MAGNETEK
UNCOMMON POWER

AURORA®

Photovoltaic Inverters

INSTALLATION AND OPERATOR'S MANUAL

Model number: PVI-3000-I-OUTD-US *Rev. 1.2*

REVISION TABLE

Document Revision	Author	Date	Change Description
1.1	R. Salutari	15/12/2004	Added UL certificate. Corrections in paragraphs 5.2.2 and 5.3
1.2	R. Salutari	15/03/2005	Corrections in : Fig.5 par. 3.3; par. 6.1 and fig.18; par. 6.3; Table A paragraphs 8.1

SAVE THESE INSTRUCTIONS !

IMPORTANT SAFETY INSTRUCTIONS

IMPORTANT SAFETY INSTRUCTIONS

This manual contains important safety and operational instructions that must be accurately understood and followed during the installation and maintenance of the equipment.
To reduce the risk of electrical shock hazards, and to make sure the equipment is safely installed and commissioned, special safety symbols are used in this manual to highlight potential safety risks and important safety information. The symbols are:

WARNING: the paragraphs highlighted by this symbol contain processes and instructions that must be absolutely understood and followed to avoid potential danger to people.

NOTE: the paragraphs highlighted by this symbol contain processes and instructions that must be rigorously understood and followed to avoid potential damage to the equipment and negative results.

The equipment is provided with several labels, some of them with a yellow background, which are related to safety issues.
Make sure to read the labels and fully understand them before installing the equipment.
The labels utilize the following symbols:

	Equipment grounding conductor (Main grounding protective earth, PE)
	Alternate Current (Ac) value
	Direct Current (Dc) value
	Phase
	Grounding (Earth)

USEFUL INFORMATION AND SAFETY STANDARD

FOREWORD

- The installation of AURORA must be performed in full compliance with national and local standards and regulations
- AURORA has no internal user serviceable parts other than fuses.
  For any maintenance or repair please contact the nearest authorized repair center. Please contact your reseller if you need to know the nearest authorized repair center.
- Read and understand all the instructions contained in this manual and become familiar with the safety symbols in the relevant paragraphs before you install and commission the equipment
- The connection to the distribution grid must be done only after receiving approval from the distribution utility as required by national and state interconnection regulations, and can be done only by qualified personnel.
- Cover the photovoltaic panels with dark opaque sheets before they are connected to avoid any chance of high voltages appearing at the connecting cable terminations.

GENERAL

During inverter operation, some parts can be powered, some not properly insulated and, in some cases, some parts can move or rotate, or some surfaces can be hot.
Unauthorized removal of the necessary protections, improper use, incorrect installation or incorrect operation may lead to serious damage to people and objects.
All transport, installation and start-up, as well as maintenance operations, shall be carried out by skilled and trained personnel (all national regulations on accidents prevention shall be complied with ! ! !).
According to these basic safety rules, qualified and trained people have skills for the assembling, start-up and operation of the product, as well as the necessary requirements and qualifications to perform such operations.

ASSEMBLY

Devices shall be assembled and cooled according to the specifications mentioned in the corresponding documents.
In particular, during transport and handling, parts shall not be bent and/or the insulation distances shall not be changed. There should be no contact between electronic parts and connection terminals.
Electrical parts must not be mechanically damaged or destroyed (potential health risk).

ELECTRICAL CONNECTION

With the inverter powered, comply with all prevailing national regulations on accidents prevention.
Electrical connections shall be carried out in accordance with the applicable regulations, such as conductor sections, fuses, PE connection.

OPERATION

Systems with inverters shall be provided with further control and protective devices in compliance with the corresponding prevailing safety rules, such as those relating to the compliance with technical equipment, accident-preventing regulations, etc. Any calibration change shall be made using the operational software. Once the inverter has been disconnected from the power grid, powered parts and electrical connections shall not be touched as some capacitors could be charged.
Comply with all corresponding marks and symbols present on each device. During operation, make sure that all covers and doors are closed.

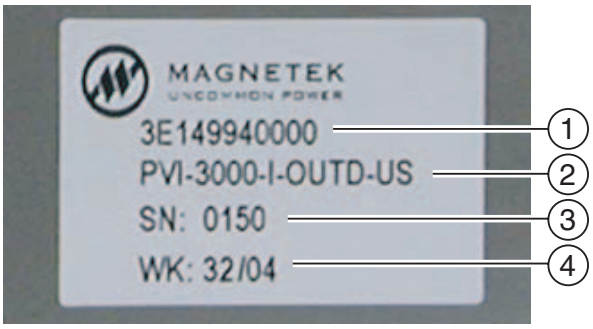
MAINTENANCE AND SERVICE

Comply with manufacturer’s recommendations.

