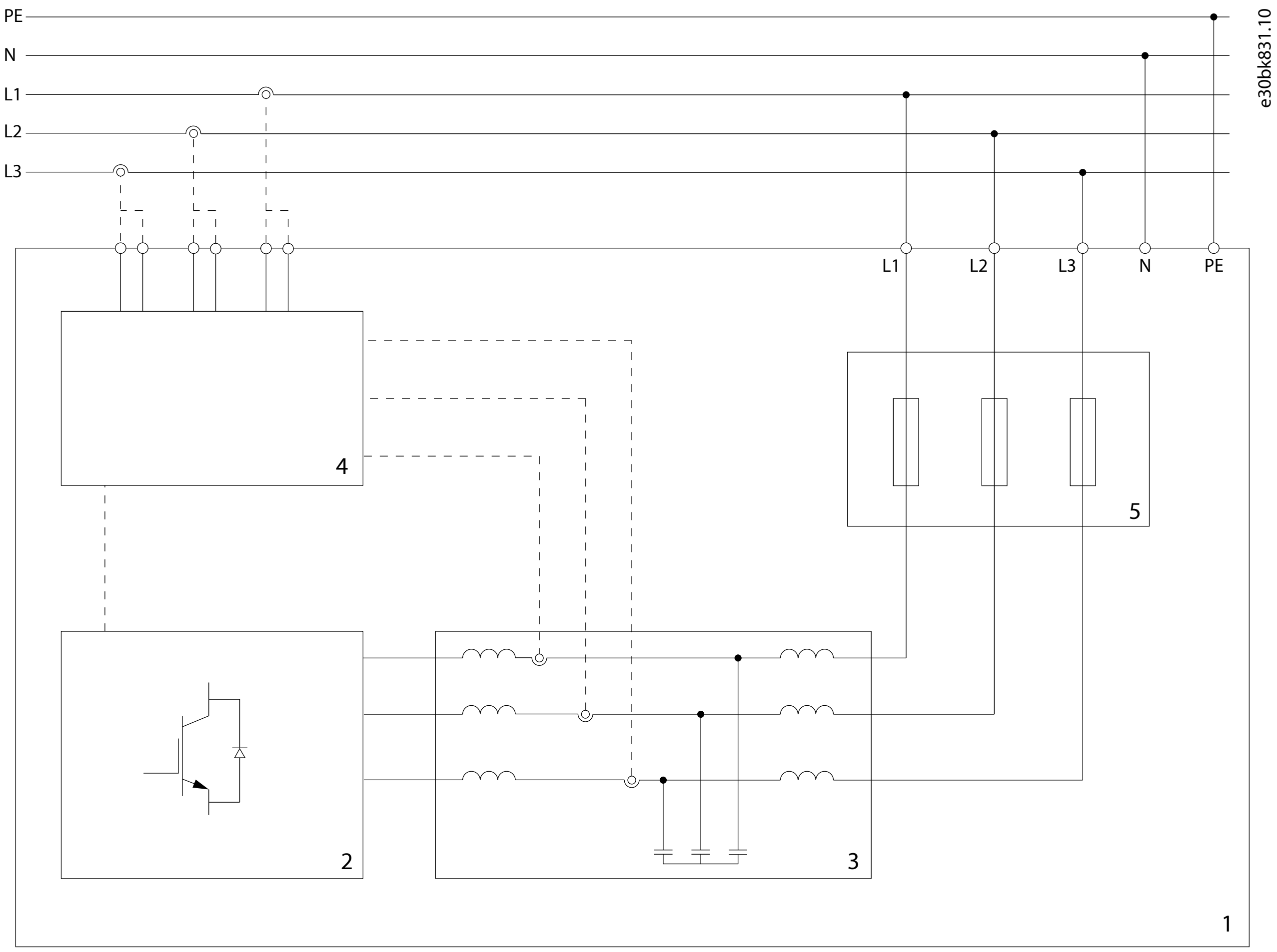
1.4 Intended Use

The Danfoss Advanced Active Filter AAF 007 is used for harmonic current mitigation, reactive current compensation, and for mains voltage balancing. The unit can be integrated in various systems and applications as a centrally installed filter, or it can be combined with a VLT®, VACON®, or iC7 drive as a packaged low-harmonic drive solution.

The active 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 counterphase to the unwanted elements of the current (harmonic distortion).



The filter sets different Silicon Carbide (SiC) switches in real time feeding a DC voltage into the grid, which creates counterphase signals. A built-in line filter smooths the compensated current waveform, ensuring that the MOSFET switching frequency and DC component is not imposed to the grid. The filter can operate on generator or transformer supply and can reduce individual motor loads, non-linear loads, or mixed loads. Consider protection for non-linear loads.



1	Active filter	**2**	Power circuit
3	Filter	**4**	Control
5	Internal fuse		

Different priorities on the compensation modes can be selected for the filter. In harmonics only (H), the full capacity is utilized to reduce the harmonic current content of the mains at the connection point up to the 60th order. In harmonic and reactive power mode (HR), all capacity that is not used for harmonic current mitigation will be utilized for reactive power compensation on the fundamental, either a fixed value for VA or towards a programmed displacement factor.

As default, the filter will try to obtain a power factor of 1 when reactive power compensation is turned ON.

If additional unbalanced load on the mains is to be balanced, this can be done with 3rd priority in HRU mode.

For information about settings of the respective compensation modes, refer to 8.1.4.1.1 Settings - Harmonic Detection Modes

1.5 Resonance Detection

As the Advanced Active Filter AAF 007 is an active switching device, it can affect the impedance of the connected network. This effect is intentionally used to reduce the harmonic content of the mains current and to reduce the harmonic content of the mains voltage. At the same time, the change of impedance can impact resonance frequencies of the local installations, which can have positive effects when a critical frequency is muted. On the other hand, existing resonance frequencies can be amplified by an active filter. This amplification is omitted by the AAF 007 by using an automatic resonance detection. This detection spots existing resonances and prevents further amplification of the same. Compensation mode *Auto* uses the resonance detection algorithm. Alternatively, manual tuning of the filter enables resonance-free operation.

2 Safety

2.1 Target Group and Necessary Qualifications

Correct and reliable transport, storage, installation, operation, and maintenance are required for the trouble-free and safe operation of the filter. Only **skilled personnel** are allowed to perform all related activities for these tasks. Skilled personnel are defined as properly trained staff, who are familiar with and authorized to install, commission, and maintain equipment, systems, and circuits in accordance with pertinent laws and regulations. Also, the skilled personnel must be familiar with the instructions and safety measures described in this manual and the other product-specific manuals. Non-skilled electricians are not allowed to perform any electrical installation and troubleshooting activities.

2.2 Safety Symbols

The following symbols are used in Danfoss documentation and products.

DANGER

Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

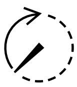
Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE

Indicates information considered important, but not hazard-related (for example, messages relating to property damage).

	ISO warning symbol for general warnings
	ISO warning symbol for hot surfaces and burn hazard
	ISO warning symbol for high voltage and electric shock
	Symbol for indicating the required discharge time of the capacitors in the product.
	ISO action symbol for referring to the instructions

2.3 General Safety Precautions

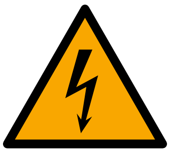
⚠ WARNING

LACK OF SAFETY AWARENESS

This guide provides important information on preventing injury and damage to the equipment or the system during installation and maintenance. Ignoring this information can lead to death, serious injury, or severe damage to the equipment.

- Only skilled personnel must perform installation, start-up, and maintenance.
- Make sure to fully understand the dangers and safety measures present in the application.
- Before performing any electrical work on the filter, lock out and tag out all power sources to the filter.
- Disconnect all power sources. Measure the power source level to verify they are de-energized. Ensure that the filter cannot re-energize.
- Wait for capacitors to discharge fully. The discharge time is shown on the exterior of the filter. Measure the voltage level to verify full discharge.

⚠ WARNING



ELECTROMAGNETIC INTERFERENCE

AC drives and filters can produce electromagnetic interference up to 300 GHz that can affect the functionality of pacemakers and other implanted medical devices.

⚠ WARNING

HAZARDOUS VOLTAGE

Filters contain hazardous voltage when connected to the AC mains. Failure to perform installation, start-up, and maintenance by skilled personnel can result in death or serious injury.

⚠ WARNING

DISCHARGE TIME

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

- Disconnect all power sources.
- Wait for capacitors to discharge fully. The discharge time is shown on the exterior of the filter.
- Measure the voltage level to verify full discharge.

⚠ WARNING

AUTOMATIC START

When the filter is connected to the AC mains, it will automatically start operation, causing risk of death, serious injury, and equipment or property damage.

- Ensure that all covers are mounted before applying mains to the filter.
- Ensure that current transformers are mounted correctly to avoid incorrect operation.
- Disable automatic connect via PC SW, if automatic start-up should be prevented.
- Disconnect the filter from mains whenever safety considerations make it necessary to avoid unintended start of the unit.
- To avoid automatic start of the filter, bridge the EPO contacts. Reset of the unit is required after opening the EPO contact.

⚠ CAUTION

INTERNAL FAILURE HAZARD

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

- Ensure that all safety covers are in place and securely fastened before applying power.

NOTICE

Whenever there is a likelihood of primary current through a current transformer, the secondary windings need to be connected to the filter or short-circuited to prevent damage or malfunction.

2.4 Electrical Installation Precautions

Precautions to observe before doing electrical installation of a filter.

⚠ WARNING

ELECTRICAL SHOCK AND FIRE HAZARD

The filter can cause a DC current in the PE conductor. Failure to use a Type B residual current-operated protective device (RCD) may lead to the RCD not providing the intended protection. This may result in death, fire, or other serious hazard.

- When an RCD is used for protection against electrical shock or fire, use only a Type B device on the supply side.

WARNING

ELECTRICAL SHOCK HAZARD - HIGH LEAKAGE CURRENT

Leakage currents exceed 3.5 mA. Failure to connect the filter properly to protective earth may result in death or serious injury.

- Ensure reinforced protective earthing conductor according to IEC 60364-5-54 cl. 543.7 or according to local safety regulations for high touch current equipment. The reinforced protective earthing of the drive can be done with:
- PE conductor with a cross-section of at least 10 mm^2 Cu or 16 mm^2 Al, or an additional PE conductor of the same cross-sectional area as the original PE conductor as specified by IEC 60364-5-54, with a minimum cross-sectional area of 2.5 mm^2 (mechanically protected) or 4 mm^2 (not mechanically protected).
- PE conductor completely enclosed within an enclosure or otherwise protected throughout its length against mechanical damage.
- PE conductor that is part of a multi-conductor power cable with a minimum PE conductor cross-section of 2.5 mm^2 (permanently connected or plugged in by an industrial connector). The multi-conductor power cable must be installed with an appropriate strain relief.

NOTICE

OVERCURRENT PROTECTION

The filter is short circuit protected by the internal fuses.

- Overcurrent protection must be provided according to local regulations.

2.5 Safe Operation

When operating the unit, refer to the operating guide for guidance and all applicable safety instructions.

- The filter is not suitable as the only safety device in the system. Make sure that additional monitoring and protection devices on drives, motors, and accessories are installed according to the regional safety guidelines and accident prevention regulations.
- Keep all doors, covers, and terminal boxes closed and securely fastened during operation.

3 Approvals and Certifications

3.1 Product Approvals and Certifications

The Advanced Active Filter AAF 007 complies with the required standards and directives. For detailed information on approvals and certification for a specific product, see the product label or visit www.danfoss.com.

Certificates and declarations are available on request or at www.danfoss.com.

Table 1: Overview of Approvals

Approval	Description
CE	The filter operates with relevant directives and their related standards for the extended Single Market in the European Economic Area. For more information, see 3.1 Product Approvals and Certifications.
c UL US	The Underwriters Laboratory (UL) mark indicates the safety of products and their environmental claims based on standardized testing. The filter complies with UL 508. For UL file number, see the product label.
UK CA	The filter complies with relevant regulation and their related standards for Great Britain. UKCA contact information: Danfoss, 22 Wycombe End, HP9 1NB, Great Britain.
	The Regulatory Compliance Mark (RCM) is a trademark owned by the electrical regulator (Regulatory Authorities (RAs)) and Australian Communications Media Authority (ACMA).

Table 2: EU Directives Applicable to Active Filters

EU directive	Description
Low Voltage Directive (2014/35/EU)	The aim of the Low Voltage Directive is to protect persons, domestic animals, and property against dangers caused by the electrical equipment, when operating electrical equipment that is installed and maintained correctly in its intended application. The directive applies to all electrical equipment in the 50–1000 V AC and the 75–1500 V DC voltage ranges. EN 62477-1:2012/A1:2017 Safety requirements for power electronic coverter systems and equipment - Part 1: General.
EMC Directive (2014/30/EU)	The purpose of the EMC (electromagnetic compatibility) Directive is to reduce electromagnetic interference and enhance immunity of electrical equipment and installations. The basic protection requirement of the EMC Directive states that devices that generate electromagnetic interference (EMI), or whose operation could be affected by EMI, must be designed to limit the generation of electromagnetic interference and shall have a suitable degree of immunity to EMI when properly installed, maintained, and used as intended. Electrical equipment devices used alone or as part of a system must bear the CE mark. Systems do not require the CE mark, but must comply with the basic protection requirements of the EMC Directive. EN 61800-3:2018: Adjustable speed electronic power drive systems - Part 3: EMC requirements and specific test methods. EN IEC 61000-3-2:2049-12 Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (not applicable as this product is reducing the harmonic current emission). EN IEC 61000-3-3:2000-07 Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection (representative for units >16 A). EN IEC 61000-6-2:2019-11 Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for inductrial environments. EN IEC 61000-6-4:2000-09 Electromagnetic compatibility (EMC) Part 6-4: Generic standards - Emission standard for industrial environments.
RoHS Directive (2011/65/EU)	The Restriction of Hazardous Substances (RoHS) Directive is an EU directive that restricts the use of hazardous materials in the manufacturing of electronic and electrical products. See www.Danfoss.com for more information. EN63000:2018 Technical documentation for the assesment of electrical and electronic products with respect to the restriction of hazardous substances.

4 Product Overview (Hardware)

4.1 35A, 55A, 100A and 150A Filter Modules

The Advanced Active Filter AAF 007 filter modules are available in 2 enclosure sizes. 35 A and 55 A share the same mechanical enclosure, while 100 A and 150 A filter modules share another enclosure. All connections for mains, current sensors, communication, and control signals are accessible from the bottom of the filter.

The connections for L1, L2, L3, and N are in the bottom towards the front side of the filter, while the PE screw connection is at the bottom backside of the chassis and clearly marked. Pay attention to the use of the Neutral terminal as it may cause malfunction if it is not done according to the parameter setup. Refer to 7.4.3 Three- and Four-wire Systems for further information.

Terminals for current transformers, communication wires, and external power off wires are at the backside of the bottom. The technical functionalities of these terminals are described in section *Control Terminals*.

Each filter module is equipped with internal fans that guide fresh air through the bottom grills along the cooling body of the top grills on the enclosure. Filter modules can be mounted vertically above each other inside a cabinet. However, it is important to provide sufficient airflow to avoid that the filter overheats. Avoid that preheated air from the lower module is sucked into the upper-mounted filter. Refer to 6.3 Cabinet Integration for more information.

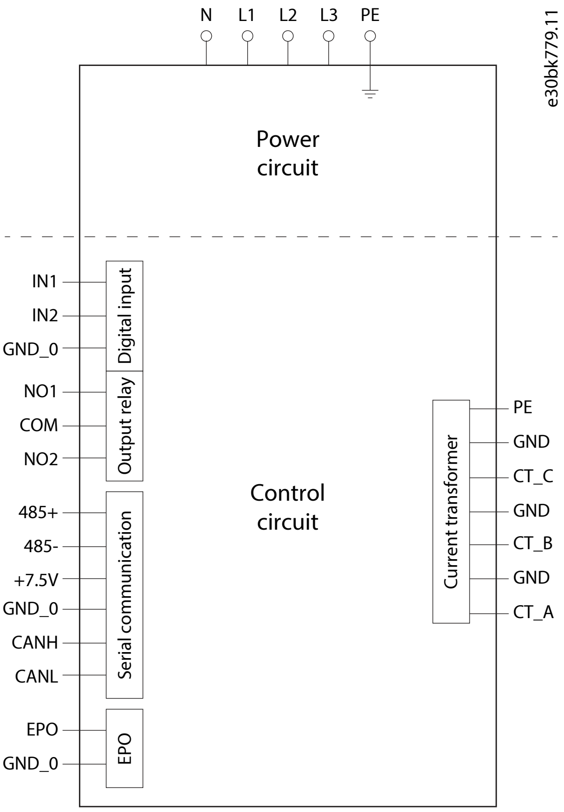
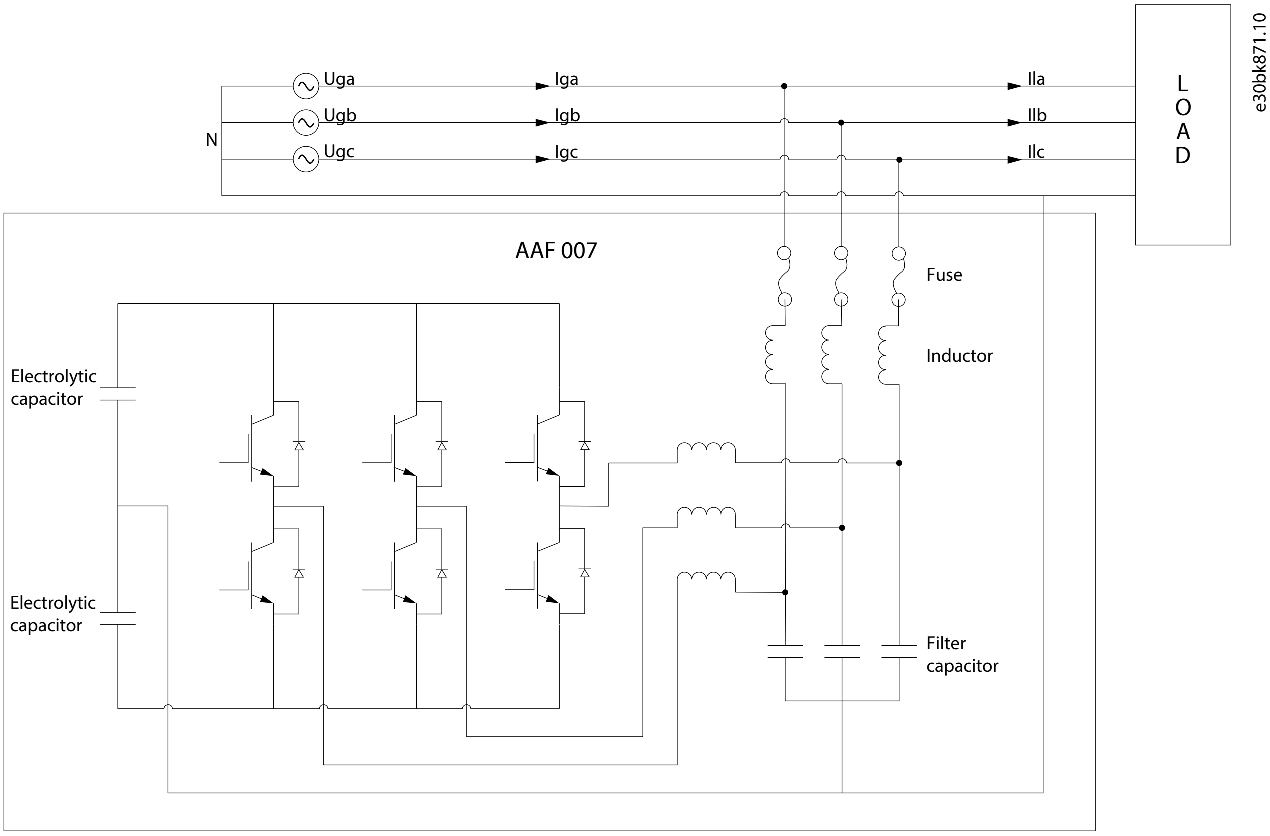


Figure 1: Wiring Diagram

The AAF 007 is based on Silicon Carbide Mosfet technology, which enables an energy-efficient operation with outstanding performance. Each filter is equipped with a properly dimensioned LCL filter for the required EMC performance.



4.2 IP20 70–600 A Filters, Based on Modules

The Advanced Active Filter AAF 007 is offered in variants from 35–600 A. Filters with 70 A, 90 A, 110 A, 200 A or more, consist of 2 or more modules for parallel installation. All modules of a filter share 1 set of current transformers, which can be connected in series or in parallel to the modules. Series installation is preferred to give the best signal quality and is therefore the standard configuration in the filter. Running current transformers in parallel requires setup changes, see 8.3 Paralleling of Filter Modules.

The IP20 cabinet version must be installed in an additional enclosure or wall mounted in a secured, locked room.

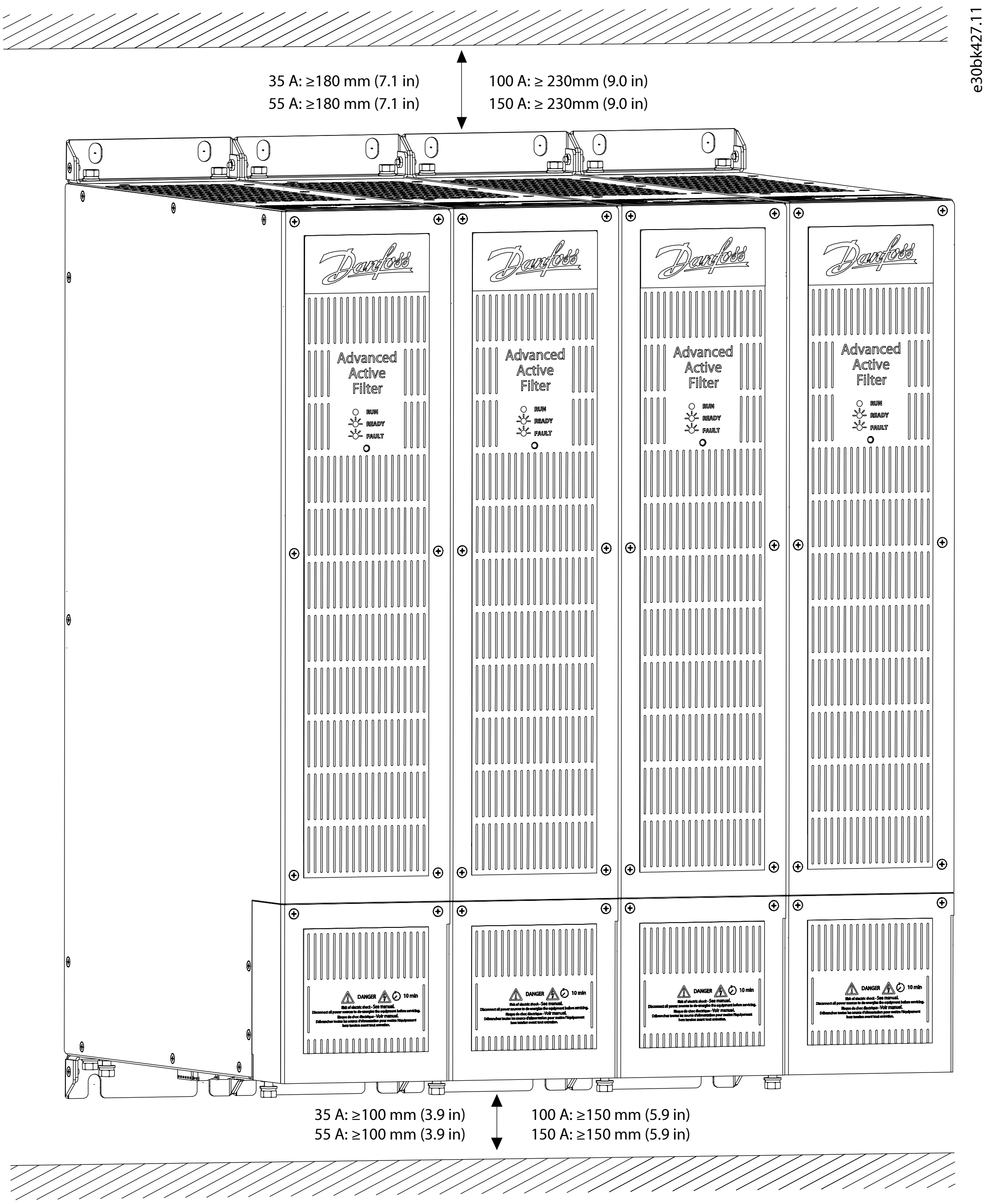


Figure 2: 220 A Filter

Each module has its own control unit and operates independently. All signal processing and compensation calculations are done by each filter module allowing them to work independently even if running in parallel. A setting in the module allows setting of load sharing and sharing of the CT signal between multiple filters. See sections *Mechanical Dimensions* and 8.3 Paralleling of Filter Modules for more information.

It is recommended to leave a gap of 1 mm between the modules for easier access if service is required.

