Installation and Operating Manual

REFUsol 48K-UL

English

REFU Elektronik GmbH

843 / 844 Series (with and without AFCI)

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⚠ WARNING
Read this entire manual and all other publications pertaining to the work to be performed before you install, operate, or maintain this equipment. Practice all plant and product safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. All personnel who work with or who are exposed to this equipment must take precautions to protect themselves against serious or possibly fatal bodily injury.
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Feedback from Customers

The technical editor of REFU Elektronik GmbH has carefully developed this handbook on the basis of research-based document design principles. Suggestions for improvements are always welcome. Please send your comments regarding the content, structure or format of these operating instructions to: info@refu-sol.com.

Table of Contents

1 About these Operating Instructions

These operating instructions form part of the product.

Important Safety Instructions

⇒ Read the operating instructions carefully before installing and using the product.

⇒ Save these operating instructions. This manual contains important instructions for the REFUsol solar inverter that shall be followed during installation and maintenance of this unit.

⇒ Keep the operating instructions readily available with the device for the entire service life of the product.

⇒ Provide all future users of the device access to the operating instructions.

⇒ Additional information on device options and troubleshooting is available at www.refu-sol.com.

1.1 Symbols and Markup

☑	Prerequisite
⇒	One-step instruction
1.	Multiple-step instruction
•	Bulleted list
Highlighting	Highlighting within a text
↬	Result

1.2 Warning Notices

1.2.1 Categories of Warning Notices

 This symbol represent important notes concerning potential harm to people, this unit, or associated equipment. This manual includes this symbol in Danger, Warning, and Caution boxes to identify specific levels of hazard seriousness.

⚠ DANGER

DANGER indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury. DANGER is limited to the most extreme situations.

⚠ WARNING

WARNING indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation that, if not avoided, could result in minor or moderate injury.

NOTICE

NOTICE is used for property-damage-only accidents.

1.2.2 Information

 Note:

A **notice** describes information, which is important for the optimum and cost-effective operation of the equipment.

2 Safety Information

2.1 Intended Use

The REFUsol 48K-UL inverter, also referred to in these operating instructions as the inverter, is a solar inverter, which transforms the direct current generated by the PV generator (photovoltaic modules) into alternating current and feeds this to the public power supply network.

The inverter is manufactured according to the rules and current state of technology and takes into account the valid EU, IEC and UL guidelines respectively.

The inverter fulfils the requirements according to protection class IP 65 / NEMA 4 and can be used indoors and outdoors.

Any other use is not considered to be a designated use. The manufacturer accepts no liability for damages resulting from this.

2.2 Safety Guidelines

Commissioning and operation of this unit must be carried out by qualified personnel. Qualified personnel includes licensed electricians, service personnel, and authorized operators who have read and fully understood all of the technical information and the safety instructions contained in this manual.

Review the following information before attempting to install and operate the product.

2.2.1 Rules for Safe Installation and Operation

Please note the following rules:

- Do not attempt to install or operate this equipment without proper training.
- Ensure that this unit is properly grounded.
- Ensure that all cables are properly connected.
- Verify that input line voltage and current capacity are within specifications before turning on the power supplies.
- Use proper electrostatic discharge (ESD) precautions.
- Always be careful around this equipment.
- Never remove the upper inverter lid.
- Safe operation requires correct transport, storage, assembly, installation, and operation.

2.3 Personal Safety

2.3.1 Suitable Personal Protective Equipment

Whenever possible, interaction with this unit should be performed under de-energized conditions.

If interaction with this unit is necessary while it is energized, always ensure that any personnel entering a safety zone wear appropriate Personal Protective Equipment (PPE) for the specific job to be performed. Identification of appropriate PPE is the responsibility of the PV system operator and shall be determined in accordance with NFPA 70E and/or local jurisdictional requirements.

2.3.2 Medical and First Aid Treatment

Personnel working in and around operating power generation equipment should be trained in arc flash hazard, fire extinguisher selection and use, first aid, cardiopulmonary resuscitation (CPR), and automated external defibrillator (AED) use when each is applicable.

2.3.3 Safety Equipment Requirements

Authorized service personnel performing operations on this unit should have the following minimum safety equipment available:

- Consult NFPA 70E, or applicable local standards, for PPE requirements on switch gear operating
- Electrical hazard footwear (ANSI Z41/Z85 rated)
- Lockout Tagout (LOTO) Kit
- Appropriate meter to verify the circuits are safely de-energized (1000 VAC and DC rated, minimum)
- Any other equipment as applicable to your operation as required by national, state, and local regulations

2.3.4 Electrical Safety

⚠ DANGER

Risk of electrical shock. High voltages are present in the inverter cabinet.

⇒ Put DC disconnect into OFF position when working on the unit.

⇒ To completely deenergize the DC input conductors, if necessary invoke an additional equipment disconnecting means, or remove the fuses from an external combiner box.

⇒ Wait 15 minutes to discharge high voltage before working of the inverter.

⇒ Put AC disconnect into OFF position.

⚠ DANGER

Risk of electrical shock

⇒ All electrical installations should be accomplished in accordance with applicable national or local standards.

⚠ DANGER

Risk of electrical shock

⇒ Before connecting the inverter to the electrical utility grid, your utility company must grant approval. Only qualified electricians should make the connection to the utility grid.

Important:

Electromagnetic radiation of the unit is equal to standard household equipment.

No special precautions are required for people with pacemakers, metallic implants, or hearing aids.

2.3.5 Wiring Requirements

Inverters must be installed by qualified individuals and in accordance with all appropriate regulations, local building, and electric codes. Consult NEC 690 (USA), CEC Section 50 and 64 (Canada), for additional information.

You must meet the AC overcurrent protection requirements according to the following table when wiring the inverters:

Power Level	Breaker Size
48 kW	80 A

Important

Maximum AC overcurrent protection for all models is 80 A.

Wiring Information

Important

You must use National Electrical Code (ANSI/NFPA 70) wiring methods.

- All wiring methods and materials shall be in accordance with the National Electrical Code ANSI/NFPA 70, as well as all state and local code requirements.
- Installations in Canada should be in accordance with the Canadian Electrical Code (CEC) or applicable local standards.
- When sizing conductors and conduits for connection to the inverters, both shall be in accordance with the National Electrical Code ANSI/NFPA 70, as well as state and local code requirements.
- The AC and DC power connections in the inverter should be securely fastened.
- AC overcurrent protection for the utility interconnect (grid-tied) must be provided by the installers as part of the inverter installation.
- Use only conductors with a minimum insulation rating of 90 °C (194 °F).
- This equipment is intended to be installed as part of a permanently grounded electrical system per the NEC or local standards.

Wiring Connections

The inverter is connected to the utility grid at the AC terminals. The inverter is configured for 480 VAC, three-phase output with separate neutral.

The inverter is connected to the DC photovoltaic array with two DC block terminal inputs rated for max. 1000 V.

2.3.6   Grounding Requirements

Determine the appropriate grounding method with the responsible authority having jurisdiction.

- System grounding, if required by Section 250 of the National Electrical Code, ANSI/NFPA 70, is the responsibility of the installer.
- The photovoltaic system grounding shall be installed per the requirements of Section 690.41 through 690.47 of the National Electrical Code, ANSI/NFPA 70, and is the responsibility of the installer.

Grounding the PV Modules

The PV frames require an equipment grounding conductor (EGC) per NEC requirements.

- The inverter is a transformerless inverter. For this reason, it has no galvanic isolation. Neither the positive (+) pole nor the negative (–) pole of the modules connected to the inverter can be grounded. Only the array frame/racking and modules frame must be grounded, or only the PV module frame and racking must be grounded.
- Insulation resistance detection (ground fault detection): Since the inverter is connected to ungrounded PV arrays, it has an insulation resistance detection circuit that measures the DC insulation resistance between the PV array inputs and earth ground prior to starting.
- An Isolation Monitor Interrupter (IMI) is used to limit ground fault and backfeed current to the array and the Protective Earth connection. This device limits shock hazards by restricting the ability of the unit to connect to the grid when the system exceeds the limits stated in UL 1741. Additionally, the PV array IMI monitors for ground fault current as required by UL 1741. If a ground fault occurs, the inverter will shut off and will not restart until the fault has been cleared.

Grounding the AC Circuit

A protective earth feedthrough terminal block is available in the AC connection area. The gauge of the AC grounding conductor must be sized in accordance with Table 250.122 of the NEC.

Important

Establish an AC ground connection to the protective earth ground (PE) terminals before connecting to the grid.

2.3.7   Heat Hazard

The cabinet surface and heat sink can reach temperatures up to 75 °C (167 °F).

⚠ WARNING
Risk of burn. The inverter components can become extremely hot during normal operation.
$\Rightarrow$ Use caution when working around the heat sink area.

2.3.8 Lockout and Tagout Requirements

To prepare the inverter for maintenance or troubleshooting, you must deenergize and isolate the AC and the DC interface energy sources before working on the unit.

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2.4 Acronyms and Frequently Used Terms

Term	Description
A/D	Analog to digital conversion
ADU	Arc Fault Detection Unit
AFCI	Arc Fault Circuit Interrupter
AFI	Insulation fault
ANSI	American National Standards Institute
BEMS	Building energy management system
CFM	Cubic feet per minute
CPUC	California Public Utilities Commission
Derating	A controlled reduction in performance, usually dependent on component temperatures.
DHCP	Dynamic host configuration protocol
DNS	Domain name service
DSP	Digital signal processor
DVI	Digital video interface
EMI	Electromagnetic interference
ESD	Electrostatic discharge
GEC	Grounding electrode conductor
GFDI	Ground fault detector interrupter
IEEE	Institute of Electrical and Electronics Engineers
IGBT	Insulated gate bipolar transistor
IP	Internet protocol
Islanding	Islanding occurs when the inverter continues to feed power to a de-energized AC main circuit.
LOTO	Lockout Tagout
MCM	1000 circular mils utilized in wire sizing
MPPT	Maximum power point tracking
NTP	Network time protocol

Term	Description
NFPA	National Fire Protection Association
PCB	Printed circuit board
PLL	Phase lock loop
PPE	Personal protective equipment
PV	Photovoltaic
PVM	PV monitoring
PVM Sync	Software application used to query inverters
PWM	Pulse width modulation
Remote enable/disable	The inverter system can be remotely turned on or off. The inverter restarts after a five minute countdown
RMS	Root mean squared
SCADA	Supervisory control and data acquisition. A computer system that monitors and controls infrastructure or facility-based processes.
Set point	Inverter is operating and delivering power at defined parameters.
String	A group of series-connected PV modules.
UL	Underwriter's Laboratory
UTC	Universal time coordinate. Also known as Greenwich mean time.
VAC	Voltage alternating current
VDC	Voltage direct current
VOC	Open-circuit voltage

2.5   Interpreting Product Labels

The following labels may appear on your unit:

	General warning sign
	Hazardous voltage

⚠️ (hot surface warning symbol)	Hot surface
ℹ️ (refer to manual symbol)	Refer to manual for more information

2.6 Product Compliance

The following sections include information about unit compliance and certification, including the conditions of use required to be in compliance with the standards and directives.

2.6.1 Safety and EMC Directives and Standards

Certain options of this unit have been tested for and comply with the following electromagnetic compatibility (EMC) and safety directives and standards and industry guidelines.

Important

This equipment must be installed and used in accordance with the Conditions of Use described in this manual. If this equipment is expanded, modified, or installed into a larger system, the user is responsible to guarantee the compliance of the overall system. If this equipment is used with external components, the user must ensure that the Safety and EMC requirements are not violated.

Safety Directives and Standards

- **UL 1741** – Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources (2010)
- **IEEE 1547** Standard for Interconnecting Distributed Resource with Electric Power Systems
- **FCC Part 15 Class B** conducted emissions
- **National Electrical Code**
  Can be installed in compliance with National Electrical Code 2008, 2011, and 2014 Editions Article 690 Solar Photovoltaic Systems
- Certified to Puerto Rico Electric Power Authority (PREPA)
- The inverter is designed to be compliant with UL 1741, UL 1998, FCC Part 15 (Class A and B), IEEE 1547, and CSA C22.2.

Utility Interconnection

- **Voltage and Frequency Variation**
  IEEE 1547.2 – Standard for Interconnecting Distributed Resource with Electric Power Systems
- **Prevention of Islanding**
  IEEE 1547.1a – Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems was used for the test method; IEEE 1547 paragraph 4.4 was used for timing requirements.

3 Description of Device

3.1 Operating Mode

The REFUsol 48K-UL transforms the direct current generated by photovoltaic (PV) modules into alternating current and feeds this into the public grid.
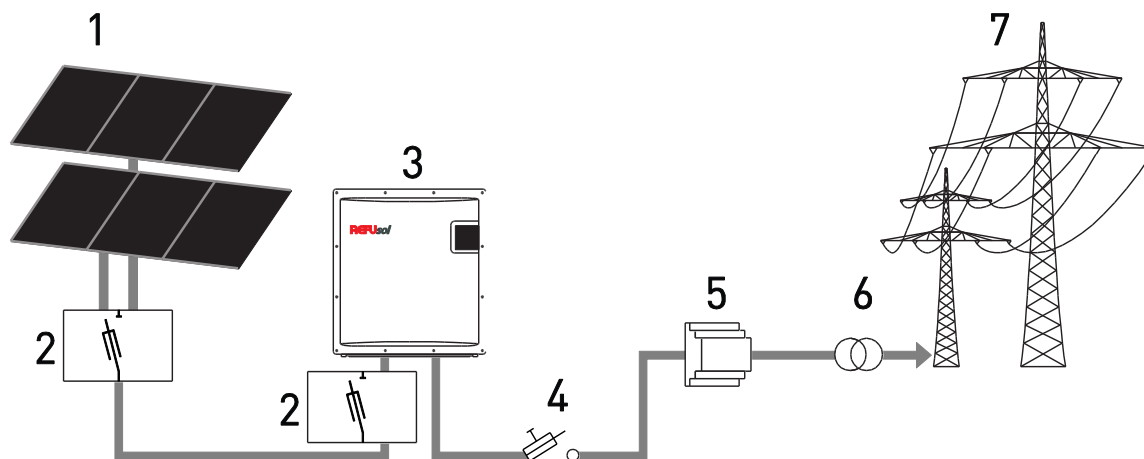
Fig. 1: How it works: a grid-connected PV system with photovoltaic inverter

1	PV modules
2	Solar string combiner box (depending on authority having jurisdiction AHJ or utility company)
3	REFUsol photovoltaic inverter
4	Fuse switch disconnector or circuit breaker
5	Grid protection (if required by authority having jurisdiction AHJ or utility company)
6	Isolation transformer is required for medium-voltage network
7	Low or medium-voltage AC grid

3.2   Features of REFUsol 48K-UL

The REFUsol 48K-UL inverter is a transformer-less, three-phase solar inverter, which has a particularly high efficiency at any operating point.

Heat is dissipated only by convection. The internal temperature control prevents the device from exceeding the permissible ambient temperature.
The inverter is designed such that the device does not have to be opened for assembly and connection work. The inverter provides communication interfaces for RS485 and Ethernet. The communication protocol is Modbus and Sunspec compliant.

An illuminated graphical display shows the development of the feed-in power and other operating data in a clearly arranged manner. An 8-key control panel below the display also provides excellent control and navigation convenience. Based on its design in protection class IP 65, the inverter can be installed at almost any outside location. The inverter has extensive safety and security features. For details, refer to Technical Data on page .