SAVE ALL DOCUMENTS IN A SAFE PLACE !

PVI-3000-I-OUTD-US

This document applies to the above-mentioned inverters, only.



The identification plate present on the inverter includes the following data:

1) Manufacturing Part Number
2) Model Number
3) Serial Number
4) Week/Year of Manufacture

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1 FOREWORD

This document contains a technical description of the AURORA photovoltaic inverter so as to provide the installer and user all the necessary information about installation, operation and use of AURORA.

1.1 PHOTOVOLTAIC ENERGY

Industrialized countries (greater energy consumers) have been experimenting with energy-saving methods and reducing pollutant levels. This may be possible through a shrewd and rational consumption of well-known resources, and also by looking for new forms of clean and in exhaustible energy.
Renewable sources of energy are fundamental to solving this problem. Under these circumstances, solar energy exploitation to generate electrical (photovoltaic) energy is becoming more and more important worldwide.
Photovoltaic energy, in any case, is of great advantage to the environment because the radiated energy we receive from the sun is transformed directly into electrical energy without any combustion process and without producing any pollution.

2 SYSTEM DESCRIPTION

AURORA is an inverter able to feed energy to the electrical power distribution grid.
Photovoltaic panels transform the solar radiation into electrical energy in the form of direct (Dc) current (through a photovoltaic field, also known as PV generator). In order to utilize this energy and feed it back to the distribution grid, this energy shall be turned into alternating (Ac) current. AURORA does this conversion, also known as Dc to Ac inversion, in a very efficient way, without using rotating parts but just static power electronic devices.
When used in parallel with the grid, the alternate current generated by the inverter is directly fed to the domestic distribution circuit, which in turn is also connected to the public power distribution grid.
The solar energy system can thus feed power to all the connected users, such as lighting devices, household appliances, etc.
If the energy generated by the photovoltaic system is not enough, the energy necessary to ensure the standard operation of the connected users is drawn from the public power distribution grid. While if the produced energy exceeds that used, the difference is directly fed to the grid, thus becoming available to other users.
According to national and local standards and regulations the produced energy can be sold to the grid or credited to the user against future consumption.

2.1 Main Elements of a PV System: "STRINGS and ARRAYS"

The so-called "string" technology has been developed in order to reduce the installation costs of a photovoltaic system as much as possible. These costs are mainly related to the wiring operations on the Dc side of the inverter and the consequent distribution on the Ac side.
A photovoltaic PANEL is composed of many photovoltaic cells assembled on the same mount. A STRING is composed of a certain number of panels electrically connected in series. An ARRAY is composed of one or more strings connected in parallel.
Larger photovoltaic systems, can be composed of a certain number of arrays, connected to one or more AURORA inverters. By maximizing the number of panels in series per string, the cost and complexity of the system wiring can be reduced.