4.3 Integrated filter solutions

The Advanced Active FilterAAF 007 is offered as integrated solution in floor standing control cabinets. Standard cabinets are only available with CE approval. Dedicated solutions for other markets or customer requirements are available and requested with different specification. The AAF 007 cabinets are equipped with a door integrated mains switch and fuses or circuit breaker for the individual filter modules inside the cabinet - depending on size and variant. Power, communication and control cables are brought from bottom through the plinth inside the cabinet and are connected centrally at the respective terminals. A local control panel is available as option. The integrated solution is also coming with a status LED in the door

NOTICE

The AAF 007 cabinet IP54 solution is not hosting a Neutral wire connection and is therefore only to be used in 3-phase/3-wire systems (3W3P)

5 Product Specifications

5.1 Mains Supply

Supply voltage	3x380 V/220 V–480 V/277 V[(1)]
Frequency	50 Hz/60 Hz (±2 Hz)
Maximum grid unbalance	10%
Maximum grid predistortion (THD_u)	8%
Supply system grounding	IT, TN, TT

1) UL/rating. (+10%/-15%)

5.2 Individual Harmonic Mitigation Performance

Table 3: Mitigation Performance Relative to Nominal Current

Order	Individual harmonic mitigation ability based on nominal current			
	35 A module	55 A module	100 A module	150 A module
1	1.0	1.0	1.0	1.0
2	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0
7	1.0	1.0	1.0	1.0
8	1.0	1.0	1.0	1.0
9	1.0	1.0	1.0	1.0
10	1.0	1.0	1.0	1.0
11	1.0	1.0	1.0	1.0
12	1.0	1.0	1.0	1.0
13	1.0	1.0	1.0	1.0
14	1.0	1.0	0.93	1.0
15	1.0	1.0	0.87	1.0
16	1.0	1.0	08.2	1.0
17	1.0	1.0	0.77	1.0
18	1.0	1.0	0.72	0.95
19	1.0	1.0	0.68	0.92
20	1.0	1.0	0.65	0.87
21	1.0	1.0	0.62	0.81
22	1.0	1.0	0.59	0.79
23	1.0	1.0	0.57	0.75
24	1.0	0.98	0.54	0.72
25	1.0	0.94	0.52	0.69

Table 3: Mitigation Performance Relative to Nominal Current - (continued)

Order	Individual harmonic mitigation ability based on nominal current			
	35 A module	55 A module	100 A module	150 A module
26	1.0	0.90	0.50	0.67
27	0.97	0.87	0.48	0.65
28	0.94	0.84	0.47	0.62
29	0.91	0.81	0.45	0.60
30	0.88	0.79	0.43	0.58
31	0.85	0.76	0.42	0.56
32	0.83	0.74	0.41	0.54
33	0.80	0.72	0.40	0.53
34	0.78	0.70	0.38	0.51
35	0.76	0.68	0.37	0.50
36	0.74	0.66	0.36	0.48
37	0.72	0.64	0.35	0.47
38	0.70	0.63	0.34	0.45
39	0.69	0.61	0.33	0.45
40	0.67	0.60	0.33	0.44
41	0.65	0.58	0.32	0.43
42	0.64	0.57	0.31	0.41
43	0.63	0.56	0.30	0.40
44	0.61	0.55	0.30	0.39
45	0.60	0.53	0.30	0.39
46	0.59	0.52	0.29	0.38
47	0.58	0.51	0.28	0.37
48	0.57	0.50	0.27	0.36
49	0.56	0.49	0.27	0.35
50	0.55	0.48	0.26	0.35
51	0.54	0.47	0.26	0.34
52	0.53	0.47	0.25	0.33
53	0.52	0.46	0.25	0.33
54	0.51	0.45	0.24	0.32
55	0.50	0.44	0.24	0.32
56	0.49	0.44	0.24	0.32
57	0.49	0.43	0.23	0.31
58	0.48	0.42	0.23	0.31
59	0.47	0.42	0.22	0.30
60	0.47	0.41	0.22	0.30

5.3 Compensation

Reactive power compensation	Cos phi setting 0–1 lagging and leading
	Reactive current up to 100% of filter capacity
Unbalance compensation	10% with kept mitigation performance(1)

1) Nominal compensation current of the filter is shared between harmonic mitigation, reactive power, and unbalanced compensation by geometric addition.

5.4 Short-circuit Current Rating (SCCR)

IP20 (AAF01, AAF02)	100 kA
IP54 (AAF03, AAF04, AAF05, AAF06)	50 kA

5.5 Cable Specifications

The filter is protected internally with semiconductor fuses. Branch protection is subject to local installation conditions and regulations, and thus no recommendations can be made. To support selection of suitable branch protection, the internal fuses of the filter are specified in Table 4.

Table 4: Cable and Fuse Specifications

Enclosure	AAF01		AAF02	
Current	**35 A module**	**55 A module**	**100 A module**	**150 A module**
L1/L2/L3 cross-section	Rigid: 2.5–35 mm^2 (2 AWG) Flexible: 2.5–25 mm^2 (14–4 AWG) Flexible with ferrule: 2.5–25 mm^2 (14–4 AWG)	Rigid: 2.5–35 mm^2 (2 AWG) Flexible: 2.5–25 mm^2 (14–4 AWG) Flexible with ferrule: 2.5–25 mm^2 (14–4 AWG)	Rigid: maximum 50 mm^2 (1-1/0 AWG) Flexible: maximum 50 mm^2 (1-1/0 AWG) Flexible with ferrule: maximum 50 mm^2 (1-1/0 AWG)	Rigid: maximum 70 mm^2 (2/0 AWG) Flexible: maximum 70 mm^2 (2/0 AWG) Flexible with ferrule: maximum 70 mm^2 (2/0 AWG)
Maximum stripping	18 mm (0.7 in)	18 mm (0.7 in)	21 mm (0.82 in)	21 mm (0.82 in)
Torque [Nm (in-lb)]	2.5–3.0 (22.12–26.5)	2.5–3.0 (22.12–26.5)	4.2 (37.17)	4.2 (37.17)
Material	Copper	Copper	Copper	Copper
Temperature rating [°C (°F)]	70 (158)	70 (158)	70 (158)	70 (158)
PE cross-section [mm^2 (AWG)]	16 (6)	16 (6)	70 (2/0)	70 (2/0)
Maximum stripping [mm (in)]	18 (0.7)	18 (0.7)	21 (0.82)	21 (0.82)
Cable lug	O-type 5–6 mm	O-type 5–6 mm	M8	M8
Torque [Nm (in-lb)]	2.5–3.0 (22.12–26.5)	2.5–3.0 (22.12–26.5)	4.2 (37.17)	4.2 (37.17)
Material	Copper	Copper	Tinned Copper	Tinned Copper
Temperature rating [°C (°F)]	70 (158)	70 (158)	70 (158)	70 (158)

Table 4: Cable and Fuse Specifications - (continued)

Enclosure	AAF01		AAF02	
Current	35 A module	55 A module	100 A module	150 A module
CT cables cross-section [mm^2 (AWG)]	2.5 (14)	2.5 (14)	2.5 (14)	2.5 (14)
Torque [Nm (in-lb)]	0.8 (7.1)	0.8 (7.1)	0.8 (7.1)	0.8 (7.1)
Control cables cross-section [mm^2(AWG)]	1 (17)	1 (17)	1 (17)	1 (17)
Torque [Nm (in-lb)]	0.8 (7.1)	0.8 (7.1)	0.8 (7.1)	0.8 (7.1)
Internal semi-conductor fuse	Sinofuse RS308-HB-4G60A 750VDC	Sinofuse RS308-HB-4G100A 750VDC	Sinofuse RS308-HB-4G160A 750VDC	Sinofuse RS308-HB-4G200A 750VDC

Table 5: Electrical and Mechanical Ratings (AAF03)

Enclosure	AAF03			
Current	100 A	110 A	150 A	165 A
L1/L2/L3 cross-section	70 mm^2 (2/0 AWG)	70–185 mm^2 (2/0 AWG–350 MCM)		
Maximum stripping [mm (in)]	24 (0.94)			
Torque [Nm (in-lb)]	6 (53.1)	18 (159.3)		
Material	Copper			
Termination	Cable lug M8	Cable lug M10		
Temperature rating [°C (°F)]	70 (158)			
PE cross-section	Minimum 35 mm^2 (2 AWG)	35–90 mm^2 (2–3/0 AWG)		
Maximum stripping [mm (in)]	18 (0.70)			
Cable lug	M10			
Torque [Nm (in-lb)]	24 (212.4)			
Material	Copper			
Temperature rating [°C (°F)]	70 (158)			
CT cables cross-section	Minimum 2.5 mm^2 (14 AWG) Maximum (end sleeve) 6 mm^2 (10 AWG) Maximum (solid cable) 8 mm^2 (8 AWG)			
Termination	Push-in cage clamp			
Control terminal PCB	0.5–1.5 mm^2 (20–16 AWG)			
Termination	Cable sleeve end			

Table 5: Electrical and Mechanical Ratings (AAF03) - (continued)

Enclosure	AAF03			
Current	**100 A**	**110 A**	**150 A**	**165 A**
Torque [Nm (in-lb)]	0.6 (5.31)			
Filter module internal semiconductor fuse [A]	160	100	200	100
Filter module protection (inside cabinet) [A]	160	80	200	80
Cabinet branch protection [A]	160	Maximum 250		

Table 6: Electrical and Mechanical Ratings (AAF04)

Enclosure	AAF04				
Current	**200 A**	**225 A**	**250 A**	**275 A**	**300 A**
L1/L2/L3 cross-section	240 mm^2 (500 AWG)				
Maximum stripping [mm (in)]	24 (0.94)				
Torque [Nm (in-lb)]	6 (53.1)	18 (159.3)			
Material	Copper				
Termination	Cable lug M10				
Temperature rating [°C (°F)]	70 (158)				
PE cross-section	Minimum 120 mm^2 (4/0 AWG)				
Maximum stripping [mm (in)]	18 (0.70)				
Cable lug	M10				
Torque [Nm (in-lb)]	24 (212.4)				
Material	Copper				
Temperature rating [°C (°F)]	70 (158)				
CT cables cross-section	Minimum 2.5 mm^2 (14 AWG) Maximum (end sleeve) 6 mm^2 (10 AWG) Maximum (solid cable) 8 mm^2 (8 AWG)				
Termination	Push-in cage clamp				
Control terminal PCB	0.5–1.5 mm^2 (20–16 AWG)				
Termination	Cable sleeve end				
Torque [Nm (in-lb)]	0.6 (5.31)				
Filter module internal semiconductor fuse [A]	160	100	160/200	100	200

Table 6: Electrical and Mechanical Ratings (AAF04) - (continued)

Enclosure	AAF04				
Current	200 A	225 A	250 A	275 A	300 A
Filter module protection (inside cabinet) [A]	160	80	160/200	80	200
Cabinet branch protection [A]	Maximum 425				

Table 7: Electrical and Mechanical Ratings (AAF05)

Enclosure	AAF05		
Current	350 A	400 A	450 A
L1/L2/L3 cross-section	2 x 185 mm² (2 x 350 MCM)		
Maximum stripping [mm (in)]	24 (0.94)		
Torque [Nm (in-lb)]	24 (212.4)		
Material	Copper		
Termination	Cable lug M10		
Temperature rating [°C (°F)]	70 (158)		
PE cross-section	2 x 90 mm² (2 x 3/0 AWG)		
Maximum stripping [mm (in)]	18 (0.70)		
Cable lug	M10		
Torque [Nm (in-lb)]	24 (212.4)		
Material	Copper		
Temperature rating [°C (°F)]	70 (158)		
CT cables cross-section	Minimum 2.5 mm² (14 AWG) Maximum (end sleeve) 6 mm² (10 AWG) Maximum (solid cable) 8 mm² (8 AWG)		
Termination	Push-in cage clamp		
Control terminal PCB	0.5–1.5 mm² (20–16 AWG)		
Termination	Cable sleeve end		
Torque [Nm (in-lb)]	0.6 (5.31)		
Filter module internal semiconductor fuse [A]	160/200		200
Filter module protection (inside cabinet) [A]	160/200		200
Cabinet branch protection [A]	Maximum 630		

Table 8: Electrical and Mechanical Ratings (AAF06)

Enclosure	AAF06		
Current	**500 A**	**550 A**	**600 A**
L1/L2/L3 cross-section	2 x 240 mm² (2 x 500 MCM)		
Maximum stripping [mm (in)]	24 (0.94)		
Torque [Nm (in-lb)]	24 (212.4)		
Material	Copper		
Termination	Cable lug M10		
Temperature rating [°C (°F)]	70 (158)		
PE cross-section	2 x 120 mm² (2 x 4/0 AWG)		
Maximum stripping [mm (in)]	18 (0.70)		
Cable lug	M10		
Torque [Nm (in-lb)]	24 (212.4)		
Material	Copper		
Temperature rating [°C (°F)]	70 (158)		
CT cables cross-section	Minimum 2.5 mm² (14 AWG) Maximum (end sleeve) 6 mm² (10 AWG) Maximum (solid cable) 8 mm² (8 AWG)		
Termination	Push-in cage clamp		
Control terminal PCB	0.5–1.5 mm² (20–16 AWG)		
Termination	Cable sleeve end		
Torque [Nm (in-lb)]	0.6 (5.31)		
Filter module internal semiconductor fuse [A]	160/200		200
Filter module protection (inside cabinet) [A]	160/200		200
Cabinet branch protection [A]	Maximum 800		

5.5.1 Connection of Equipment with High-harmonic Content

In installations with high-harmonic content, pay special attention to the sufficient layout of cables and busbars. Refer to 7.1 Power Connections for guidelines on cable diameters for active filters.

5.5.2 Current Transformer Specifications

In 3-phase/3-wire systems, only 2 current transformers (on phases 1 and 3) are required. In applications with additional neutral wire, a 3rd current transformer is required on phase 2.

The impedance of the filter module at the current transformer terminals is 5.5 mΩ.

Consider that IP54 products also consist of multiple modules. Therefore the burden of all connected modules needs to be summed up.

The Advanced Active Filter AAF 007 current transformer input is designed for a secondary current rating of 5 A.

Accuracy class 0.5 or better is required to guarantee the specified harmonic mitigation performance.

For more information regarding selection and installation of current transformers, refer to 7.4 Current Transformers Considerations.

5.6 Control Terminals

5.6.1 Digital Inputs

All digital inputs are galvanically isolated from the supply voltage (PELV) and other high-voltage terminals. To use the digital input an external source is required to drive the signal.

Table 9: Digital Input Functions

Port	Input range	Function
IN1	Low: 0–3 V DC High: 10–24 V DC	This signal is used for controlling the filter operation (RUN). When the input is high, the unit will start running. When the signal is low, the unit will stop. This function is only active for run mode *Manually*.
IN2	Low: 0–3 V DC High: 10–24 V DC	For different grid conditions, different parameter settings can be used, for example, Generator during power shutdown. Low: The primary parameter is set. High: The secondary parameter is set. To set the secondary parameter, the input must be high during setup. It is recommended not to change the settings during operation of the filter.
GND_0	–	Input common

5.6.2 Serial Communication

The RS485 terminals are galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

Table 10: Serial Communication Functions

Port	Input range	Function
485+ 485-	485 interface for remote control via computer. A standard RS485 communication interface required shielded or twisted wires. If the wire length exceeds 1 m (3.28 ft), GND_0 must be connected.	485 interface for remote control via computer or Modbus RTU connection.
GND_0	Common ground for RS485 and CAN communication.	–
+7.5 V DC	–	Auxiliary output - not to be used.
CANH/CANL	CAN communication.	Only to be used by factory.
P-com 1, 2, 3	–	Ready for future applications.

5.6.3 Relay Output

The Advanced Active Filter AAF 007 has 2 available relay outputs. Connect an external voltage source to use the relays. The maximum ranges are shown in Table 11.

Table 11: Relay Output Functions

Port	Input range	Function
NO1	2 A/250 V AC 3 A/30 V DC	Failure state. High: no failure. Low: failure.
NO2	2 A/250 V AC 3 A/30 V DC	Only in combination with NO1, see Table 12
COM	Relay common	–

If an alert or power failure occurs, NO1 opens.

Table 12: Port Settings

	NO1	NO2
Mains drop/power failure	0	0
Standby	1	1
Run	1	0
Failure	0	1

5.6.4 External Power Off (EPO)

The filter has an input relay for an external power OFF. To clear the event of a power off, a "clear fault" command must be sent via Modbus or PC, or the filter must be power cycled.

NOTICE

Do not use this relay for any emergency or safety-related functions.

Table 13: Ports and Functions

Port	Function
EPO	EPO connection for usage as part of the POWER OFF line. If the contact to be wired is closed, the POWER OFF function is active.
GND	

5.7 Ambient Conditions

Table 14: Ambient Conditions

	Modules	Cabinet solution	
Rating [A]	**35 - 600**	**100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600**	**110,165, 220, 275**
Protection rating	IP20 / open type	IP54	
Vibration test	IEC 60068-2-6, Fc	MIL-STD-810H: 2019	
Relative humidity	5%~95% class F without condensation		

Table 14: Ambient Conditions - (continued)

	Modules	Cabinet solution	
Rating [A]	**35 - 600**	**100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600**	**110,165, 220, 275**
Maximum ambient temperature [°C (°F)]	50 (122)		
Maximum ambient temperature without derating [°C (°F)]	40 (104)		37 (98.6)
Minimum ambient temperature [°C (°F)]	-10 (14)		
Ambient temperature (transport) [°C (°F)]	-25 (-13)~+70 (158) (following DIN EN 50178)		
Ambient temperature (storage) [°C (°F)]	-25 (-13)~+55 (131) (following DIN EN 50178)		
Maximum altitude above sea level without thermal derating [m (ft)]	1000 (3,280)		
Maximum altitude above sea level with thermal derating [m (ft)]	4000 (13,123.35)		
EMC standards, emission	EN/IEC 61000-3-2:2019-12		
	EN/IEC 61000-3-3:2020-07		
	EN/IEC 61000-6-4:2020-09		
EMC standards, immunity	EN/IEC 61000-6-2:2019-11		

5.8 General Specifications

Switching frequency	40–60 kHz
Audible noise level	<60 db
Response time	0.02 ms
Setting time	5 ms
Start-up time, Auto mode	Maximum 180 s
Start-up time, Manual mode	Maximum 15 s
Maximum parallel filter modules	8 on 1 set of current transformers

5.9 Electrical Losses and Airflow Requirements

IP20 Modules	
Filter losses at 100% load (35 A/55 A)	556 W/833 W
Filter losses at 100% load (100 A/150 A)	1283 W/2120 W
Airflow requirements (35 A/55 A)	>160 m^3/h
Airflow requirements (100 A/150 A)	>430 m^3/h

IP54 Cabinets

Current Size	Filter loss
100 A	1883 W
110 A	2149 W
150 A	2625 W
165 A	2982 W
200 A	3311 W
225 A	3847 W
250 A	4061 W
275 A	4720 W
300 A	4821 W
350 A	5789 W
400 A	6549 W
450 A	7289 W
500 A	7992 W
550 A	8732 W
600 A	9472 W

5.10 Derating for Temperature and Altitude

The Advanced Active Filter AAF 007 operates at maximum 50 °C (122 °F) and at altitudes below 4000 m (13126.35 ft). Operating the filter outside these limits, independent of each other, reduces product lifetime and operation stability.

Derating is required if the filter is operated above an ambient temperature of 40 °C (104 °F) and/or is installed at an altitude >1000 m (3280 ft) above sea level. Derate according to the following graph.

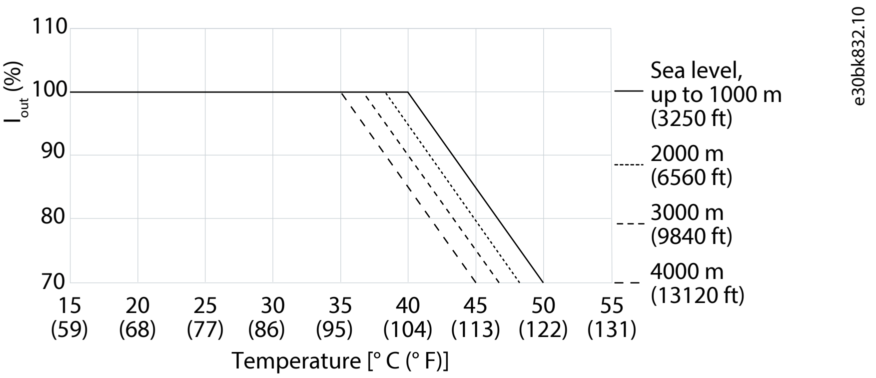


Figure 3: Derating for Temperature and Altitude

Below 40 °C (122 °F) and 1000 m (3280 ft) altitude, derating is not required.

6 Mechanical Installation Considerations

6.1 Pre-installation

6.1.1 Planning the Installation Site

To select the most appropriate installation site, consider the following:

- Ambient temperature conditions.
- Altitude at the installation point.
- Installation and compensation method.
- Cooling.
- Position of the active filter.
- Current transformer installation point and possibility to reuse existing current transformers.
- Cable routing and EMI conditions.
- Ensure that the filter rating matches the grid voltage and frequency.
- Ensure that the external fuses are rated correctly.

6.1.2 Receiving the Unit

When receiving the unit, ensure that the packaging is intact and note any damage that may have occurred during transport. If there are signs of damage, immediately contact the shipping company to file a complaint.

Before unpacking the active filter, place it as close to its final installation site as possible. To avoid damage, keep the filter boxed and on the pallet as long as possible.

6.1.3 Mechanical Dimensions

6.1.3.1 IP20

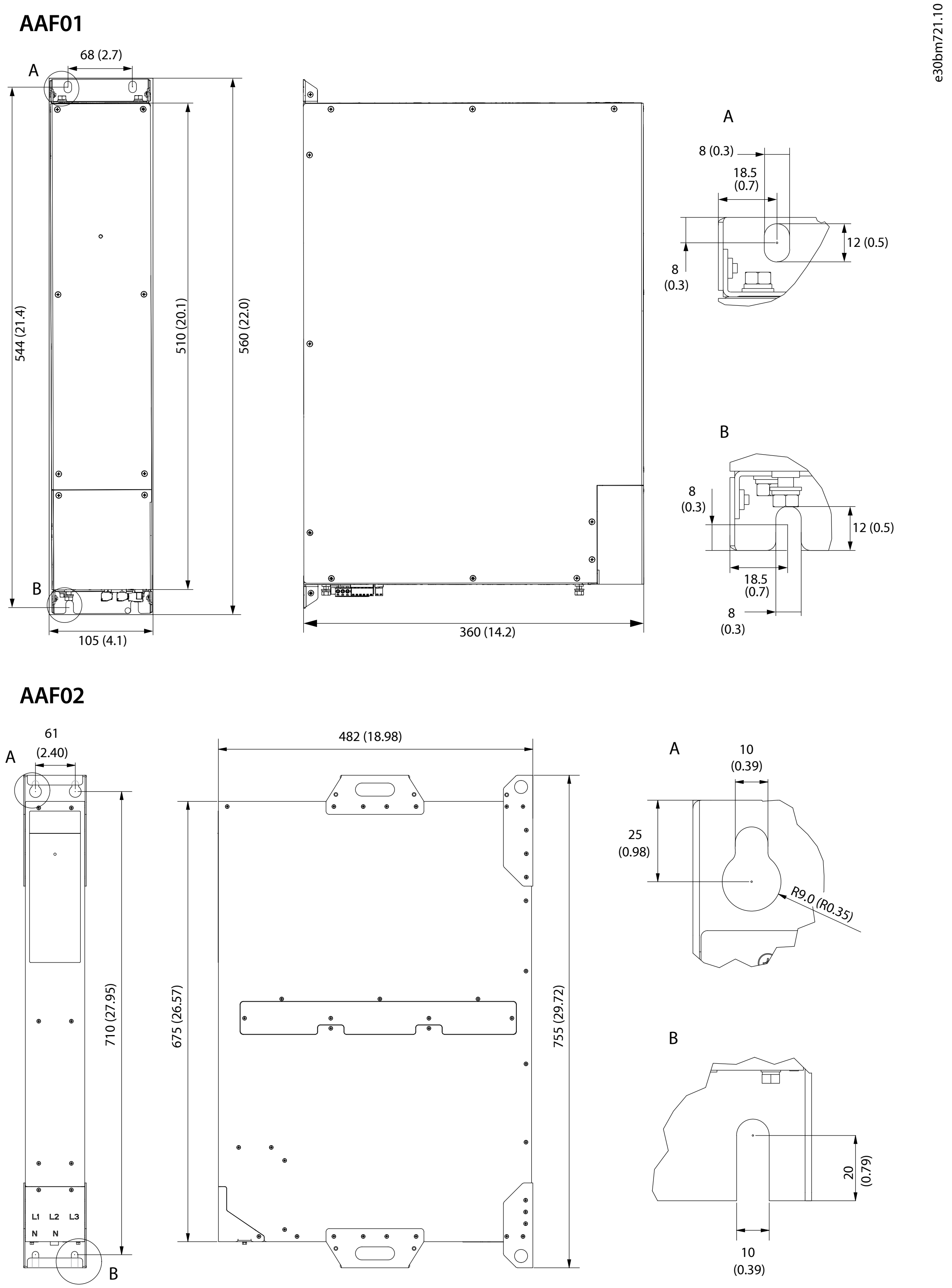


Figure 4: Mechanical Housing of AAF01 (35 A and 55 A) and AAF02 (100A and 150A) Modules

Table 15: Shipping and Unit Dimensions of IP20 Units Based on AAF01 Enclosures

Nominal current		35 A	55 A	70 A	90 A	110 A	165 A	220 A	275 A	330 A	385 A	440 A
Shipping dimensions	Height [mm (in)]	560 (22)	560 (22)	560 (22)	560 (22)	560 (22)	560 (22)	610 (24)	610 (24)	700 (27.6)	700 (27.6)	700 (27.6)
	Width [mm (in)]	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)	800 (31.5)	800 (31.5)	1200 (47.2)	1200 (47.2)	1200 (47.2)
	Depth [mm (in)]	400 (15.7)	400 (15.7)	400 (15.7)	400 (15.7)	400 (15.7)	400 (15.7)	600 (23.6)	600 (23.6)	800 (31.5)	800 (31.5)	800 (31.5)
	Weight [kg (lbs)]	23 (50.7)	24 (52.9)	39 (86)	40 (88.2)	41 (90.4)	58 (127.9)	80 (176.4)	97 (213.8)	125 (275.6)	147 (313.1)	159 (350.5)
Unit dimensions (1)	Height [mm (in)]	560 (22)	560 (22)	560 (22)	560 (22)	560 (22)	560 (22)	560 (22)	560 (22)	560 (22)	560 (22)	560 (22)
	Width [mm (in)]	105 (4.1)	105 (4.1)	210 (8.3)	210 (8.3)	210 (8.3)	315 (12.4)	420 (16.5)	525 (20.7)	630 (24.9)	735 (29)	840 (33.1)
	Depth [mm (in)]	360 (14.2)	360 (14.2)	360 (14.2)	360 (14.2)	360 (14.2)	360 (14.2)	360 (14.2)	360 (14.2)	360 (14.2)	360 (14.2)	360 (14.2)
	Weight [kg (lbs)]	16 (35.3)	17 (37.5)	32 (70.5)	33 (72.8)	34 (75)	51 (112.4)	68 (149.9)	85 (187.4)	102 (224.9)	119 (262.4)	136 (299.9)

1) Units dimensions without cabling and enclosure, side-by-side mounting. The weight is without current transformers.