3.3 External Dimensions

752 mm (29.61″) 40 mm (1.57″) 281 mm (11.06″)

899,1 mm (35.4″)
819,1 mm (32.25″)
423 mm (16.65″)
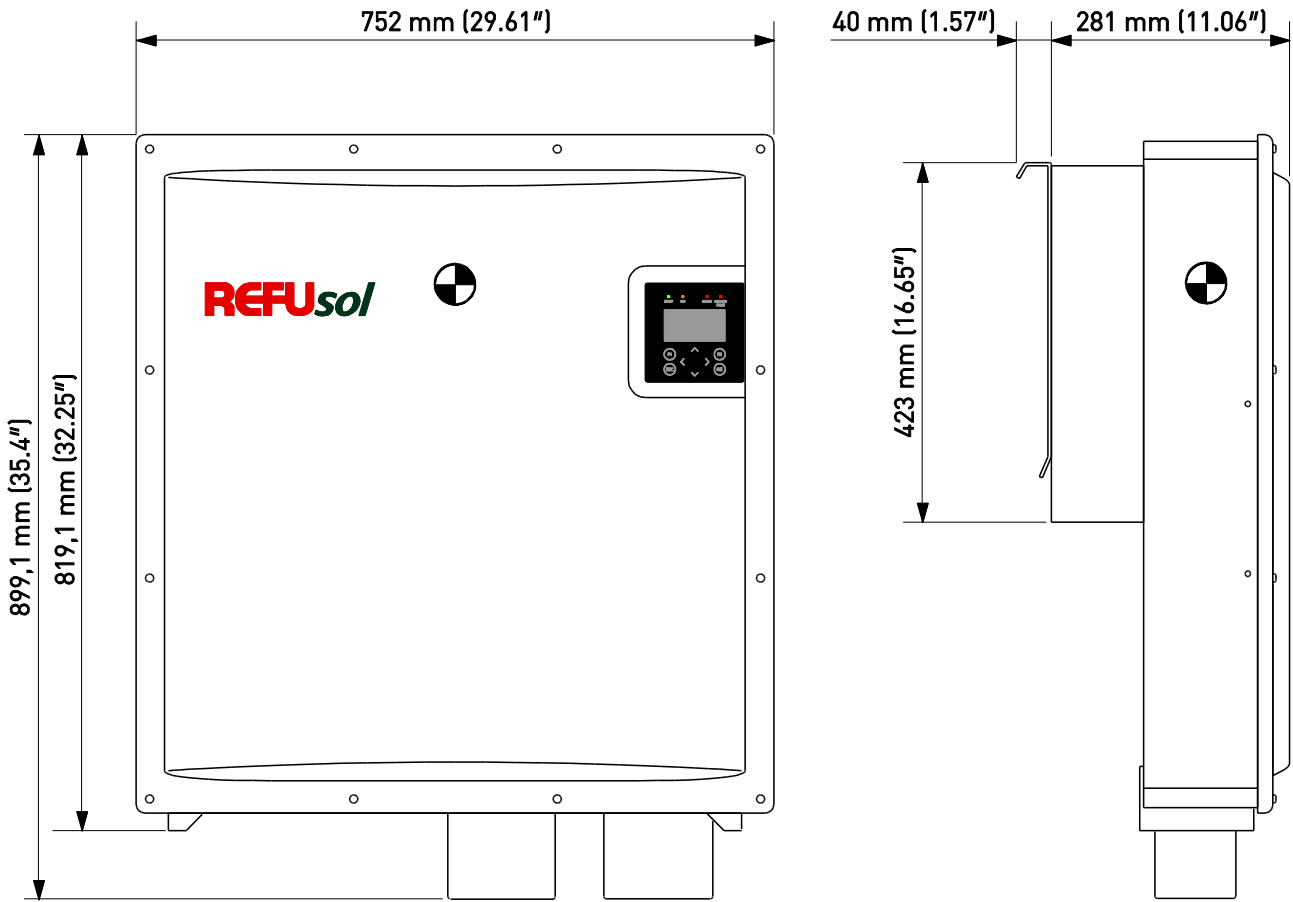
Fig. 2: External dimensions

Note

When installing a DC Combiner Box mind that additional space is needed!

3.4 Block Diagram
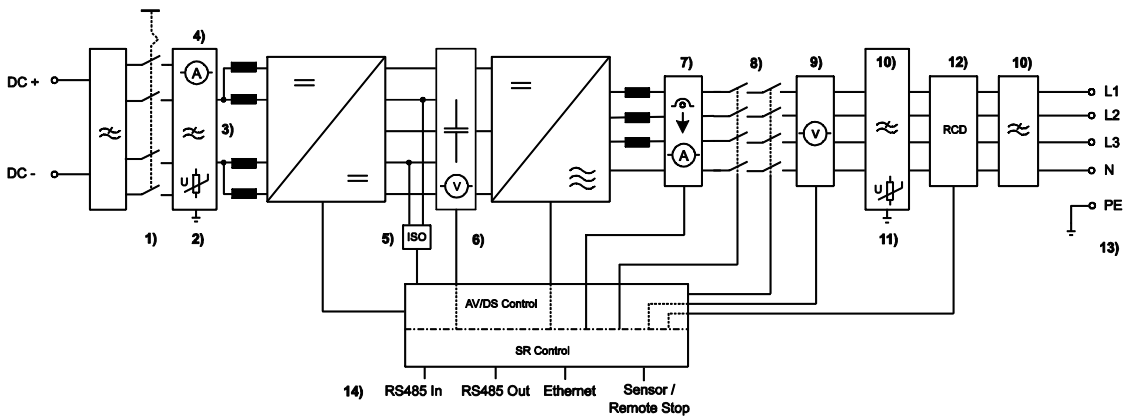
Fig. 3: Block diagram

1) DC switch
2) DC overvoltage protection type 3 (SPD)
3) DC EMC filter
4) DC current measurement
5) Isolation monitoring
6) DC voltage measurement
7) AC current measurement
8) AC grid relays (redundant)
9) AC voltage and frequency measurement
10) AC EMC filter
11) AC overvoltage protection type 3 (SPD)
12) Fault current monitoring, Type 2
13) Protective earth connection
14) Interfaces (Ethernet, RS485, Sensors, remote stop)

3.5 System Block Diagram
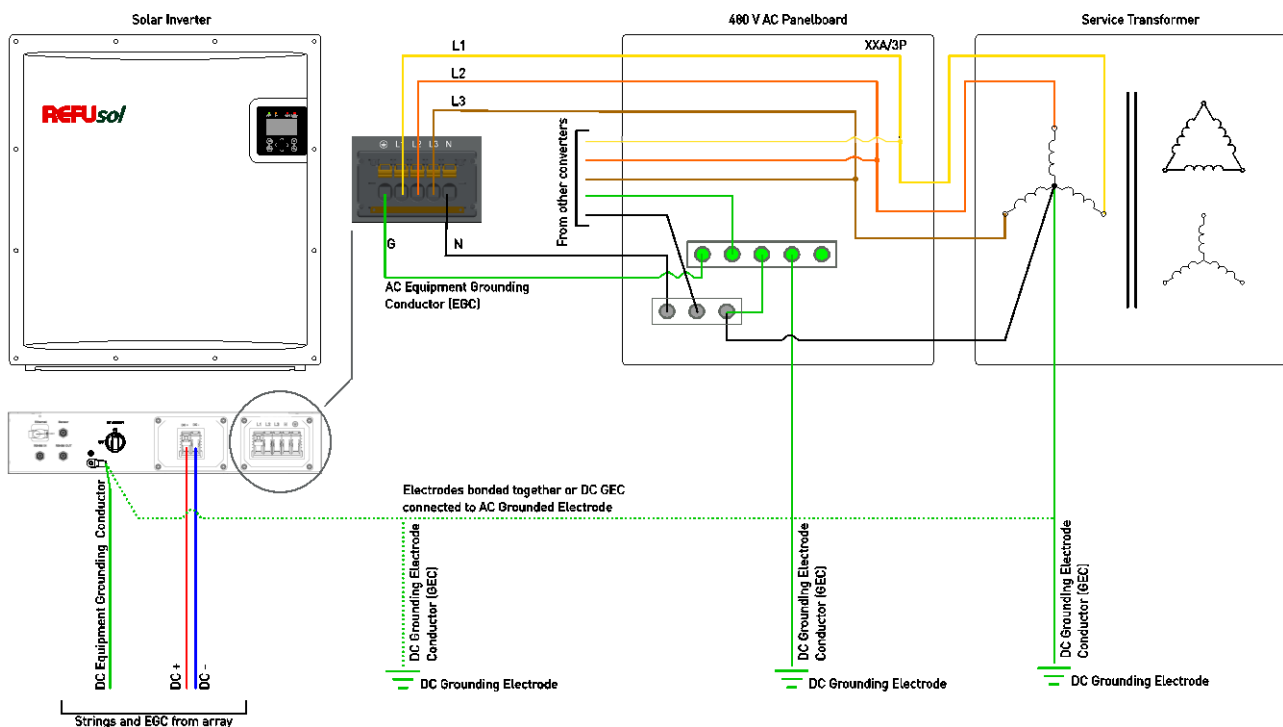
Fig. 4: System block diagram (exemplarily described on the 48K-UL model)

3.6 Control Panel

The graphical user interface which is integrated on the front of the device and comprises 128 x 64 pixels can be used to display the development of data, such as the feed-in power or yield. The parameters required are selected and entered on the 8-key control panel. The control panel is illuminated when a key is pressed and turns dark automatically.
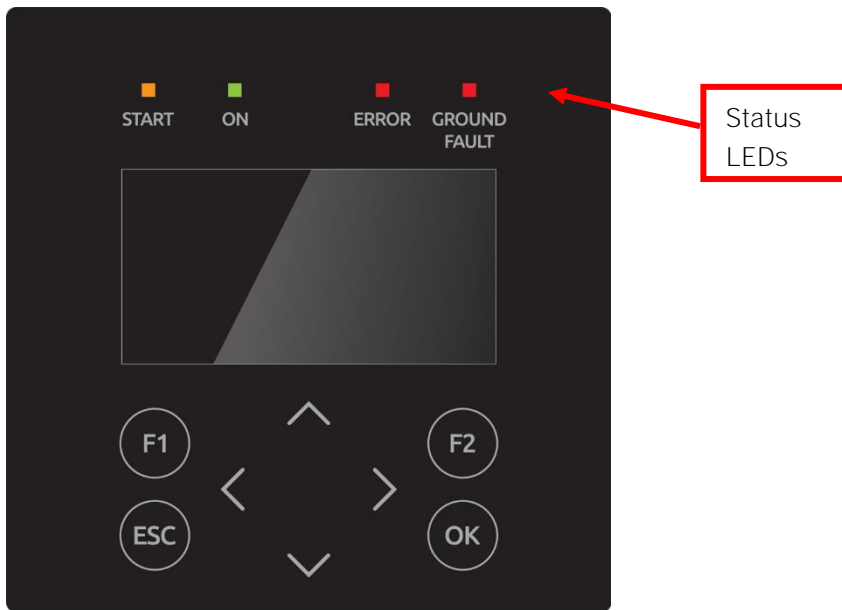
Fig. 5: Control panel

3.7   Internal Data Logger

The inverter features an internal data logger that allows measured values to be simultaneously recorded in the form of parameters. If the storage capacity is full, the oldest data is overwritten. With the default setting on delivery, the data logger logs 16 measuring channels, which can be displayed an analyzed by REFUlog.

Recording cycle	Storage time
1 minute	2.5 years
2 minutes	5 years
5 minutes	12.5 years
10 minutes	25 years

4   Installation

4.1   Assembly Site Requirements

⚠ DANGER

Danger to life due to fire or explosion.

⇒ Do not install inverter in areas with risk of explosion.

⇒ Do not install inverter on flammable materials. Uphold fire protection class according to NFPA regulation.

⇒ Do not install inverter in areas where easily flammable materials are stored.

⇒ Under no circumstances are the cooling fins of the heat sink to be covered.

⚠ WARNING

Danger of accident

⇒ When installing and servicing, unrestricted and safe access to the devices must be ensured.

The following requirements of the installation site must be upheld:

- Only vertical installation is permitted as otherwise the cooling of the device cannot be guaranteed (convection cooling).
- Prolonged exposure to direct sunlight can cause an internal temperature rise, leading to power derating of the device. It is recommended to especially avoid easterly or westerly installation orientations, or to install a sunshade to mitigate the thermal impact of irradiation.
- A fixed wall or a metal construction is necessary for installation. The weight of an inverter amounts up to **75.6 kg (166 lbs)**. Relevant construction regulations must be observed.
- The device is to be mounted at an appropriate distance from combustible materials.
- Installation in non-ventilated ended cabinets and enclosures is not allowed because the unit in operation emits heat.
- To allow for the heat dissipation required, keep the following minimum distances from the ceiling and wall as well as from neighbouring devices:
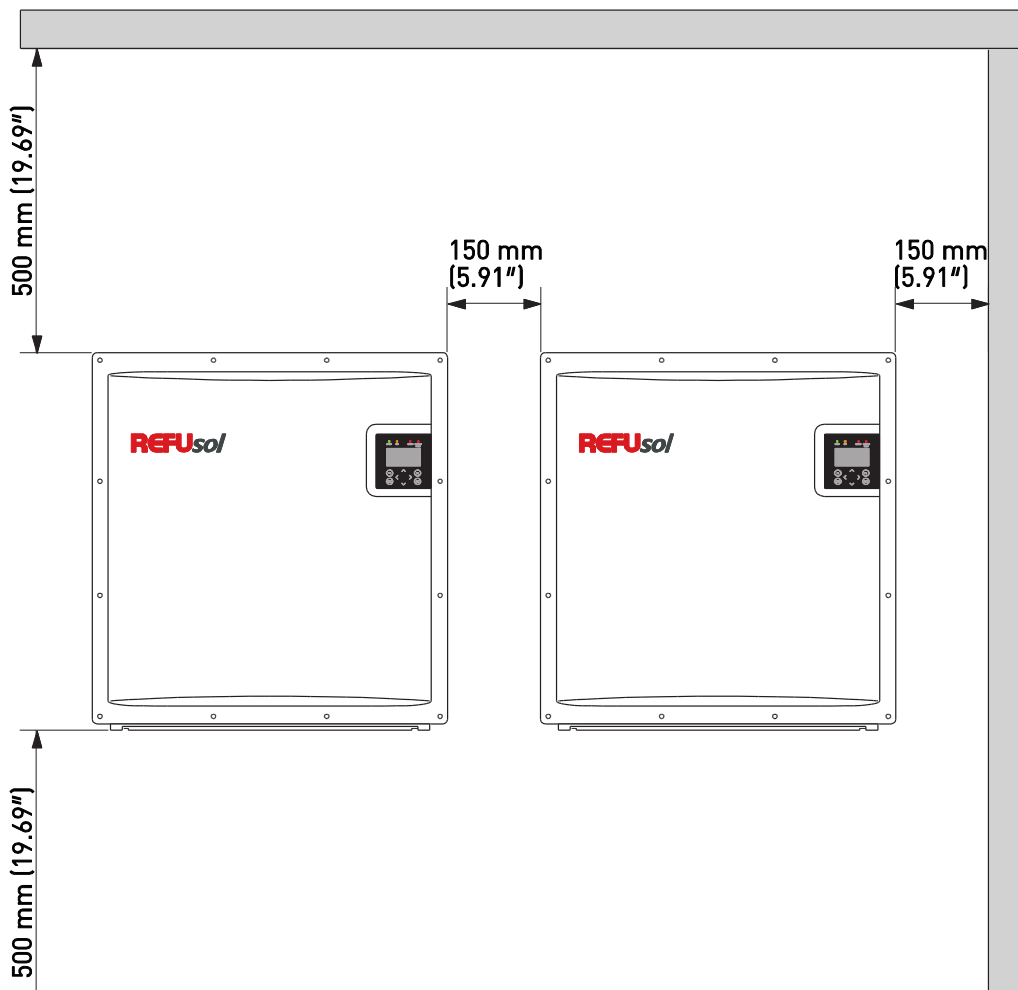
Fig. 6: Minimum distances

The device is best operated if the display is at eye level.

4.2 Transport

The devices must be transported under clean and dry conditions, if possible in their original packaging. The transport temperature must be between -40 – +60 °C (-40 – 140 °F). Permissible variations in temperature may not exceed 20 °C (36 °F) per hour.

4.3 Storage

The devices must be stored in clean and dry premises, if possible in their original packaging. The storage temperature must be in the range of **-40 – +60 °C (-40 – 140 °F)**. Permissible variations in temperature may not exceed 20 °C (68 °F) per hour.

Note:

The inverter contains electrolytic capacitors which can be stored for no more than 1 year and at a storage temperature of ≤ 40 °C / ≤ 104 °F while in a de-energized state. If the storage time has been exceeded, please contact contact REFU Elektronik GmbH Service before connecting the inverter to your system!

4.4   Check Delivery

The scope of delivery includes the following:

- Solar Inverter REFUsol 48K-UL

- Wall mounting plate

- 2 x mounting eyes for the handling of the device with the crane

- 2 x connection housing DC and AC connection

- 4 x connection housing gaskets

- 8 x M5 locking nuts for connection housing

- 1 x M5 nut for grounding bolt

- 3 x M5x20 ISO 14583 VZ mushroom head bolts for fixing of the inverter at the wall mount

The screws for attaching the wall mounting plate 10 mm (3/8″) to the wall and the grounding lug are not included.

4.5   Unpacking the Device

NOTICE
Exposure to moisture, dust, or debris while unmounted in a non-vertical orientation poses a risk of ingress
⇒   Only unpack the device when it is to be installed. Failure to do so voids your warranty!

