

AFE USER MANUAL







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GLOSSARY

Term	Meaning
AFE	Active Front End
COS Protocol	Current OS Protocol
V	Voltage/ Volts
А	Current/ Amperes
IP	Ingress Protection
IGBT	Insulated Gate Bipolar Transistor
UI	User Interface
FAT	Factory Acceptance Test
Trained personnel	Person which is qualified by training or experience with electrical equipment and COS systems operation/equipment, along with any hazards that may be involved.



1 PREFACE

1.1 Description of the User

This document is aimed at personnel responsible for setting up, installing commissioning, and operating the device and the system in which it is installed. Personnel must possess basic knowledge in the following areas:

- DC Installations
- COS Protocol
- Electrical Installations

1.2 Explanation of Safety Warnings



Danger indicates a hazard with a high level of risk which, if not avoided, will result in death or severe injury.

Warning indicates a hazard with a medium level of risk which, if not avoided, could result in death or severe injury.



Caution indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.

1.3 Obtaining Documentation and Information

1.3.1 Internet

The latest version of the documentation is available by request by sending an email to the following address, **support@dc.systems**. Further contact information can be found on at the following web address: <u>https://www.dc.systems/index.php</u>.

1.3.2 Ordering Documentation

Enquiry for documentation pertaining to this project can be requested by calling DC Systems at +31 850 444 000

1.3.3 Documentation Feedback

Any suggestions can be addressed to <u>support@dc.systems</u> on the company website.



2 DESCRIPTION OF THE PRODUCT

2.1 Purpose of the Product

A product that makes a DC smart grid possible for public lighting, office applications, greenhouses, and COS compatible grids. This device combines electrical power with grid-interactive system for load-supply balancing, and it is an innovation in the field of DC. A unique concept of DC Systems, which is also the first in the world. By adding the communication to the system, the behaviour of each device can be individually controlled and regulated, from the Current OS system.

Features

- Isolated DC output for 350V or 700V Systems
- Bidirectional power flow
- Suitable for PV applications and DC loads
- Superior AC/DC efficiency >96%
- 700V or 350V grids with COS compatibility
- Monitoring RS485 MODBUS
- Current OS compliant
- Ease of maintenance
- Communication port
 - RS485 MODBUS AC Side for AC parameters and grid operator functionality.
 - RS485 MODBUS DC Side for DC parameters and Current/OS functionality
 - USB-B connector for user config and monitoring
- Can be combined with:
 - FG-SPO-xxx PV solar micro converters for 350V systems
 - AMPT PV string optimizer for 700V systems
 - o Solid-state Current Routers
 - o Hybrid Current Routers
 - DC/DC Battery converters



Block Diagram



Figure 1 AFE block diagram

2.2 Technical Data

1432 AH Aalsmeer

Logistical Data				
Specification Item	Value			
Product Name	AFEF-700V-100	0kW-3-400V-IAC2EIWIS	A1R1	
Minimal Order Quantity MOQ	1			
	•			
Absolute Max Values				
Specification Item	Value	Limit	Condition	
Input voltage	500	V AC		
DC voltage	900	V DC	Semiconductor limits	
Electrical Input Data				
Nominal input voltage	400	V AC	Between phases	
Maximal input voltage	440	V AC	Nominal working	
Minimal input voltage	360	V AC	Nominal working	
Maximal input current	180	A AC	RMS	
Efficiency	>96	%	100% output	
Power Factor	>0.98			
Electrical Input Data	<u>.</u>			
Nominal output voltage	700	V DC	Droop Curves	
Nominal output current	150	A DC	Droop Curves	
Max output voltage	760	V DC	Droop Curves	
Min output voltage	640	V DC	Droop Curves	
Electrical Connections				
Incoming cable minimal	70	mm ²		
Cooling				
DC Systems BV				
Oosteinderweg 127C	Oosteinderweg 127C			