Table 16: Shipping and Unit Dimensions of IP20 Units Based on AAF02 Enclosures

Nominal current		100 A	150 A	200 A	250 A	300 A	350 A	400 A	450 A	500 A	550 A	600 A
Shipping dimensions	Height [mm (in)]	450 (17.7)	450 (17.7)	610 (24)	610 (24)	610 (24)	770 (30.3)	770 (30.3)	770 (30.3)	930 (36.6)	930 (36.6)	930 (36.6)
	Width [mm (in)]	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)
	Depth [mm (in)]	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)
	Weight [kg (lbs)]	44 (97)	46 (101.4)	79 (174.1)	81 (178.5)	83 (182.9)	116 (255.7)	119 (262.3)	121 (266.7)	154 (339.5)	156 (343.9)	158 (348.3)

Table 16: Shipping and Unit Dimensions of IP20 Units Based on AAF02 Enclosures - (continued)

Nominal current		100 A	150 A	200 A	250 A	300 A	350 A	400 A	450 A	500 A	550 A	600 A
Unit dimensions (1)	Height [mm (in)]	755 (29.7)	755 (29.7)	755 (29.7)	755 (29.7)	755 (29.7)	755 (29.7)	755 (29.7)	755 (29.7)	755 (29.7)	755 (29.7)	755 (29.7)
	Width [mm (in)]	91 (3.6)	91 (3.6)	182 (7.2)	182 (7.2)	182 (7.2)	273 (10.7)	273 (10.7)	273 (10.7)	364 (14.3)	364 (14.3)	364 (14.3)
	Depth [mm (in)]	482 (19)	482 (19)	482 (19)	482 (19)	482 (19)	482 (19)	482 (19)	482 (19)	482 (19)	482 (19)	482 (19)
	Weight [kg (lbs)]	31 (68)	33 (73)	62 (137)	64 (141)	66 (146)	95 (209)	97 (214)	99 (218)	128 (282)	130 (287)	132 (291)

1) Units dimensions without cabling and enclosure, side-by-side mounting. The weight is without current transformers.

6.1.3.2 IP54

Table 17: Shipping and Unit Dimensions of Integrated IP54 Filters Units Based on AAF03 and AAF04 Enclosures

Enclosure		AAF03				AAF04				
Nominal current		100 A	110 A	150 A	165 A	200 A	220 A	250 A	275 A	300 A
Shipping dimensions	Height [mm (in)]	2300 (90.5)	2300 (90.5)	2300 (90.5)	2300 (90.5)	2300 (90.5)	2300 (90.5)	2300 (90.5)	2300 (90.5)	2300 (90.5)
	Width [mm (in)]	1200 (47.2)	1200 (47.2)	1200 (47.2)	1200 (47.2)	1200 (47.2)	1200 (47.2)	1200 (47.2)	1200 (47.2)	1200 (47.2)
	Depth [mm (in)]	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)
	Weight [kg (lbs)]	302 (665.7)	309 (681.2)	304 (670.2)	327 (720.9)	363 (800.2)	369 (813.5)	365 (804.6)	388 (855.3)	367 (809)
Unit dimensions (1)	Height [mm (in)]	2100 (82.7)	2100 (82.7)	2100 (82.7)	2100 (82.7)	2100 (82.7)	2100 (82.7)	2100 (82.7)	2100 (82.7)	2100 (82.7)
	Width [mm (in)]	408 (16.1)	408 (16.1)	408 (16.1)	408 (16.1)	608 (23.9)	608 (23.9)	608 (23.9)	608 (23.9)	608 (23.9)
	Depth [mm (in)]	653 (25.7)	653 (25.7)	653 (25.7)	653 (25.7)	667 (26.3)	667 (26.3)	667 (26.3)	667 (26.3)	667 (26.3)
	Weight [kg (lbs)]	183 (403)	190 (419)	185 (408)	208 (459)	244 (538)	250 (551)	246 (542)	269 (593)	247 (547)

1) Units dimensions without cabling and enclosure, side-by-side mounting. The weight is without current transformers.

Table 18: Shipping and Unit Dimensions of Integrated IP54 Filters Units Based on AAF05 and AAF06 Enclosures

Enclosure		AAF05			AAF06		
Nominal current		350 A	400 A	450 A	500 A	550 A	600 A
Shipping dimensions	Height [mm (in)]	2300 (90.5)	2300 (90.5)	2300 (90.5)	2300 (90.5)	2300 (90.5)	2300 (90.5)
	Width [mm (in)]	1200 (47.2)	1200 (47.2)	1200 (47.2)	1200 (47.2)	1200 (47.2)	1200 (47.2)
	Depth [mm (in)]	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)	800 (31.4)
	Weight [kg (lbs)]	434 (956.8)	436 (961.2)	438 (965.6)	509 (1122.1)	511 (116.5)	513 (1130.9)
Unit dimensions (1)	Height [mm (in)]	2100 (82.7)	2100 (82.7)	2100 (82.7)	2100 (82.7)	2100 (82.7)	2100 (82.7)
	Width [mm (in)]	802 (31.4)	802 (31.4)	802 (31.4)	1002 (39.4)	1002 (39.4)	1002 (39.4)
	Depth [mm (in)]	667 (26.3)	667 (26.3)	667 (26.3)	667 (26.3)	667 (26.3)	667 (26.3)
	Weight [kg (lbs)]	315 (694)	317 (699)	319 (703)	390 (860)	392 (864)	394 (869)

1) Units dimensions without cabling and enclosure, side-by-side mounting. The weight is without current transformers.

6.2 Mechanical Installation

6.2.1 Required Tools

- Tape measure
- Slotted screwdrivers (SL1/SL2)
- PH1, PH2 screwdrivers
- Ratchet
- Wrench 17 mm, 19 mm
- Screwdriver blade 5.5 x 0.8 mm (for wall mounting)
- Screwdriver blade 2.5 x 0.6 mm
- Screwdriver blade 3.5 x 0.6 mm

6.2.2 Installation Location

The Advanced Active Filter AAF 007 modules are rated IP20/open type. To minimize the risk of electrical and fire hazards, install the filter in a supplementary enclosure.

6.2.3 Clearance Requirements

To allow airflow and cable access, ensure that there is sufficient space above and below the unit. Filters can be installed side by side with other AAF 007 filters but require a minimum of 100 mm (in) clearance to other equipment to ensure proper functionality in respect to electromagnetic interference and heat dissipation.

The AAF 007 IP54 cabinets require 1 meter clearance in front of the device, as the ventilation system is placed in the door.

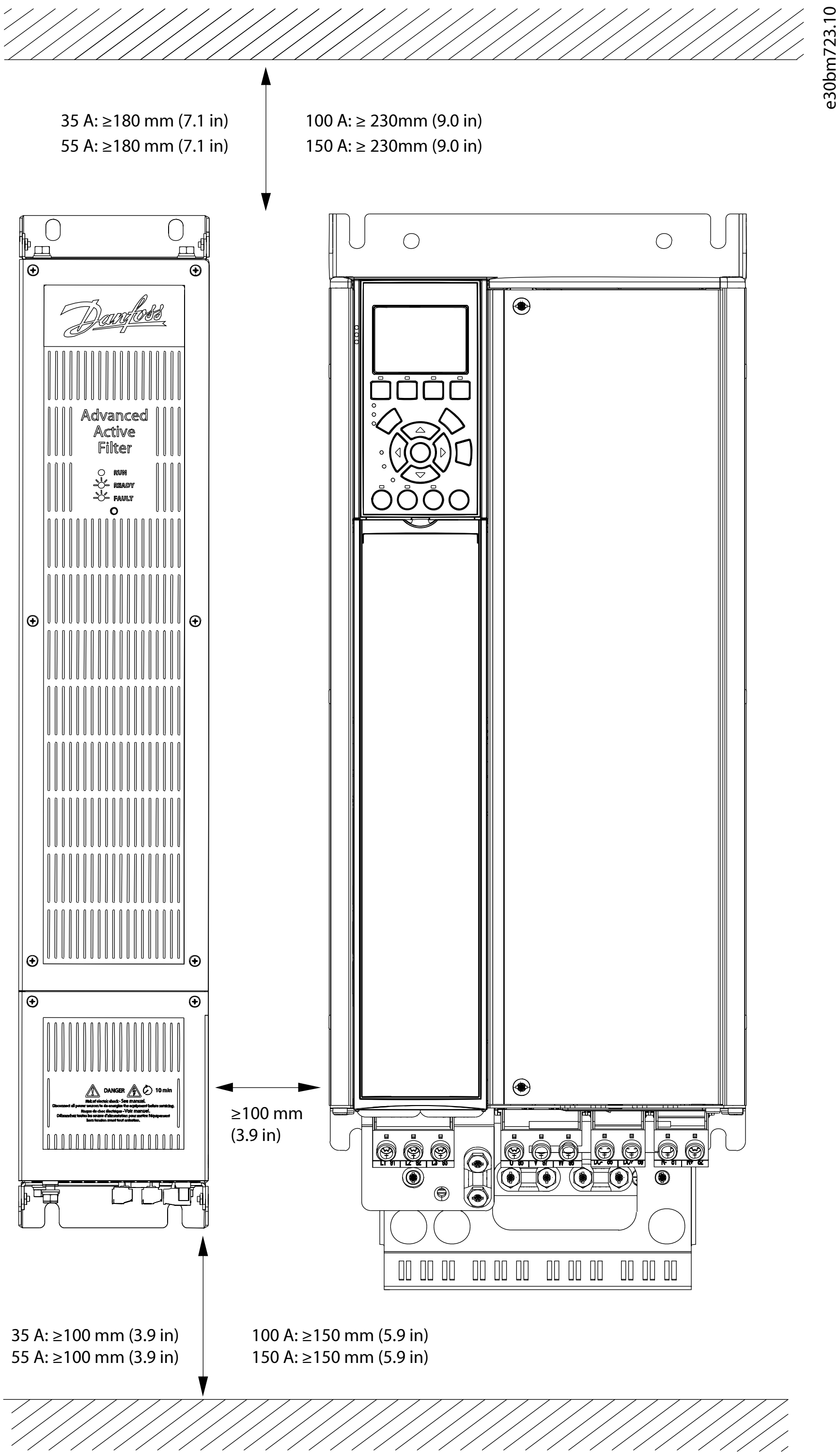


Figure 5: Clearance Distances

6.3 Cabinet Integration

The cabinet integration of the Advanced Active Filter AAF 007 is effortless due to the little weight and dimension of the modules. They can be integrated side by side, but also on top of each other to allow for a small footprint of the cabinet.

Side-by-side installation allows a possible lower cabinet or integration of multiple other options below the filter, such as mains breakers, branch protection, individual fuse disconnect, or circuit breakers.

In the cabinet door, it is possible to integrate LEDs that indicate the state of the filter module on the outside of the cabinet.

Both underpressure and overpressure cabinets can be used for integration of the AAF 007. In some integration designs, a rooftop fan can be more efficient than door fans. For more information on general considerations for positioning of fans, grids, and filters in the cabinet, refer to section 6.4.2.

The following illustration shows a simplified example of a 1000 mm (39 in) cabinet with 8 filter modules, rooftop fans, and a handle for the mains breaker.

The Advanced Active Filter AAF 007 is offered as floorstanding cabinet in IP54 with CE conformity as well. Cooling and IP requirements have been realized by parallel door fans, that are placed at the bottom of the door and create an overpressure inside the cabinet. The Cabinet products come with a central main switch and status LED in the front as well as individual branch protection in front of the filter modules which is used to disconnect individual filter modules.

Optional a touch panel can be ordered for easy commissioning and monitoring of the system.

The cable entry is from the bottom, but cables can be routed through all sides of the plinth.

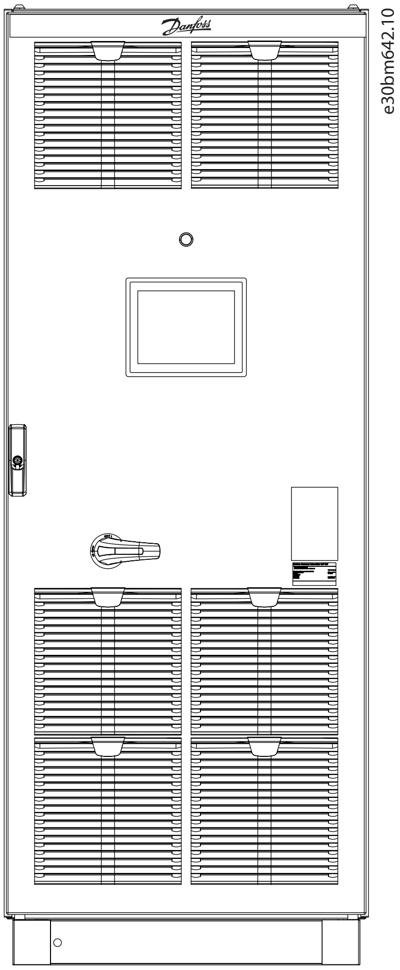


Figure 6: Example of Cabinet Integration of a 440 A Filter

6.4 Cooling and Airflow

The Advanced Active Filter AAF 007 has 3 inbuilt fans for cooling which guide the cool air from the bottom of the filter through the filter to the outlet at the top. The fans are controlled as functions of operation condition and internal temperatures.

Each filter module requires a minimum volume flow of 160 m^3/h at maximum load for proper heat dissipation. This specification shall be considered when designing the cooling for the installation location.

When filter modules are to be placed on top of each other, pay extra attention to the warm excess air of the lower filter modules. As the warm air of the lower filter module must not be taken in by the upper filter modules, it must be passed by the upper filter. A recommended method is to guide the warm air behind the upper row of filter modules to the top of the installation location as illustrated in Figure 7.

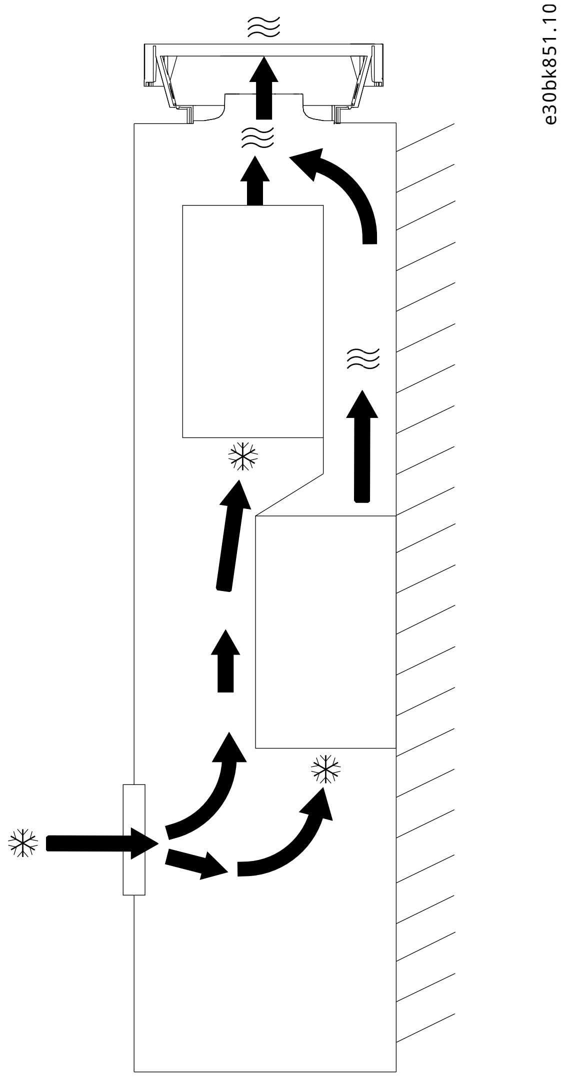


Figure 7: Airflow Considerations when Modules are Installed Above Each Other

6.4.1 Overpressure and Underpressure Cabinets

Cabinets can be designed as overpressure or underpressure cabinets. This means that fresh air can either be pushed actively into the cabinet from the lower part of the door and let out at the top part of the door. Alternatively, the warm air could be pulled out actively via the cabinet top generating underpressure and thereby pulling in fresh air.

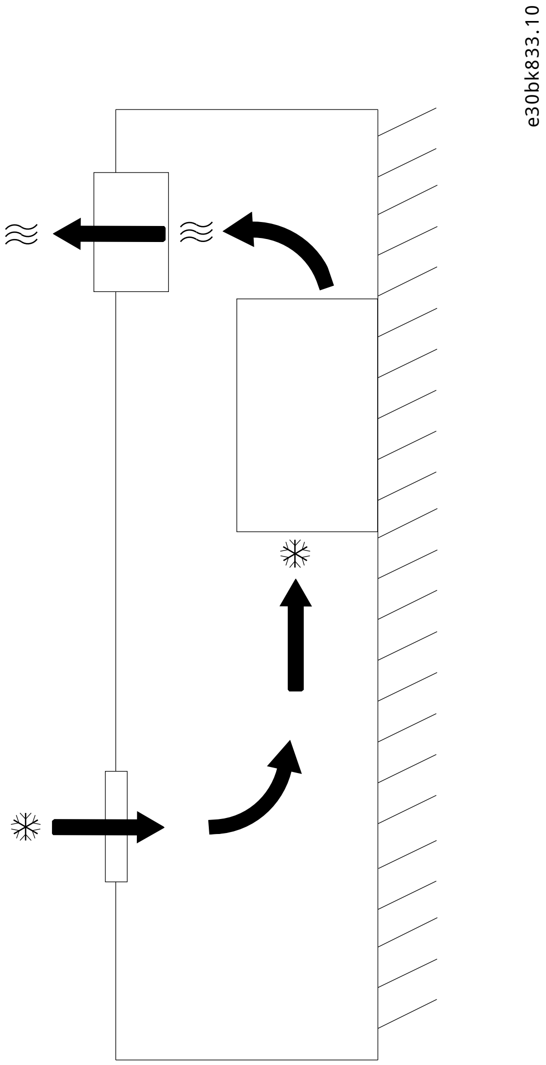
Overpressure cabinets are often preferred in outdoor applications or environments with minor air quality to avoid dust and particles inside the cabinet.

When designing overpressure cabinets, pay special attention to the flow of warm air in the top part of the cabinet to eliminate heat pockets. To avoid derating of the filter due to high temperature, ensure that the excess heat of the filters does not circulate in the top of the cabinet. Depending on layout and positioning of the filter modules, mechanics for guiding the warm air secure proper heat transmission.

6.4.2 Positioning of Door Fans and Rooftop Fans

When designing underpressure cabinets, 1 or more fans are used to push the warm air out of the cabinet. It is usually the smoothest approach to dissipate the heat from the cabinet. To secure good cooling, some aspects of fan location are important:

- Intake grills in the door must be located below the lowest-installed filter.
- Door fans must be located above the highest-installed filter.



The illustration shows the relative positions of filter, air intake grills, and fans.

When filters are stacked in a cabinet, or there are space constraints that do not allow placing a door fan higher than the filter, a roof top fan is recommended to secure proper heat dissipation as shown in Figure 7.

7 Electrical Installation Considerations

7.1 Power Connections

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

The required derating is calculated as 2 separate factors:

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

The specifications of the optimized mains cable are:

- copper wires
- single conductors
- busbars

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

A factor of 1.2 should be applied to the nominal RMS current of a filter to determine the mains cross-section for a copper connection. An additional factor of 1.2 should be applied for aluminum connections.

7.1.1 Grounding

To obtain electromagnetic compatibility (EMC), consider the following when installing an active filter:

- 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 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 prevents having different high-frequency voltages for the individual devices, and it prevents the risk of radio interference currents running in connection cables that may be used between devices. Thus, radio interference is reduced. To obtain a low high-frequency impedance, use the fastening bolts of the devices as high-frequency connection to the back plate. Remove any insulating paint or similar substances from the fastening points.

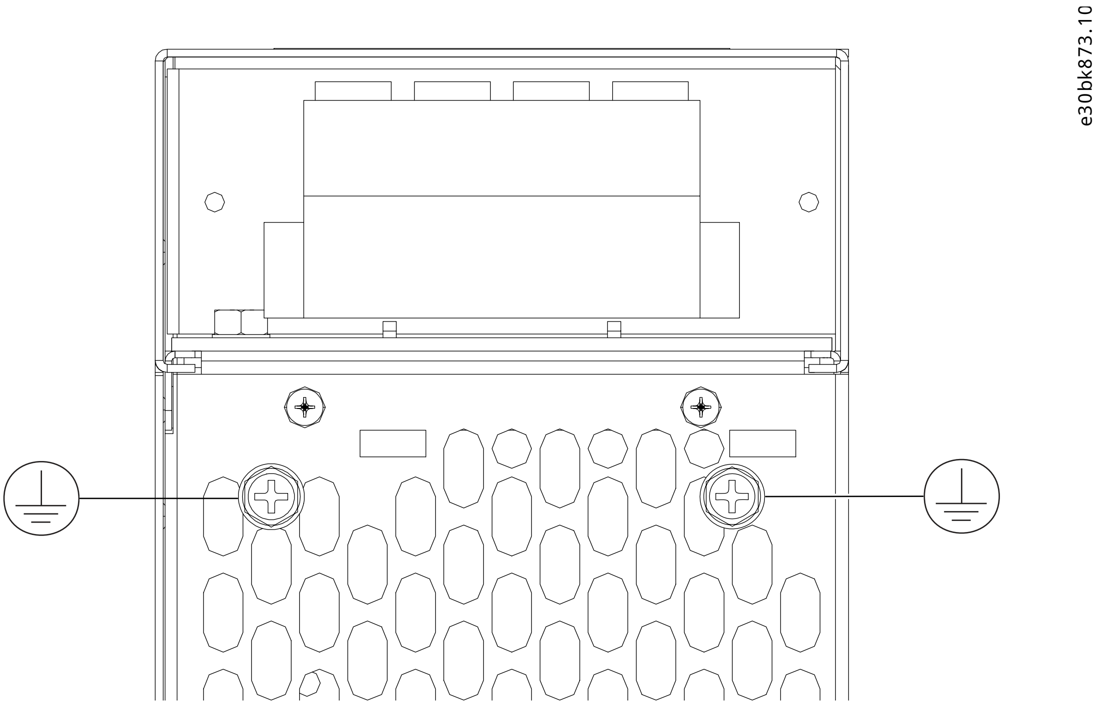


Figure 8: Positioning of Grounding Terminals for 35 A and 55 A filter modules

Connect 2 of the PE terminals to the local PE busbar in the installation to ensure redundancy and sufficient grounding surface on the filter (35A and 55A)

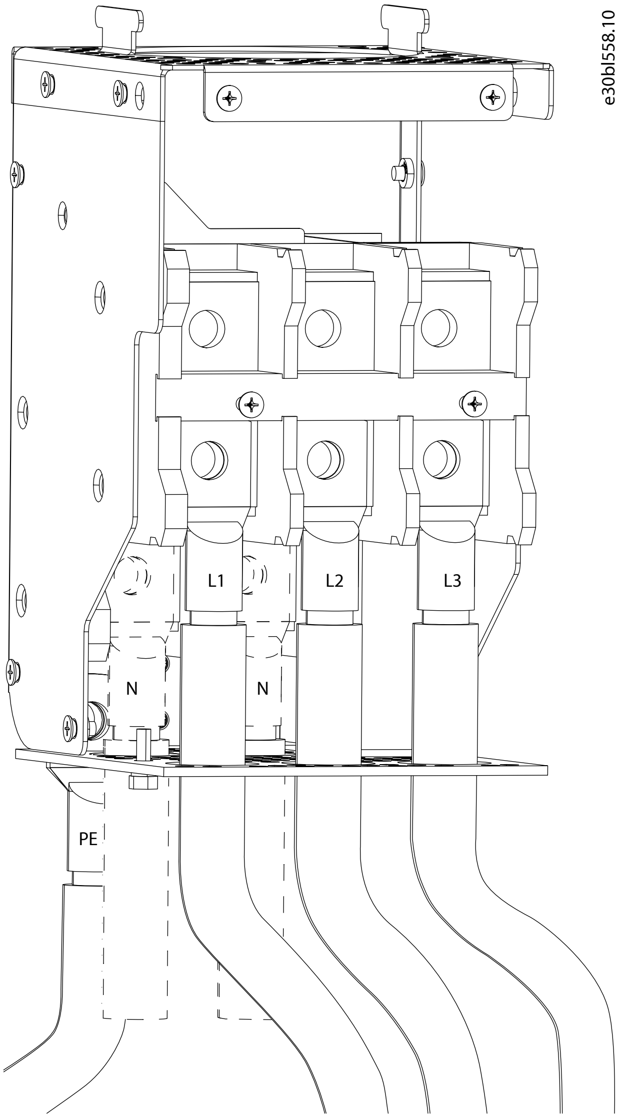


Figure 9: Mains and PE Connection for 150 A Module

7.2 Fuses and Branch Protection

Branch circuit protection

To protect the installation against electrical and fire hazards, all branch circuits in an installation, switchgear, machines, and more must be short-circuit and overcurrent-protected according to national/international regulations.

Either fuses or circuit breakers can be used for branch protection in front of the filter.

Table 19: Recommended Fuse Types

Filter module	IEC	UL	Minimum SCCR	Maximum SCCR
35 A	gG, 60 A	Class J or T, 60 A	1.6 kA	100 kA
55 A	gG, 80 A	Class J or T, 80 A	2 kA	100 kA
100 A	gG, 160 A	Class J or T, 160 A	4 kA	100 kA
150 A	gG, 200 A	Class J or T, 200 A	5.5 kA	100 kA

Short-circuit protection

Each filter module is equipped with internal semi conductor fuses to protect the device and avoid electrical or fire hazards.

Table 20: Branch Protection Recommendation for Filter Cabinets

Filter module	IEC	Maximum SCCR
100 A	gG, 160 A	50 kA
110 A	gG, 200 A	50 kA
150 A	gG, 200 A	50 kA
165 A	gG, 250 A	50 kA
200 A	gG, max 425 A	50 kA
220 A	gG, max 425 A	50 kA
250 A	gG, max 425 A	50 kA
275 A	gG, max 425 A	50 kA
300 A	gG, 425 A	50 kA
350 A	gG, max 630 A	50 kA
400 A	gG, max 630 A	50 kA
450 A	gG, 630 A	50 kA
500 A	gG, max 800 A	50 kA
550 A	gG, max 800 A	50 kA
600 A	gG, 800 A	50 kA

7.3 Network Topologies

The Advanced Active Filter AAF 007 is capable of operating on various mains topologies like TN, TT, and IT.

7.4 Current Transformers Considerations

The Advanced Active Filter AAF 007 needs measuring signals from external current transformers to function. Current transformers ordered with the filter are pretuned from factory and ensure optional configuration. It is possible to use existing current transformers or order current transformers separately. Using existing transformers or buying the transformers separately requires additional configuration and tuning of the filter, see 8.1.4.1 Settings - Device for more details.

To obtain the best filter performance, use current transformers with the following specifications:

- Nearest 10% higher current transformer to the maximum RMS current to avoid saturation.
- Current transformers with 5 A secondary rating.
- Current transformers with IEC accuracy class 0.5 or better (optimal read accuracy).