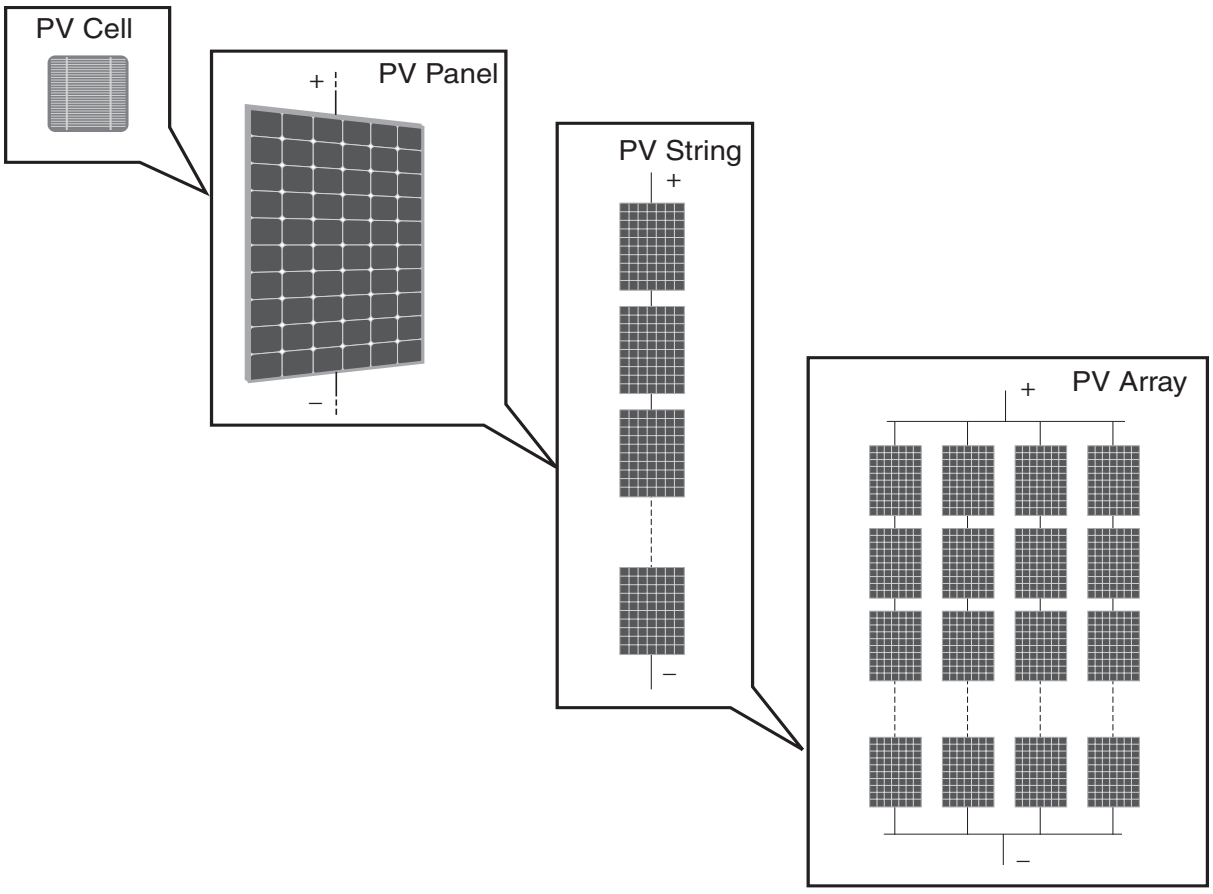


Fig.2 Array Composition

Array voltage value shall be within an acceptable range for the inverter. Please refer to the technical data for the AURORA for details on the Dc operating voltage range.

WARNING: String voltage shall not exceed 600 Vdc for any reason, so as to avoid damage to the equipment.

The total current of an array must also be within the capability limits of the inverter. The 3000W model of AURORA is capable of handling 2 separate arrays. For AURORA the maximum current from each input can be 10Adc.
In case the photovoltaic system exceeds the capabilities of a single AURORA inverter, additional inverters can be added to the system, each connected to a suitable section of the photovoltaic field on the Dc side, and to the grid on the Ac side.
Each AURORA inverter will work independent of the others and will push to the grid the maximum power available from its own section of the photovoltaic panels.
The actual decisions on the way the photovoltaic system is structured and wired depend on a number of factors and considerations, such as type and model of panels, available area, location, energy targets, as well as on good design practices
Magnetek provides a system configuration tool on its website (www.alternative-energies.com) that can assist in modelling the system.

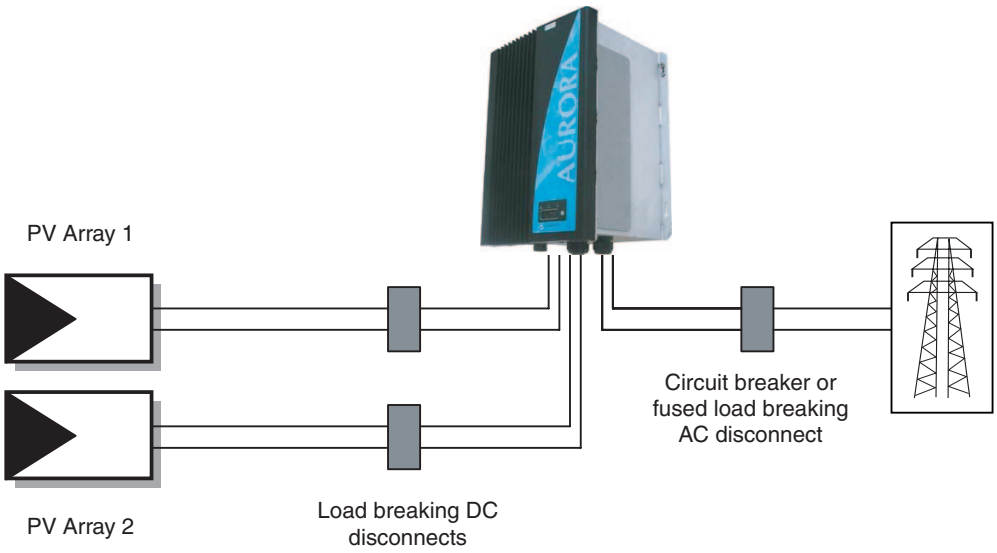


Fig.3 Simplified diagram of a photovoltaic system

2.2 Data Transmission and Check

In case multiple inverters are used, they can be monitored remotely by using an advanced communication system based on the serial interface RS485 or on the Power Line Modem (PLM) technology. For further information, refer to the corresponding sections of this manual.