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Volumetric Flow	650	m³/h		
Remark	The Converter	is active cooled by	a long-life low-noise	
	centrifugal fan v	with ball bearings. The	design is optimized for	
	efficient cooling.	-		
Mechanical Data				
Height	2170	mm		
Width	710	mm		
Depth	650	mm		
Weight	765	Kg		
IP rating enclosure	IP2XD	*		
Environment Conditions				
Max ambient temperature	50	°C	@50kW	
Max ambient temperature	35	°C	Full power w/o	
100%			derating	
Min ambient temperature	-5	°C	Standby	
Case temperature (T-Life)	35	°C		
Maximal case temperature	60	°C		
Storage temperature	-10 to 60	C°		
Humidity operation	90	%	Non-condensing	
Humidity storage	80	%	*	





2.3 Product Elements





- A. Output airflow vent
- B. User Interface
- C. Key door opening handle
- D. AC Main Switch Disconnector
- E. Inlet airflow vents
- F. IGBT Module Removable Tray
- G. DC Filter
- H. Control Board
- I. Boost Inductor
- J. AC Filter
- K. Front Panel
- L. Grid Isolation Transformer



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2.4 Understanding the User Interface

The User Interface (UI) for measurement and indication is located at the top right of the AFE placed on the removable tray, as shown in Figure 2. A transparent panel has been placed for observation of the voltage, current meters, and LED indicators, when the door is closed. The UI consists of the following components:

- a. Voltmeter: Provides the user the real time analog value of the voltage present in the DC Bus.
- b. Amp-meter: Provides the user the real time analog value of the current present in the DC Bus.
- c. Red LED (Error): Indication when there is an error in the AFE or when nominal voltage is not reached, therefore, this LED is ON during startup.
- d. Green LED (Cooling): LED in its ON position indicates the fans of the AFE are operational.
- e. White LED (AFE ON): When in the ON position, it indicates that the AFE is operational.



Figure 2 User Interface



3 SAFETY INSTRUCTIONS

WARNING: Product must be handled, inspected, and maintained by trained personnel only!

3.1 How to Use the Product Safely

3.1.1 General Safety Information

- a. All personnel must follow the safety and warning signs placed on the AFE and follow the instructions of the site concerning safety matters.
- b. Equipment operators are responsible for the safe maintenance, operation and required documentation of the equipment they are operating.
- c. Please ensure the product is operated in an enclosed and dry environment. The 100% ambient temperature of operation is between –5 and +35° C and it is recommended to operate the device within this range.
- d. In the event of a malfunction, immediately stop the device. Procedure to switch off the device is mentioned in Section 4. Report the fault to the manufacturer and have the fault corrected by appropriately trained personnel.

3.1.2 Technical Life Span

- a. The lifespan of the AFE is dictated by the lifetime of individual components, cables, or other materials inside the AFE.
- b. Please refer to section 6 for maintenance information of the AFE.

3.1.3 Safety Information related to the Intended Use and Foreseeable Misuse

- a. The product and equipment are designed and intended for specific purpose as described. Each product may only be used under the operating conditions outlined in the documentation.
- b. Users must be qualified to handle the device and be aware of the hazards potentially associated with the process. The use of protective gear (gloves, safety shoes and glasses) is recommended when handling the AFE.
- c. The company does not accept any liability beyond the intended usage as mentioned in this document.
- d. Please be aware that the handle placed on the removable tray could reach temperatures that is deemed unsafe to touch if the AFE is operated at full load at 50°C for extended periods of time. It is advisable to proceed with caution and take necessary precautions before accessing this part of the circuit.
- e. Misuse of the system may lead to dangerous situations so please consider the following:
 - Never operate the system in explosive atmospheres.
 - Never incorporate/ store flammable substances near the device.
 - Never bypass or manipulate the safety equipment or safety components.
 - Never exceed specific thresholds (temperature and pressure conditions) of the system.



- Never carry out unauthorized changes or other technical modifications to the system.
- Never use replacement parts, other than those approved by the manufacturer.