Filters operating with oversized RMS current transformer rating and/or with less than 0.5% accuracy have reduced harmonic performance and result in higher losses. The filter is not able to operate with 1 A secondary CT rating.

As standard, the filter is configured for symmetric 3-phase systems and requires only 2 current transformers. Install the current transformers on phases L1/A and L3/C. A 3rd current transformer can be installed on L2/B and connected to the filter without any issues. However, this will not give any advantages for the filter performance in a 3-phase 3-wire system.

NOTICE

The AAF 007 cabinet IP54 solution does not host a neutral wire connection and is only used in 3-phase/3-wire systems (3W3P).

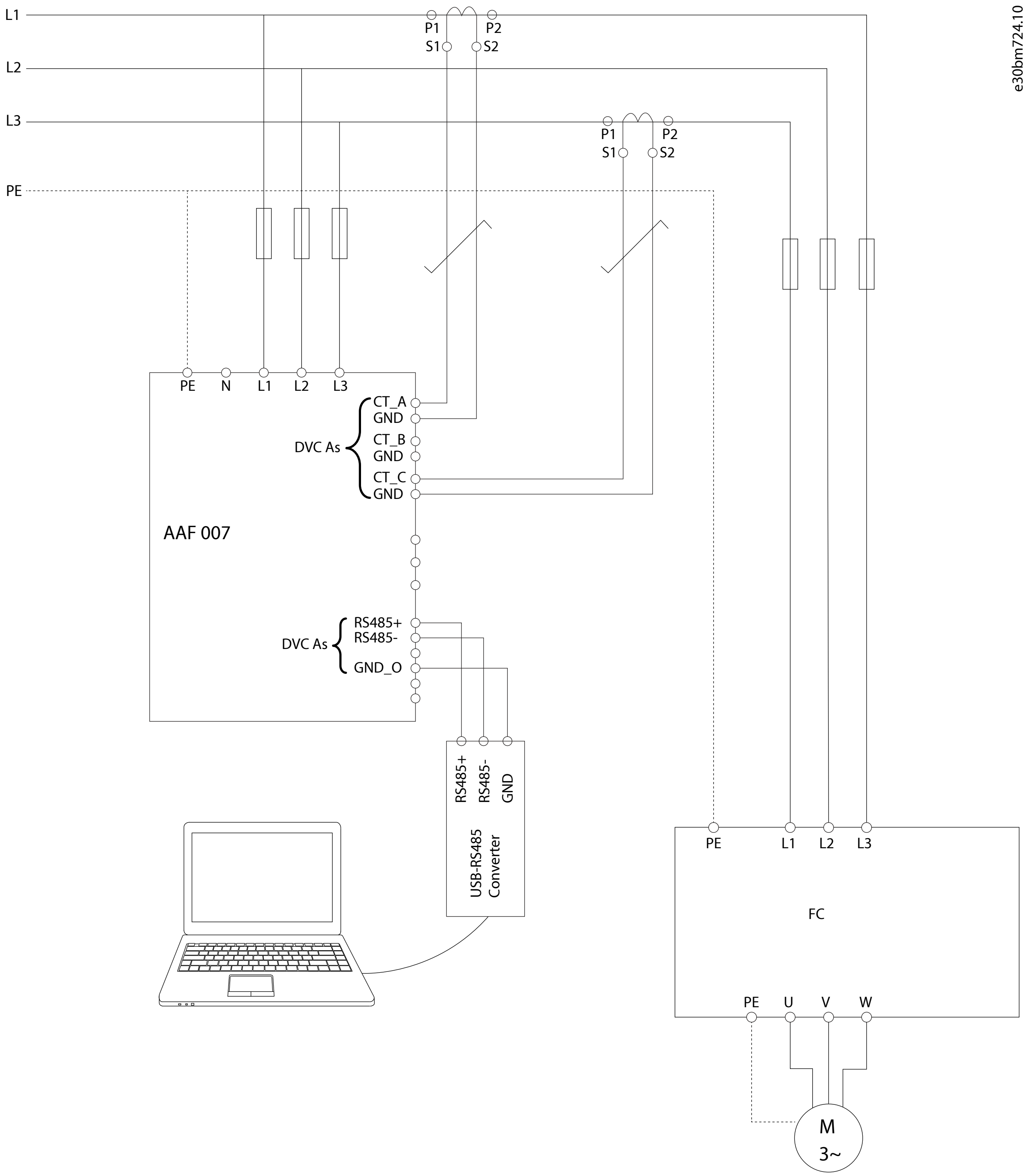


Figure 10: Installation of Current Transformers on Load-side Configuration/Open Loop

NOTICE

If current transformers are installed on all 3 wires, reprogram the filter to a 4-wire system.

7.4.1 Placing of Current Transformers

The location of the current transformers defines the filter operation pattern, whereas the filter power connection determines the harmonic current flow of the system.

It is recommended to install the current transformers downstream from the filter. This open-loop configuration is the preprogrammed setup. The filter mitigates by counteracting the harmonic current of the read signals. In the following illustration, the filter compensates harmonics on all loads at PCC2.

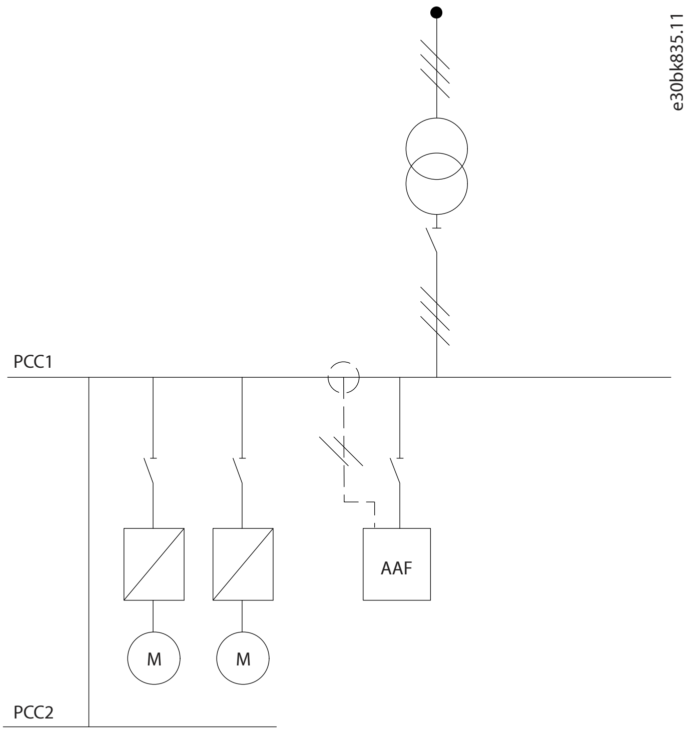


Figure 11: Open-loop Configuration

The filter can also run in closed-loop operations as shown in the following illustration, but this requires changes in the filter configuration. In this configuration, the filter controls reaching a sinusoidal current waveform on the read current transformers, and it compensates harmonics on all loads at PCC1.

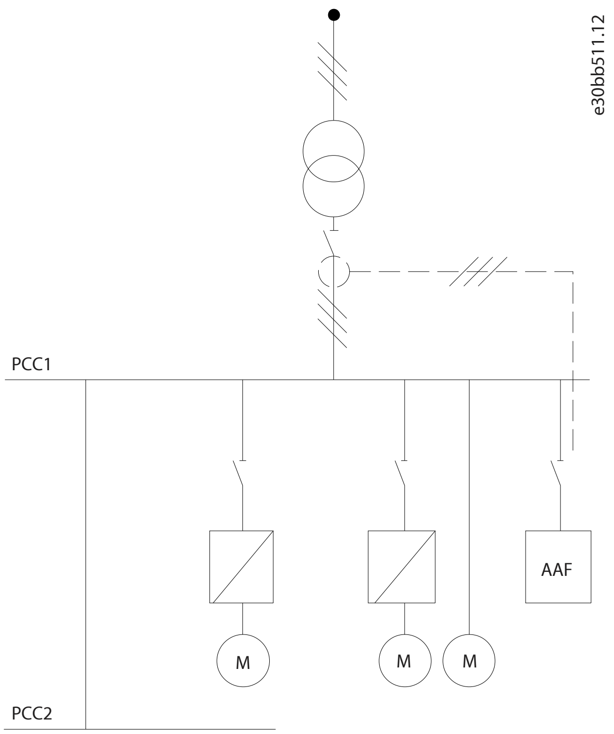


Figure 12: Closed-loop Configuration

No matter the configuration, the filter can compensate both single and multiple loads. To achieve the optimal harmonic flow of the system, install the filter at the same point of common coupling as the harmonic source it is intended to compensate.

7.4.2 Connections and Polarities

Be cautious about the polarity of the current transformers. Wrong polarity will result in harmonic doubling instead of mitigation. Notation of the current transformer terminals varies by brand. The most commonly used are S1/S2, K/L, or X1/X2. For correct polarity, use this connection sequence for all connections to the filter.

S1 = K = X1 = CT_A/C

S2 = L = X2 = GND

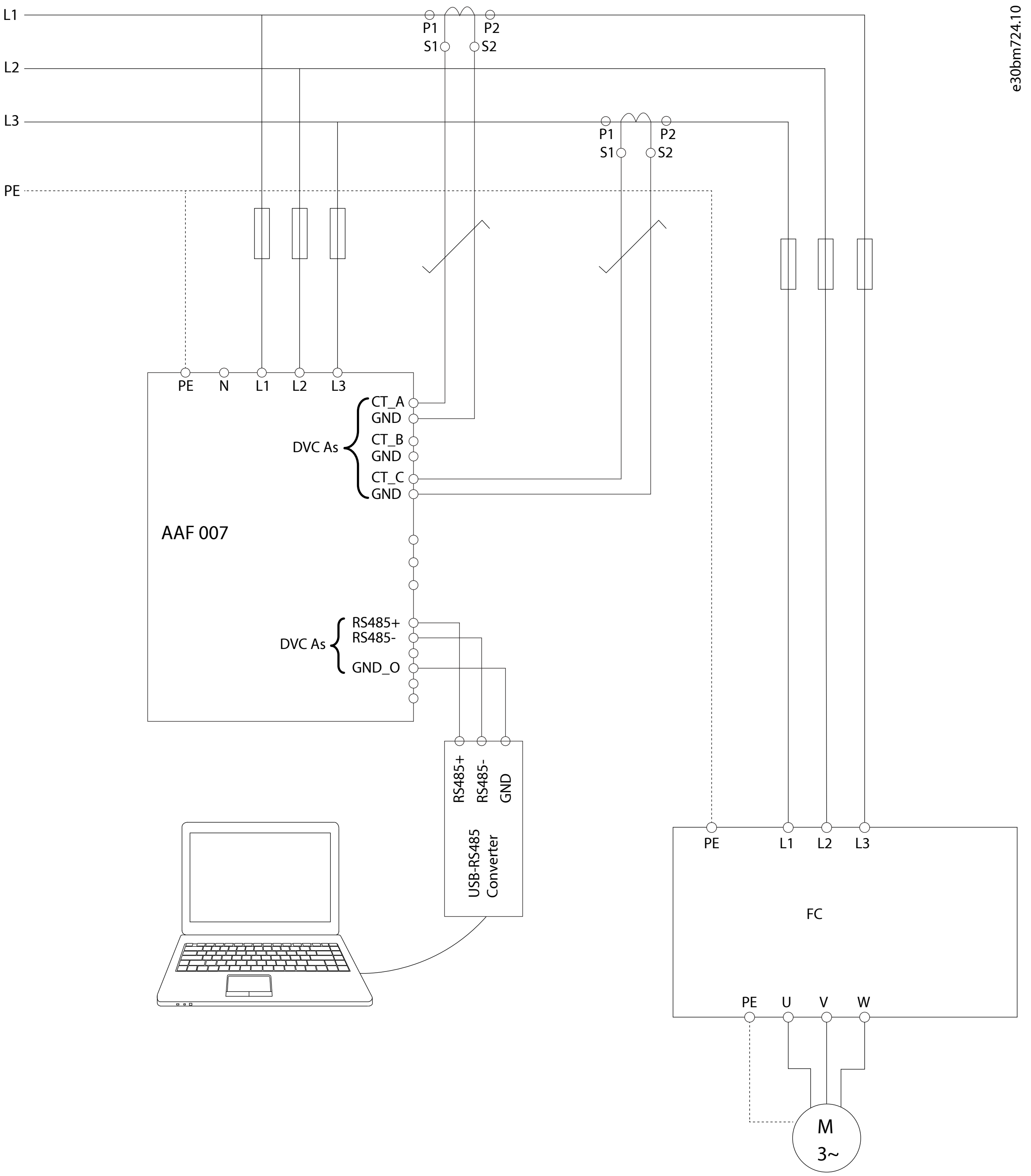


Figure 13: Connection Details

GND connectors on the filter are not shared. GND connection points cannot be interchanged between filters.

NOTICE
To avoid interchanging of current transformer cables, it is recommended NOT to use the same color twice.

7.4.3 Three- and Four-wire Systems

The Advanced Active Filter AAF 007 filter is preconfigured to compensation for Danfoss drives in a symmetric 3-wire operation mode. For systems with asymmetric loads, such as single-phase loads, the filter must be reconfigured for 4-wire operation. In this mode, equip the filter with 3 current transformers, 1 on each phase. Furthermore, the neutral power connection must be done. Reconfiguration is also required for correct performance.

The enclosed and integrated Advanced Active Filter AAF 007 IP54 filter solutions do not provide a terminal for a neutral wire. 4-wire operation is thereby not possible with IP54 products due to physical constrains in the cabinets.

NOTICE

The enclosed and integrated Advanced Active Filter AAF 007 IP54 filter solutions do not provide a terminal for a neutral wire. 4-wire operation is thereby not possible with IP54 products due to physical constrains in the cabinets.

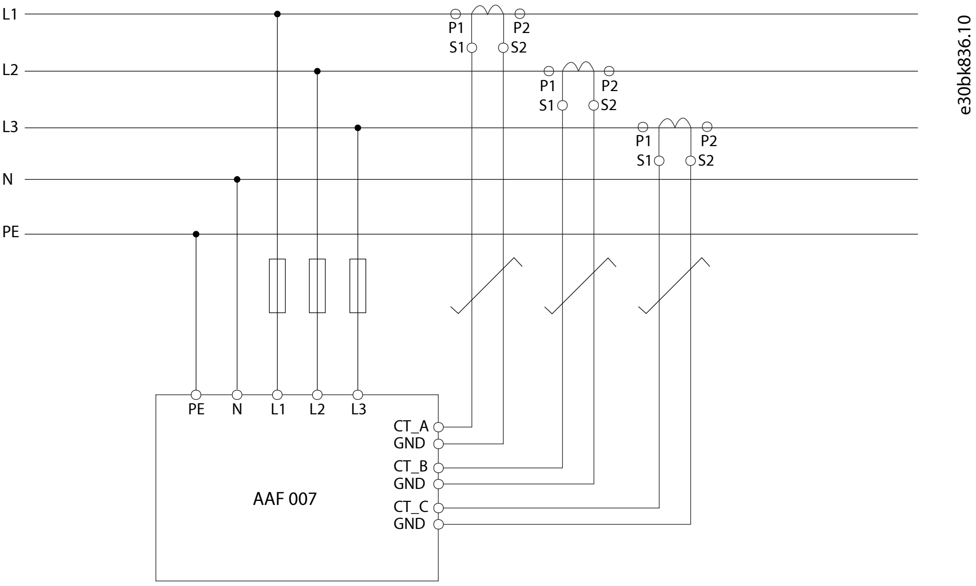


Figure 14: Four-wire Configuration

7.4.4 Connection of Several Filter Modules to the Same Current Transformer

It is often required to install several filter modules in parallel to achieve the needed compensation effect. Each filter can use its own set of current transformers or share common sets of current transformers. A maximum of 8 filters modules can share 1 common set of current transformers.

For sharing current transformers, connect the filters as shown:

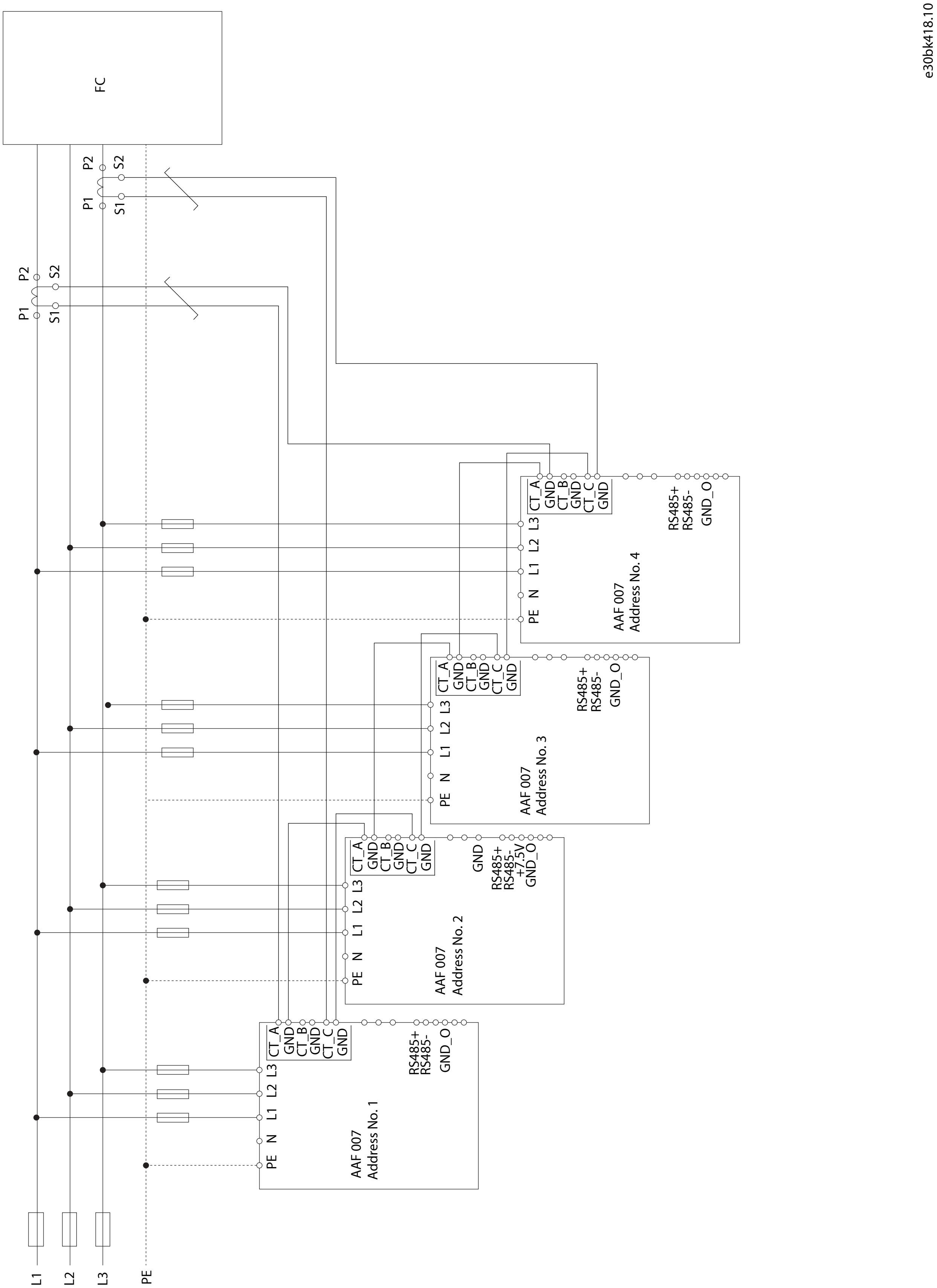


Figure 15: Connection for Current Transformer Sharing

NOTICE

Calculate burden for the total cable length. In the previous illustration, it includes all the 5 wires that connect the individual current transformers to the 4 filter modules.

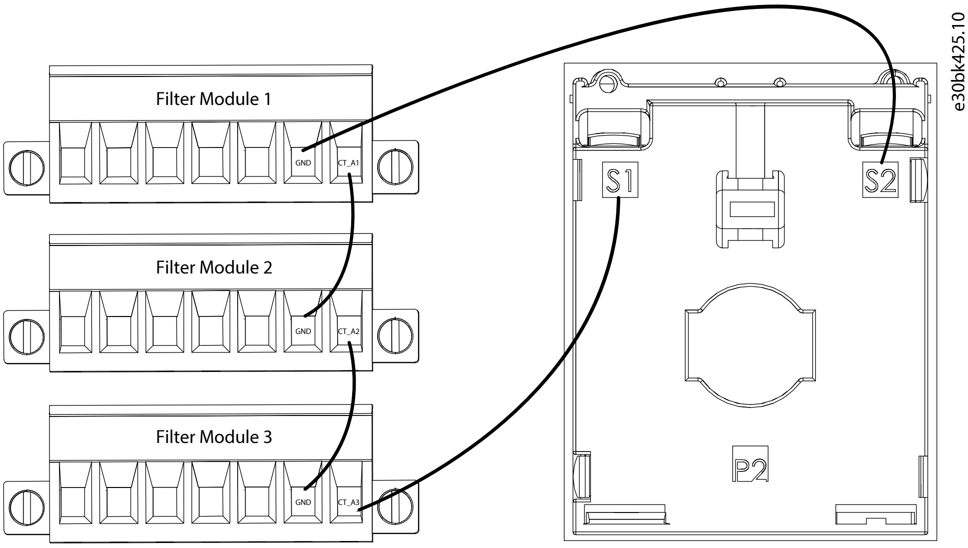


Figure 16: Wiring of a Current Transformer to 3 Filters in Series

7.4.5 Current Transformer Burden and Signal Quality Management

To ensure signal integrity, the current transformer and wiring system must be designed to avoid current sensing quality degradation. CT signal integrity is a combination of several factors:

- Total VA output of the transformer (maximum burden).
- The used current transformer wire gauge.
- The total length of the current transformer cable.
- The resistance of the filter.

The impedance of the filter's current transformer terminals is 5.5 mΩ per module.

To ensure signal integrity, the total power output of the current transformer per module must be higher than the load of the wiring system and the filter.

The burden of a current transformer is expressed in [VA] and is either directly available in the datasheet or calculated based on the current transformer impedance value:

[VA] = secondary current^2 x Impedance value

The burden of the current transformer secondary side is calculated based on length [m] and resistance [Ω/m] of the current transformer wiring plus the filter impedance:

[VA] = 5^2 ([Ω/m] x 2 x [m] + 0.0055)

The following graph shows the minimum current transformer burden requirement for various copper cable lengths for 1.5 mm^2 (13.3 mΩ/m) and 2.5 mm^2 (8.2 mΩ/m) wire gauge.

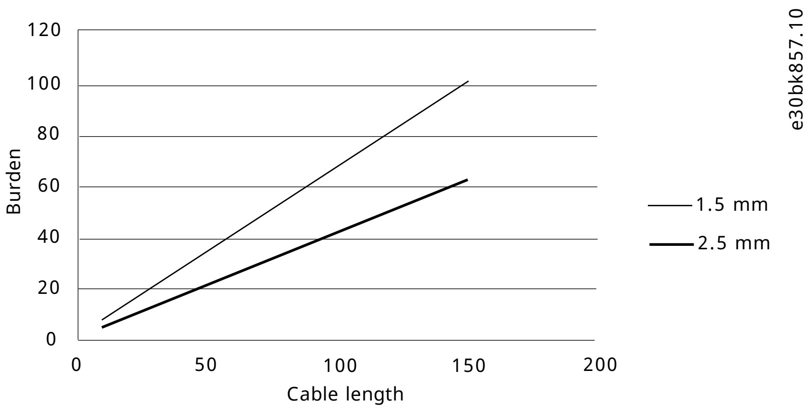


Figure 17: Burden Requirement for 1.5 and 2.5 mm Cable

The burden calculation must include all wires in the installation and must be conducted for the longest total wire string.

For filters where the current transformer signal is looped between several filters, the additional wire between the filters is to be included in the calculation.

To increase the possible length of a current transformer cable without increasing the burden too much, bigger diameter cables with less impedance can be used. This is practicable, especially, when secondary CT cabling is applied outside a filter cabinet.

Burden calculation for the summation current transformer is the sum of the respective secondary current transformers ([VA1]+[VA2]...).

The impedance of the filter modules current transformer terminals is 5.5 mΩ. Addition of the individual filter modules impedance gives the impedance of filter systems like integrated solutions.

7.4.6 Systems with Backup Generators, Redundant Power-feed Option, or Multiple-source Compensation

In systems with dual-current infeed possibility where harmonic compensation is targeted, specific sets of loads may require summation current transformers. These are typically systems with emergency backup generators or redundant power grid architecture. Summation current transformers are designed to summarize several synchronous AC currents of equal phase relation with any angle of phase difference, that is, summarizing the secondary currents of a number of main current transformers.

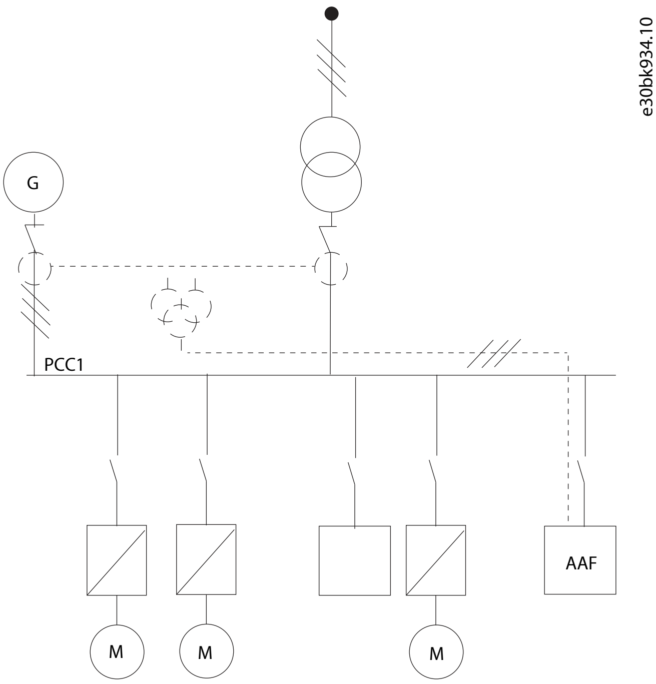


Figure 18: Multi Power Source Infeed in Close-loop Configuration

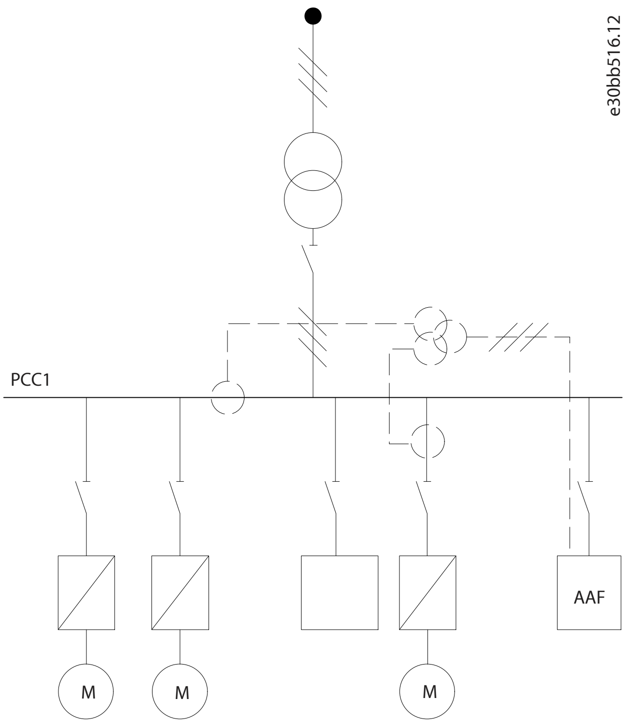


Figure 19: Selected Load Compensation in Open-loop Configuration

Summation current transformers are available with multiple inputs and 1 common output. For applications using summation current transformers, ensure that all current transformers connected to the summation are from the same manufacturer and have common:

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

- Phase sequence

When using summation current transformers, it is important to ensure correct phase relation, current direction, and primary and secondary rating. Incorrect installation causes incorrect filter operation. Also, pay special attention to the total current transformer burden calculation, see 7.4.5 Current Transformer Burden and Signal Quality Management.