The device is delivered in a cardboard box:
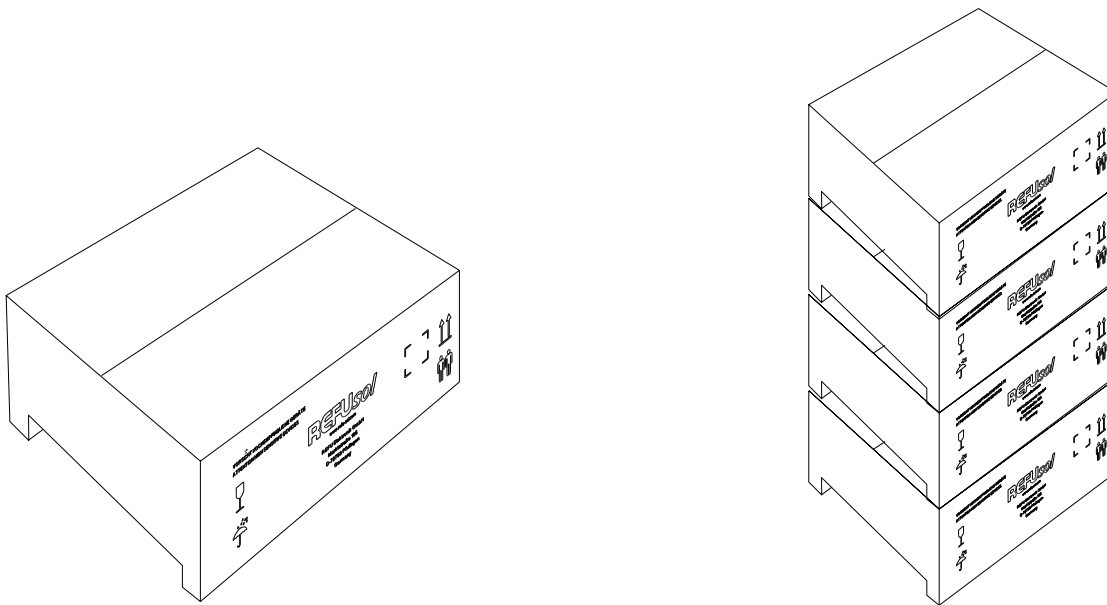
They can be stacked up to a maximum of 4 boxes high.

1.   Open the box.

2.   Take out the wall mount plate.

3.   Take out the corner protection at the top of the inverter.

4.   Fix the lifting eye plates into the slot (see red arrows):
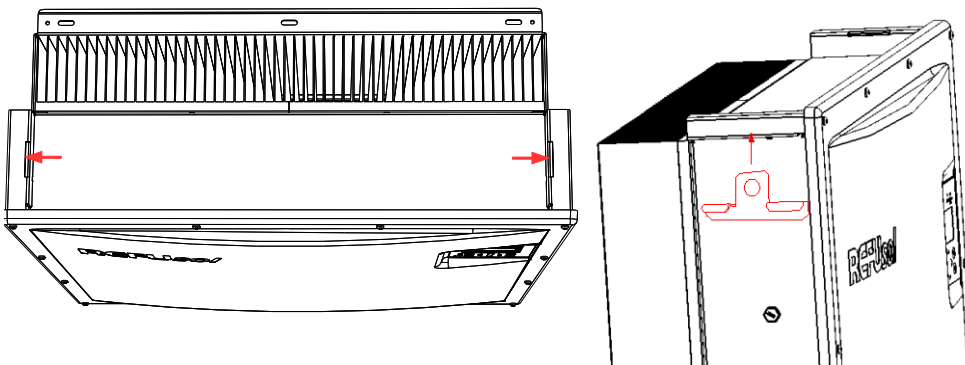
5.   Carefully lift the inverter out of the box with a crane or with 2 persons. Keep the product weight of 75.6 kg (166 lbs) in mind!
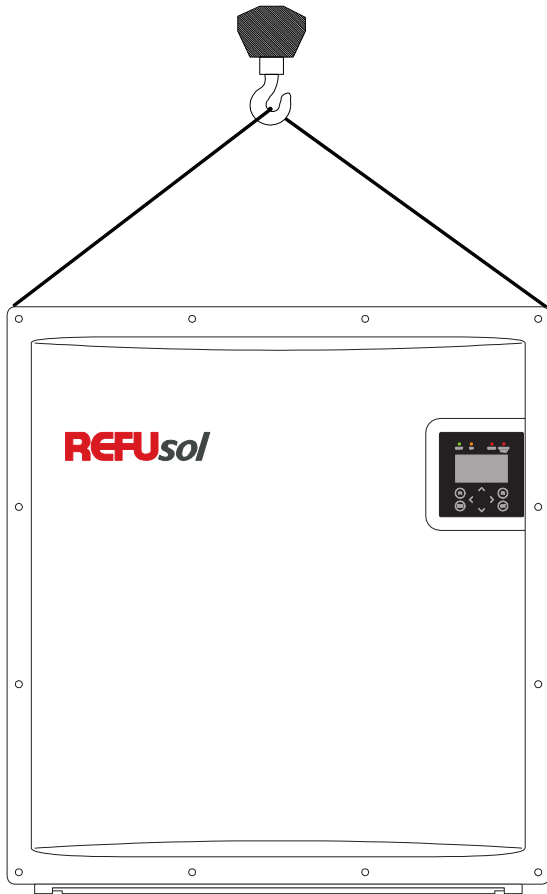
4.6 Installation

⚠ CAUTION

Danger of injury

⇒ When designing the attachment of the wall-mounting plate, take the product weight of **75.6 kg (166 lbs)** into account.

⇒ Do not open device. Opening the device voids the warranty.

NOTICE

Danger of damage to property

⇒ Do not use the cover to hold the device. Only use the four holding grips to move the device.
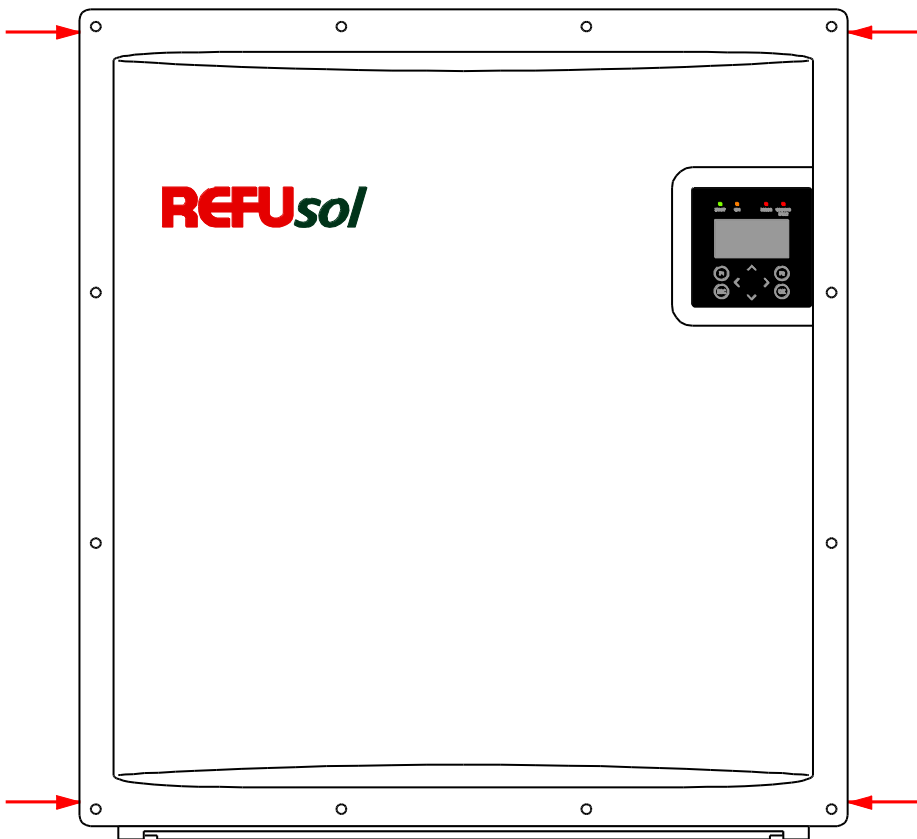
Fig. 7: Handles on the inverter

The inverter is mounted using the wall-mounting plate which is included in the scope of delivery.
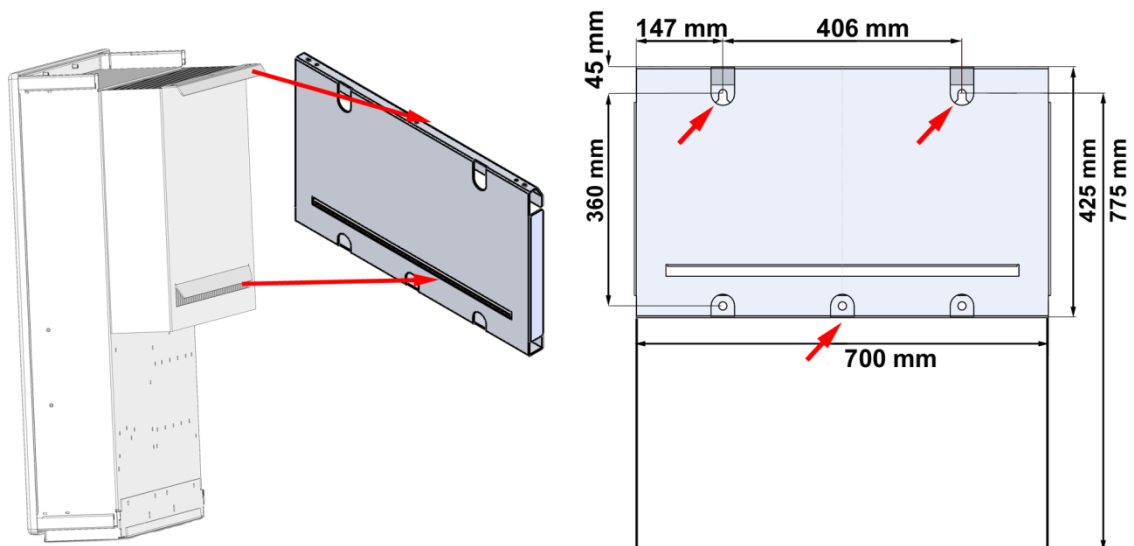
Fig. 8: Mounting the inverter

1. Use the wall bracket to mark the positions of the holes to be drilled.

2. Attach the wall-mounting plate to the wall using maximal 5 screws. The screws for attachment to the wall are not included. Screws with a diameter of 10 mm (3/8″) must be used.

3. Attach the lower clip into the slit of the wall mounting-bracket and apply the upper clip.

4. Attach the inverter with the 3 screws included (M5x20) at the top of the wall-mounting bracket (red arrows).
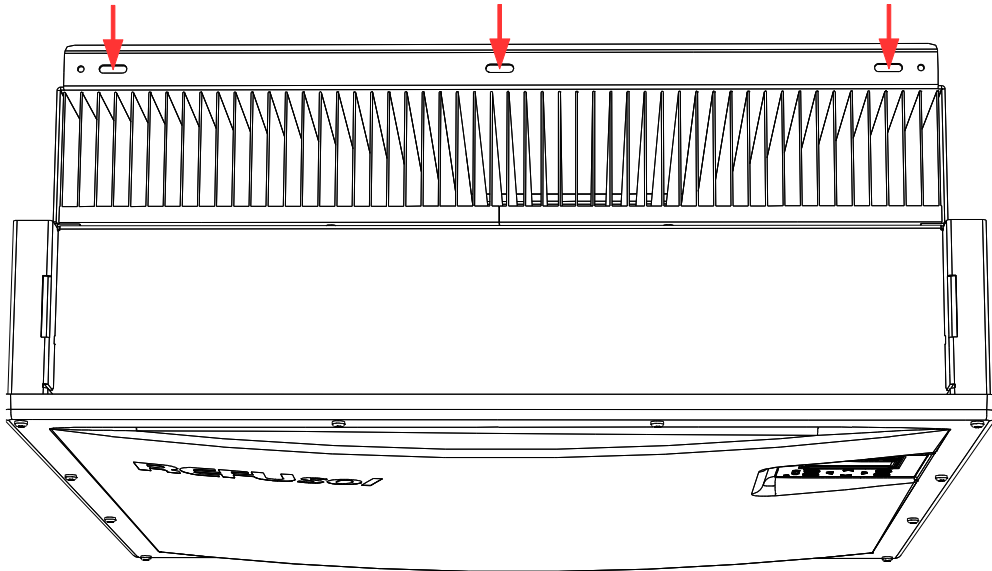
Fig. 9: Attaching with 3 screws

5. Tighten to torque of 2.5 Nm (1.8 ft lbs).

6. In order to avoid adhesive residue on the inverter, remove the display protection immediately after installation.

4.7   Device Connectors

The following figure shows the DC switch and connectors of the inverter on its bottom side:
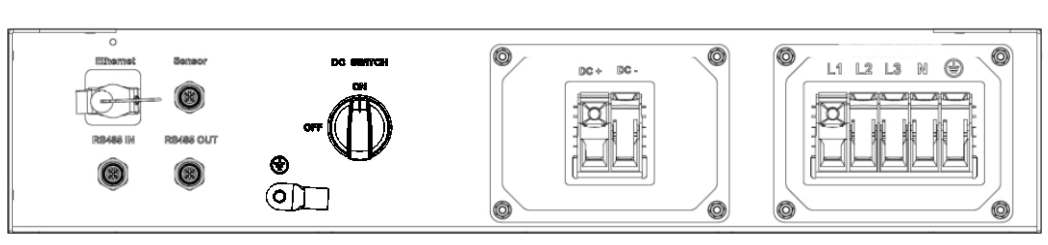
Fig. 10: Device connectors

The inverter is provided with the following connectors, as seen from left to right, top to bottom:

- Ethernet interface
- Sensor (irradiation, temperature or remote shutdown signal)
- RS485 connections (IN and OUT)

- Inverter earthing connection

- DC Connection for Solar Generator (DC+, DC-)

- AC Grid Connection (L1, L2, L3, N, PE)

4.8   Grounding

⚠ DANGER
Danger to life from electric shock!
⇒ The inverter must be earthed with the grounding bolt, otherwise a potential difference can build up, causing a risk of electric shock!

The inverter features a threaded bolt at the left bottom side for additional grounding. Grounding is intended to ensure optimum overvoltage protection. The cross section for the ground must be 16 mm² (AWG 5) for copper and 25 mm² (AWG 3) for aluminum. Depending on the function and use of the additional ground wire other wire sizes may be required depending on the local regulation.

The maximum permissible torque for the grounding screw is 10 Nm (7 ft lbs).
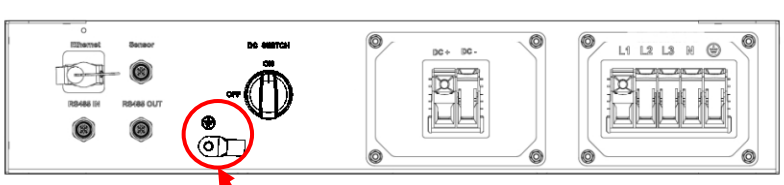
Fig. 11: Grounding bolt

M8 grounding bolt

4.9   Residual Current Protection

This inverter is equipped with a Residual Current Detection (RCD) circuit to protect PV source and output circuits against ground faults, in accordance with the 2014 National Electrical Code, article 690.35 (C).

An operational isolation error occurs when the device detects a residual current in the circuit, and is indicated on the display of the inverter. In the event of an isolation error, please check the system isolation. If the isolation impedance is in the normal range, please contact REFU Elektronik GmbH Service at service.usa@prettl-energy.

Note:
This photovoltaic inverters meets the fault protection requirements according to the 2014 U.S. National Electrical Code ® section 690.35 C.

4.10 DC and AC Wiring Feedthrough

NOTICE

For outdoor installations, suitably rated fittings or hubs must be used

To ensure the NEMA 4 protection class, only use the DC input connectors provided and connect them according to the connector manufacturer's mounting instructions. Use the enclosed DC and AC small housings to connect conduit to the inverter. To prevent any penetration of moisture and dirt, and maintain NEMA 4 protection class, use only UL listed rainproof or wet location hubs with rubber seals. Failure to do so could void your warranty!
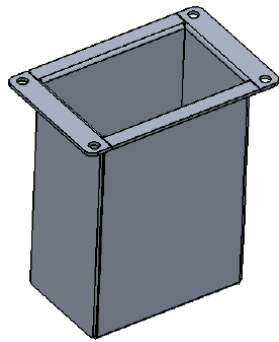
DC and AC Connection

Fig. 12: Small electrical housings provided for AC and DC conduit connections.

1. Drill the desired size hole in the small electrical housings provided with the inverter

2. Make sure the seal provided is used with the corresponding small electrical housings to maintain NEMA 4 protection

3. Insert an appropriately-sized NEMA 4 conduit hub in each feedthrough opening.

4. Insert the appropriately sized wires through the hub.

4.11 Grid Line Impedance

For better efficiency, large line cross-sections in single cables are increasingly used for power supply lines, especially if local conditions require long supply lines.

In large-scale plants, it is recommended as a best practice to locate the inverters in close proximity to the step-up transformer. If the inverters are located in a decentralized fashion, with long distances to the transformer, the higher AC cable inductance can lead to increasing line impedances. This can lead to voltage distortions and error messages with regards to:

- Grid overvoltage (long cable)
- Increased operating noise of the inverters (short cable)

To avoid these disadvantageous conditions, twisted lines should be used for power supply if possible. If laying of twisted lines is not possible, the following requirements must be met for single cores:

- Lay single cores next to each other.
- It is not allowed to lay single cores in closed, magnetically conducting materials (e.g., sheet steel pipe).
- If laid in open cable ducts, single cores should be laid such that the spacings between them are as small as possible.

Minimum spacing between single cores!