2.3 AURORA Technical Description

Figure 4 shows a block diagram of AURORA. The main blocks are the input Dc-Dc converters (called boosters) and the output inverter. Both the Dc-Dc converters and the output inverter work at high switching frequency to minimize size and weight.
The outdoor isolated models utilize a high-efficiency toroidal transformer to provide galvanic isolation between the equipment and the distribution grid, so as to comply with very important standards, such as those relating to safety and electromagnetic compatibility.

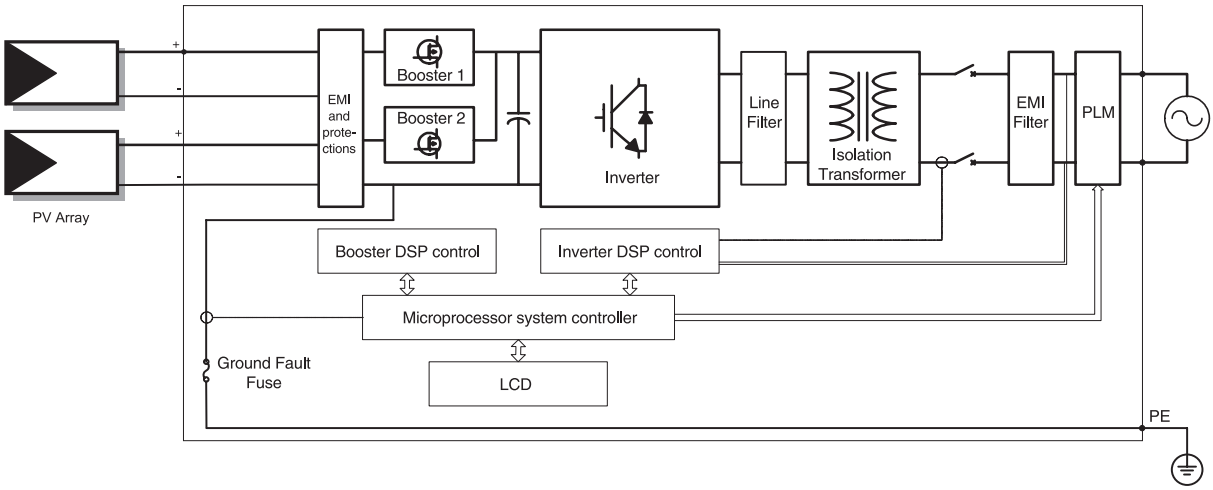


Fig.4 AURORA block diagram

The block diagram shows the model AURORA PVI-3000-I-OUTD-US with its two independent input Dc-Dc converters. Each Dc-Dc converter is dedicated to a separate array with independent maximum power point tracking (MPPT) control. This means that the two separate arrays can be installed in different positions and orientation and/or with a different quantity of modules in series. Each array has its own MPPT control circuit.
Thanks to its high efficiency and large heat-sink, AURORA offers max. power operation in a wide ambient temperature range.
The inverter is digitally controlled by means of two independent Digital Signal Processors (DSP), and one microprocessor.
Two single-chip independent computers maintain control in full compliance with the electric standards relating to systems power supply and safety.
The AURORA operating system performs inter-process communication checks to ensure the entire unit operates properly.
This process ensures optimal performance levels of the whole units, as well as a high efficiency under all insolation and load conditions and always in full compliance with the applicable directives, standards and regulations.

2.4 Protective Devices

2.4.1 Anti-Islanding

When the local power distribution grid fails due to a fault or when the equipment is shut down for maintenance operations, AURORA shall be physically disconnected under safety conditions, so as to protect the people working on the grid, in full compliance with the applicable prevailing national standards and regulations. To avoid any possible islanding operation, AURORA is provided with an automatic disconnection protective system called Anti-Islanding.
The AURORA PVI-3000-I-OUTD-US model is equipped with an advanced Anti-Islanding protection certified according to the UL 1741 standard.

2.4.2 Panel Ground Fault

Safety standards require the photovoltaic array system to be grounded. AURORA internally provides the system grounding of the array. The AURORA inverter grounds the negative leg of each array input. An advanced ground fault protection circuit continuously monitors the ground connection and shuts down AURORA in case a ground fault is detected and indicates the ground fault condition by means of a red LED on the front panel. For additional safety a 1A fuse is provided on the grounding connection internal to AURORA to interrupt the ground fault current path. A terminal for the equipment grounding conductor is provided in the AURORA inverter, see section 3.5 for additional information.