7.4.7 Selection and Installation Example

In this example, only harmonics for drive 1 (200 kW) and drive 3 (132 kW) of the installation shall be mitigated. All drives are installed in the same cabinet, and the current transformer distance to the drives is 10 m (32.8 ft).

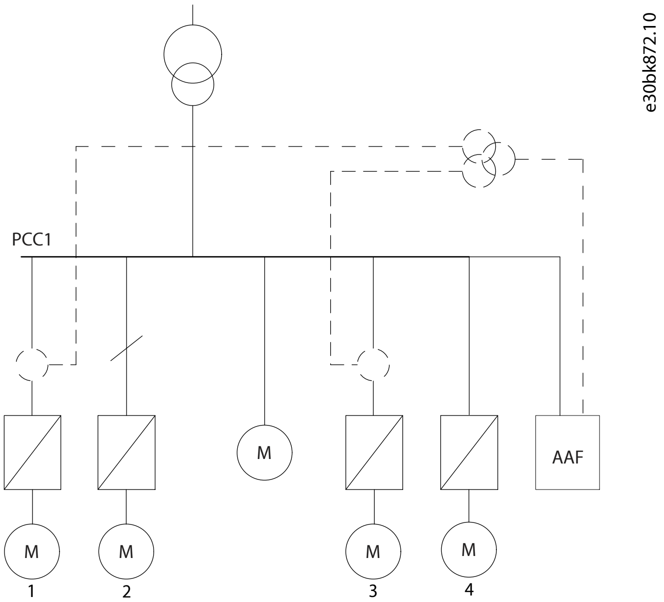


Figure 20: Example of Selective Group Compensation

Current transformers are installed on each of the drive supply cables, and summation transformers are used. The filter is running in open loop. The RMS current of the 200 kW drive is 385 A, hence both drives shall use 500 A current transformers. The filter burden must be configured to a 1000 RMS current transformer. The cable used is 1.5 mm^2 (16 AWG) and the current transformer minimum burden is:

(5A)^2 x 2 x 10m x 13.3mΩ = 6.65 VA. The summation transformer burden = 2 x 6.65 VA + 0.0055Ω x (5A)^2 = 13.44 VA.

To lower cost and ease availability of summation current transformers, it is possible to use 2.5 mm2 (14 AWG) wire instead and reduce burden demand to less than 10.

7.5 VD00, VD01

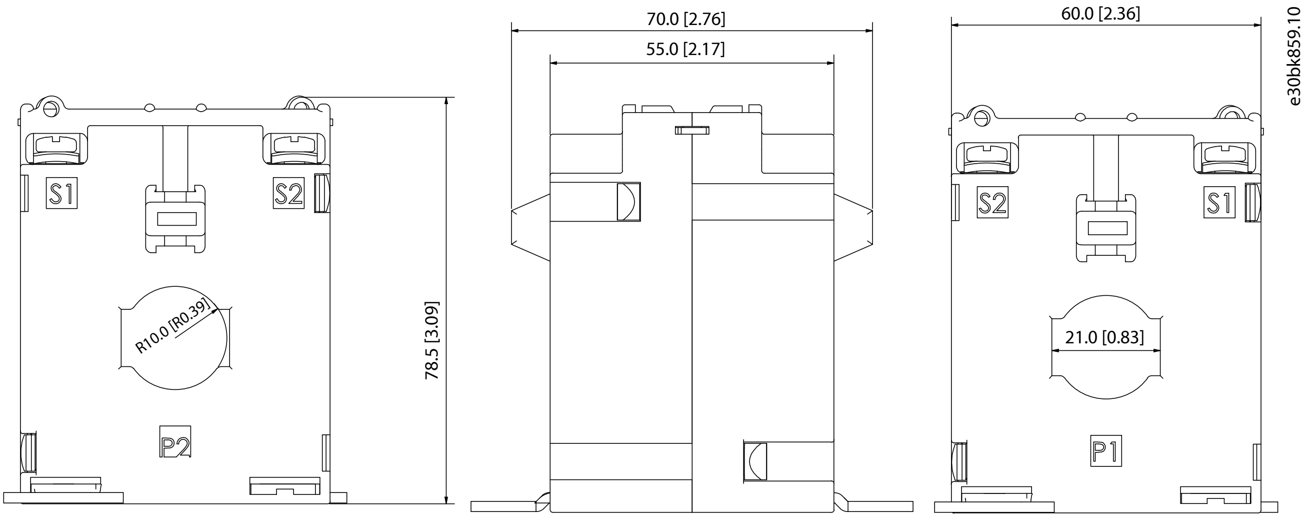


Figure 21: Dimensions, Current Transformers with Primary Currents of 80 A and 150 A

7.6 VD02, VD03, VD04, VD05

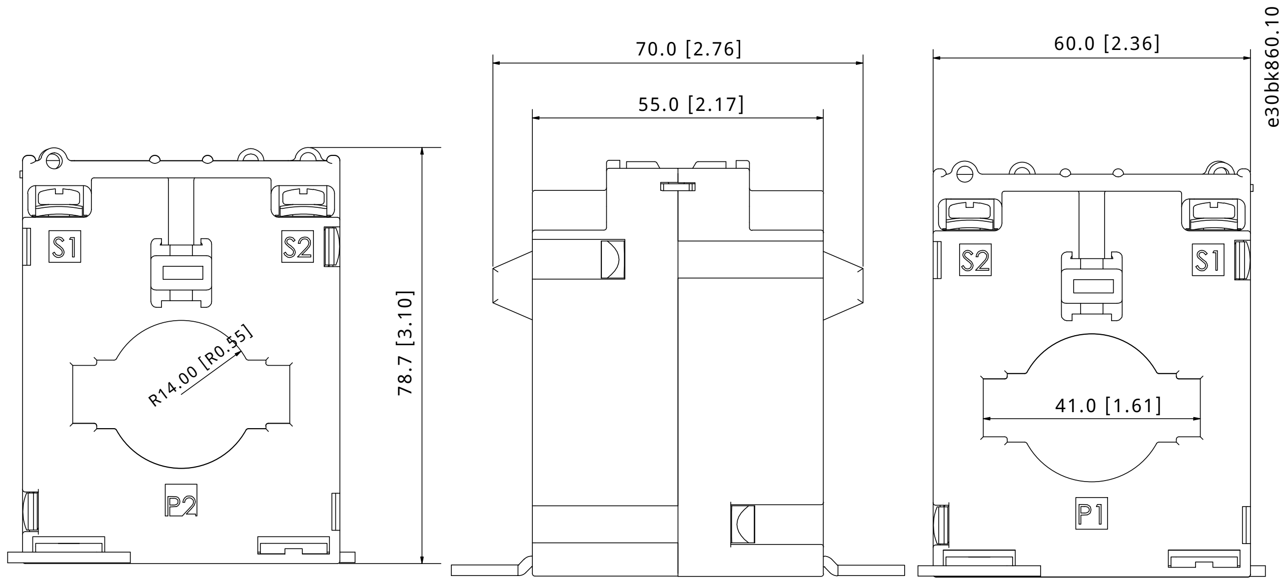


Figure 22: Dimensions, Current Transformers with Primary Current of 250 A, 400 A, 600 A, and 800 A

7.7 VD06, VD07, VD08

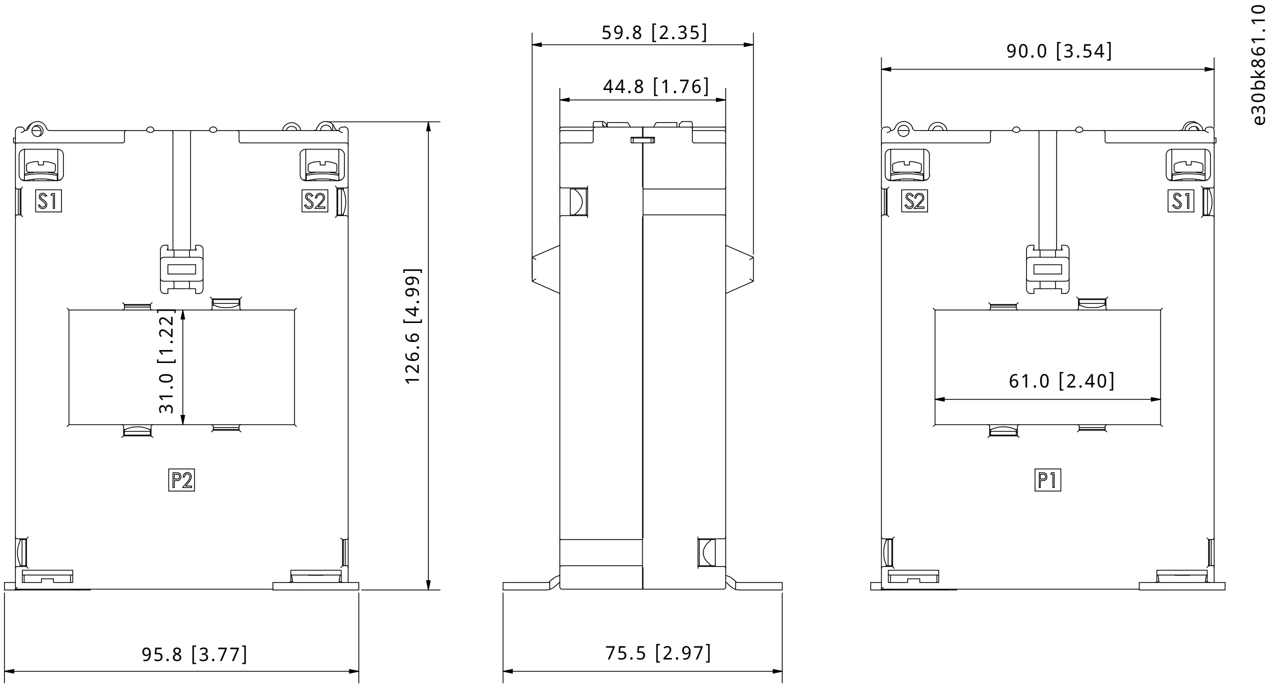


Figure 23: Dimensions, Current Transformers with Primary Current of 900 A, 1000 A, and 2000 A

7.8 VD09, VD10

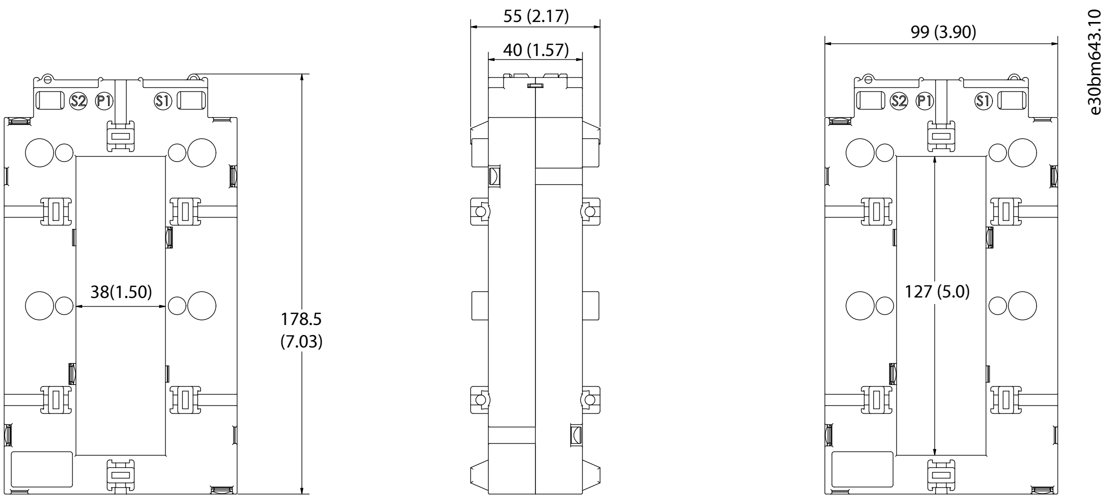


Figure 24: Dimensions, Current Transformers with Primary Current of 2500 A and 3000 A

7.9 Operation with Capacitor Banks

The Advanced Active Filter AAF 007 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. The filter's operating range is 40–60 kHz.

Always use detuned capacitor banks in installation with drives and active filters to avoid resonance phenomena, unintended tripping, or component breakdown.

Detuned capacitors should have a resonant frequency that is an inter-harmonic order lower than the 3rd order.

NOTICE

Resonances can occur when capacitor banks are not installed with detuning chokes close to an active switching device.

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

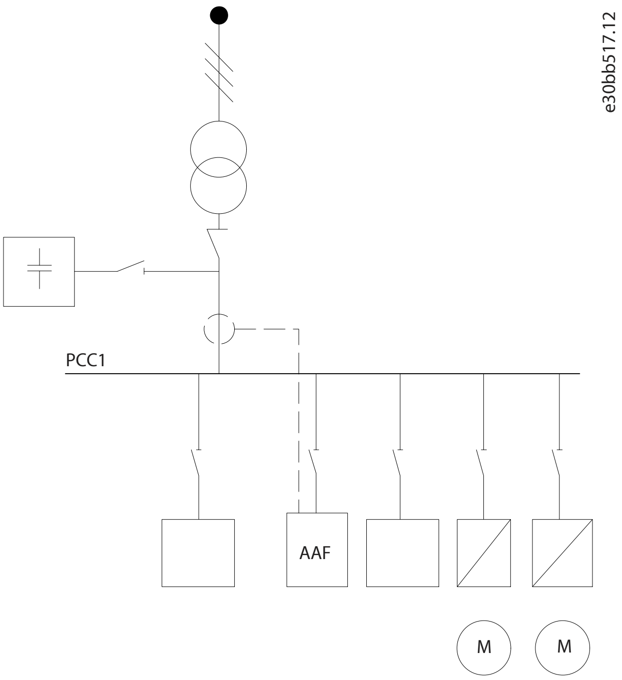


Figure 25: Capacitor Bank Mounted Upstream - Current Transformers do not Measure Capacitor Current

The above illustration shows the recommended installation of the active filter and current transformer location in installations containing capacitor banks.

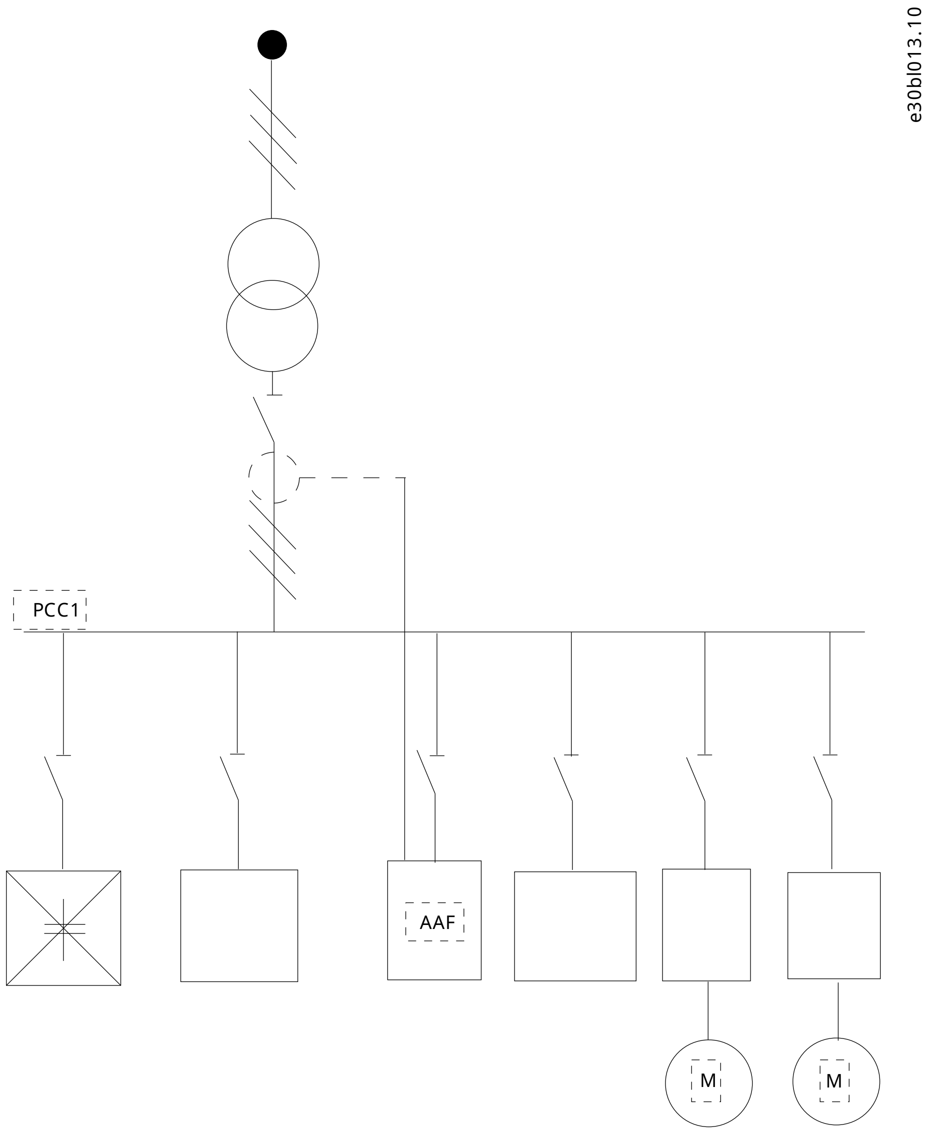


Figure 26: Incorrect Installation

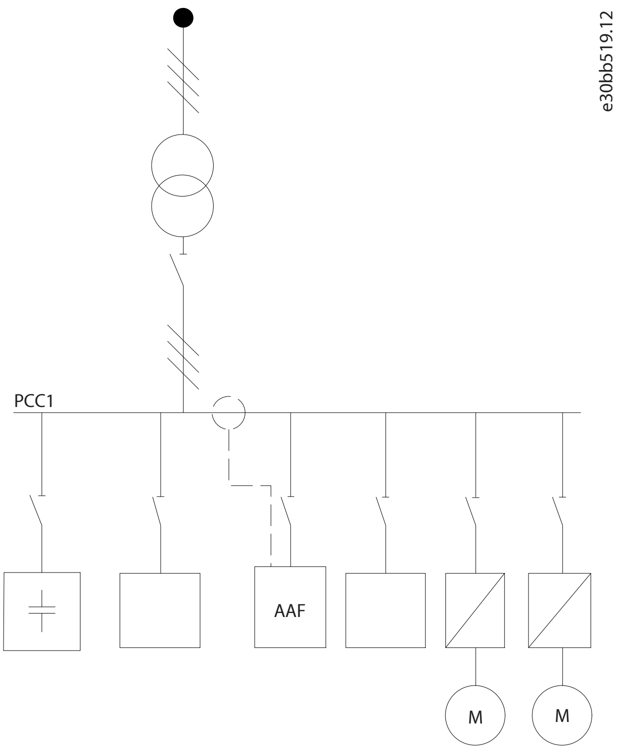


Figure 27: Current Transformers do not Measure Capacitor Current

For installations where the current transformer connection point can be moved, the configuration shown in Figure 27 is also possible. In some retrofit applications, summation current transformers are needed to ensure that the capacitor current is not measured. Summation current transformers can also be used to subtract 2 signals from each other and so subtract the capacitor-bank-corrected current from the total current.

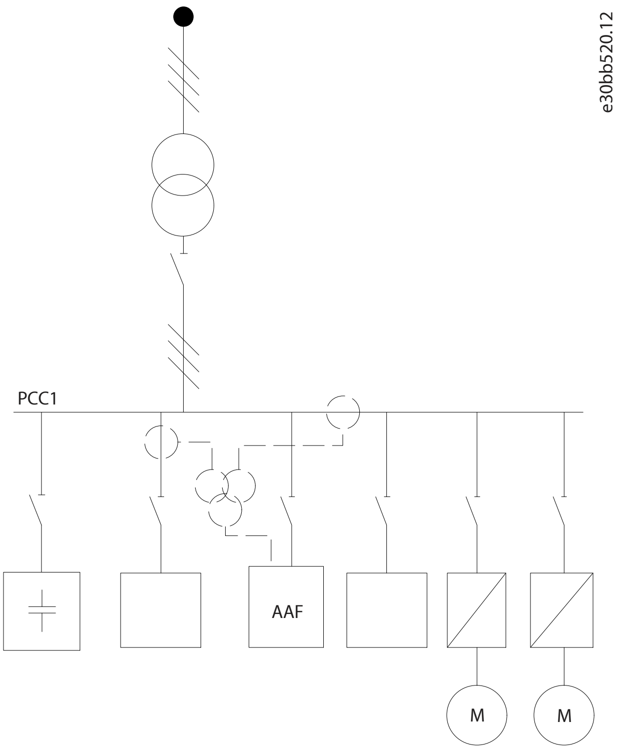


Figure 28: Capacitor Bank Mounted on PCC

In the previous illustration, current transformers ensure that the capacitor-corrected current is not measured.

8 Basic Operation and Applications

8.1 PC Tool

The Advanced Active Filter AAF 007 Setup tool is available in the MyDrive® Suite. The tool can be used for commissioning of the filter and for monitoring of current and grid voltages of the filter or connected load and grid. The tool is a freeware that requires a user name and a password to be able to log in. As the access data may change with versions of the tool, consult the README file in the zip file of the tool to retrieve user and password information.

The tool helps to understand the actual status of the filter and gives access to the error log.

Extract the downloaded *.zip folder to a non-temporary folder on the computer to make it fully executable. Some machines require administrative privileges to execute successfully.

To use the PC tool with the filter, use the RS485 connections on the filter and connect to the PC, possibly via the USB converter. Grounding is required when the cable way exceeds 1 m (3.28 ft) to avoid degraded performance of the communication.

NOTICE

To confirm entered values, press *Enter*.

8.1.1 Logging in and Connecting to Filter

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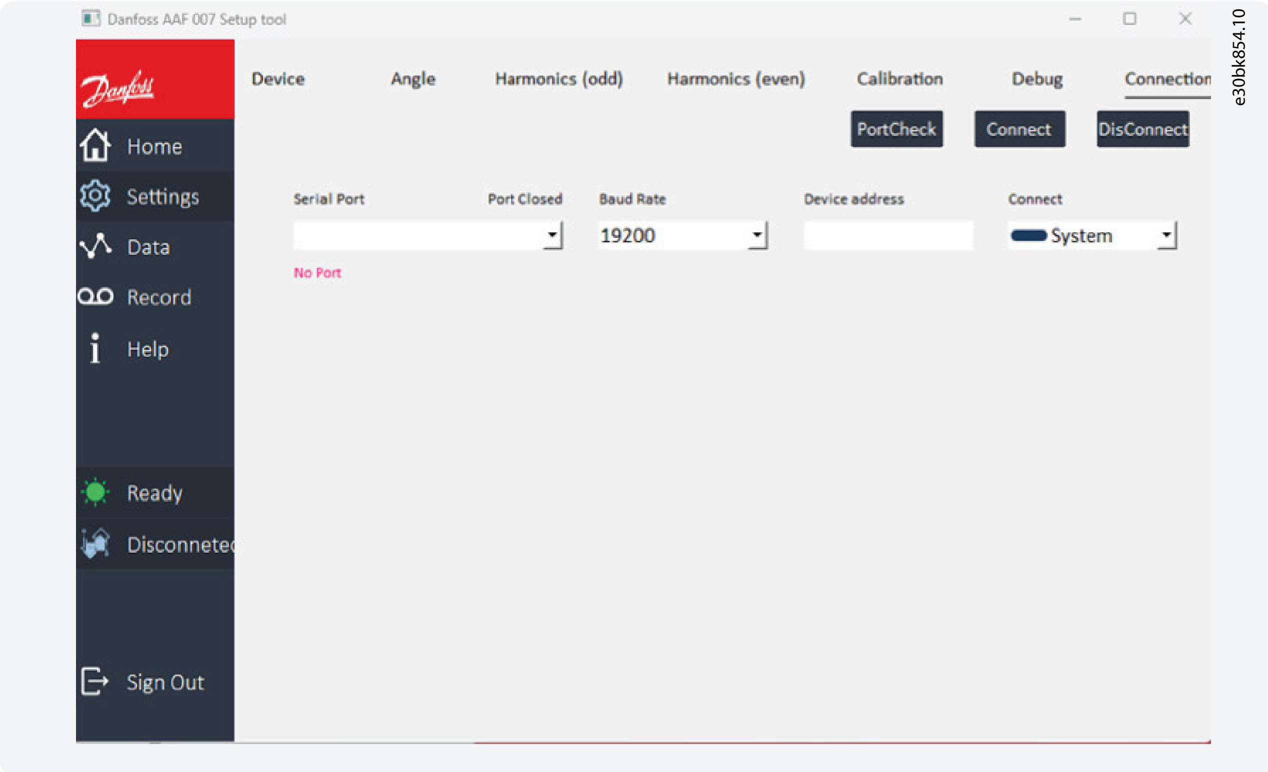
Figure 29: Welcome Screen

1. On the Welcome screen, enter user name and password.
2. Click *Log in*.

The screen for connecting to the filter appears.