L3 PE

L1 L2 N
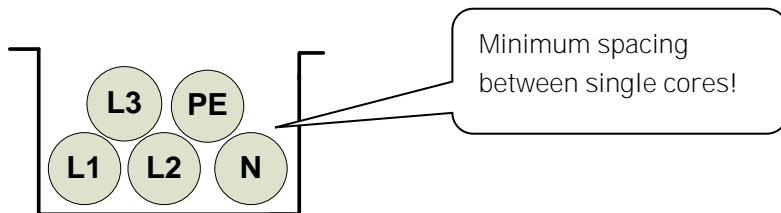
Note:

To avoid unnecessary loss of energy yield, the sum total of the resistive and inductive voltage drop on the power supply line at nominal load should not exceed 1 % of the line voltage.

4.12   DC Connection of the Solar Generator

⚠ **DANGER**

Danger to life due to high voltages from active PV strings

⇒ Before connecting the PV strings, connect the inverter to the power supply and additional ground connection.

⇒ The connection of the PV strings must always be carried out deenergized. The inverter must be earthed with the grounding bolt, otherwise a potential difference can build up, causing a risk of electric shock!

The inverter has a single DC input for connecting the solar generator. The module strings must be combined in a separate DC string combiner box.

The DC terminals can be used with aluminum and copper wires. Please also check the installation instruction of Phoenix Contact.

DC+ DC-
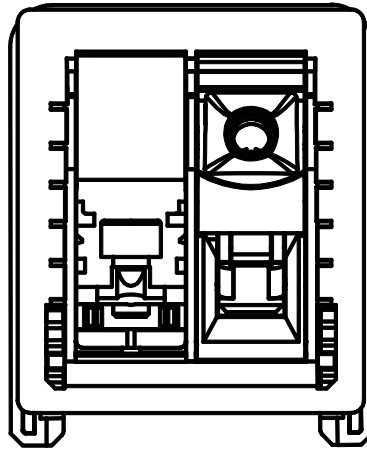
Fig. 13: DC connection Phoenix Contact TW50 (picture shows the plus connection closed and the minus open)

- Before connecting the PV strings an isolation measurement must be taken.

- Whenever it is switched on, the inverter automatically checks the insulation of the PV generator. If the isolation resistance measurement is below the acceptable threshold, the inverter does not start and the error "GROUND FAULT" is displayed. The inverter can only be started once the PV generator isolation error has been removed.

- Be absolutely sure to verify proper polarity when connecting the PV strings. Any inappropriate connection of individual strings may damage the PV generator.

- The solar inverter is protected against reverse polarity connection by an integrated diode.

The PV generator may not exceed the following operational characteristics under any circumstances!

Device type	REFUsol 48K-UL
Max. DC voltage at each input	1000 V
Max. short-circuit current DC input	160 A
Max. DC operating current	84 A

NOTICE

Failure to observe this can lead to damage to the inverter and therefore void the warranty.

4.13   DC and AC Terminal Connections

The terminals for DC and AC connection are suitable for use with conductors from AWG 7 – 1. Stranded conductors without ferrules should only be used if AWG 2 or larger.

The provided connection housing protects the terminal block and saves the cable from mechanical stress.

Follow these steps for the connection:

1.   Drill a hole into the cabinet housing for the appropriate conduit diameter:
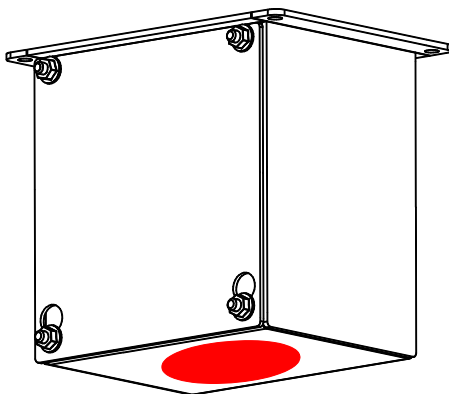
2.   Fix the connection housing conduit onto the housing.

3.   Put the seal element on top of the connection housing.

4.   Lift the connection housing onto the inverter housing, fitting it onto the 4 pem studs:
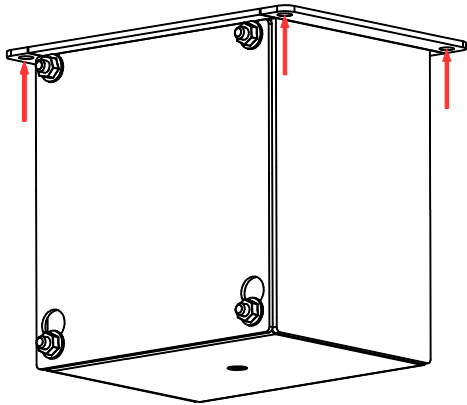
5. Tighten four M5 screws on the connection housing with 3 Nm (2 ft lbs).

6. Unscrew the front cover of the connection housing to remove:
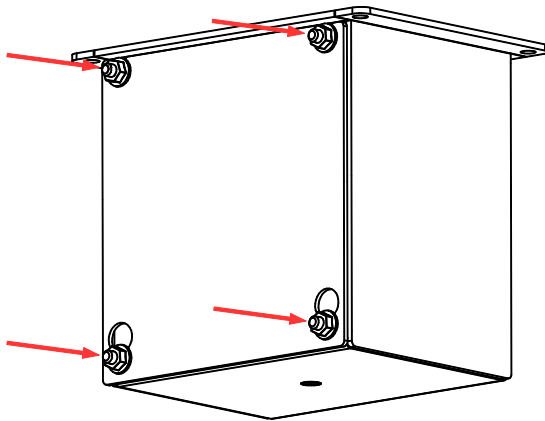
7. Put the cable through the conduit into the connection housing:
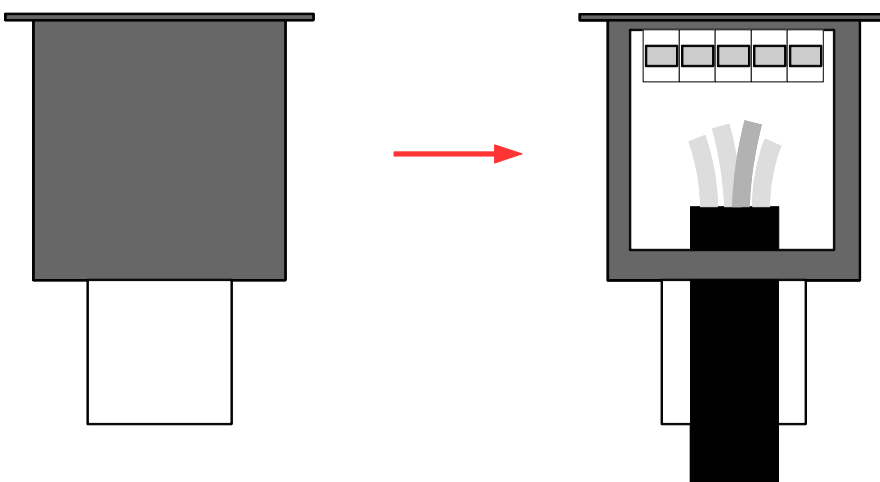
8. Strip the insulation from the conductor.

- AWG 3 – 7 = 0.71″

- AWG 2 – 1 = 0.78″

9. Route the conductor into the terminal point, leaving a service loop.

10. To clamp and unclamp the terminal point, insert a screwdriver into the round opening on the orange cover and lever downwards fully to complete the cable connection.
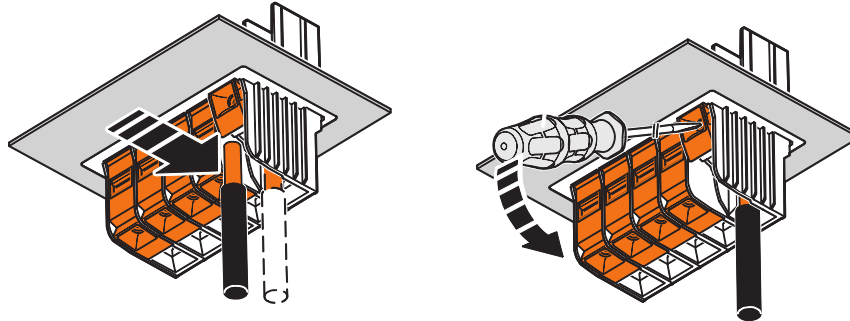
11. Close the connection housing cover with four M5 screws with 3 Nm (2 ft lbs).

4.14   Interface Port RS485

The RS485 interface supports the USS (Universal Serial Interface Protocol) and Modbus/Sunspec protocols, which can be used for transmission of data, for example, to a data logger of a remote monitoring system.
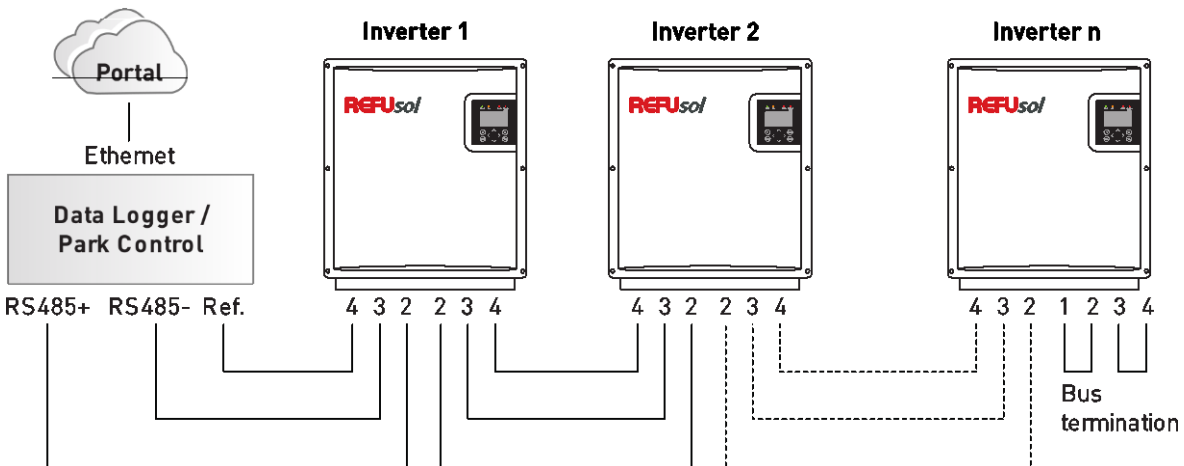
Fig. 14: Standard interface

When using this interface, please note that each device using the bus requires a unique address.

The bus termination is made by means of wire jumpers on RS485 **OUT to the last bus user (inverter "n").** To make the termination take a short cable, remove the cable insulation, and connect the pin 1 to pin 2 as well as pin 3 to pin 4.

Pin	Signal
Pin 1	(only used for termination)
Pin 2	RS485 +
Pin 3	RS485 -
Pin 4	Reference
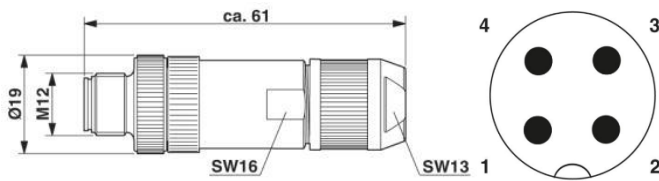
Fig. 15: Connector M12 x 1 straight, shielded; pole arrangement:male M12, 4 pins, A-coded, view of male connector side

---

NOTICE

In order to ensure IP 65 protection and the required and declared conformity with the domestic EMC standard a PHOENIX CONTACT type M12MS SACC-4SC SH plug and a shielded cable must be used. The outer diameter of the connecting cable can be max. 8 mm.
Failure to observe this can lead to damage to the inverter and therefore void the warranty.
The plug pair can be ordered at REFU Elektronik GmbH with Art. No. 922001.

4.15   Ethernet Interface Connection

The Ethernet interface supports Modbus TCP/IP protocol, and is Sunspec compliant, which can be used for transmission of data, for example, to a data logger of a remote monitoring system. Daisy-chaining of devices is not supported. Each inverter must be connected to an ethernet switch, in parallel.

Please use an Ethernet cable with S/FTP design (shielded foiled twisted pair) and Phoenix Contact plug type Quickon VS-08-RJ45-5-Q/IP67.
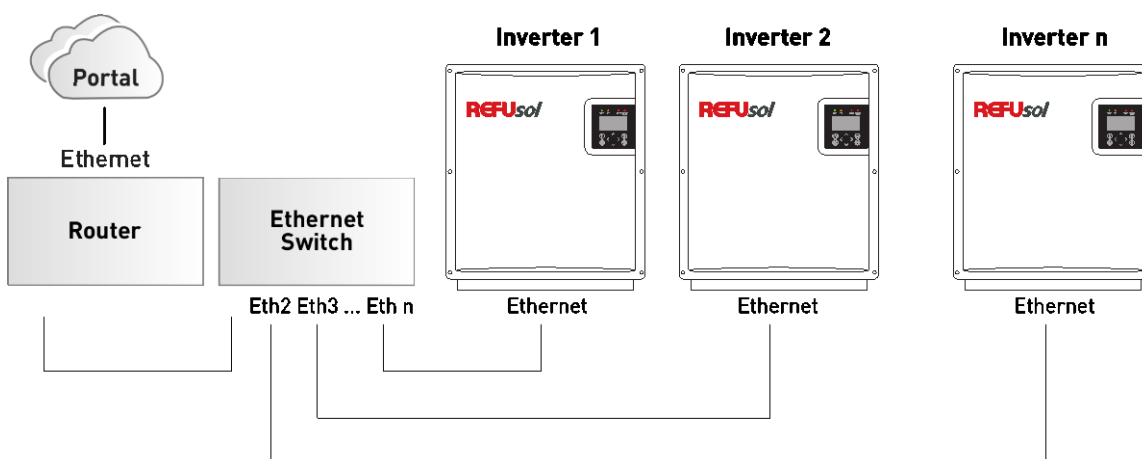
Fig. 16: Ethernet interface

NOTICE

In order to ensure IP 65 protection, the plug type mentioned above must be used.
Failure to observe this can lead to damage to the inverter and therefore void the warranty.
The plug can be ordered from REFU Elektronik GmbH with Art. No. 922002.

---

5 Commissioning

Before commissioning the inverter, be sure the following steps have been completed:

- ☑ Measurements tests were performed and summarized in a test report:
  The grounding connection has been checked.
  Isolation of strings to ground has been checked.
- ☑ Functional tests were performed and summarized in a test report:
  The correct grid code (IEEE 1547 or IEEE 1547a) is selected.
- ☑ If applicable, further requirements and technical rules need to have been considered in this context (e.g. Authority Having Jurisdiction (AHJ)).

5.1 Switching on the Device at Initial Start-up

- ☑ The electrical system to be connected was prepared according to the five safety rules.

⚠ DANGER

Risk of death by electric shock

Disconnect electrical systems according to the 5 safety rules:

⟹ Disconnect mains.

⟹ Prevent reconnection.

⟹ Test for absence of harmful voltages.

⟹ Ground and short circuits.

⟹ Cover or close of nearby live parts.

- ☑ The grounding and DC connection of the inverter/combiner box is installed.

1. Connect PV strings to the inverter or combiner box.

2. Check that all connections and covers are securely fastened.

3. Turn on DC voltage across switch separator.

4. Close the inverter's AC branch circuit breakers.

↷ If at the DC input of the inverter sufficient voltage is present, the inverter starts operation.

Note:

The control panel, including its status indicators, display, and operator keys, is only active when the PV generator is supplying sufficiently voltage.

5.2 Switching on the Device after Replacement

☑ The electrical system to be connected was prepared according to the five safety rules.

⚠ DANGER

Risk of death by electric shock

Disconnect electrical systems according to the 5 safety rules:

⇒ Disconnect mains.

⇒ Prevent reconnection.

⇒ Test for absence of harmful voltages.

⇒ Ground and short circuits.

⇒ Cover or close of nearby live parts.

---

1. Remove any covers and barriers to adjacent live parts.

2. Remove any temporary short-circuit or grounding jumpers previously installed in the DC and/or AC system conductors.

3. Connect PV strings to the inverter or combiner box.

4. Checking of the AC and DC voltages applied on the connection.

5. Remove LOTO devices in accordance to the site owner's electrical safety procedures.

6. Switch the DC combiner box disconnect switch to the "ON" position.

7. If applicable, close the inverter's DC equipment disconnecting means.

8. Close the inverter's AC branch circuit breakers.

↪ If at the DC input of the inverter sufficient voltage is present, the inverter starts operation.

Note:

The control panel, including its status indicators, display, and operator keys, is only active when the PV generator is supplying sufficiently high voltage.

5.3 Disconnecting Device Power

⚠ DANGER

Risk of death by electric shock

Disconnect electrical systems according to the 5 safety rules:

⇒ Disconnect mains.

⇒ Prevent reconnection.

⇒ Test for absence of harmful voltages.

⇒ Ground and short circuits.

⇒ Cover or close of nearby live parts.

---

1. To stop the operation of the inverter push on the inverter's control panel ESC and OK at the same time.

2. Open the inverter's AC branch circuit breakers.

3. Switch the DC combiner box disconnect switch to the "OFF" position.

4. If applicable, open the inverter's DC equipment disconnecting means.

5. Secure separators against being switched back on. Install LOTO devices in accordance to the site owner's electrical safety procedures.