3.1.4 Personal Protective Equipment

- a. Personnel must use necessary personal protective equipment when required or when instructed to do so by the supervisor or safety officer. Personal protective equipment includes gloves, safety shoes and safety glasses.
- b. High visibility vests are required when working around mobile machinery or when instructed to do so by the site safety personnel.
- c. Hardhats and safety boots must be always worn, unless stated by the site safety personnel.
- d. All injuries, no matter how minor, are to be immediately reported to the site safety officer or first aid attendant.
- e. No shorts or sleeveless shirts shall be worn.
- f. Personnel must protect themselves from fall hazards by implementing appropriate protection measures.

3.1.5 Product Limitations and Restrictions

Please refer to section 2.2 to understand the limitations of the product and the product compliance list.

3.1.6 Installation Safety Information

The initial installation includes setting up the product, equipment, and its connection. The following information summarizes the key aspects to be observed during the setup. They also apply to re-installation at the workplace after a change of location or after temporary suspensions from use.

- a. Checks prior to setup and connection.
- b. Danger due to electrical power connection.
- c. Danger of injury from current spikes due to short circuits.

3.1.7 Safety Information regarding the Use

- a. Risk of accidents may occur if approved operating components and materials are not used.
- b. Danger of material damage if material specifications and recommended operational environments are not considered.

3.1.8 Maintenance Safety Information

Follow the maintenance guidelines, general safety information and instructions of the site safety personnel when performing inspections and maintenance checks.



4 PREPARATION

NOTICE: Whilst every effort will be made to ensure the highest level of care is applied during transportation, DC Systems will not be liable for any damage or inconvenience arising. In no event will DC Systems be liable for its affiliates, agents, and licensors to you (and/or any third party) arising out of any legal claim (whether in contract or otherwise) in any way connected with the service to which the claim relates.

4.1 Transporting and Storing the AFE

4.1.1 Dimensions, Mass, and Centre of Gravity

The Active Front End structure (As shown in Figure 3) has a weight of 750 kg, has dimensions of $2000 \times 650 \times 600$ (mm).



Figure 3 Overview of the Active Front End

4.1.2 Lifting, Handing, and Transporting the Product

This section addresses the recommended ways to lift, handle and transport the Active Front End safely. The AFE door must always be closed during transit, none of the components, wiring or internal panels should be left exposed. The transportation of this product should only be handled by qualified personnel.

To lift the product safely:



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It is recommended to use a forklift for this operation.

- a. The base plate of the AFE must be removed using a screwdriver and stored in a safe, dry environment at room temperature (refer to Section 4.3).
- b. Ensure both forks are centered and are as far under the AFE as possible before lifting.
- c. The AFE should be lifted slowly and carefully only after the load is balanced and fully secure.
- d. Additionally, the lift eyes on top of the enclosure can also be used for lifting operations.

To handle the product safely:

- a. The AFE must be wrapped with a plastic film and adequate padding at vulnerable points to protect the enclosure, neutralise excessive vibrations and avoid damage during transit.
- b. The AFE also must be securely fastened to the transport vehicle using a harness.

To transport the product safely:

- a. The forklift/transport vehicle must be operated in a safe environment, driven at low speeds when the AFE is secured on the vehicle.
- b. Road speeds, signs and regulations must be followed, the operator must be alert for any obstacles and refrain from sudden movements.

4.1.3 Storing the AFE

This section outlines the steps to follow to store the AFE in a safe environment:

- a. The AFE should be stored in a clean, enclosed, dry environment in an accessible location.
- b. The recommended temperature range for storage is -10° C to $+35^{\circ}$ C.
- c. The floors are sound and level.
- d. The device must not be stored next to chemicals or any hazardous substances.

4.1.4 Securing the AFE against Shocks

It is recommended to use foam-in-place solutions that use polyurethane foam to prevent damage or polystyrene "packing peanuts" to fill lose space around the AFE, if transported in a larger enclosure.

4.2 Installing The AFE

4.2.1 Removal of the Transport and Packaging Restraints

Removal of the device from a vehicle should be performed by qualified persons only. The AFE should always remain in a vertical upright position.

- a. Ensure the AFE has not being damaged during transit.
- b. Ensure the AFE is balanced and stable.
- c. If transported in a large vehicle, remove the protective harnesses that keeps the AFE in place and navigate the forks of the forklift to be centred under the AFE.
- d. As the device is being removed from the vehicle, always ensure adequate clearance from the ground.