WARNING: Do not connect the AURORA inverter to Bi-polar configured arrays. The AURORA inverter is designed for connection to floating Photovoltaic arrays only. The negative connection of the PV array is connected by AURORA inverter to ground.

NOTE: "Dc Ground Fault Fuse Replacement"

The Dc ground fault fuse must be replaced only by qualified personnel, using a UL listed Fast acting Type fuse, 1A, 600VDC, Type KLKD-1 LITTELFUSE. The replacement steps are as follows:

- De-energize Dc and Ac connections to the AURORA inverter.
- Verify that the Dc ground fault fuse is open, if it is open proceed.
- Inspect entire PV installation for ground fault conditions, correct any ground fault conditions found.
- Replace the Fuse.
- Re-energize Dc and Ac conditions
- If the ground fault indication is still present, please contact the Service Center.

NOTE: For detailed information on AURORA disconnection and on malfunctioning causes, refer to the corresponding sections.

2.4.3 Further Protective Devices

AURORA is equipped with additional protections to guarantee safe operation under any circumstances. The protections include:

- Continuous monitoring of the grid voltage to ensure the frequency and voltage values are within the proper operational limits;
- Control of the internal temperatures to automatically limit power when needed to make sure the unit does not overheat (heat-sink temperature <=70°C [158°F]).

Many control devices are fitted to AURORA, making its design redundant, but at the same time ensuring a perfect and fully safe operation.

3 INSTALLATION

WARNING: The electrical installation of AURORA must be made in accordance with the electrical standards prescribed by the local regulations and by the National Electric Code (ANSI/NFPA 70 standard).

WARNING: The connection of AURORA to the electrical distribution grid must be performed only after receiving authorization from the utility that operates the grid.

3.1 Package Inspection

NOTE: The distributor presented your AURORA to the delivering carrier securely packed and in perfect condition. Upon acceptance of the package from the distributor the delivering carrier assumes responsibility for its safe arrival to you. Regardless of the attention paid by carrier in handling it, sometimes the package and its contents might be damaged.

Please, carry out the following checks:

- Examine the shipping box for any visible damage: punctures, dents or any other signs of possible internal damage;
- Describe any damage or shortage on the receiving documents and have the carrier sign their full name;
- Open the shipping box and inspect the contents for internal damage. While unpacking, be careful not to discard any equipment, parts or manuals. If any damage is detected, call the delivering carrier to determine the appropriate action. They may require an inspection. Save all shipping material for the inspector to see!

- If the inspection reveals damage to the inverter call your supplier, or authorized distributor. They will determine if the equipment should be returned for repair. They will also provide instructions on how to get the equipment repaired;
- It is your responsibility to file a claim with the delivery carrier. Failure to properly file a claim for shipping damages may void warranty service for any physical damages later reported for repair;
- Save AURORA original packaging, as it will have to be used in case the equipment has to be shipped out for repairs, or the responsible inspector requires it.

3.2 Package Check List

Description	Quantity (No.)
Photovoltaic Inverter	1
Box with 4 screws, 4 blocks and 1 Tap wrench Torx TX20	1
One mounting reference drawing	1
One copy of this manual	1
One certificate of warranty	1
CD-Rom with communication software	1

3.3 Choosing Installation Location

The location for the installation of AURORA should be selected in accordance to the following recommendations:

- AURORA should be placed at a suitable height from ground to allow easy reading of the front display and the status LEDs.
- Leave enough room around the unit to allow easy installation and maintenance.
- Choose a location sheltered from sun radiation and able to provide some ventilation. Avoid locations where air cannot freely circulate around the unit, or directly exposed to the sun.
- Minimum clearance requirements on the sides easily access the side cover and to obtain the best performance of the unit are as per the following figure:

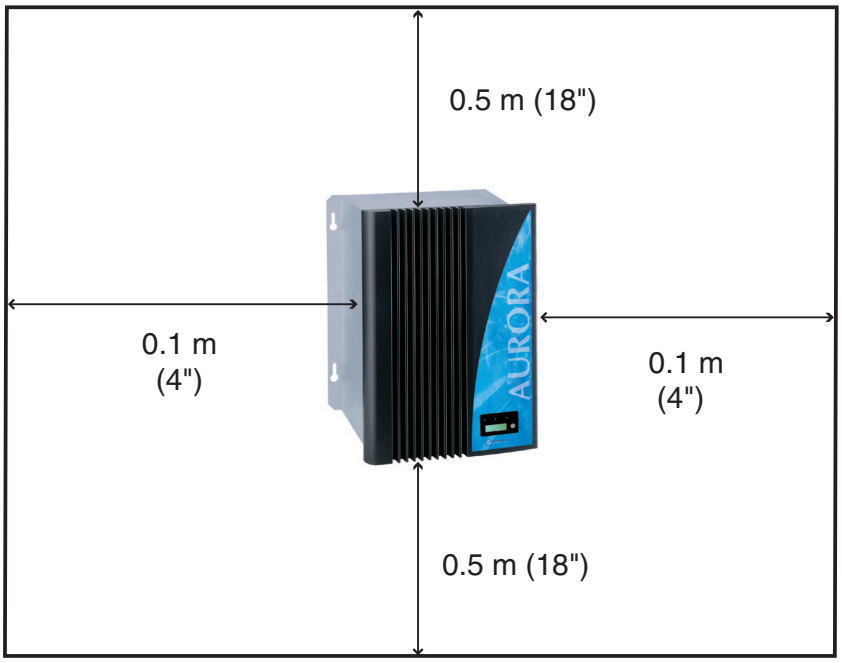


Fig.5 Minimum clearance requarments

3.4 Wall Mounting

AURORA should be mounted in a vertical position as shown in figure 7.

NOTE: AURORA ratings are based on a vertical mounting position. Although it is possible to mount AURORA in a tilted position, the thermal performance in that case may be de-rated. In any case avoid mounting AURORA with the front plate rotated, always make sure that the fins of the front heatsink are vertical.

To facilitate wall mounting a reference drawing is provided in the package (Fig.6). Use the drawing to locate the holes on the wall. A set of standard expansion stainless steel screws is included in the package for use in mounting the AURORA to a masonry wall. In case of different materials make sure to select the proper mounting hardware. Always use stainless steel mounting hardware, if the supplied hardware is not used.

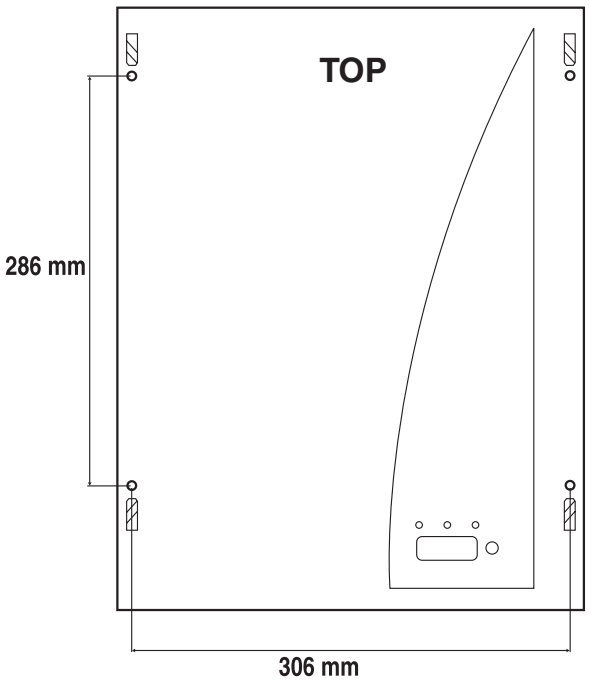


Fig.6 Wall mounting diagram

Install the expansion screws in the wall so that the head of the screws is about 4mm (~1/6") from the wall surface. Then hang AURORA on the wall by fitting the screw heads in the mounting slots as shown in Fig.7, and secure the screws.

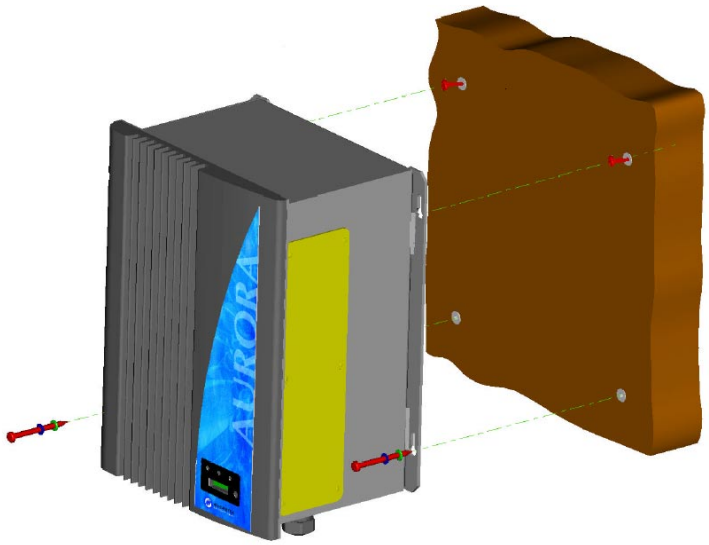


Fig.7 AURORA wall mounting

Mounting AURORA in a tilted position as shown in Fig.8 is possible but thermal dissipation is not optimized and power de-rating may occur. It is recommended that the unit is not placed in direct sunlight.