6. Wait 15 minutes until capacitors are discharged.

7. Determine absence of voltage, observe stored energy and discharge time in the intermediate circuit.

8. If applicable, install short-circuit or grounding jumpers in the DC and AC supply side.

↯ Inverter is de-energized and out of service.

5.4 Setting the Country Code and the Menu Language

When switching on for the first time an initial configuration is necessary.

The country code defines the country-specific grid monitoring parameters. The menu language is automatically set when the country code is selected. The menu language can subsequently be selected as desired at any time, independent of the country abbreviation set in the menu. The country code is not set on delivery.

NOTICE

The selected country code can only be changed by service personnel.

After the initial setting and confirmation of the country code the country code can only be altered within 40 hours. This is also valid for replacement devices. The country code can then only be changed by authorized service personnel.

NOTICE

Cancellation of the operating license!

Operating the REFUsol inverter with the wrong country code can lead to the withdrawal of the interconnection agreement from the energy supplier.
We assume no liability for the consequences of an incorrectly set country code!

5.4.1   Set Country Code/Grid Guideline

The following window appears on the display after initial switch on of the DC voltage and prompts you to set the country code. You can choose from among the offered countries.

```
Configuration
 Country
  Canada
  Mexico
  USA
```
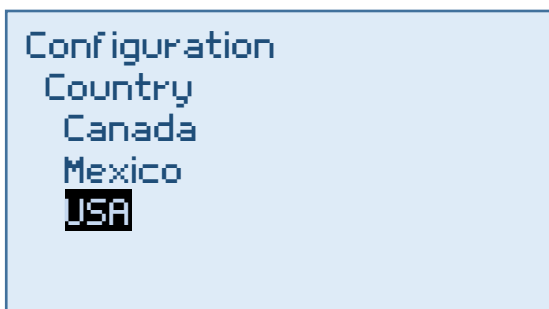
1. Use the ⌃ and ⌄ keys to select the country code which is specific for your country and your location. The menu language is selected simultaneously with the country code. However, the menu language can later be changed independently of the country code.

2. Press **OK** to confirm. Then the grid feed guideline given by the energy supplier must be selected.

```
Configuration
 Country
  USA
   IEEE1547
   IEEE1547a
   CPUC R21
```
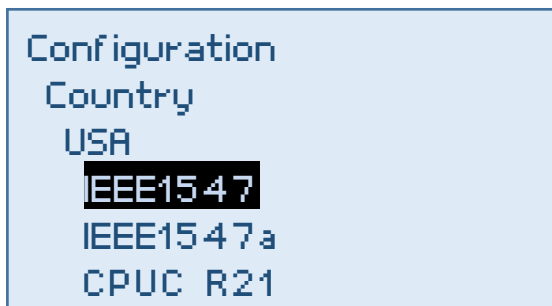
3. Select valid grid feed guideline with ⌃ and ⌄ buttons.

4. Press **OK** to confirm.

5.4.2   Accepting the Country Code

To be certain, you will be asked whether you wish to accept the country code. After accepting the country code it can only be changed within 40 hours.

```
Set Country to
USA - IEEE1547a ?




Cancel                    OK
```

Only confirm the country code if you are absolutely sure it is correct.

If you are not sure, press **ESC** to cancel your selection. In this case the device cannot be operated.

If the country code is to be accepted, then confirm with **OK**.

A restart then takes place:

☞ "ERROR" and "GROUND FAULT" status LEDs flash red alternately.

```
PAC          8260 W
VAC           405 V
VDC           634 V
E day        27.6 kWh

         Reboot
Menue
```
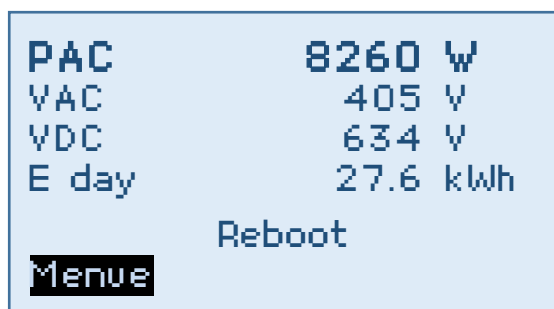
5.5   Device Start

Description of the abbreviations on the display:

PAC	Feed power in watts (W)
VAC	Line voltage in volts (V)
VDC	Solar cell voltage in volts (V)
E day	Energy yield of the day (kWh)

☑ Solar modules are irradiated with sufficient sunlight.
☑ Country code is set.
☑ Time and date is set.

The following procedure follows:

Self-test   All status LEDs are lit for approx. 6 seconds

Check   "START" status LED lights orange.

Activation   "START" status LED lights orange/LED "ON" flashes green.

Feed in   "ON" status LED lights green/normally all other status LEDs are off.

5.6 Control Panel
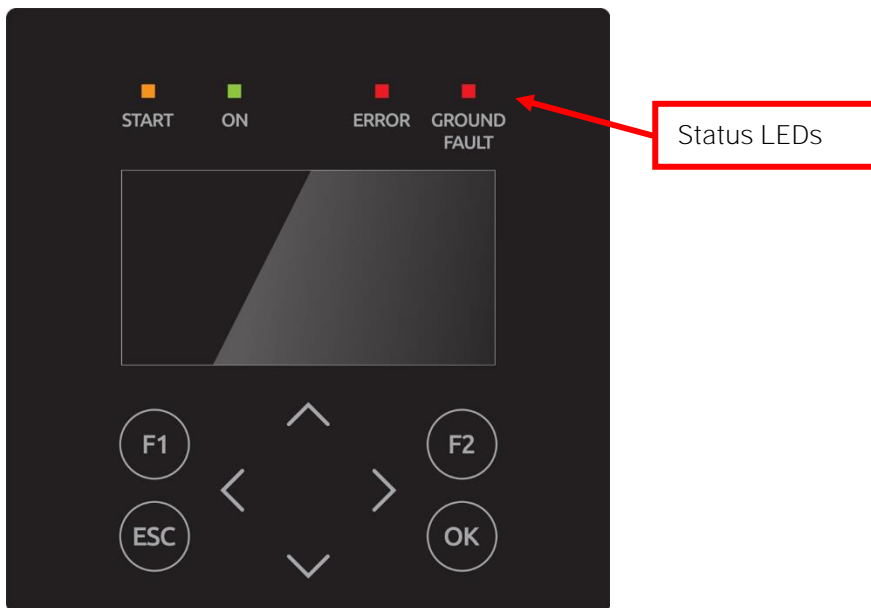
Fig. 17: Control panel with status LEDs, display and keys

F1	Displays the Menu
F2	In basic display: Reboot of display "Energy / x kWp" display: Input of standardized (normalized) data
‹ ›	Function in the menu: Navigation within the menu level (previous menu, next menu). Function while parameters are edited: digit to the left, digit to the right (decade jump)
⌃ ⌄	Selection within the menu.
ESC	Acknowledge failures and exit from menu level, exit from input menu without entering data
OK	Confirm the selected menu (next menu level) and entered data.

5.7 Graphical Display

Press the ‹ arrow key once to display the development of the day's feed power.
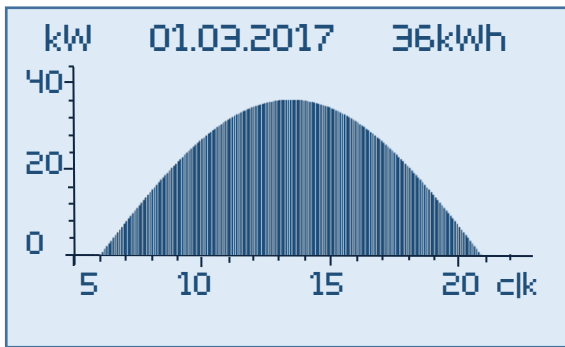
Fig. 18: "Today's" feed power display

Press the ✔ arrow key to display the development of the previous days.

Press the **ESC** key to return to the basic screen display.

5.8 Energy Yield Data Display

Press the ❯ arrow key to display the current yield data and the operating hours having currently elapsed.
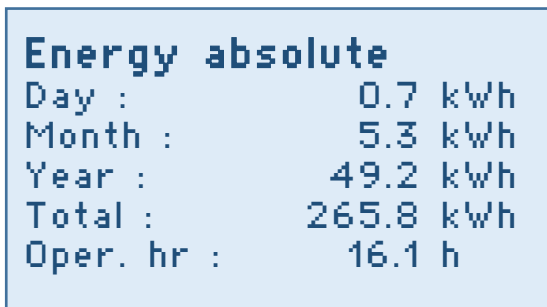
Fig. 19: Energy yield absolute display

5.9 Standardized Energy Yield Data Display

Press the ❯ arrow key, then the ✔ arrow key to display the development of standardized energy yield data.
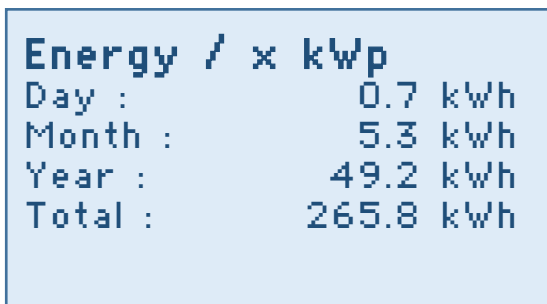
Fig. 20: Energy yield normalized on the display

Press the **ESC** key to return to the basic screen display.

5.9.1　Input of Standardized Data

To change the normalization, press the **F2** key and enter the currently connected PV generator power as follows:

‹ › keys:	Press the ‹ key to select the digits before the point.
	Press the › key to select the digits after the point.
^ key:	Press the ^ key to increment the selected digit by 1.
⌄ key:	Press the ⌄ key to decrement the selected digit by 1.

```
Installed PV [kWp]



                          15.0

```
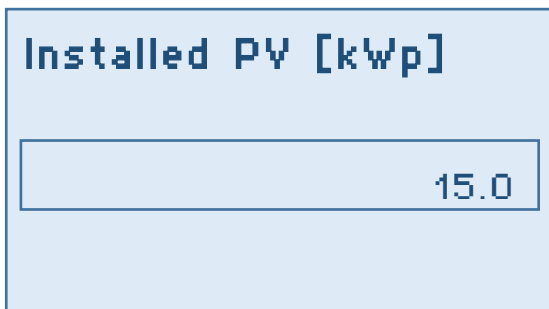
Fig. 21: Standardized data input display

Press the **OK** key to apply the set value.

Press the **ESC** key to discard the value and display the previous "normalized yield" level.

Press the **F1** key to display the menu.

5.10   Menu Structure

The menu structure serves as a support to change to the individual information displays and setting displays.

```
                          ┌──────────────────────┐
                          │ Energy absolute      │        ┌────────────────────┐
                          │ Energy normalized────────────│ Norm Factor        │
                          │                  [F2]│        └────────────────────┘
                          │                      │
                          │                      │
                          └──────────────────────┘

                          ┌──────────────────────┐
                          │ DC                   │
                          │ AC                   │        ┌────────────────────┐
                          │ Sensors              │        │ Ethernet           │
┌────────────────────┐    │                      │        │ RS485              │
│ Analysis───────────────│                      │        │                    │
│ Actual values──────────┘                      │        │                    │
│ Fault memory       │    └──────────────────────┘        │                    │
│ Configuration      │                                    │                    │
│ Device Information │    ┌──────────────────────┐        └────────────────────┘
└────────────────────┘    │ Languages            │
                          │ Limitation PAC       │
                          │ Communication────────────────┘
                          │ Date / Time          │        ┌────────────────────┐
                          │ Portal settings──────────────│ Activation         │
                          │ Extended             │        │ Sending config     │
                          └──────────────────────┘        │ Portal Test        │
                                                          │                    │
                          ┌──────────────────────┐        └────────────────────┘
                          │ Overview             │
                          │ Version number       │
                          │ Country              │
                          │ Current language     │
                          │ Ethernet             │
                          └──────────────────────┘
```
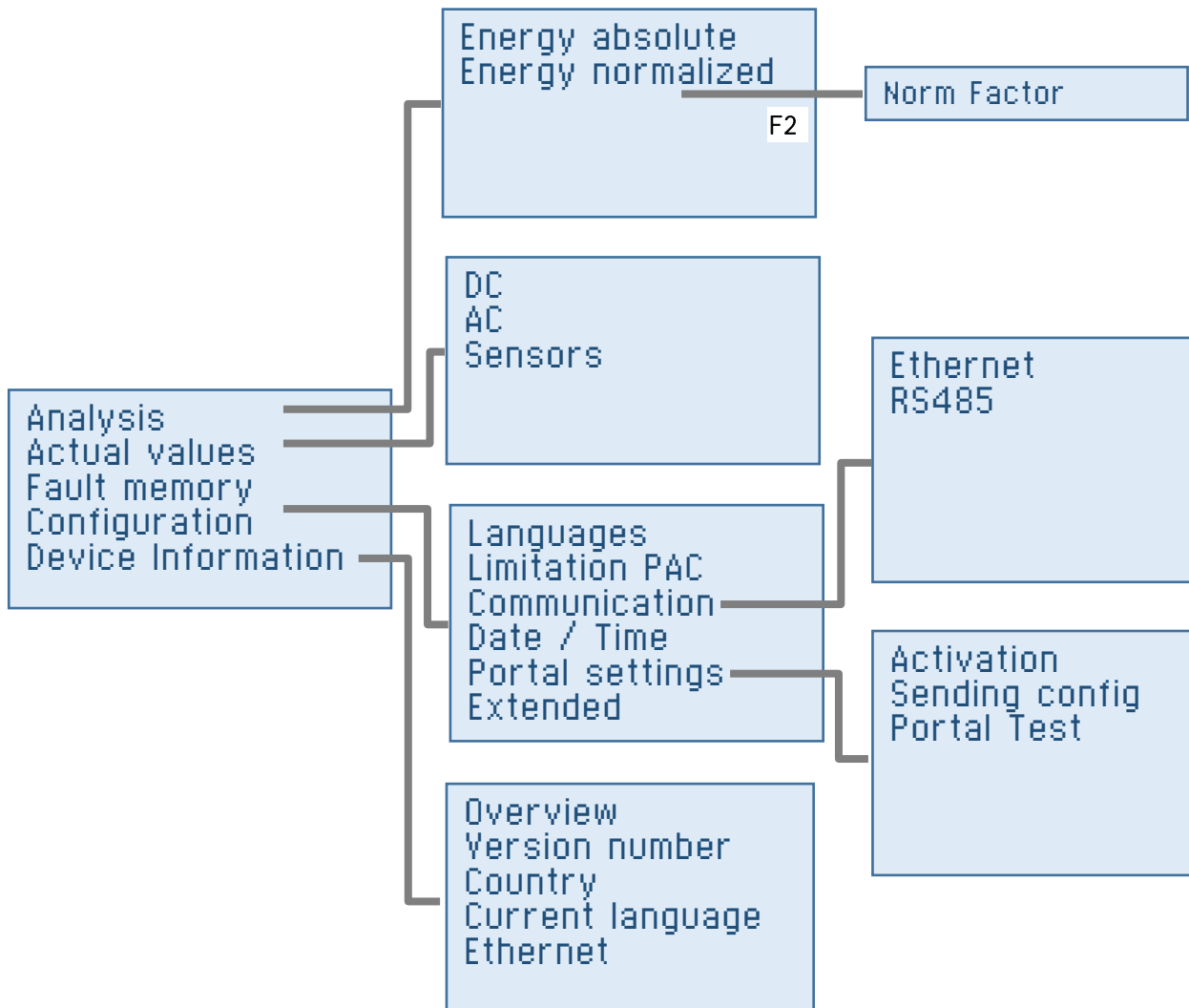
6 Configuration

6.1 Changing the Menu Language

The language selection has no effect on the country code. Proceed as follows to change the menu language:

1. Press **F1** to open the menu.

2. Use the ⌄ and ⌃ keys to select the fourth menu item "Configuration".

```
Analysis
Actual values
Failure memory
Configuration
Device information


Menue
```
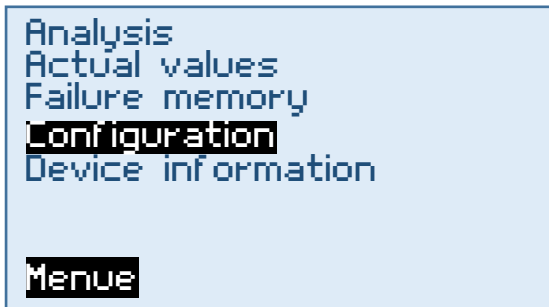
3. Press **OK** to confirm.

4. Use the ⌄ and ⌃ keys to select the first menu item "Languages".

```
Configuration
   Languages
   Limitation PAC
   Communication
   Date / Time
   Portal settings
   Extended
Menue
```
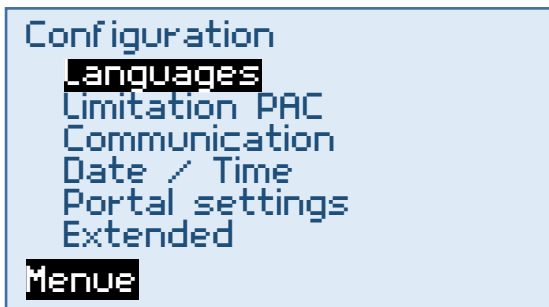
5. Press **OK** to confirm.