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4.2.2 Unpacking the Product

Once the AFE is in an enclosed, dry, sound, level and clean environment, the packaging material can be removed. Please ensure that no damage is caused to the AFE structure if using potentially sharp objects to remove the packaging.

4.2.3 Packaging Contents

The package will be received with the following items:

- a. The AFE structure with the door, side and back panels already attached.
- b. The base plate: To allow the AFE to be transported, the base plate is removed, the base plate can be found with its screws in the package.
- c. Documentation: As well as this report, a completed Factory Acceptance Test (FAT), a product specification sheet will be attached.

4.2.4 Minimum Space

Space should meet the dimensions stated by the manufacturer. Additional space is useful for inspections and maintenance.

4.3 Installation of Product

Please confirm the presence of the quality assurance sticker and a completed factory acceptance test (FAT) document is delivered along with the product. If not, please contact the manufacturer **before** installation.

4.3.1 Installation of Input Cables

External input voltage cables need to be supplied to the AFE via the cable ducts at the bottom of the structure, these inputs include:

- a. Three phase AC inputs to be connected according to Figure 4. These connections are made to the bottom of the main switch, S1 and to the PE AC. Please note that the connection should be in the correct order of phase.
- b. DC Input connection, according to Figure 5. Connect to PE DC (green), Middle (blue) and Positive (red).
- c. Refer to Site Planning Data document for detailed information.

Please note that a strain relief is also provided for the input cables.





Figure 4 AC Input connections



Figure 5 DC Input connections



4.3.2 Installation of the Base Plate

The base plate of the AFE should be installed on site once all other external connections have been made. Use the screws in the package and place the base plate over the exposed section of the AFE as shown in Figure 6.



Figure 6: Connected base plate.



4.3.3 Installation of the Enable Signal Cables

There are provisions for an enable signal to control the AFE, two cables can be found towards the bottom right of the front panel of the AFE, on the DIN rail, next to the RS-485 communication as mentioned in Figure 7, the polycarbonate sheet needs to be removed from the front panel before these connections can be made. The points for connection are shown in Figure 8.



Figure 7: Location of communication cables



Figure 8: Connections of communication and enable signal cables.



5 AFE OPERATION

5.1 Product Usage

5.1.1 Operational Environment

Operate according to the operation specifications included in section 2.2.Do not operate in wet or explosive atmospheres. Keep product surfaces clean and dry. Please pay attention and follow the safety signs on the product.

5.1.2 Enable Signal Operation

The AFE is delivered with factory settings that allow the customer to operate the AFE with an enable signal. The monostable enable signal is a logic signal on 12V DC level. This feature allows more flexibility since can be controlled by a PLC or similar control applications. The AFE monostable enable signal must be held at true for as long as the AFE is needed to be powered.

To start up the AFE:

- a. Make sure the cable connectors are not loose.
- b. Fuse integrity must be checked.
- c. Make sure all the tray connections are in place.
- d. Close the door.
- e. Turn the switch handle to a closed contact position.
- f. Power up the AC side (three phase AC input of the AFE)
- g. Power the 12V line (Logic true); This value must be held to have the AFE always enabled.
- h. AFE starts pre-charging phase.
- i. RED LED lights up only during pre-charge time
- j. Green LED lights up enabling the input fans.
- k. Skip module starts automatically.
- I. White LED lights up showing power on the DC output of the AFE.

Note: To switch OFF remove the 12V signal

5.1.3 Discharging the AFE

Discharge of the AFE is done automatically with the help of bleeding resistors that are connected on the DC Bus. The time it takes to completely discharge the AFE is 12-15 mins. The user should wait the entire amount of time before assuming that the AFE has been completely discharged. The manufacturer also recommends verifying this assumption by measuring the voltage present in the Bus with the help of a multimeter.

Some models (upon request) are delivered with an option to manually discharge the DC Bus using a push button present in the user interface, as can be seen in Figure 2. Upon pressing the button, the DC Bus discharges in 5-10 seconds.