3. Click *PortCheck*.
4. In the field *Serial Port*, enter the relevant port number.
5. In the field *Baud Rate*, enter the value 19200.
6. In the *Connect* field, select *System* or *Individual filter module*.
7. Click the *Connect* button.
8. Verify that the status on the side bar changes from *Disconnected* to *Connected*.

8.1.2 Connection - Parallel Setup

The Advanced Active Filter AAF 007 filters rated >150 A are constellations of parallel modules. When ordered this way, the filter modules are set for parallel operation by factory. Settings for the filter can be changed on system level. If the compilation of active filters is changed, it can be necessary to reconfigure the parallel setup.

Changes done on system level result in changes on all connected filter modules. Changes done in 1-16 result in changes on the equivalent filter module with the corresponding Modbus address 1-16. The limit of 8 modules in parallel is based on the burden of the current transformers and the belonging cables, even though the communication ports allow configuration of a system with 16 modules.

To run the filter modules in parallel, all filter modules must be set to the correct total compensation current connected, refer to 8.1.4.1 Settings - Device.

Example

AAF-0073B04-220AE20 is an active filter with 220 A compensation current. It is a compilation of 4 x AAF-0073B04-55A0E20. The total parallel total compensation current is 220 A.

This setting can be done in system mode and will be distributed to all modules.

8.1.2.1 Configuring the Modbus Address

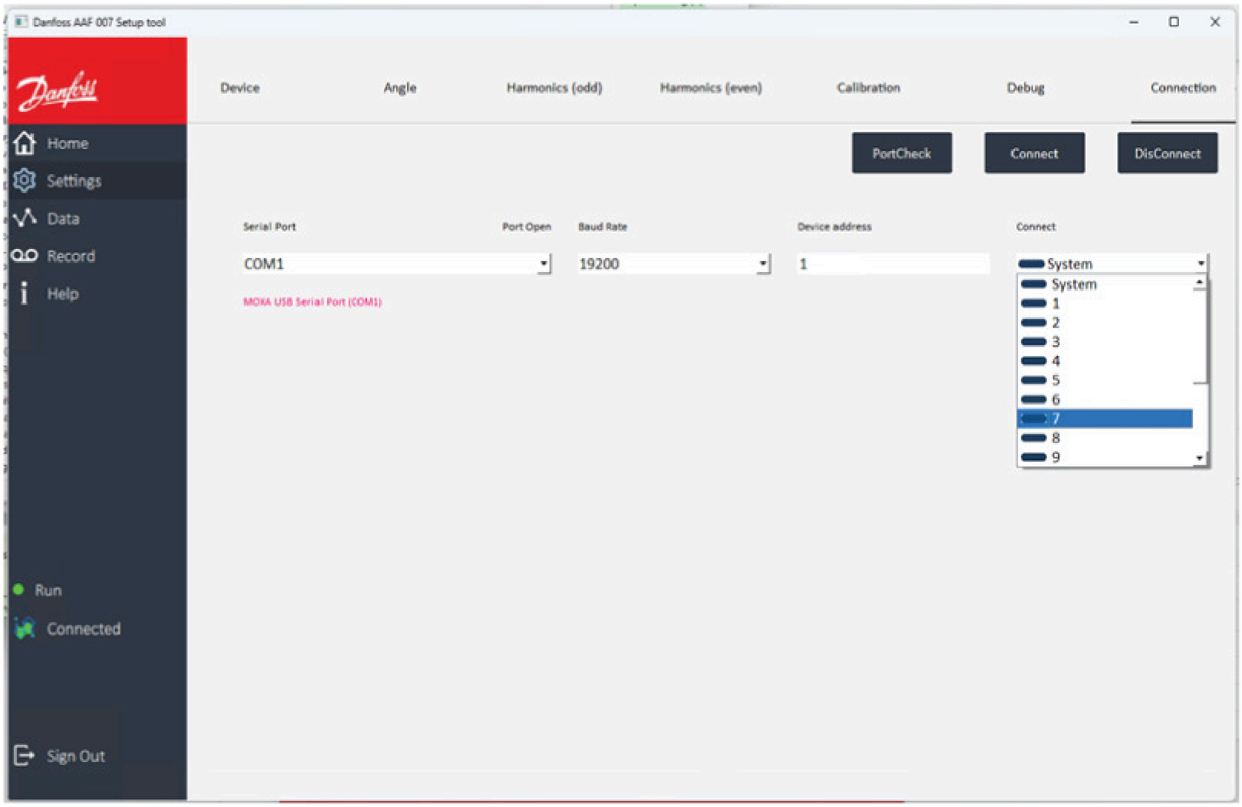


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Figure 30: Selection of Filter Module and Address

1. Connect the RS485 connector to device 1 in the setup (no other filter modules may be connected).
2. Connect to the filter as described in 8.1.1 Logging in and Connecting to Filter.
3. Add *1* in the *Device address* field and press *Enter*.
4. Disconnect the RS485 connector from device 1.
5. Connect the RS485 connector to device 2 in the setup (no other modules may be connected).
6. Connect to the filter as described in 8.1.1 Logging in and Connecting to Filter.
7. Add *2* in the *Device address* field and press *Enter*.
8. Proceed with this procedure for the required number of parallel units.

All filter modules can now be connected via RS485 connection. Individual filters can be addressed by using the filter selection menu.

8.1.3 **Home Page**

The HOME page shows an overview of system values, such as:

- Voltage
- Grid power
- Grid current
- Load current

Besides the *Run* and *Shut down* buttons for starting and stopping the filter, the *Clear fault* button is available for clearing faults.

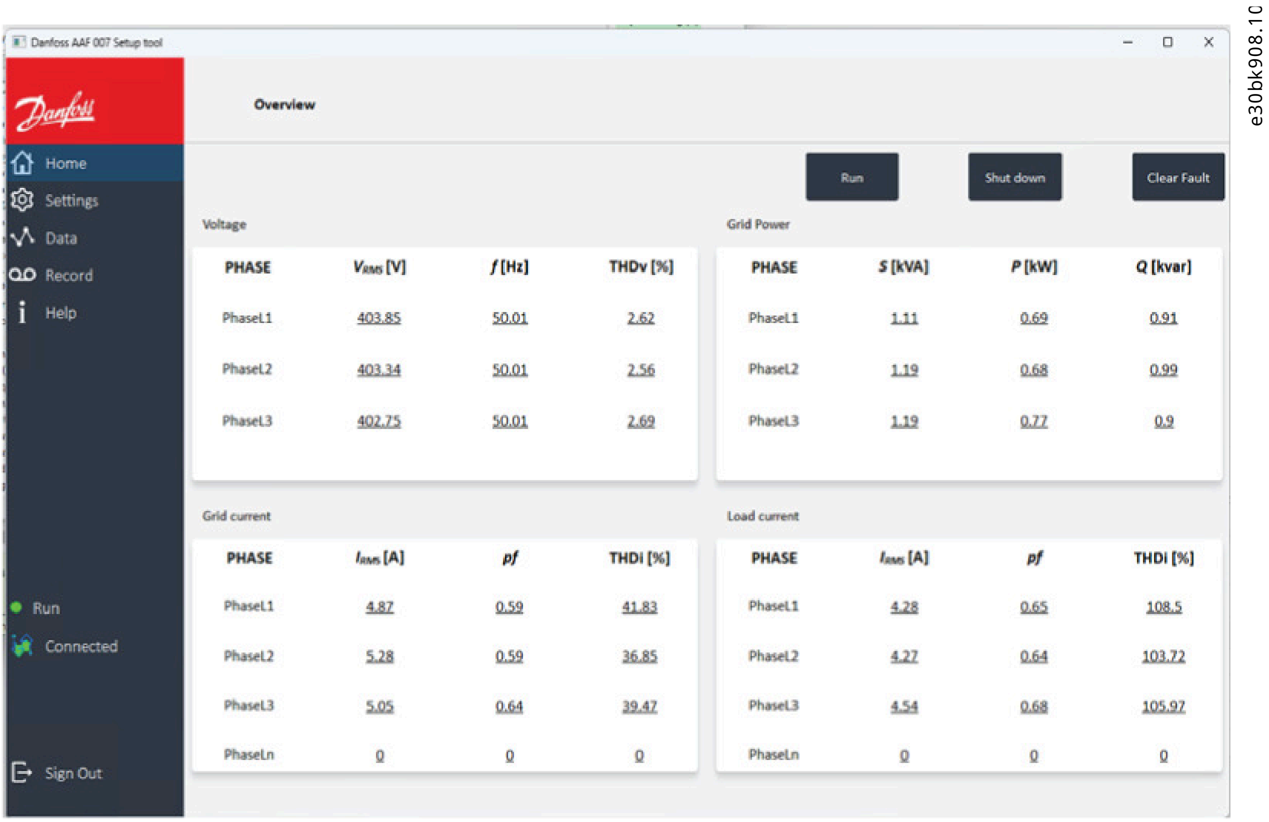

Figure 31: HOME Screen of the PC Tool

8.1.4 Parameter Settings

On all settings pages, the following functions are available:

- Start the filter with the *Run* button.
- Stop the filter with the *Shut down* button.
- Upload and download the parameter set for the settings.

The parameter sets, which are up- or downloaded as CSV files, cover all settings of the filter, not just the settings of the respective page.

8.1.4.1 Settings - Device

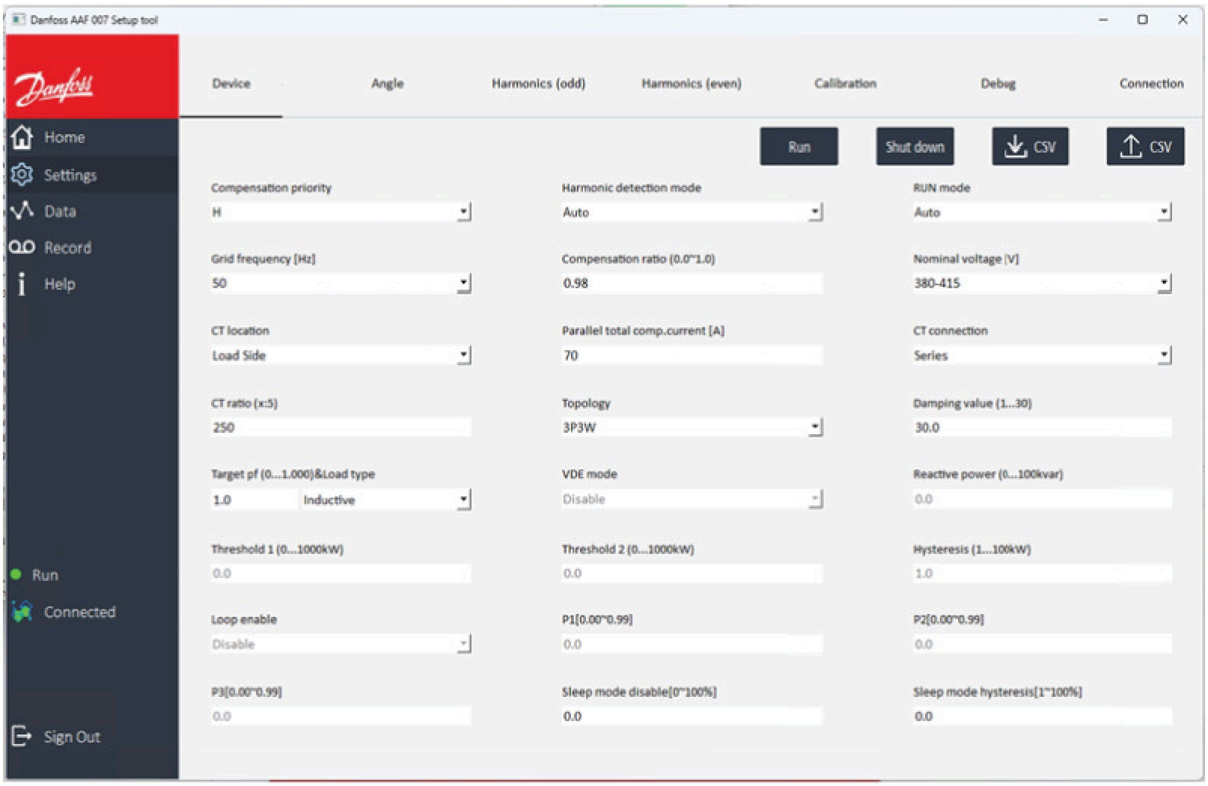

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Figure 32: Device Settings

Table 21: Overview of Settings and Selections on the Device Settings Page

Setting	Selection/value range	Factory default
Compensation priority	H. Harmonic mitigation only. HR: Harmonic mitigation and fundamental reactive current compensation (Priority Harmonic mitigation) HRU: Harmonic mitigation, fundamental reactive current compensation, and current unbalance (Harmonic mitigation 1st priority, fundamental reactive current compensation 2nd priority) R: Fundamental reactive current compensation only RU: Fundamental reactive current compensation and current unbalance mitigation (Priority: Fundamental reactive current compensation) RH: Fundamental reactive current compensation and harmonic mitigation (Priority: Fundamental reactive current compensation) Self-Aging: Used only for factory testing/troubleshooting.	H
Harmonic detection mode[(1)]	This parameter changes the algorithm of the harmonic compensation mode. Preferred mode: Auto mode. Auto: Searching for optimum settings range, best for resonance detection. Individual settings for individual harmonics will be used as maximum values. Manual: Exact settings in accordance to the individual harmonics settings Completely: Mitigates all harmonics independent of the individual harmonics settings	Auto
RUN mode	Auto: Starting automatically, when mains is powered on. Manual: The filter requires a command via PC software, command via Modbus, or digital input.	Auto
PFC capacitance	Use this setting if the AAF is used together with passive filters. In this mode, the AAF controls the additional passive PFC equipment. The value entered corresponds to the individual capacity of the passive PFC circuit in µF.	N/A

Table 21: Overview of Settings and Selections on the Device Settings Page - (continued)

Setting	Selection/value range	Factory default
Grid frequency [Hz]	Setting of fundamental grid frequency. Will be automatically detected by the software. Can be adjusted or corrected manually. Will be reset with every restart.	N/A
Compensation ratio	Limitation of harmonic current to give reactive power more priority in HR and HRU mode.	~1
Nominal voltage	Setting of mains voltage. Will be automatically detected by the software. Can be adjusted or corrected manually. Will be reset with every restart.	N/A
CT location	Grid side: Closed-loop control. Load side: Open-side control.	Load side
Parallel total comp. current	Current of the filter/system that is sharing 1 set of current transformers.	Value of ordered filter
CT connection	Not relevant when current transformers are connected to only 1 filter module of 35 A or 55 A. When the current transformer signal is looped through multiple modules, it should be set to "series".	Series
CT ratio	Primary current rating of connected current transformer. If more summation current transformers are used, the ratio might change, for example, the value must be doubled.	If current transformers are ordered as part of the filter, the respective value will be preset.
Topology	3P4W: 3-phase 4-wire system. The neutral wire must be connected and current transformers on all 3 phases must be present. 3P3W: 3-phase 3-wire system. The neutral must not be connected and current transformers are only needed on phases 1 and 3.	3P3W
Damping value	Damping of current controller. Recommended: • 10 for 4W system. • 30 for 3W system. • 20 for 3P3W system with EC fan or slim DC bus drive spectrum. Lower value corresponds to less damping in the compensation.	30
Target PF	Displacement factor/cosphi, can be set negative or positive.	1
Loop enable	Needs to be enabled for closed loop operation.	Disable

Table 21: Overview of Settings and Selections on the Device Settings Page - (continued)

Setting	Selection/value range	Factory default
P1	When 'Loop enable' is set to 'Enable', set this parameter to 0.95. When 'Loop enable' is set to 'Disable', set this parameter values to 0.3<P1<0.6 only if there is resonance where the filter struggles to run and keep tripping on 'Inverter Current Error'. Usage of this parameter helps to improve the stability of the filter. Do not use to improve the THDI.	0
P2	When 'Loop enable' is set to 'Enable', set this parameter to 0.99.	0
P3	When 'Loop enable' is set to 'Enable', set this parameter to 0.99.	0
Sleep mode disable	RUN mode needs to be "Auto". The setting for sleep mode shall be done on system level and not for individual modules. Entry range is from 0 to 100. The value relates to the primary current of the CT ratio settings and is compared to the actual measured load current, as the decision to leave sleep mode and start the filter. For example, the CT primary current is 500 A and the "sleep mode disable" is "20", the filter starts operation when the measured load current > 100 A.	0%
Sleep mode hysteresis	RUN mode needs to be "Auto". The setting for sleep mode shall be done on system level and not for individual modules. Entry range is from 0 to 100. The value relates to the primary current of the CT ratio settings and is compared to the actual measured load current, as the decision to enter sleep mode. The value must be < sleep mode disable. For example, the CT primary current is 500 A and the "sleep mode hysteresis" is "15", the filter stops operation when the measured load current < 100 A.	0%
High-Speed RS-485	Disable	Disable

1) Detailed description in section 8.1.4.1.1.

8.1.4.1.1 Settings - Harmonic Detection Modes

The menu *Settings⇒Device* offers 3 harmonic detection modes:

- Auto
- Completely

- Manually

The selection of the harmonic-detection mode has an impact on the effect of the settings for the harmonics (odd and even) and for the angle.

In the sub-menus *Angle* and *Harmonic (odd/even)*, detailed settings for the harmonic compensation can be done. This can be required, if the filter is not running optimally due to various external factors like poor current transformer signals, local resonances in the mains, or high predistortion on the mains.

A power meter might be required to determine the phase angle displacement on certain frequencies and for spectrum analysis where resonances occur.

The values of the *Harmonics* and *Angle* settings are used in the controller in the modes *Auto* and *Manually*. In *Completely* mode, these settings are not relevant for the controller.

Table 22: Harmonic Detection Modes

Mode	Description	Example
Auto	In this mode, the actual individual values are never exceeding the set maximum compensation rate. The auto algorithm dynamically adjusts the compensation current for different situations (for example, resonances) but does not exceed the maximum compensation rate.	Compensation rate 5th Harmonic is set to 1.0 Compensation rate 7th Harmonic is set to 0.8 5th Harmonic is compensated with maximum 100% in accordance to the measured value. 7th Harmonic is compensated with maximum 80% of the measured value. During this mode, the resonance detection is active. Local resonance frequencies – evaluated during commissioning - should be set to a significant lower value within the individual harmonic settings.
Completely	The individual harmonic settings are *not* active. All values are set to 1. All Harmonics are compensated in accordance to measured(1) current values. Individual fine-tuning is not possible.	Compensation rate 5th Harmonic is set to 1.0 Compensation rate 7th Harmonic is set to 0.8 5th Harmonic is compensated with maximum 100% in accordance to the measured(1) value. 7th Harmonic is compensated with maximum 100% in accordance to the measured(1)value.
Manually	In this mode, the actual individual values are corresponding to the exact compensation rate. In this mode, there is no dynamic adjustment of the current.	Compensation rate 5th Harmonic is set to 1.0 Compensation rate 7th Harmonic is set to 0.8 The filter aims to compensate 5th Harmonic completely in accordance to the measured(1) value. The filter aims to compensate 80% of the measured(1) 7th Harmonic.

1) When closed-loop mode is used (current transformers on the grid side), the harmonic currents on the load side are calculated based on the external measurements and the internal measurements of the filter.

8.1.4.2 Settings - Harmonic (Odd/Even)

The filter injects harmonics of the same amplitude as the measured value in counterphase. The deviation between the measured value and the injected valued can be adjusted in the *Harmonic (odd/even)* menu.

Values are referring to a factor of the individual harmonic amplitude (1.05 corresponds to a compensation of 105%). This setting is used to fine-tune the performance of the filter. These settings can be changed during operation of the filter. The valid range for settings is 0.0–1.1.

NOTICE

Even order harmonics may be caused by unbalance in the load. For symmetrical load, compensation of the even order harmonics should not be required and settings of 0.00 is recommended.

8.1.4.2.1 Settings - Harmonic Fine-tuning

To achieve the best possible performance, fine-tuning of individual harmonics is recommended.

1. Install PQ-Analyzer upstream of the AAF 007.
2. Start the filter and view the result in bar-graph mode.
3. Identify the harmonic with the largest harmonic content on PQ-Analyzer.
4. Add +0.01 to the corresponding harmonic value in the PC tool.
5. Review the result:
   a. If harmonic content is less than before, repeat step 6.
   b. If harmonic content is higher, insert the previous value and move to step 8.
6. Add +0.01 to the corresponding harmonic value in the PC tool.
7. Review the result:
   a. If harmonic content is less than before, repeat step 6.
   b. If harmonic content is higher, insert the previous value and move to step 12.
8. Add -0.01 to the corresponding harmonic value in the PC tool.
9. Review the result:
   a. If harmonic content is less than before, move to step 10.
   b. If harmonic content is higher, insert the previous value and move to step 12.
10. Add -0.01 to the corresponding harmonic value in the PC tool.
11. Review the result:
    a. If harmonic content is less than before, repeat step 10.
    b. If harmonic content is higher, insert the previous value and move to step 12.
12. Review the overall harmonic spectrum and THD.
    a. Are the values within the specification, the commissioning is finalized.
    b. Are the individual harmonics or THD outside the specifications, move to step 13.
13. Repeat steps 4–11 with harmonic order containing the next highest harmonic content.

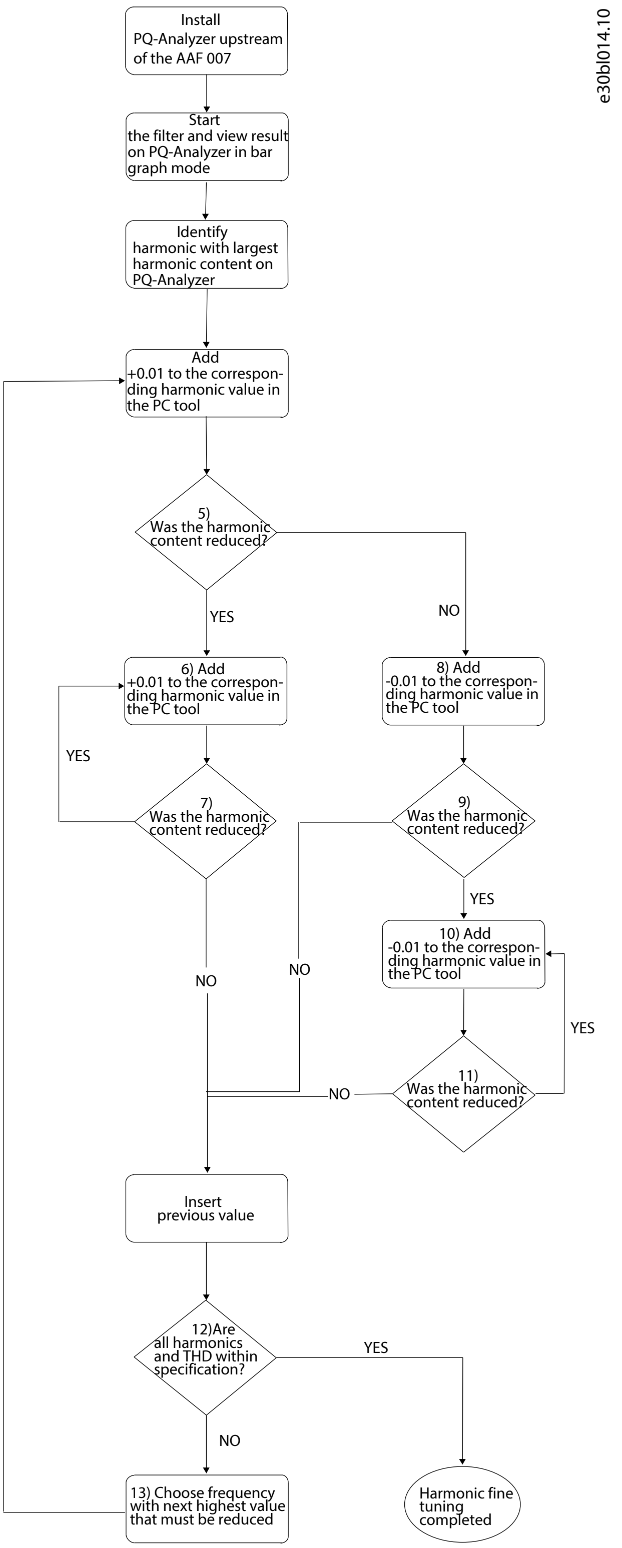


Figure 33: Flowchart of Harmonic Fine-tuning

8.1.4.3 Settings - Angle

The Advanced Active Filter AAF 007 is injecting harmonics of opposite angle compared to the measured value. Deviation between the measured value and the injected value can be adjusted in the *Angle*settings. Values are referring to degree (2.20 corresponds to an offset of 2.2°). Negative values are possible. These settings can be changed during operation.

Adjustments of fundamental or specific frequencies across phases will be accumulated to settings that made for specific phases (L1, L2, or L3).

Fundamental angle	Angle offset of fundamental angle compensation.
Phase A angle	Angle offset of complete signal measured via L1.
Phase B angle	Angle offset of complete signal measured via L2.
Phase C angle	Angle offset of complete signal measured via L3.
3rd angle	Angle offset of 3rd harmonic for L1–L3.
n angle	Angle offset of n harmonic for L1–L3.
25th angle	Angle offset of 25th harmonic for L1–L3.

NOTICE

- Avoid entering the value "-0.1" in any angle parameter.

8.1.4.4 Settings - Calibration

On the *Calibration* page, measurement values of the filter on voltages and currents can be adjusted if an offset is observed or wanted. The entered numbers are represented as RMS value.

When entering the *Calibration* page, no live data from the filter is shown, only the entered value is visible.

To change as specific value, enter the actual RMS value determined by an external measurement device in the field and press *Enter*.

8.1.4.5 Settings - Debug

The *Debug* page can give information on different Modbus RTU addresses. This page is reserved for factory use only.

8.1.4.6 Settings - Connection

Port check	Checks for available RS485 devices.
Connect	Connects the PC SW to the AAF 007 if settings are correct.
Disconnect	Disconnects the PC SW to the AAF 007.
Serial port	Shows available RS485 devices. Select the device corresponding to the RS485-USB connector.
Baud rate	Different baud rates are available. Select 19200.
Device address	Setting for individual Modbus address of the AAF 007.
Connect (dropdown menu)	Selecting between individual AAF 007 filters or system level. At system level, several parallel filters act as 1 device.