6. Use the ⌄ and ⌃ keys to select the desired menu language.

7. Press **OK** to confirm.

   ↪ The menu switches to the selected language. The display is initially empty.

8. Press **ESC** to return to the menu.

6.2 Limitation of the Power Output

Proceed as follows in order to limit the power output of the inverter:

1. Using the **F1** key, select the menu item "Configuration" and confirm with the **OK** key.

2. Select the sub-menu "PAC Limit" and confirm with the **OK** key.

3. Enter the invert power output as percentage of the nominal power and confirm with the **OK** key.

   ↪ The power limit is immediately applied.

6.3 Monitoring with REFUlog

TheREFUsol 48K-UL inverter can be connected to the monitoring portal REFUlog using direct Ethernet connection to the internet, or via RS485 and the REFUcontrol data-gateway.

Once an internet connection is established, the inverter will automatically start to send data to REFUlog every 5 minutes. The sending interval can be changed with the configuration tool REFUset.

To view the inverter data, open www.refu-log.com with your browser and login or register as a new user.

You can use the activation code provided on the type label of the inverter to assign one or more inverter to a PV system.
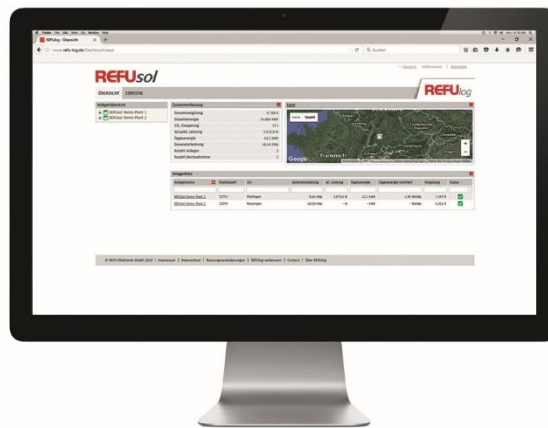
6.4 REFUset – PC Configuration Tool

You can upgrade the firmware of the inverters and change country-specific parameters of the inverter with the PC Software REFUset. You can connect the PC with the inverters via Ethernet or USB using a RS485-USB converter.

For extended settings, you will receive a personal password on request from service@refu-sol.com

Functions

- Firmware update

- Export of inverter data

- Feed-in conditions voltage and frequency

- Ramp starting time in the event of a grid error

- Average voltage monitoring

- Phase conductor voltage monitoring

- Frequency-dependent power reduction

- Actual voltage monitoring (rapid disconnection)

- Actual frequency monitoring

- Reactive power (cos φ)

- Power-up time

- K factor (fault ride through)

REFUset can be downloaded from www.refu-sol.com.

6.5 Communication via Ethernet

The settings for the Ethernet communication can take place either manually or automatically (via DHCP). Manually is the default setting.

6.5.1 Automatic Setting via DHCP

1. Navigate to Menu **Configuration > Communication > Ethernet > DHCP**.

2. Enter "1" in DHCP input field.

3. Press **OK** to confirm.

4. Restart inverter by opening and re-closing the DC switch.

> ✍ The settings for IP address, subnet mask, standard gateway and DNS are automatically taken from the DHCP server, e.g. the router.

6.5.2 Manual Setting

In order to ensure a trouble-free operation, all values must be given by the responsible network administrator and individually set in each inverter.

1. Navigate to **Configuration > Communication > Ethernet > IP address**.

2. Enter IPv4 address. The IPv4 address is arbitrary, but must be consistent throughout the subnet.
   Default value: **192.168.130.30**

3. Press **OK** to confirm.

4. Navigate to **Configuration > Communication > Ethernet > Subnet mask**.

5. Enter IPv4 mask. The IPv4 mask is arbitrary, but must be consistent throughout the subnet Default value: **255.255.0.0**

6. Press **OK** to confirm.

7. Navigate to **Configuration > Communication > Ethernet > Standard gateway**.

8. Enter the address of the router that allows connection to the internet
   Default value: **192.168.1.1**

9. Press **OK** to confirm.

10. Navigate to **Configuration > Communication > Ethernet > DNS**.

11. Enter arbitrary IPv4 address of the superior DNS server
    Default value: **0.0.0.0**

12. Press **OK** to confirm.

13. Restart inverter.

6.6   Communication via RS485

For monitoring via RS485, you need to use REFUcontrol device to forward data to the monitoring portal REFUlog.

You need to assign an unique USS address to each connected inverter.

Addresses: 1 to 31

This address is required for communicating with the inverter via RS485.

   ⇒   After entering the address, restart the inverter to activate the new address.

Protocol type: 1: REFU USS protocol (preset)

                      2: (not used)

                      3: Meteocontrol USS

                      4: Modbus RTU Sunspec
(address 0 cannot be used – address 0 is automatically set to address 1!)

                      5: Multimode USS / Modbus RTU Sunspec
(in Multimode, you cannot use USS address 0 and 2!)

Baud rate: 57600 (preset and recommended)

                      115200 (for short RS485 networks)

Parity: even

Handshake: no

Data bits: 8

Stop bits: 1

Protocol: REFU USS protocol

6.7 Portal Monitoring

To ensure the inverter sends data via Ethernet to the REFUlog monitoring portal, the portal monitoring must be active.

Open Menu Configuration > Portal Monitoring and enter the following value:

0 = Portal monitoring via Ethernet not active

1 = Portal monitoring via Ethernet active

Notice

If the inverter is connected with RS485 to REFUcontrol, the setting 0 (Portal Monitoring via Ethernet not active) must be used!

6.8 Sending Config

Menu Configuration > Portal monitoring > Config sending

The configuration data is required by REFUlog in order to recognise the inverter. If you want to send it manually, select the menu and set the parameter to 1. If the sending was successful, the parameter will be set back to 0 automatically.

6.9 Portal Test Function

Menu Configuration > Portal monitoring > Portal Test

On request of our service, you can send a test data package to the portal. Open the **menu and select „yes".**

7   Operating the Arc Fault Detection Unit (ADU)

7.1   General Description

Important

The Arc Fault Detection Unit (ADU) is only included in the products of the Art. No. 876P024.000 and 844P048.000.

The Arc Fault Detection Unit (ADU) is an arc fault detection device designed to detect series arcs in DC photovoltaic installations. The ADU monitors the current flow at the string level. The ADU detects a range of arc faults from 100 VDC 1 A to 1000 VDC 40 A. The ADU can detect arcing events over a maximum of 66 meters upstream or downstream of the installed location. When an arc fault occurs, the information is provided using the following methods:

- Buzzer provides an audio alarm

- Message **Arc fault detected** is displayed on the inverter screen

- Inverter stops operating and disconnects from the grid

7.2   Normal Operation of the Arc Fault Detection Unit

In normal operating circumstances, the arc fault detection unit monitors the current flow and analyzes the signal being measured to determine if there is an arc fault situation. The unit will do this continuously until an arc fault occurs or the DC power supply is removed.

During normal operation, the following should be considered:

- Make sure that the alarm can be easily heard, and that proper follow-up is assured.

- Check the system monthly for faults.

7.2.1   To Operate the ADU in Normal Conditions

1.   Turn the AC/DC disconnect switch to the **ON** position. If the solar modules are receiving sufficient sunlight and no fault exists, a quiet beep is emitted.

2.   Verify that the self-test procedure is complete by confirming that the START LED is continuously lit.

7.3   Responding To An Arc Fault

When an arc fault is detected by the ADU, the inverter will provide the following signals:

- A buzzer sounds for 30 seconds.

- The arc fault error message is displayed.

- An event is sent to REFUlog, if the inverter is using REFUlog.

After the first 30 seconds, the buzzer will sound once per minute.

7.3.1 To Resolve an Arc Fault

1.   Resolve the cause of the arc fault.

2.   Press the **ESC** button on the inverter to confirm the arc fault is resolved.
        Monitoring will resume.

3.   Turn the inverter off, and then on using the DC disconnect switch.

If the fault situation continues to occur, contact REFU Technical Support for additional information.

8 Troubleshooting

8.1 Self-Test – Error Message

After the initialization routine, the system runs through a self-test. The individual parts of the system, such as firmware and dataset, are checked and data is read in from the power control board. If an error continues to be detected, possible remedial measures must be taken according to the type of error.

8.2 Transient Failure

In certain operating states the inverter goes temporarily offline.

Unlike malfunctions, "transient failures" are automatically acknowledged by the inverter which attempts to restart once the error no longer exists.

A transient failure is indicated by the red LED "ERROR" on the control panel flashing and remains stored in the fault memory even in the event of a power failure. .

8.3 Faults

Permanently programmed and customizeable limit values are continuously monitored during ongoing operation. In order to be protected, the inverter power section is isolated from voltage supply if a limit value is exceeded or if a failure occurs. However, the DC and AC voltages may still be available. The corresponding fault message appears in the display.

The fault is indicated on the control panel by the red "ERROR" LED emitting steady light.

Fault messages are stored in the fault memory, where they will remain even in the event of a power failure. The fault memory can be called up via the display. The last 100 faults are recorded in the fault memory. The latest fault is kept at memory location S0, the oldest at S100. A new fault is always stored to memory location S0. When this happens, any fault already at memory location S100 will be lost.

8.4 Fault Acknowledgement

After shutdown due to a fault, the device remains locked against reactivation until the fault is acknowledged. It is not possible to acknowledge the fault while the cause of the fault still exists. The fault can only be acknowledged after the cause of the fault has been eliminated.

⇒ To acknowledge the fault message, press the ESC key or turn the inverter off with the DC switch and wait min. 30 seconds to turn the inverter ON again.

8.5 List of Error Messages

Note

Under certain weather conditions, condensation may form in the display. This is normal and causes no malfunction of the inverter.

Error Code	Text	Description	Action
90006	Grid overvoltage	Phase overvoltage (AC) has been detected.	Check the phase voltages (with a true RMS measurement device). If you consider the phase voltages to be in order, contact Service.
90007	Grid undervoltage	Phase undervoltage (AC) has been detected.	
90008	Overfrequency	The grid frequency has exceeded the limit value.	As long as the inverter is detecting an over or under-frequency: check the frequency of the phases. If you consider the frequencies to be in order, contact Service
90009	Underfrequency	The grid frequency has dropped below the limit value.	
9000A	DC link 3	Dc-voltage measurement error.	Wait for the measuremets to become stable again. If this takes more than 2-3h, please contact Service.
9000B	DC link 1	Imbalance low: Difference between the DC link voltages is too high.	
9000C	DC link 2	Imbalance high: Difference between the two boosted DC link voltages is too high	
9000D	DC link 4	The boosted DC-voltage has dropped below the mains peak value	
90010	DC link 5	The boosted DC link voltage is too high.	
90011	DC link 6	The DC link voltage is too high.	
90017	Communication LT	Communication malfunction between power section and control and regulation unit	The inverter will acknowledge the error automatically. If problem occurs repeatedly, contact Service
90018	Grid frequency LT	Power section has detected under/overfrequency	As long as the inverter is detecting a LT grid frequency: check the frequency of the phases. If you consider the frequencies to be in order, contact the Service
90019	Grid overvoltage LT	The power section has detected a phase overvoltage.	As long as the inverter is detecting a grid overvoltage or under voltage: check line voltages (with a true RMS measurement device). If you consider the line voltages to be in order, contact the Service.
9001A	Grid undervoltage LT	The power section has detected a phase undervoltage.	
9001B	RCD fault	The AFI-Board unit has detected a residual current.	Check system isolation. As long as you consider the isolation impedance to be in order, contact Service.
9001D	RCD warning	Leads to an immediately shutdown	

Error Code	Text	Description	Action
90020	Initialisation C1	Initialisation has failed.	Restart inverter. If this does not rectify the error, contact Service.
90021	Initialisation C0		
90024	SR parameter error	Error in parameter initialisation. The device has been permanently shut down.	Please contact Service.
90029	Update fault	Update failed	The update has failed. Contact Service.
9002A	Keep Alive	Internal communication monitoring has determined a fault.	Please contact Service.
9002B	Update End	Update successful notification.	An update was successfully completed. The device will resume normal operation.
9002C	AntiIslandPhase Shift	Islanding of the connected grid section has been detected	Wait for the grid to become stable again
9002D	AntiIslandRocof		
9002F	FFS is read-only	Internal data can't be written anymore.	Please contact Service.
90030	DC share too high	The measured DC-Part in AC current exceed the defined limit.	
90031	ETH link lost	The Ethernet cable has been removed	Check the Ethernet cable on the device and the receiver (router, switch) for a correct fit. If the cables are correctly connected and should the notification still be there, please contact Service.
90032	Restart	The system has been rebooted.	Should these notifications occur repeatedly during daily operation, please contact Service.
90050	AC condition	AC switch on condition not fulfilled	Wait until the network is stable
90051	DC condition	DC switch on condition not fulfilled	Wait until the solar voltage is high enough
90052	User lock active	The inverter can't connect to the grid, as the User-lock has been set.	Deactivate user lock
90053	Communication SR	Internal communication problems	Fault is independently resolved after a few minutes. If not, switch device off and on again. If this does

Error Code	Text	Description	Action
			not resolve the problem, contact Service.
90054	Overvoltage 2	The phase voltage has exceeded the limit value of the voltage average monitor for too long.	As long as the inverter is detecting the voltage error: monitor line voltages (analyse grid). If you consider the line voltages to be in order, contact Service.
90055	Grid overvoltage	Line-to-line overvoltage (AC) detected	
90056	Grid undervoltage	Line-to-line undervoltage (AC) detected	
90057	Watchdog C0	Internal protection function is triggered.	Contact Service.
90058	Watchdog C1		
90059	LT Firmware	The software of the LT is defective.	
90060	FRT stability	Stability issue with the DC link detected.	Please contact the service if it happens repeatedly
90061	Update fault	This notification can be ignored.	No measures necessary.
90062	Fault ride through	Grid-instability which is handled with respect to the grid code standards.	
A0013	PM isolation RCD SR	The measured value of the residual currents are over the limits: Measured value >150 mA -> Trip within 20 ms Measured value >60 mA -> Trip within 130 ms Measured value >30 mA -> Trip within 280 ms	Check system isolation. If you consider the system isolation to be in order, contact Service.
A0020	External cut-off	External monitoring has triggered a disconnection.	During the inverter detects an external cut-off: Verify external cut-off signal . Possible causes: wire breakage or wrong sensor selected. Refer to the manual for the right settings.
A0021	ARC fault detected	Arc fault detection has triggered a disconnection	Reset the arc fault detector. Press ESC on the Disblay.
A0022	Ext. OVGR Signal	External stop signal OVGR is detected.	During the inverter detects OVGR: Verify External stop signal OVGR. Possible causes wire breakage.

Error Code	Text	Description	Action
A0102	Overtemperature LT 1	Cooler overtemperature (right)	Check temperature of direct surroundings and reduce this as required.
A0103	Overtemperature LT 2	Interior overtemperature (left)	
A0104	Overtemperature LT 3	Interior overtemperature (right)	
A0105	Overtemperature LT 4	Cooler overtemperature (left)	
A0106	Supply voltage LT	Supply voltage at the power section is too low.	Please contact Service
A010C	PM isolation LT	Power section detects an isolation error on activation.	Check system isolation. If you consider the isolation resistance to be in order, contact Service.
A010E	Device fault LT	Power section hardware shutdown	Note: When did the error occur (precisely: day, kW output, time).
A0114	PM isolation RCD LT	Residual current measured from the LT exceeded the limits. residual current > Limit values of 20 mA, 130mA, 280mA respectively	Please contact Service
A0116	R-detect	0	Do nothing. The inverter will acknowledge the error automatically. If problem occurs repeatedly, contact Service.
A0117	Isolation test unit	Test isolation test is taking too long.	Please contact Service
A0118	Voltage offset LT	Offset adjustment values between power section and control and regulation unit divergent	
A011A	Activation LT 1	Voltage booster self-test failed.	Do nothing. The inverter will acknowledge the error automatically. If problem occurs repeatedly, contact Service.
A011B	Activation LT 2	DC link voltage drop during activation	
A011C	Activation LT 3	Target value for balancing is invalid.	
A011D	Activation LT 4	Balancing has failed.	Please contact Service
A011E	Activation LT 5	Voltage booster mailfunction	

Error Code	Text	Description	Action
A011F	Parameter error LT 5	Faulty reading or writing process in power section memory	1.) Switch off device with DC disconnector. 2.) Wait until the display has turned off completely. 3.) Switch on device with DC disconnector. If this does not rectify the error, contact Service.
A0172	P24V LT aux. supply	P24V supply voltage at the power stack is too low.	Please contact Service
A0173	P5V LT aux. supply	P5V supply voltage at the power stack is too low.	
A0174	P15V LT aux. supply	P15V supply voltage at the power stack is too low.	
A0178	Temp. Sensor KR LT	checking open loop or short loop for temperature sensor cooler right	
A0179	Temp. Sensor IL LT	checking open loop or short loop for temperature sensor cooling interior left	
A017A	Temp. Sensor IR LT	checking open loop or short loop for temperature sensor cooling interior right	
A017B	Temp. Sensor KL LT	checking open loop or short loop for temperature sensor cooler left	
A017C	N15V LT aux. Supply	N15V supply voltage at the power stack is too low.	
A017D	Phase defect	an error has been detected in the power modules	

9 Options

9.1 Irradiation and Temperature Sensor

For recording the irradiation and the module temperature, an irradiation and temperature sensor can be connected to the sensor interface of the inverter. The recommended type is Si-13TC-T-K and can be ordered at REFU Elektronik GmbH with art. no. 922009. The sensor plug can separately be ordered with art. no. 922010.