WARNING: During operation, inverter surface can reach very high temperatures.
DO NOT touch inverter surface to prevent the risk of burns.

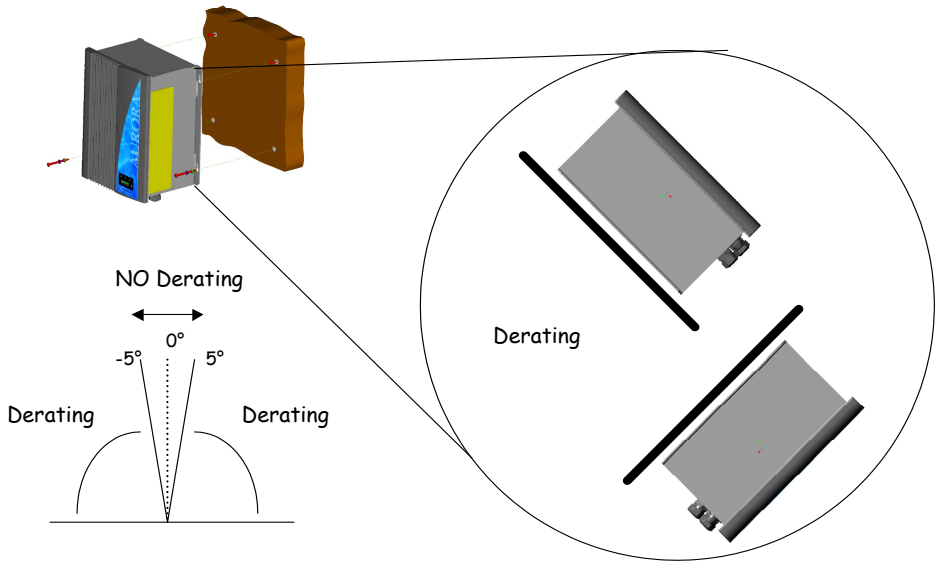


Fig.8 Inverter tilted mounting

3.5 Electrical Connections

WARNING: The electrical connections can be done only after AURORA is firmly mounted to the wall.

WARNING: For further details on each single step, carefully read and follow the "step-by-step" instructions of this section (and sub-sections), as well as all safety warnings. Any operation non-complying with the instructions below can lead to operator/installer hazards and to equipment damage.

WARNING: Always respect the nominal ratings of voltage and current defined in chapter 9 (Technical Characteristics) when designing your system. In particular, regarding the photovoltaic system:

- Maximum Dc array input voltage for each MPPT circuit: 600Vdc in any condition.
- Maximum Dc array input current for each MPPT circuit: 10Adc in any condition.

WARNING: Check the National and local standard regulations to make sure your electrical installation design is in compliance with them.

NOTE: According to the typical assembly diagram (see Fig. 9) each array must be connected to a fused Dc load breaking disconnect. A fused Ac load break disconnect or a circuit breaker must be used to connect AURORA to the grid. Although fuses are not mandatory if a circuit breaker is used, we recommend using the fuses to avoid grid instability. Recommended ratings for the Ac disconnect or circuit breaker is maximum 20A, 240V.