A connection procedure is described in 8.1.1 Logging in and Connecting to Filter.

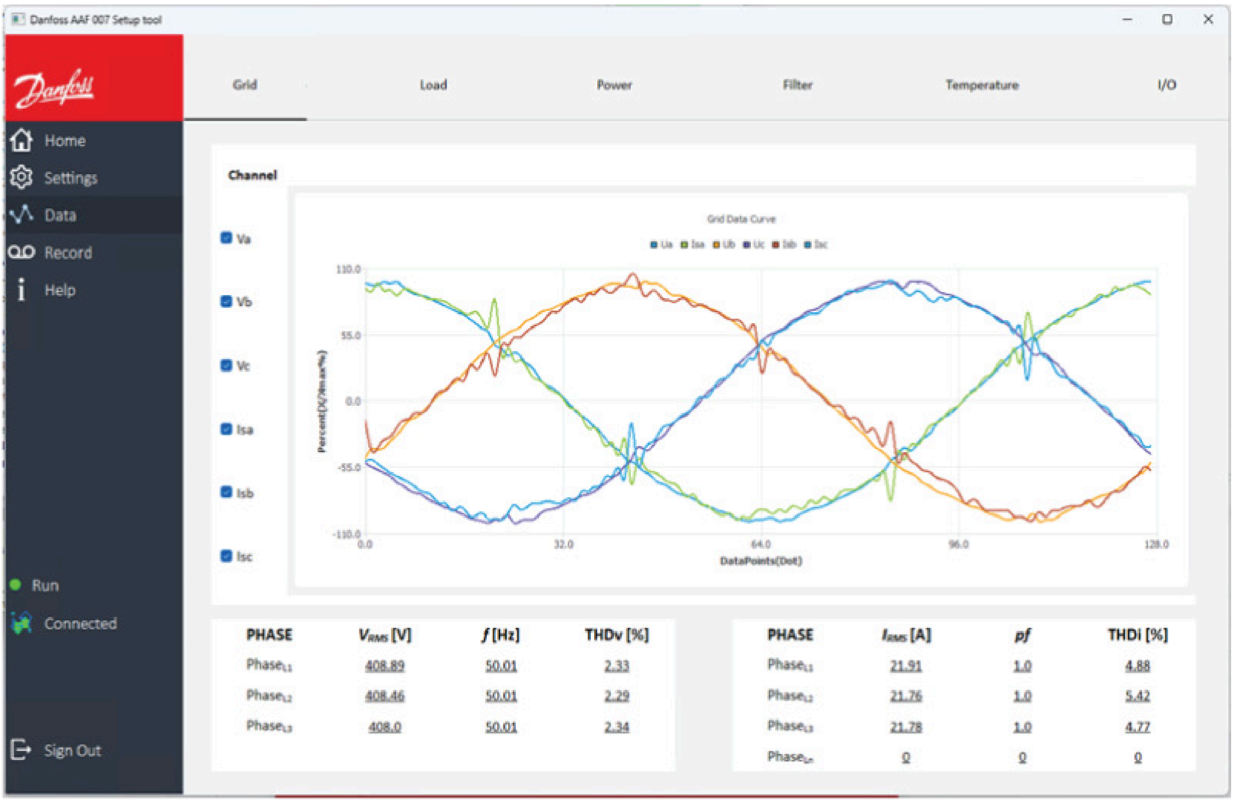
8.1.5 Data

In the *Data* menu, information about the filter and the connected mains can be shown.

8.1.5.1 Grid

On the *Grid* page, voltage and current waveforms of the grid side can be shown. To enable or disable the individual current and voltage, use the check marks on the left side of the page.

In this view, the correct sequence of the voltages can be checked. By enabling current and voltage pairwise, it can also be investigated if the current transformers are mounted on the correct phase. If the current waveform is 180° shifted to the corresponding voltage, the polarity of the current transformer is probably wrong. If so, change either the direction of the primary current through the current transformer core or change the connection of the secondary current connection.



e30bk911.10

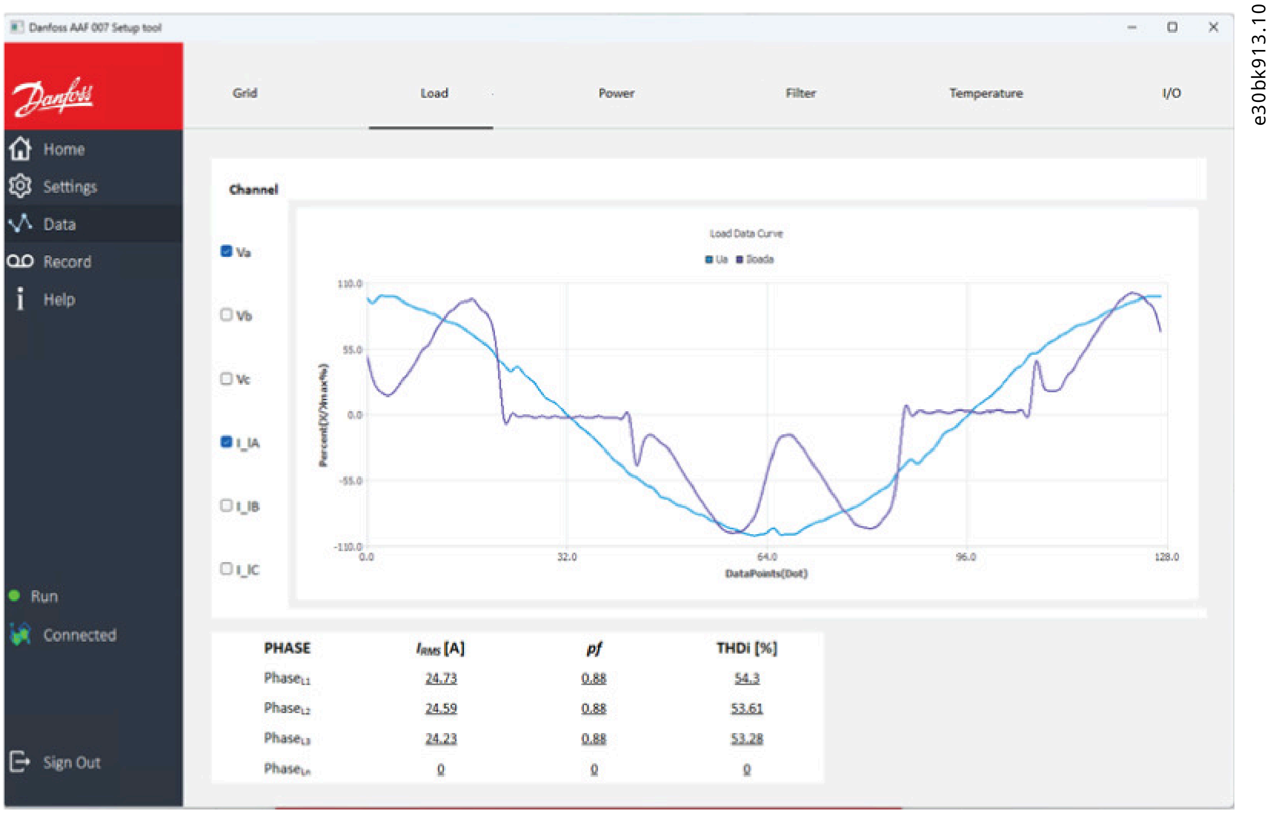
Figure 34: Grid Voltages and Currents

NOTICE

When current transformers are installed on the load side, there are no measurements of the grid-side current. The grid-side current should only be considered as approximation of the true current waveform.

8.1.5.2 Load

On the *Load* page, voltage and current waveforms of the load side can be shown. This individual current and voltage can be enabled and disabled using the checkmarks on the left side of the screen.



PHASE	I_{RMS} [A]	pf	THDi [%]
$Phase_{L1}$	24.73	0.88	54.3
$Phase_{L2}$	24.59	0.88	53.61
$Phase_{L3}$	24.23	0.88	53.28
$Phase_{Ln}$	0	0	0

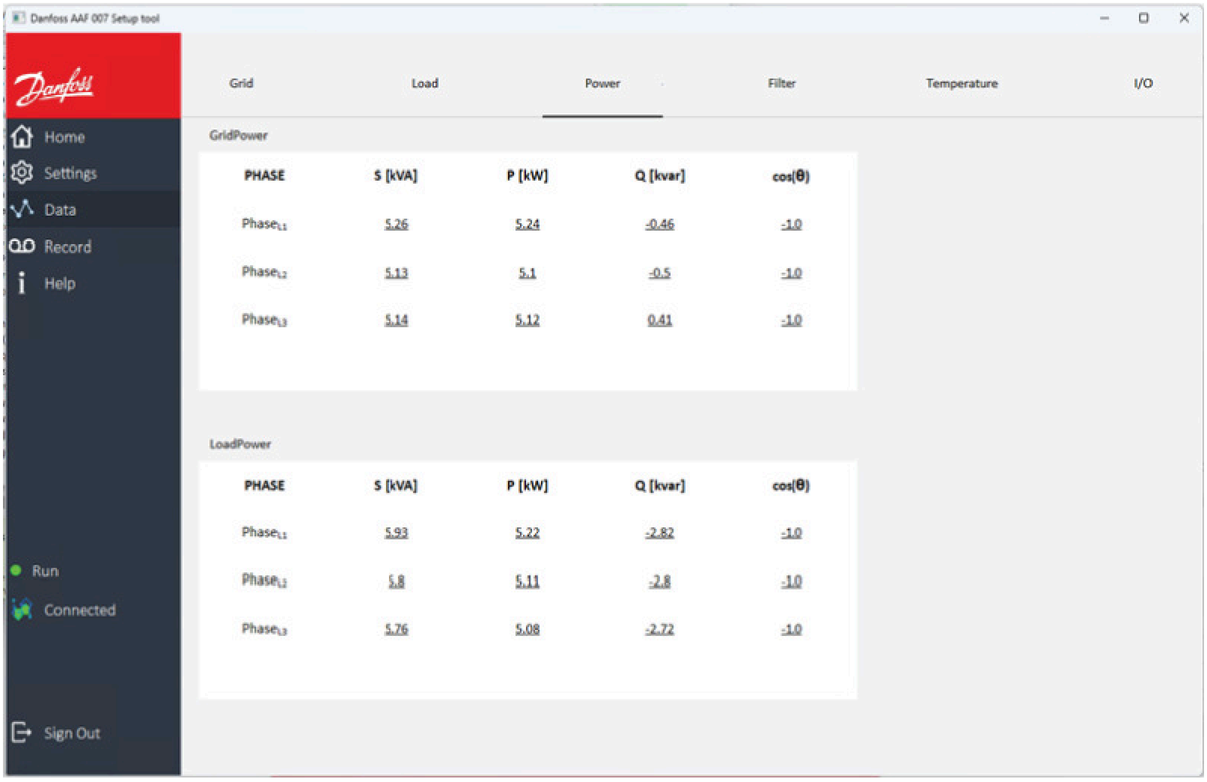
Figure 35: Load Voltages and Currents (Only Phase A Visualized)

NOTICE

When current transformers are installed on the grid side, there are no measurements of the load-side current. The load-side current should only be considered as approximation of the true current waveform.

8.1.5.3 Power

The *Power* page shows the load-side and grid-side apparent power, active power, reactive power, and cos(φ) (displacement factor).



e30bk914.10

Figure 36: Power Data Overview

NOTICE

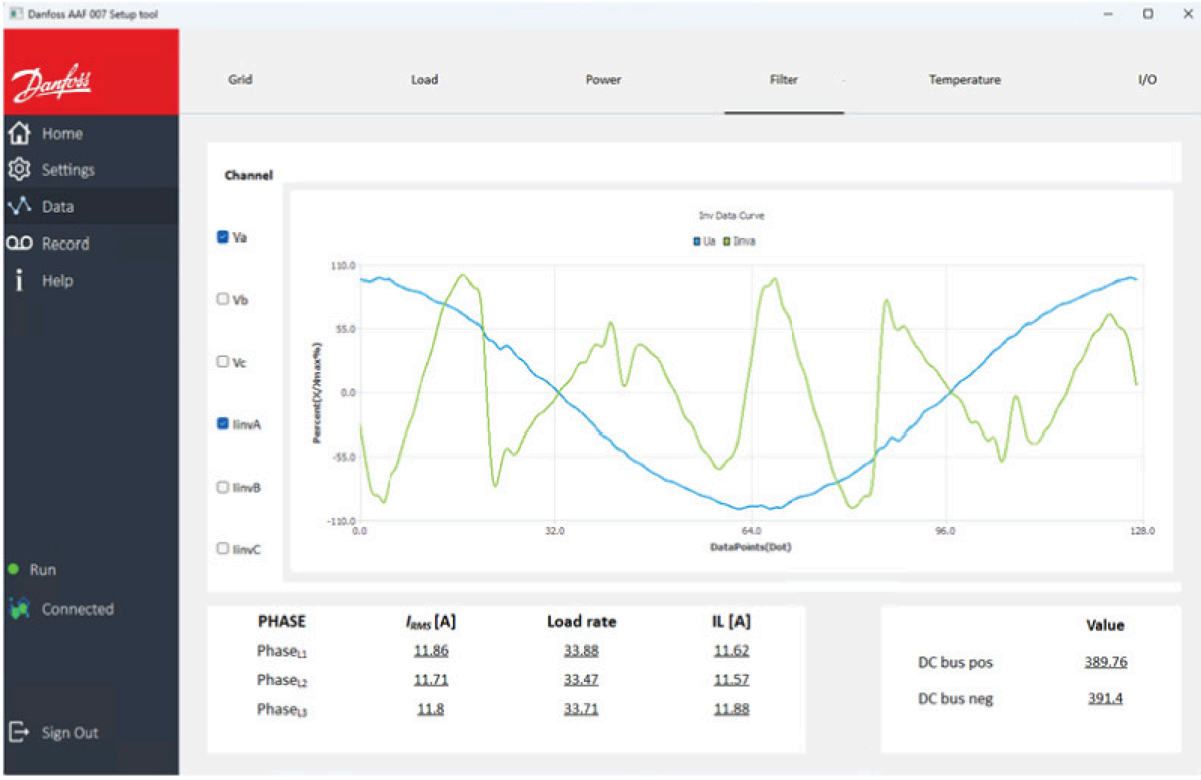
For current transformers on the load side, there are no measurements of the grid-side current. The values for the grid side should be considered as approximation only.

NOTICE

For current transformers on the grid side, there are no measurements of the load-side current. The values for the load side should be considered as approximation only.

8.1.5.4 Filter

On the *Filter* page, the voltage and current waveforms of the filter can be visualized. The individual current and voltage can be enabled and disabled using the checkmarks on the left side of the screen. This page also shows the DC-bus voltage which can be used to indicate errors.

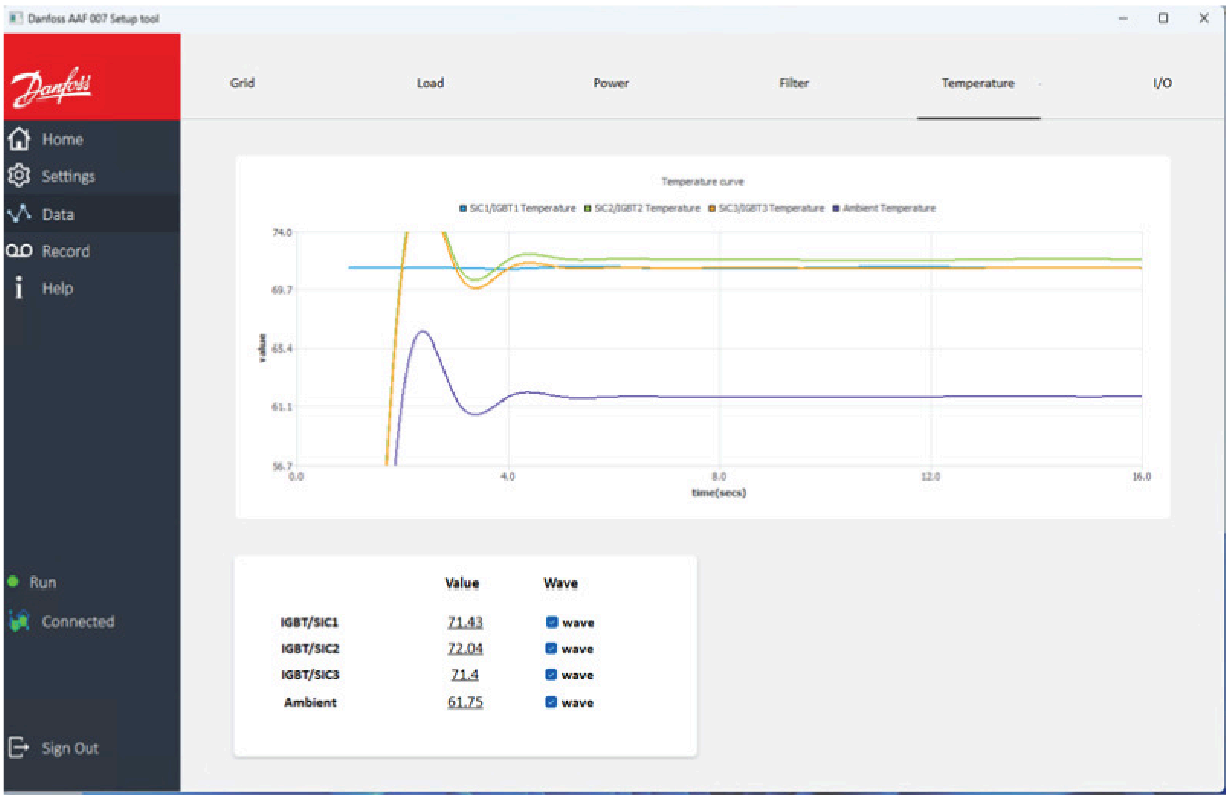


e30bk915.10

Figure 37: Filter Currents and Voltages (Phase A)

8.1.5.5 Temperature

The Temperature page shows the individual temperatures of the SiC switching components together with the ambient temperature.



e30bk917.10

Figure 38: Temperature Values of Switching Devices in the Filter

8.1.5.6 I/O

The *I/O* page shows the status of the input and output relays. The function of the output relays can be changed in these settings. The output relay is suitable for 2 A/500 V AC or 3 A/30 V DC. The input signal is considered low for 0–3 V and high for 10–24 V.

Table 23: I/O

<table>
<tr><th>Relay</th><th>Description</th></tr>
<tr><td>NO1 (dropdown 1)</td><td>Default Setting: Fault
Fault State: NO1 relay opens in case of alert or power failure.
Threshold 1: NO1 relay closes when the power threshold set in parameter "threshold 1" is reached. It is used for hybrid harmonic filter.
.</td></tr>
<tr><td>NO2 (dropdown 1)</td><td>Default Setting: Run
Run: This signal to be used in combination with NO1- Fault signal in accordance to the below table:
<table>
<tr><th></th><th>NO1 - fault</th><th>NO2 - Run</th></tr>
<tr><td>Power failure</td><td>0</td><td>0</td></tr>
<tr><td>Standby</td><td>1</td><td>1</td></tr>
<tr><td>Run</td><td>1</td><td>0</td></tr>
<tr><td>Failure</td><td>0</td><td>1</td></tr>
</table>
Threshold 2: NO2 relay closes when the power threshold set in parameter "threshold 2" is reached. It is used for hybrid harmonic filter.</td></tr>
<tr><td>Input1–IN1</td><td>This signal is used for controlling the filter operation (RUN)
Low: Shut down.
High:Turns unit into run.
This function is only active for run mode: Manually.</td></tr>
<tr><td>Input2–IN2</td><td>For different grid conditions, different parameter settings are used. For example, Generator during power shut down.
Low: Primary parameters are set.
High: Secondary parameters are set.
To set secondary parameters, the input must be high during setup. Do not change the settings during operation of the RHF-Active (shut down)</td></tr>
<tr><td>RSVD1</td><td>Reserved for future purpose.</td></tr>
<tr><td>RSVD2</td><td>Reserved for future purpose.</td></tr>
</table>

8.1.6 Record

The *Record* page shows all ongoing and cleared alerts. Cleared alerts are only stored in the PC software. Disconnecting from the device result in loss this stored data.

For further information on the shown messages, refer to 10.3 Fault Finding and Troubleshooting.

8.2 Modbus Setup

8.2.1 Introduction

Modbus is a communication protocol on application layer, which is currently widely spread for industrial controls and is close to being a de-facto-industrial standard.

This chapter describes the implementation of Modbus communication protocols in the AAF 007 product series. The communication starts the answer mode, the host initiates the request, and the follower performs the request and answers.

This chapter does not describe the standard specification of the Modbus communication protocol. Detailed information is in the standard specification of Modbus RTU communication protocol.

8.2.2 Base Protocol

The base protocol is standard Modbus RTU. Asynchronous String protocol UART is applied with 19200 baud. The transmission mode is asynchronous and half duplex, there is 1 start bit, 8 data bits, no parity, and 1 stop bit.

8.2.3 Data Types

The storage format of integer values is 2 bytes. First transmit the high-byte D15 ~ D8, then transmit the low-byte D7 ~ D0.

The storage format of floating-point values is 4 bytes. The IEEE32-bit standard-floating-point format (standard-C-language format) is used. The transmission order is as follows: high-byte D31 ~ D24, then D23 ~ D16, then D15 ~ D8, and finally low-byte D7 ~ D0.

8.2.4 Communication Mode

After sending the host request, wait 100 ms for the answer from the follower. If no answers or wrong answers are received within this time, the communication process has failed.

8.2.5 Definitions of the Application-layer Packaged Data/Frame Format

8.2.5.1 Checksum

The check uses a 16-bit CRC check (2 byte). The whole information is used for the check. The content of CRC is calculated by the help of the cyclic redundancy recognition process. The content of CRC is added to the end of the information, starting with the low-byte followed by the high-byte.

8.2.5.2 Supported Function Codes

It is only possible to read data from the filter via Modbus RTU.

Table 24: Supported Function Codes

Function code	Function description
02	Read status and alarm of the unit.
03, 04	Read of analog values, waveform data (curve, histogram), and manufacturer information.

8.2.5.2.1 Function Code 02

Table 25: Requested Format

Format	Address	Function code	Status of start address high byte	Status of start address low byte	Number of status bits high byte	Number of status bits low byte	Checksum
Number of bytes	1	1	1	1	1	1	2

The address range of the unit is 0–247, 0xff is the broadcast address, and the standard address is 1.

Table 26: Response Format

Format	Address	Function code	Number of bytes	Data	Cheksum
Number of bytes	1	1	1	…..	2

8.2.5.2.2 Function Code 03, 04

Table 27: Requested Format

Format	Address	Function code	Register start address - high byte	Register start address - low byte	Number of registers high byte	Number of registers low byte	Checksum
Number of bytes	1	1	1	1	1	1	2

Table 28: Response Format

Format	Address	Function code	Number of bytes	Data	Checksum
Number of bytes	1	1	1	…..	2

Number of bytes = Number of registers X 2.

8.2.6 Detailed Command/Answer Information

For AAF 007, data is sent in segments. Data in 8.2.6.1 Read of Status and Alarm of the Unit is sent in 1 single segment until 0x0024 once the register 0x0000 is addressed. Data in 8.2.6.2 Read of AAF 007 Analog Values is sent according to the following table.