The sensor comes with a 3 meter UV-resistant connecting line (5 x 0.14 mm²). The line can be extended with a 5 x AWG 23 (0.25 mm²) shielded line, max. 328 ft (100 m).

9.1.1 Inverter Sensor Interface

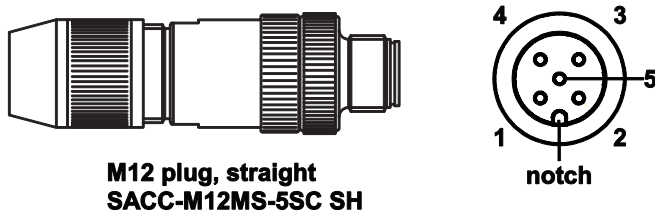**M12 plug, straight**
SACC-M12MS-5SC SH

Fig. 22: Connector M12 x 1 straight, shielded; pole arrangement: male M12, 5 pins, A-coded, view of male connector side, PHOENIX CONTACT designation: SACC-M12MS-5SC SH

Inverter sensor pins	Signal
Pin 1	Supply voltage (24 VDC, max. 2 W)
Pin 2	Ground
Pin 3	Signal Input 1 (0-10 V)
Pin 4	Signal Input 2 (0-10 V)
Pin 5	Shield

9.1.2 Sensor Type Si-13TC-T-K Cable

Sensor cable color	Signal
Red	Supply voltage (12-28 VDC)
Black	Ground
Orange	Measurement signal irradiation (0-10 V)
Brown	Measurement signal temperature (0-10 V)
Black, thick	Shield

9.1.3 Assembling of the Sensor Plug
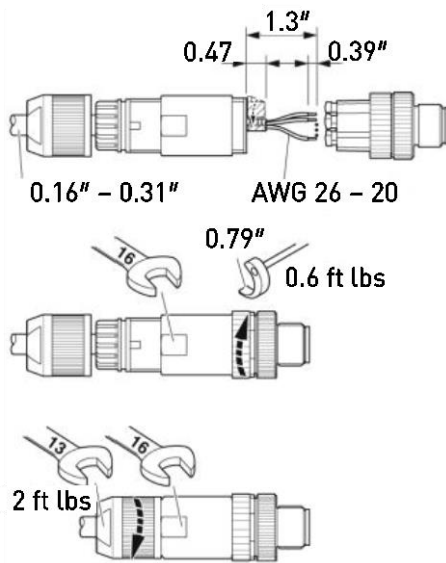
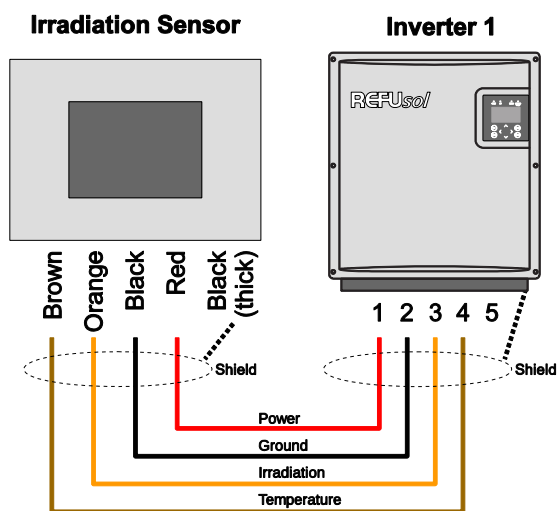### 9.1.4 Connection of the Sensor at the Solar Inverter

Fig. 23: Standard connection at a solar inverter (not applicable at AFCI variant)
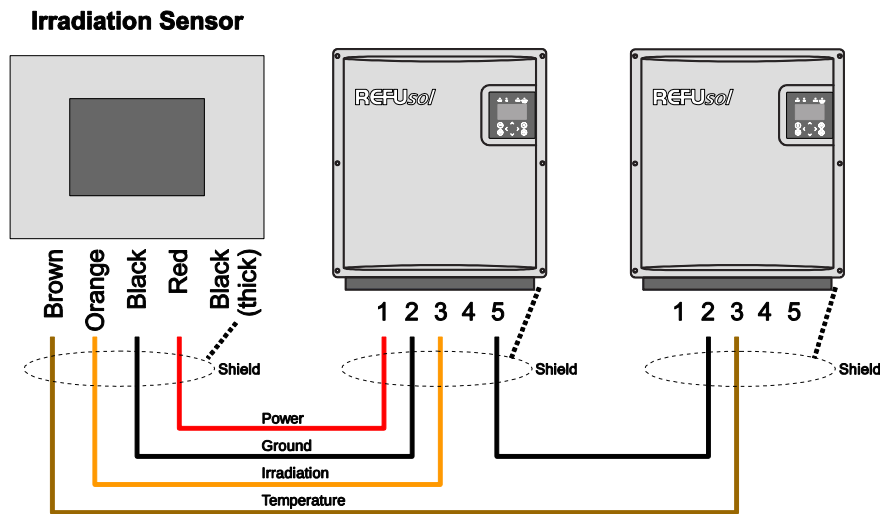
Fig. 24: Connection to two inverters (for AFCI variant)

In the AFCI variant, the irradiation and temperature sensor is connected individually to one inverter.

9.1.5 Configuration

The actual values of the sensor are shown on the display of the inverter at **Actual values > Sensor**.

The assignment of the sensor signals can be configures with PC software REFUset.

The data are recorded by the datalogger and are visible within REFUlog portal.

Note:

The shield of the sensor line (dotted line) must be applied to PIN 2 and PIN 5!
The outer diameter of the connecting cable can be max. 8 mm.

Note:

If you do not use the temperature input, wire a jumper across PIN 4 and PIN 5.
Alternatively, you can also wire the jumper to the intermediate terminal point
(cable extension).

The actual values of the sensor can be viewed in **Actual values > Sensor**. The data continues to be recorded with the data logger and can be viewed via REFUlog.

9.2 External Turn Off Signal

9.2.1 Overview

REFUsol solar inverters have an internal grid protection relay and section switch.

Depending on local connection, installation instructions and the selected line voltage level either the internal grid protection relay can be used with section switch, or an external grid protection relay must be used with section switch also.

It is also possible to combine the internal to the external grid protection relay.
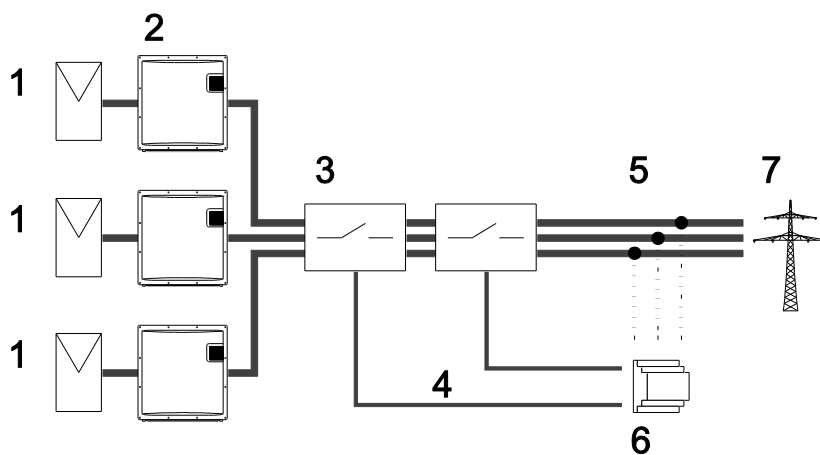
1   Photovoltaic modules

2   Solar Inverter

3   Three phase, redundant section switch

4   Control line

5   Grid measurement

6   Grid protection device

7   Public grid

9.2.2 Function

The internal section switches of the inverter can be controlled by an external signal.

At a signal voltage between 7.5 and 10 V the inverter feeds into the grid. If the signal voltage falls below 7.5 V, an error message will occur and the inverter will stop to work within the configured switch of time.

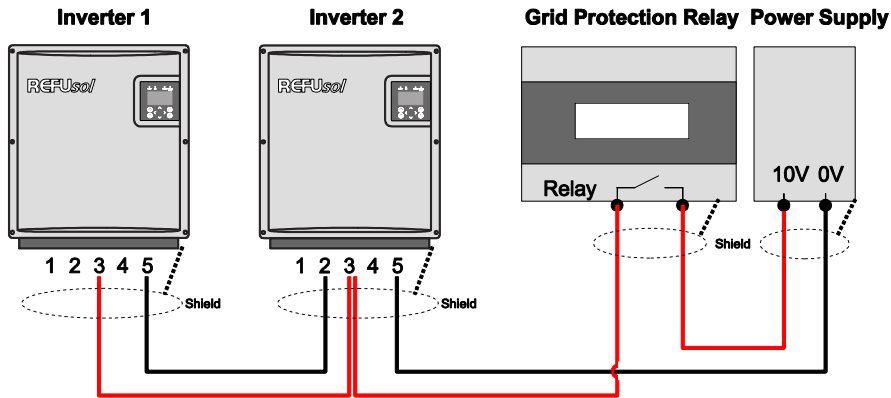| Nominal voltage	10 VDC
Voltage (operation)	7.5 ... 10 VDC
Voltage (Stop)	0 ... 7.5 VDC
Standard switch-off time inverter	50 ms
Switch-off time range	50 ms ... 100 ms

9.2.3   Configurations
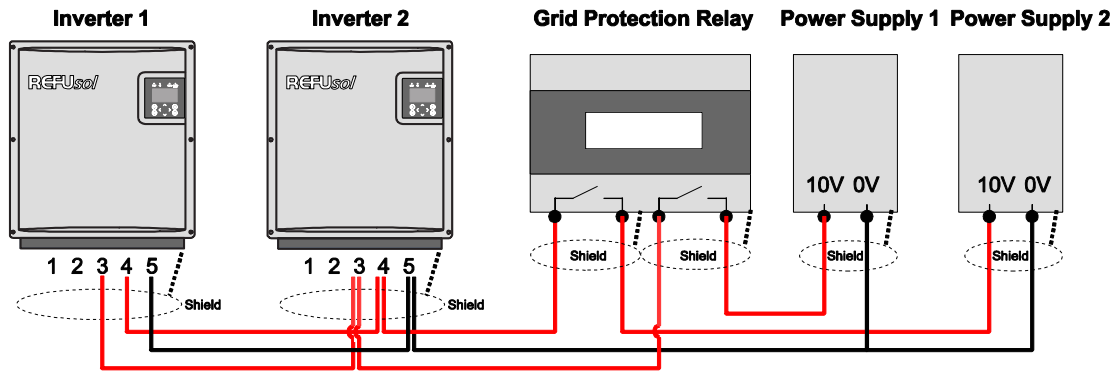

Fig. 25: Single external stop signal

Fig. 26: Redundant external stop signal (does not apply to AFCI variant)
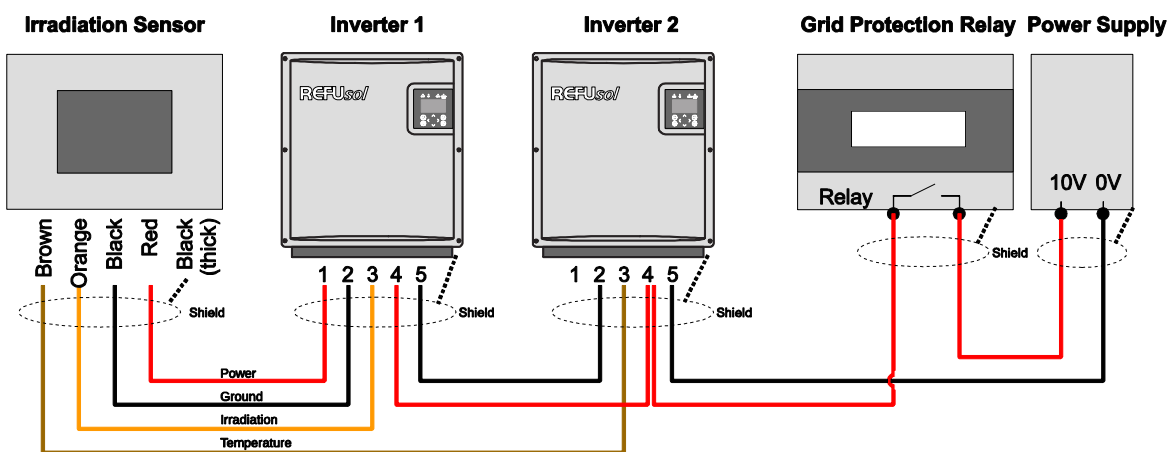

Fig. 27: Single external stop signal with sensor connected (does not apply to AFCI variant)

Note:

In order to ensure the function of the switch off signal, the sensor selection must be correctly set in the inverters.

The configuration of the inverter is possible with the REFUset tool. Other switch off times required by the utility, for example, or other voltage ranges can be configured here. It is also possible to deactivate the internal grid protection relay function of the inverter if an external grid protection relay is connected to switch off the inverter and if your grid supplier allows it.

9.2.4 Configuration

The sensor function can be configured at the inverter display at **Configuration > External Signal**.

It is also possible to perform the configuraton with REFUset. This PC tool allows to define different voltage ranges and switch-off times. The inverter integrated grid protection can be deactivated if authorized by the grid operator.

⚠ DANGER
Risk of electric shock and fire caused by high discharge current.
⇒ Before **connecting** the device to the supply circuit, establish a ground connection.

10 Maintenance

10.1 Maintain the Inverter

The cooling of the inverter is exclusively through natural convection, therefore the cooling system is maintenance free.

Periodically, based on site conditions, visual inspection of the cooling fins is recommended to identify any debris accumulation that could occur. If found, the debris must be removed to ensure that the convection cooling is not inhibited.

Cleaning with high-pressure cleaners is prohibited.

Annually, the DC switch has to be operated without electricity 5 times.

11   Decommissioning

> ⚠ **CAUTION**
>
> **Danger of injury**
>
> ⇒ When decommissioning the inverter, take the weight **75.6 kg (166 lbs)** into account.
>
> ⇒ Do not open device. Opening the device voids the warranty.

> **NOTICE**
>
> **Danger of damage to property**
>
> ⇒ Do not use the cover to hold the device. Only use the four holding grips to move the device.
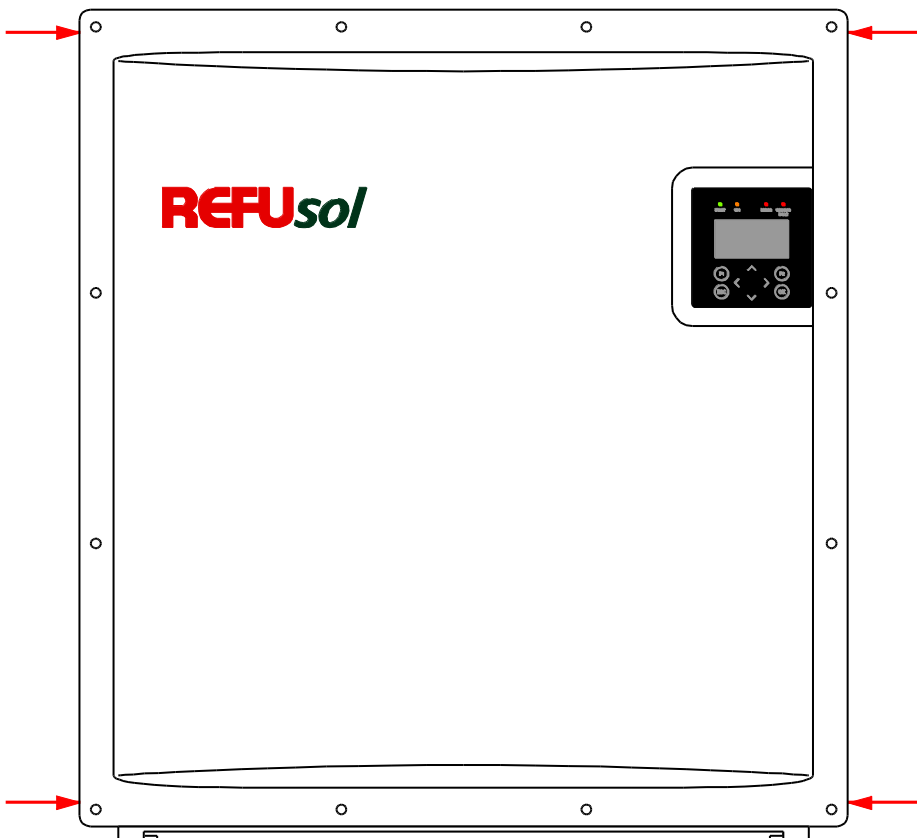

Fig. 28: Handles on the inverter

11.1 Remove Inverter

1. Deenergize the inverter completely; see "Disconnecting Device Power", p. 37 for the deenergization procedure.

2. Remove all cables from the inverter.

3. Loosen the 3 screws (M5x20) securing the inverter to the wall-mounting bracket.

4. Remove the inverter from the wall-mounting bracket (see "Installation", p. 24).

11.2 Package Inverter

If possible, package the inverter in its original packaging or a similar packaging.