6 EMERGENCY AND EXCEPTIONAL SITUATIONS

6.1 Emergency

In case of fire:

a. Action the emergency stop button¹.

6.2 Exceptional Situations

In case of an uncontrolled AFE:

- a. Remove AC input power by means of the emergency switch.
- b. Turn the door handle to an open contact position².
- c. Contact the manufacturer.

¹ In a COS compatible environment there should always be an emergency stop button installed in the system.

² The door handle actions the main disconnector which feeds the AC input to the AFE.



7 MAINTENANCE

7.1 Product Maintenance

7.1.1 Product Maintenance by Trained Persons

Product maintenance should only be carried out by trained personnel.

Access to Front Panel

To access the front panel, the transparent polycarbonate sheet needs to be uninstalled. The following procedure indicates how to safely access the front panel for maintenance or inspections:

- a. The user should ensure complete discharge of capacitors of the Active Front End before accessing the front panel of the device, please refer to Section 5, under sub-section 5.1 for a detailed procedure on protocols to follow for discharging the AFE.
- b. As shown in Figure 9, a transparent polycarbonate sheet is held to the front panel of the device using four screws (circled in Red).



Figure 9 Installed transparent polycarbonate sheet with connectors to AFE structure highlighted.

- c. Using a screwdriver, carefully remove the screws individually by rotating anti-clockwise while holding the polycarbonate sheet in place until all four screws have been removed.
- d. Store the polycarbonate sheet at room temperature without any weight added to the top of the sheet to prevent damages.



Removal of Tray

To access the boost inductor, IGBT module and other parts of the circuit, the tray must be removed from the AFE. The following procedure outlines this process. Please note that it is recommended to wear gloves throughout this procedure as a protection. Additional care should be taken when handling the glass fibre fixture.

a. Once the AFE has been switched off and the capacitors are completely discharged, the door of the AFE can be opened. Before physically removing the tray, the following connections need to be uninstalled manually by the user. Figure 10 outlines the components that need to be disconnected, the screwable holder (1) can be removed by rotating anticlockwise, a flat screwdriver should be used to unfasten the male connectors.



Figure 10. Connectors to be removed from tray highlighted in red.



Pull the tray out using the handle placed next to the user interface of the Active Front End as shown in Figure 11 and Figure 12.



Figure 11. AFE Handle





Figure 12. AFE Tray removal



7.2 Planned Maintenance of the AFE

Maintenance tasks shall be done according to the following plan:

Task	Frequency	Replaced by
Dust filters	Yearly	Service Engineer
Replacing capacitors	Every 10 years	Manufacturer
IGBT module	Every 20 years	Manufacturer
Input fans	Every 7 years	Service Engineer

Note: Values considered at ambient temperature 25°C.



8 TROUBLESHOOTING

8.1 How to Identify and Solve Problems

WARNING: Troubleshooting should only be performed by trained personnel.

8.1.1 Error Identification

Errors can cause the AFE control board to switch off to protect the AC grid, DC grid side or the AFE itself. When the error situation is solved then the reset trip command can be used to make the system active again. This command can be given through MODBUS or an external input.

Name	LED Blinks	Error Relay	Remark
EEPROM Error	1	Y	Manufacturer intervention required.
Power Failure	2	Y	24V supply problem
Temperature Error	3	Y	Temperature of IGBT module too high
Parameter Error	4	Y	Parameter out of range, manufacturer intervention required.
EEPROM CRC error	10	Y	Parameter block in EEPROM has wrong CRC. Manufacturer intervention required.
Phase Direction	6	Y	Just a warning
Emergency Stop	7	Y	
Skiip Stack Trip	8	Y	
Pre-charging error	9	Y	Pre-charging takes too long.
No Serial Number Error	5	Y	Manufacturer intervention required.
AC Overvoltage Error	12	Y	
AC Undervoltage Error	13	Y	
DC Overvoltage Error	14	Y	
DC Undervoltage Error	15	Y	

The error relay is active when there is no error. When connected to an indication lamp, be sure to use the Normally Closed contacts. Error status is available through Modbus.





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