Segment number	Start address
1	0x0000
2	0x0024
3	0x0048
4	0x006C
5	0x0090

8.2.6.1 Read of Status and Alarm of the Unit

Table 29: Function Code 02, Status Start Address = 0x0000

Status address	Number of bits	Name	Remark	Data attributes
0x0001	1	Operational state	0: standby. 1: operation.	–
0x0002	1	Reserved	–	–
0x0003	1	Reserved	–	–
0x0004	1	Reserved	–	–
0x0005	1	Reserved	–	–
0x0006	1	Reserved	–	–
0x0007	1	Reserved	–	–
0x0008	1	Reserved	–	–

Table 29: Function Code 02, Status Start Address = 0x0000 - (continued)

Status address	Number of bits	Name	Remark	Data attributes
0x0009	1	Reserved	–	–
0x000A	1	Reserved	–	–
0x000B	1	Reserved	–	–
0x000C	1	Reserved	–	–
0x000D	1	Reserved	–	–
0x000E	1	Reserved	–	–
0x000F	1	Reserved	–	–
0x0010	1	IO output 1	0: low level 1: high level	–
0x0011	1	IO output 2	0: low level 1: high level	–
0x0012	1	IO output 3	0: low level 1: high level	–
0x0013	1	IO output 4	0: low level 1: high level	–
0x0015	1	IO output 5	0: low level 1: high level	–
0x0016	1	Reserved	–	–
0x0017	1	Reserved	–	–
0x0018	1	Reserved	–	–
0x0019	1	Reserved	–	–
0x001A	1	Reserved	–	–
0x001B	1	Reserved	–	–
0x001C	1	Reserved	–	–
0x001D	1	Reserved	–	–
0x001E	1	Reserved	–	–
0x001F	1	Reserved	–	–
0x0020	1	Reserved	–	–
0x0021	1	Reserved	–	–
0x0022	1	Reserved	–	–
0x0023	1	Reserved	–	–
0x0024	1	Reserved	–	–
0x0025	1	Reserved	–	–
0x0026	1	Reserved	–	–
0x0027	1	Reserved	–	–
0x0028	1	Inverter short circuit	0: normal 1: abnormal	–

Table 29: Function Code 02, Status Start Address = 0x0000 - (continued)

Status address	Number of bits	Name	Remark	Data attributes
0x0029	1	Overcurrent	0: normal 1: abnormal	–
0x002A	1	Error supply voltage	0: normal 1: abnormal	–
0x002B	1	Fuse error	0: normal 1: abnormal	–
0x002C	1	Fan error	0: normal 1: abnormal	–
0x002D	1	Inverter overtempera-ture	0: normal 1: abnormal	–
0x002E	1	Inverter overtempera-ture	0: normal 1: abnormal	–
0x002F	1	Inverter overload	0: normal 1: abnormal	–
0x0030	1	System error	0: normal 1: abnormal	–
0x0031	1	Frequency error	0: normal 1: abnormal	–
0x0032	1	Voltage error	0: normal 1: abnormal	–
0x0033	1	Phase sequence error	0: normal 1: abnormal	–
0x0034	1	Control-firmware version wrong	0: normal 1: abnormal	–
0x0035	1	Controller error	0: normal 1: abnormal	–
0x0036	1	Device parament error	0: normal 1: abnormal	–
0x0037	1	Capacity error	0: normal 1: abnormal	–
0x0038	1	External power OFF	0: normal 1: abnormal	–
0x0039	1	DC difference value error	0: normal 1: abnormal	–
0x003A	1	Reserved	–	–
0x003B	1	U3Comm error	0: normal 1: abnormal	–
0x003C	1	Software version error	0: normal 1: abnormal	–

Table 29: Function Code 02, Status Start Address = 0x0000 - (continued)

Status address	Number of bits	Name	Remark	Data attributes
0x003D	1	Reserved	–	–
0x003E	1	Soft start error	0: normal 1: abnormal	–

8.2.6.2 Read of AAF 007 Analog Values

Table 30: Function Codes 03 and 04, Status Start Address = 0x0000

Register address	Number of bytes	Name	Unit	Data attributes
0x0000	4	Load current phase A	A	–
0x0002	4	Load current phase B	A	–
0x0004	4	Load current phase C	A	–
0x0006	4	Load current THDI phase A	%	–
0x0008	4	Load current THDI phase B	%	–
0x000A	4	Load current THDI phase C	%	–
0x000C	4	Load displacement factor phase A	–	–
0x000E	4	Load displacement factor phase B	–	–
0x0010	4	Load displacement factor phase C	–	–
0x0012	4	Inductor current phase A	A	–
0x0014	4	Inductor current phase B	A	–
0x0016	4	Inductor current phase C	A	–
00x0018	4	Mains apparent power phase A	kVA	–
0x001A	4	Mains apparent power phase B	kVA	–
0x001C	4	Mains apparent power phase C	kVA	–
0x001E	4	Mains active power phase A	kW	–
0x0020	4	Mains active power phase B	kW	–
0x0022	4	Mains active power phase C	kW	–
0x0024	4	Mains neutral current	A	–
0x0026	4	Load neutral current	A	–
0x0028	4	Mains current phase A	A	–

Table 30: Function Codes 03 and 04, Status Start Address = 0x0000 - (continued)

Register address	Number of bytes	Name	Unit	Data attributes
0x002A	4	Mains current phase B	A	–
0x002C	4	Mains current phase C	A	–
0x002E	4	Mains current THDI phase A	%	–
0x0030	4	Mains current THDI phase B	%	–
0x0032	4	Mains current THDI phase C	%	–
0x0034	4	Mains power factor phase A	–	–
0x0036	4	Mains power factor phase B	–	–
0x0038	4	Mains power factor phase C	–	–
0x003A	4	Temperature phase 1	°C	–
0x003C	4	Ambient temperature	°C	–
0x003E	4	Temperature 3 - not in use	°C	–
0x0040	4	Mains reactive power phase A	kVAr	–
0x0042	4	Mains reactive power phase B	kVAr	–
0x0044	4	Mains reactive power phase C	kVAr	–
0x0046	4	Mains displacement factor COSPHI phase A	–	–
0x0048	4	Mains displacement factor COSPHI phase B	–	–
0x004A	4	Mains displacement factor COSPHI phase C	–	–
0x004C	4	Load reactive power phase A	kVAr	–
0x004E	4	Load reactive power phase B	kVAr	–
0x0050	4	Load reactive power phase C	kVAr	–
0x0052	4	Compensation current phase A	A	–
0x0054	4	Compensation current phase B	A	–
0x0056	4	Compensation current phase C	A	–

Table 30: Function Codes 03 and 04, Status Start Address = 0x0000 - (continued)

Register address	Number of bytes	Name	Unit	Data attributes
0x0058	4	Compensation current utilization ratio phase A	%	–
0x005A	4	Compensation current utilization ratio phase B	%	–
0x005C	4	Compensation current utilization ratio phase C	%	–
0x005E	4	Temperature 4 - not in use	°C	–
0x0060	4	Temperature phase 2	°C	–
0x0062	4	Temperature phase 3	°C	–
0x0064	4	Load apparent power phase A	kVA	–
0x0066	4	Load apparent power phase B	kVA	–
0x0068	4	Load apparent power phase C	kVA	–
0x006A	4	Load active power phase A	kW	–
0x006C	4	Load active power phase B	kW	–
0x006E	4	Load active power phase C	kW	–
0x0070	4	Load displacement factor COSPHI phase A	–	–
0x0072	4	Load displacement factor COSPHI phase B	–	–
0x0074	4	Load displacement factor COSPHI phase C	–	–
0x0076	4	Mains voltage phase A	V	–
0x0078	4	Mains voltage phase B	V	–
0x007A	4	Mains voltage phase C	V	–
0x007C	4	Mains frequency phase A	Hz	–
0x007E	4	Mains frequency phase B	Hz	–
0x0080	4	Mains frequency phase C	Hz	–
0x0082	4	Mains Voltage THDU phase A	%	–
0x0084	4	Mains Voltage THDU phase B	%	–
0x0086	4	Mains Voltage THDU phase C	%	–

Table 30: Function Codes 03 and 04, Status Start Address = 0x0000 - (continued)

Register address	Number of bytes	Name	Unit	Data attributes
0x0088	4	Adjustable variable value 1	–	–
0x008A	4	Adjustable variable value 2	–	–
0x008C	4	Adjustable variable value 3	–	–
0x008E	4	Adjustable variable value 4	–	–
0x0090	4	Adjustable variable value 5	–	–
0x0092	4	Adjustable variable value 4	–	–
0x0094	4	AAF 007 active operation hours	h	–
0x0096	4	AAF 007 active operation hours with load >50%	h	–
0x0098	4	AAF 007 active operation hours with load <50%	h	–
0x009A	4	DC-bus voltage (+)	V	–
0x009B	4	DC-bus voltage (-)	V	–
0x009E	4	Inductor temperature	°C	–

8.2.6.3 Read of AAF 007 Waveform Data (Curves in Time Domain)

A complete curve consists of 128 points in 2 sets of data, and each byte represents the value of 1 point. 128 points represent 1 complete curve. A sequence of data transmission starts at low and ends at high. The 1st bit represents the 1st point, and so on.

Table 31: Function Codes 03 and 04, State Register Start Address = 0x0500

Register address	Number of bytes	Name	Remarks	Data attributes
0x0500	128	Mains voltage curve phase A	–	–
0x0540	128	Mains voltage curve phase B	–	–
0x0580	128	Mains voltage curve phase C	–	–
0x05C0	128	Load current curve phase A	–	–
0x0600	128	Load current curve phase B	–	–
0x0640	128	Load current curve phase C	–	–
0x0680	128	Compensations current curve phase A	–	–

Table 31: Function Codes 03 and 04, State Register Start Address = 0x0500 - (continued)

Register address	Number of bytes	Name	Remarks	Data attributes
0x06C0	128	Compensations current curve phase B	–	–
0x0700	128	Compensations current curve phase C	–	–
0x0740	128	Mains current curve phase A	–	–
0x0780	128	Mains current curve phase B	–	–
0x07C0	128	Mains current curve phase B	–	–

8.2.6.4 Read of AAF 007 Waveform Data (Curves in Frequency Domain/Histrogram)

Table 32: Function Codes 03 and 04, State Register Start Address = 0x0B00

Register address	Number of bytes	Name	Remark	Data attributes
0x0B00	80	Mains voltage THDU histogram phase A	–	–
0x0B28	80	Mains voltage THDU histogram phase B	–	–
0x0B50	80	Mains voltage THDU histogram phase C	–	–
0x0B78	80	Load current THDI histogram phase A	–	–
0x0BA0	80	Load current THDI histogram phase B	–	–
0x0BC8	80	Load current THDI histogram phase C	–	–
0x0BF0	80	Mains current THDI histogram phase A	–	–
0x0C18	80	Mains current THDI histogram phase B	–	–
0x0C40	80	Mains current THDI histogram phase C	–	–

8.2.6.5 Read of AAF 007 Manufacturer Information

Table 33: Function Codes 03 and 04, State Register Start Address = 0x1000

Register address	Number of bytes	Name	Data attributes
0x1000	2	Protocol versions number	Decimal notation, for example, 100 refers to protocol version V100.
0x1001	2	Software version number	Decimal notation, the higher 12 bits represent the main version and the lower 4 bits represent the secondary version. Example: 0x0041 means main version 100 and secondary version 01.
0x1002	2	AAF 007 unit address	1~247
0x1003	2	Reserved	–

8.2.6.6 Read of Supervision Information

Table 34: Function Codes 03 and 04, State Register Start Address = 0x1200

Register address	Number of bytes	Name	Data attributes
0x1200	2	Protocol versions number	Decimal notation, for example, 100 refers to protocol version V100.
0x1201	2	Software version number	Decimal notation, the higher 12 bits represent the main version, and the lower 4 bits represent the secondary version. Example: 0x0041 means main version 100 and secondary version 01.
0x1202	2	AAF 007 unit address	1~247
0x1203	2	Reserved	–
0x1204	2	Input dry contact	1: high 0: low
0x1205	2	Output dry contact	1: high 0: low

8.2.7 CRC Calculation

- Input parameter: the buffer calculates the CRC-array-pointer.
- Length: length of data to be calculated.
- Calculated value: 16-bit CRC checksum

```
Unsigned short calculateCRC16(const unsigned char * buffer, int length

{

                unsigned short InitCrc = 0xffff;
                unsigned short Crc = 0;

                int i =
                0;int j =
                0;

   if ((buffer == 0) | | (length ≤ 0))

   {

     return 0;

   }

   for(i=0; i<length; i++)

   {

     InitCrc^=
     buffer[i];for(j=0;
     j<8; j++)

     {
                Crc = InitCrc;
                InitCrc >>= 1;
                if(Crc&0x000
                1)
                   InitCrc ^= 0xa001;
     }
   }
```

e30bk927.10

Figure 39: Example of CRC Calculation

8.3 Paralleling of Filter Modules

Filters ordered with ratings above 55 A are made up of parallel setup of multiple filter modules. These filters can be ordered directly from Danfoss with or without current transformers.

An ordered filter of, for example, 220 A consists of 4 55 A modules. These modules are already programmed and tested as a 220 A unit from the factory. When ordered with current transformers, all settings are made so that the product can be installed and commissioned directly.

If a module is to be exchanged in a filter, or if a filter is enhanced with an extra module to increase compensation current, reprogramming of the filter modules is required to ensure proper operation.

8.3.1 Modbus Address

When exchanging a module in a filter, assign the address of the old module to the new module.

If a filter is enhanced by adding a new module, assign the next free address to the new module. See 8.1.2 Connection - Parallel Setup for more information on assigning addresses.

8.3.2 Current Transformer

Up to 8 filter modules can share 1 set of current transformer. Electrical installation of current transformers to parallel modules is explained in 7.4.4 Connection of Several Filter Modules to the Same Current Transformer.

It is important that the parameter/value *Parallel Total Comp. Current* is set up correctly as it has significant impact to the performance of the filter. If the value is not according to the installed compensation current, the filter might compensate too much or too little, which in both cases results in degraded power quality.

Therefore, it is important to program this value correctly for exchanged modules, and in case the filter is changed in size by removing or adding modules.

8.3.3 Control Signals

The functions of the control signals are explained in 5.6.4 External Power Off (EPO). RS485 and digital inputs can easily be wired in parallel without further considerations.

The 2 output relays are fixed to show the status of the drive. These signals can be used individually or require a logic to combine the status with the total filter status, as illustrated below.

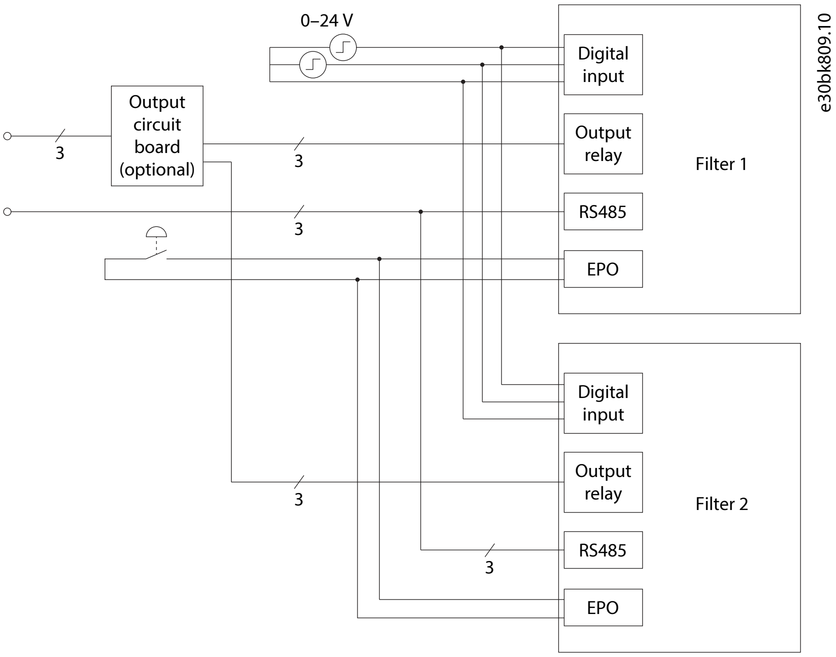


Figure 40: Example of Control Wiring for 2 Filter Modules

8.3.4 Serial Communication

Each filter module has a terminal to connect 3 wires (485+, 485-, GND_0) to the bus system.

Connect all the components on this communication bus with shielded 3-pole wires in accordance to the serial communication guidelines:

- As short as possible and direct from filter to filter, no central point of connection. Maximum overall wire length < 5 m (16.4 ft).
- Appropriate distances or metal cable duct to separate from power wiring to respect general EMC-guidelines for laying wires in electrical installation.
- Connect the shield of the cables to the GND_0 terminal in harsh environments.

When applying the HMI, use the integrated converter. No additional converter is needed nor recommended. If an RS485 to USB converter is used to connect a PC or other equipment, it is important that this converter is equipped with **FTDI**-chip set for proper connection.

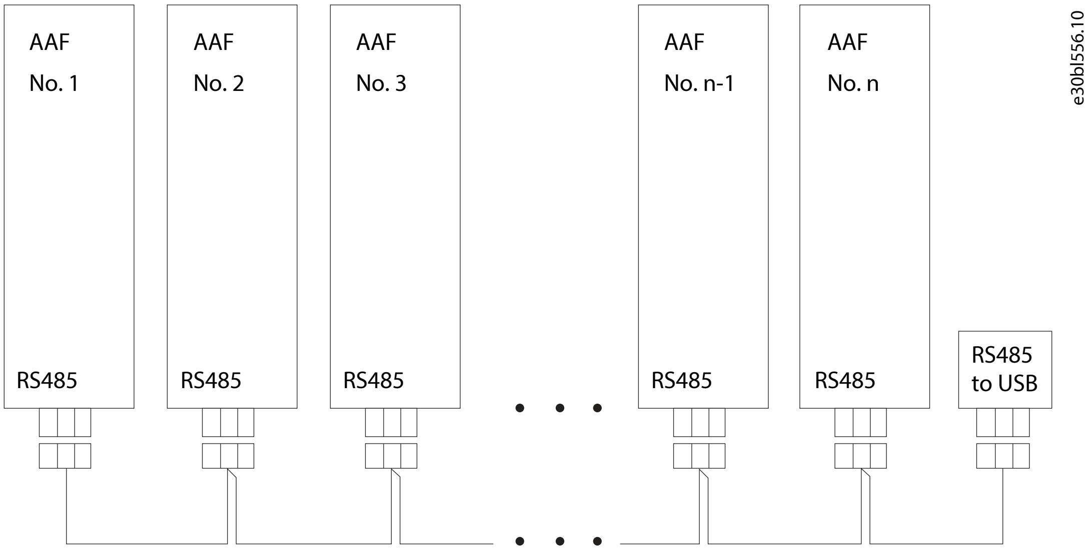


Figure 41: RS485 wiring

8.4 Installation of Active Filters in Proximity of Drives

The filter sets different MOSFET switches in real time feeding a DC voltage into the grid, which creates counter-phase signals.

NOTICE

This pattern is decreasing the local impedance for the higher harmonic currents, and therefore non-linear loads (diode-feed loads) will experience steeper current flanks on the input.

Drives with integrated AC coils will dampen this effect and reduce the harmonic content of current, while drives with DC coil will reduce the harmonic current on the input of the drive. However, the DC coils are not able to change the dI/dt value at the input section due to their position. To evaluate if special measures are to be considered for installation of active filters very close to drives, contact the local supplier.

8.5 Reduction of Source RMS Current While Using Active Filters

Adding an active filter to an installation increases the overall current from the mains towards the installation, as a new switching device is added.

Even though an active filter consumes a minor portion of active power, the overall current from the mains reduces. It is because the filter acts like a source for the harmonic current demand, that non linear consumers have.

The typical spectrum of a frequency converter grid current imposes a THD of 35%, which increases the RMS current compared to a purely active sinus current with 6% due to the harmonics. A reduction of the harmonic current from the mains to 5% instead of 35% would reduce the RMS current level to nearly the same value as there were no harmonics (0,1%).

The only additional current results from the switching losses of the filter and is around 1% of the load current.

The application of active filters, consequently does not impact the dimensioning of upstream equipment, like cables circuit breaker and trafos in a way, that equipment need to be sized up.

NOTICE

DOWNSIZING OF EQUIPMENT DUE TO THE USAGE OF ACTIVE FILTER NEEDS TO BE EVALUATED CAREFULLY, DUE TO THE RISK OF OVERHEATING AND EARLY AGING OF EQUIPMENT.

9 How to Order

9.1 Filter Configuration

Use the code number system to design an active filter according to the application requirements. For the Advanced Active Filter AAF 007, it is possible to order standard filters based on modules by sending a modelcode string describing the product to the local sales office. For example, AAF-0073B04-220AE20+VD04.

These IP20 products consist of 1 or more filter modules including a set of current transformers if such have been selected. The filter modules are tested and parametrized in the ordered product configuration.

9.2 Ordering Form Type Code

This section describes each character in the type code. As the Advanced Active Filter AAF 007 series is constantly evolving, the following table may show options that are not yet released for sales. It is indicated in the table which selections are available. In the example, a standard 55 A filter with IP20 protection rating is selected for a 380–480 V net, including 150 A current transformers. The internet-based configurator configures the right filter for the right application and generates a type code string and a model 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 sales representative. The configurator is available at https://store.danfoss.com/en/Drives/Drives-Configurators/General-Configurators/c/13934.

Table 35: Type Code Description

Description	Remark	Options
Product group	–	AAF-007
Product type	–	-3B
Mains voltage	–	04
Current rating	–	-35A0: 35 A -55A0: 55 A -70A0: 70 A -90A0: 90 A -100A: 100 A -110A: 110 A -150A: 150 A -165A: 165 A -200A: 200 A -220A: 220 A -250A: 250 A -275A: 275 A -300A: 300 A -330A: 330 A -350A: 350 A -385A: 385 A -400A: 400 A -440A: 440 A -450A: 450 A -500A: 500 A -550A: 550 A -600A: 600 A

Table 35: Type Code Description - (continued)

Description	Remark	Options
Protection rating	–	-E20: IP20 -E54: IP54
Mains input device	For cabinet products	AJXX: None
Control panel	–	BFXX: None BF05: Control panel AAF OPX50
Product SW ID	–	ECXX: Latest released version
Documentation	–	EHXX: Multi language
Door signal lights	For cabinet products	IIXX: None IICD: RUN, READY, FAULT
Current transformers (2 pieces)	–	VDXX: None VD00: 80 A VD01: 150 A VD02: 250 A VD03: 400 A VD04: 600 A VD05: 800 A VD06: 900 A VD07: 1000 A VD08: 2000 A VD09: 2500 A VD10: 3000 A
Frame designation	–	AAF01: Filter module/package small AAF02: Filter module/package big AAF03: Rital 400 mm width AAF04: Rital 600 mm width AAF05: Rital 800 mm width AAF06: Rital 1000 mm width

9.3 Accessories

Table 36: Code Numbers, Accessories

Code number	Description
136B3264	AAF 007 current transformer 80 A
136B3265	AAF 007 current transformer 150 A
136B3266	AAF 007 current transformer 250 A
136B3267	AAF 007 current transformer 400 A
136B3268	AAF 007 current transformer 600 A
136B3269	AAF 007 current transformer 800 A
136B3270	AAF 007 current transformer 900 A
136B3271	AAF 007 current transformer 1000 A
136B3272	AAF 007 current transformer 2000 A

Table 36: Code Numbers, Accessories - (continued)

Code number	Description
136B3961	AAF 007 current transformer 2500 A
136B4007	AAF 007 current transformer 3000 A
136b4672	AAF 007 Plinth 100 mm x 400 mm
136b4752	AAF 007 Plinth 100 mm x 600 mm
136b4753	AAF 007 Plinth 100 mm x 800 mm
136b4754	AAF 007 Plinth 100 mm x 1000 mm
136b4673	AAF 007 Control board
136b4674	AAF 007, 2 Shunting boards
136b4675	AAF 007, 3 Shunting boards

10 Troubleshooting

10.1 Service and Maintenance

There is no dedicated service and maintenance plan for the filter modules or parts of the modules that require attention. The best conditions are achieved in an environment with constant ambient temperature, which allows a proper cooling of the filter.

10.2 Replacing a Filter Module in a Filter with Multiple Modules

Prerequisites:
Download the settings in the Settings/Device menu and note the Modbus address of the filter.

If a filter module is to be replaced, certain settings must be done to ensure proper operation of the newly added module.

NOTICE

Carefully read *chapter 2 Safety* to become familiar with the safety precautions.

1. Remove the old module from the filter.
2. Install the new module and power it up.
3. Connect to the module via the serial connection and set the Modbus address to the same address as the replaced module had.
4. Upload the settings file from the old module in the *Settings/Device* menu to adjust the settings of the new module.

   If no settings file is available, copy the settings from another module in the same filter as they are typically the same. Adjust the following first to ensure safe operation:

   a. Parallel total compensation current
   b. Current transformer location
   c. Current transformer ratio
   d. Current transformer connection

5. Check that all other settings/parameters have the same value as the old module to ensure proper operation.

10.3 Fault Finding and Troubleshooting

If the filter does not work properly, read out the fault name and investigate possible root causes for the fault.

Fault names can be read out via the PC tool, section 8.1.4.5 Settings - Debug, or via the Modbus protocol, section 8.2.6.1 Read of Status and Alarm of the Unit.

Table 37: Overview of Faults and Troubleshooting Hints

Fault number	Fault name	Reason	Possible fault	Troubleshooting
1	Inverter short error	MOS tube drive circuit reports a fault.	1. The MOS tube is damaged. 2. The drive circuit is damaged.	Return the filter module to Danfoss for investigation/repair.
2	DC voltage error	Single-side voltage of the DC bus exceeds 480 V or is lower than 180 V, or the total bus exceeds 890 V/180 V.	Bus voltage error, which may be due to resonance or high grid voltage.	1. Check the value of the bus voltage. 2. Check for resonance. Check if there is a 3P3W or 3P4W error. Return the filter module to Danfoss for investigation/repair.
3	Epo	There is a short circuit in the EPO circuit.	Check the EPO circuit.	Return the filter module to Danfoss for investigation/repair.
4	Inverter current error	Inverter current fault detected.	1. Resonance. 2. Inverter current sampling fault.	1. If it is caused by resonance, the 3rd-party detection equipment is required to confirm the resonance point and then adjust the compensation rate. 2. If it is caused by the sampling fault of the inverter current, return the filter module to Danfoss for investigation/repair.
5	System frequency error	Abnormal grid frequency	1. Abnormal grid frequency. 2. Resonance. 3. Three-phase voltage sampling circuit fault.	1. Use the instrument to test the frequency of the power grid, if the power grid frequency is abnormal. When restored, the filter automatically clears the fault. 2. If it is caused by resonance, eliminate the resonance to restore filter. 3. If the power grid is normal, and the sampling waveform of the equipment is incorrect, check the voltage sampling circuit: Voltage sampling circuit failure. 4. Return the filter module to Danfoss for investigation/repair.

Table 37: Overview of Faults and Troubleshooting Hints - (continued)

Fault number	Fault name	Reason	Possible fault	Troubleshooting
6	DC difference value error	The voltage difference between the positive and negative buses exceeds 80 V.	1. Check the difference of the bus voltage. 2. Check if there is a 3P3W or 3P4W selection error.	1. If both positive and negative buses have voltage, the fault may be caused by resonance. After eliminating resonance, restart the filter to return to normal operation.
7	Supply power error	Low output voltage fault of auxiliary power supply board.	Check whether the LED light is on.	1. When the power grid is normal, confirm whether the filter is restored. If the LED light is not on under normal conditions of the power grid, the filter is damaged. 2. Check the fuse.
8	System voltage error	The grid voltage is too high or too low.	Check the grid voltage or sample circuit.	1. Wait for the power grid to return to normal. 2. Return the filter module to Danfoss for investigation/repair.
9	U3Comm error	Abnormal communication (CAN communication) between U1 board (DSP control board) and U3 board (STM32 board).	Check whether the input and output dry contacts can be used normally.	1. If the software version is wrong, upgrade the software of the U3 board. 2. Replace the U3 board of the DSP board.
10	Fan error	Fan error	Check whether the fan does not work.	1. Check whether the fan is stuck. 2. Return the filter to Danfoss for investigation/repair.
11	CtrlSoftware version error	DSP board software version compatibility fault.	Check the software version.	1. Upgrade the correct DSP software.
12	Inverter overtemperature	Filter overtemperature.	Check power and ambient temperature or radiator temperature.	1. Wait until the temperature returns to normal, then restart the filter. 2. Return the filter module to Danfoss for investigation/repair.

Table 37: Overview of Faults and Troubleshooting Hints - (continued)

Fault number	Fault name	Reason	Possible fault	Troubleshooting
13	CT set error	The setting of external current transformers is wrong, and the detection current is >1.5 times of the rated value.	Check the actual curcurrentd CT value.	1. Set the correct current transformer transformation ratio. 2. It may be caused by surge current. Ignore this situation and it will recover automatically.
14	Device parament error	Parameter setting failure.	Parameter setting failure.	1. When setting the current transformer on the grid side, the harmonic detection mode Completely is not allowed. 2. When the grid voltage is 480 V, it can only be used in 3P3W mode. 3. The parallel capacity must be greater than the rated capacity of the filter.
15	Overload	The compensation current is >1.5 times of the rated load.	1. Load current overload. 2. Check whether there is resonance.	1. The load current is overloaded, and the load current transformer must be replaced, or the load current reduced. 2. If it is caused by resonance, wait for 5 minutes. The fault then clears automatically. Alternatively, power off and restart the filter. 3. Return the filter module to Danfoss for investigation/repair.

10.4 Disposal

Danfoss accepts defective filter modules for disposal.

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DK-6300 Graasten
drives.danfoss.com

M00417