11.3 Disposal

Dispose of the packaging and replaced parts according to the rules applicable in the country where the inverter is installed.

Do not dispose of the inverter with normal domestic waste.

The inverter conforms to RoHS. That means that the device can be taken to municipal disposal sites for household appliances.
REFU Elektronik GmbH takes the inverter back completely. Please contact the Service team at service.usa@prettl-energy.

12 Technical data

12.1 Inverter

TYP	REFUsol 48K-UL
Art. No.	843P048.000 (no AFCI) 844P048.000 (with AFCI)
DC DATA	
Max. recommended PV power (kWp)	72
MPPT range at nominal power (V)	580 – 850
Max. voltage DC (V)	1000
DC start voltage (V)	200
DC start voltage feed-in (V)	350
Max. operational current DC (A)	84
Max. short circuit current ISC of PV system (A)	160
MPP trackers	1
No. DC inputs	1 Plus, 1 Minus
DC input terminal	T-LOX knee lever connection
DC input cables	10 – 50 mm² (AWG 7 – 1) Aluminum / Copper
DC load break switch	Integrated
AC DATA	
AC nominal power (kW)	48
Max. apparent power (kVA)	48
AC grid connection / Feed-in phases	3 AC 480 V Y+N
Nominal power factor / Range	1 / 0.8i – 0.8c
Nominal voltage AC (V)	480
Voltage range AC (V)	423 – 528
Nominal frequency / Frequency range (Hz)	60 / 57 – 63 adjustable
Max. AC current (A)	3 x 59
Max. THD (%)	< 3 %
AC circuit breaker	External
Max. efficiency (%)	98.3 %
CEC efficiency (%)	> 98.0 %
Feed-in from (W)	20
Self consumption night (W)	< 0.5
AC input terminal	T-LOX knee lever connection

AC input cables	10 – 50 mm² (AWG 7 – 1) Aluminum / Copper
AMBIENT CONDITIONS	
Cooling	Natural convection
Ambient temperature at nominal power (°C / °F)	-25 – +45 °C (-13 – 113 °F)
Operation ambient temperature (°C / °F)	-25 – +60 °C (-13 – 140 °F)
Storage/Transport temperature (°C / °F)	-40 – +60 °C (-40 – 140 °F)
Rel. air humidity (%)	4 % – 100 % (non-condensing)
Elevation (m / ft above sea level)	4,000 m[1] (13,000 ft)
Noise (dBA)	< 45
Environment classification (IEC 721-3-4)	4K4H
Pollution degree (IEC 62109-6-3)	3
Type of protection	NEMA 4
SAFETY AND PROTECTION FUNCTIONS	
DC circuit switch	Integrated
Isolation monitoring	Yes
String fuses	External
Grid monitoring	Voltage, Frequency, Anti-Islanding, DC injection
Residual Current Monitoring (RCD)	Yes
Arc Fault Detection (AFCI)	Integrated in type 844P048.000
Internal overvoltage protection (EN 61643-11)	Type 3
Protection class (IEC 62103)	I
Overvoltage category (EN 60664-1)	DC: II, AC: III
GENERAL DATA	
Interfaces	Ethernet, RS485, Irradiation and temperature sensor / External stop signal
Dimensions W x H x D (mm / in)	755 x 820 x 300 mm (30″ x 32″ x 12″)
Weight (kg / lbs)	75.6 kg (166 lbs)
Certification	UL1741, UL1998, CSA C22.2 No. 107.1-01 ed: 3, UL 1699B, EMI Industrial latest certificates you find at http://www.refu-sol.com

[1] The derating of the maximum open circuit voltage depends on the installation altitude:

Altitude above sea level	Max. DC voltage
up to 2600 m (8,530 ft)	1000 V
up to 3000 m (9,843 ft)	950 V

up to 3500 m (11,483 ft)	900 V
up to 4000 m (13,123 ft)	850 V

12.2   Sensor

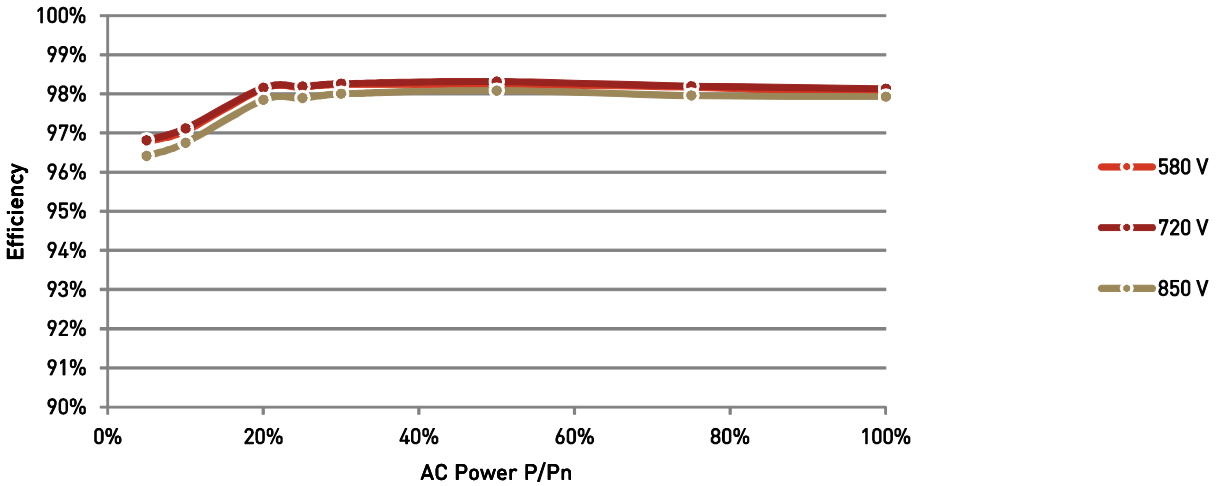| TYPE	Si-13TC-T-K
GENERAL	
Shunt resistor	0.10 Ω (TK = 22 ppm/K)
Working temperature	-20 – +70 °C (-4 – +158 °F)
Power supply	12 – 24 VDC
Current draw	0.3 mA
Connecting cable	4 x 0.14 mm² (AWG 6), 3 m (UV-resistant) (118.11″)
Cell dimension	50 mm x 34 mm
Exterior dimension W x H x D (mm / in)	145 x 81 x 40 mm (5.71″ x 3.19″ x 1.57″)
Weight	340 g (0.75 lbs)
INSOLATION	
Measuring range	0 – 1,300 W/m²
Output signal	0 to 10 V
Measuring accuracy	±5 % of final value
MODULE TEMPERATURE	
Measuring range	-20 – +90 °C (-4 – 194 °F)
Output signal	2.268 V + T [°C]* 86.9 mV/°C
Measuring accuracy	±1.5 % at 25 °C (77 °F)
Non-linearity	0.5 °C (32.9 °F)
Max. deviation	2 °C (35.6 °F)
PIN ASSIGNMENT	
Orange	Measurement signal for insolation (0 to 10 V)
Red	Supply voltage (12 – 24 VDC)
Black	GND
Brown	Measurement signal for temperature (0 – 10 V)
Power supply	Temperature and radiation sensor or PowerCap

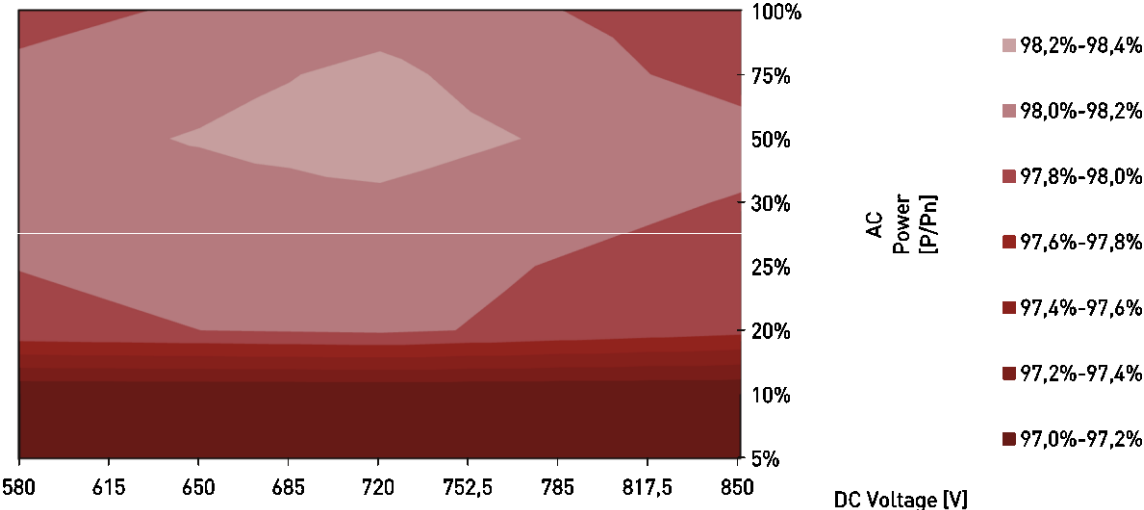# 12.3 Efficiency Measurement REFUsol 48K-UL (843P048.000)

12.3.1 Efficiency Graph

Legend:
- 98,2%-98,4%
- 98,0%-98,2%
- 97,8%-98,0%
- 97,6%-97,8%
- 97,4%-97,6%
- 97,2%-97,4%
- 97,0%-97,2%

AC Power [P/Pn]

DC Voltage [V]
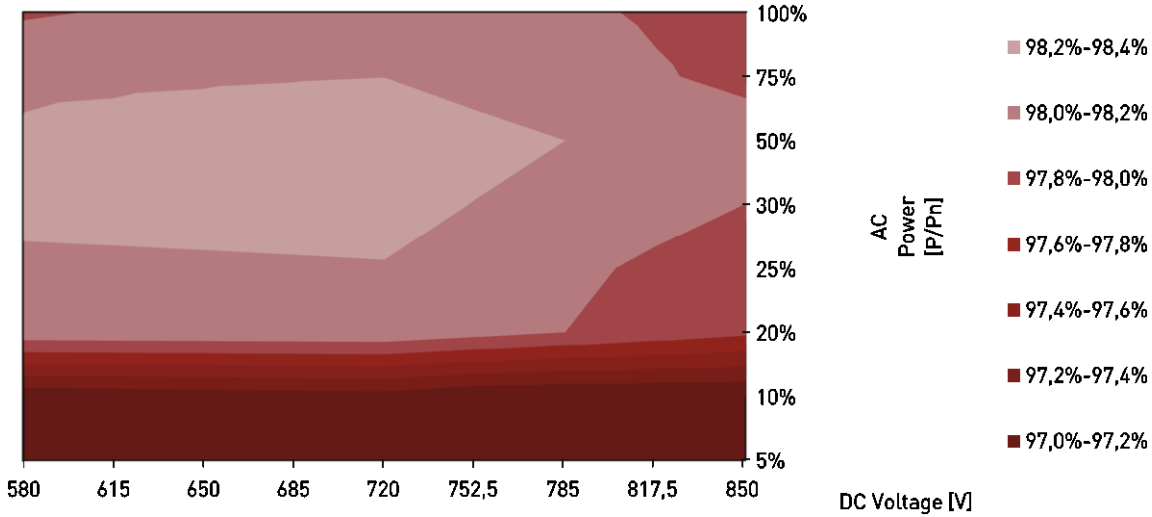
12.3.2 Efficiency Curves

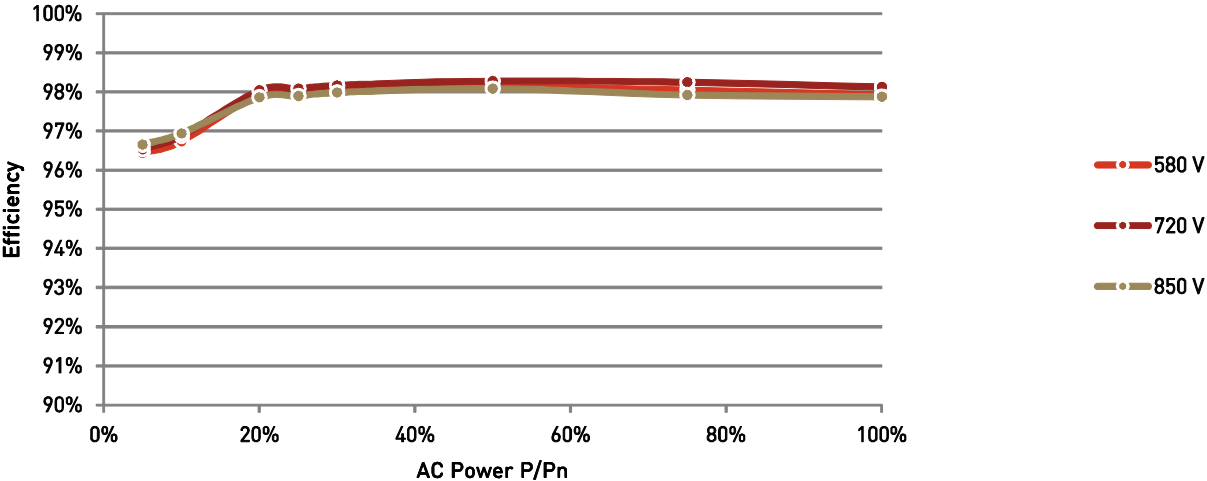Legend:
- 580 V
- 720 V
- 850 V

12.4 Efficiency Measurement REFUsol 48K-UL (844P048.000)

12.4.1 Efficiency Graph

12.4.2 Efficiency Curves
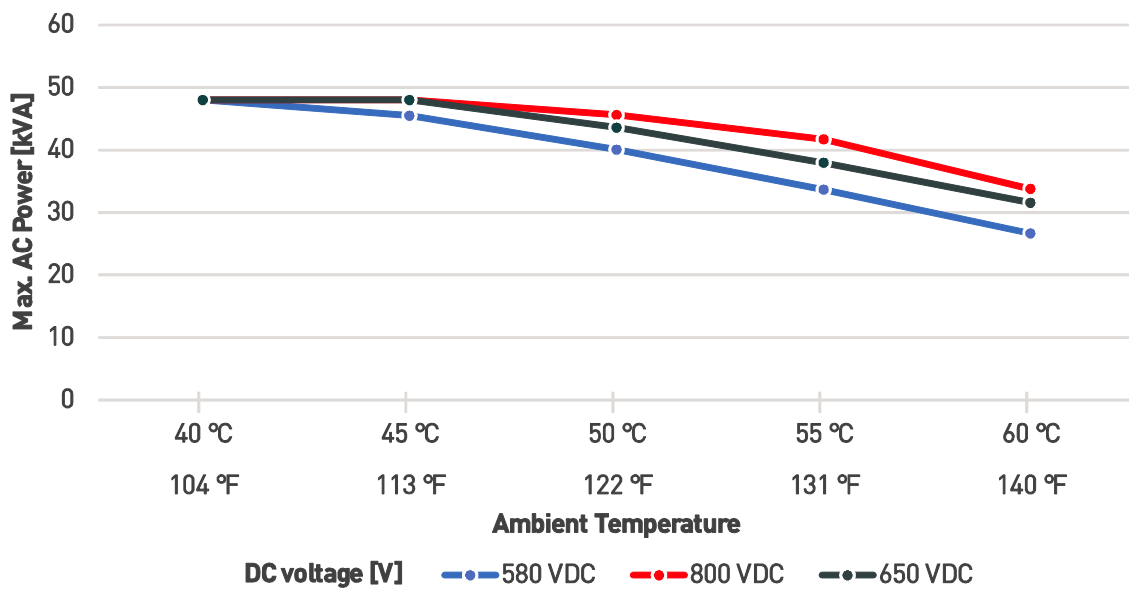
12.5   Temperature Derating Curve

Fig. 29: Temperature derating REFUsol 48K-UL (843P048, 844P048)

13　　Contact

Please address any questions on malfunctions or technical problems to

Mexico / North America

Service-Hotline:　　+ 1 970-318-2301

　　　　　　　　　(24 hours)

Europe

Service-Hotline:　　+49 (0)7121 4332 – 333

　　　　　　　　　(Monday - Thursday, 8 am to 5 pm, Friday 8 am to 4 pm)

Online

Email:　　　　　　service.usa@prettl-energy

Website:　　　　　www.refu-sol.com

Direct Link:　　　　www.refu-sol.com/en/accessories/technischer-support/

You should have the following data at hand:

- Exact description of the error with error code.
- Data from the type label, particularly the device type on the top left of the type label.