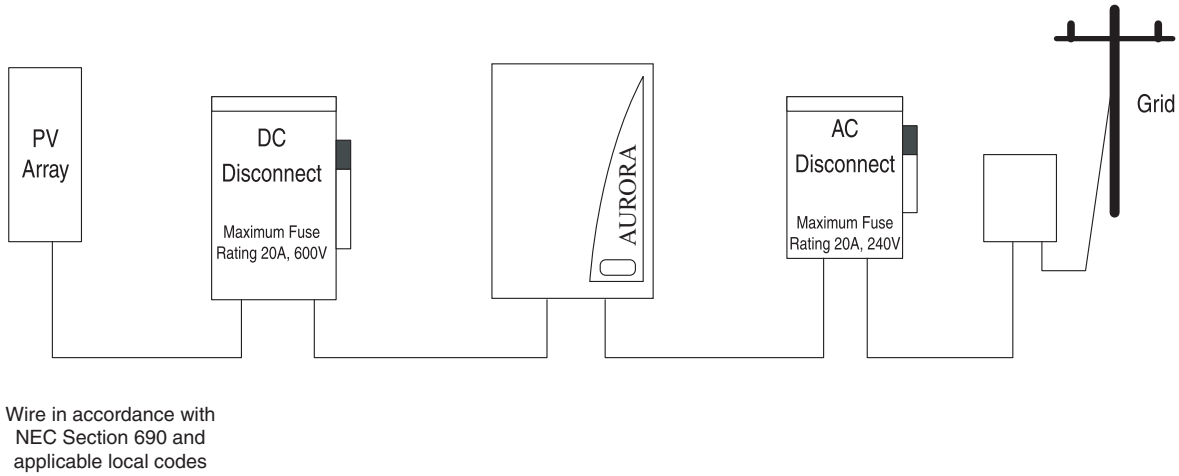


Fig.9 General wiring diagram

CAUTION: To reduce the risk of fire, connect only to a circuit provided with 20A maximum branch circuit overcurrent protection in accordance with the National Electical Code, ANSI/NFPA 70.

WARNING: All power wires connecting AURORA must have a section of at least 14 AWG (2.5mm^2) and must be able to operate at temperature of at least 90 °C. All wiring must be sized in accordance with the National Electrical Code section 690 requirements and applicable local codes. The wire size may need to be increased due to temperature, wire length and conduit fill factors. The wiring should be rated for wet location, UV sunlight-resistant and outdoor location. Consult with a qualified electrical designer when determining system wiring.
Minimum PV array connection Dc wire size, 14 AWG, 12 Amps.
Minimum Ac wire size, 14 AWG, 13 Amps.

The AURORA must be installed using watertight wiring methods. This requires the use of UL listed watertight components and locknuts with the applicable wiring method. On the bottom of the unit there are four 29mm diameter holes (Trade size 3/4") covered with cap Elektrozubehoer, type H 400 P (model designation K 426 21 P) or equivalent UL listed watertight cap. Un-used holes shall be left sealed by the caps. Fig.10 shows an example of locknuts assignment.

WARNING: It is the installer responsability to make the conduit connection watertight, by using the proper UL listed components and locknuts, and by applying the correct tightening torque.

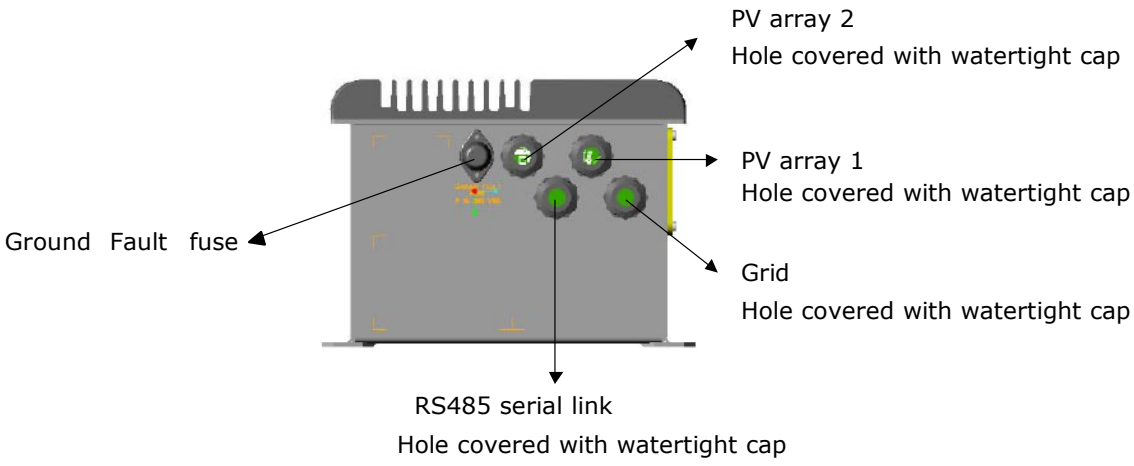


Fig.10: Position of the holes on the bottom side

WARNING: Use UL listed watertight conduit connectors to maintain the enclosure rating of the AURORA inverter.

To access the wiring terminal strip inside of the AURORA inverter remove the side panel as shown in Fig.11. Removing the panel allows you to access the screw terminal blocks and the conduit access holes.

Fig.11: Removing the side panel

WARNING: To avoid the risk of electric shock from energy stored in capacitors. Wait 5 minutes after disconnecting both Ac and Dc connections before opening the side panel.

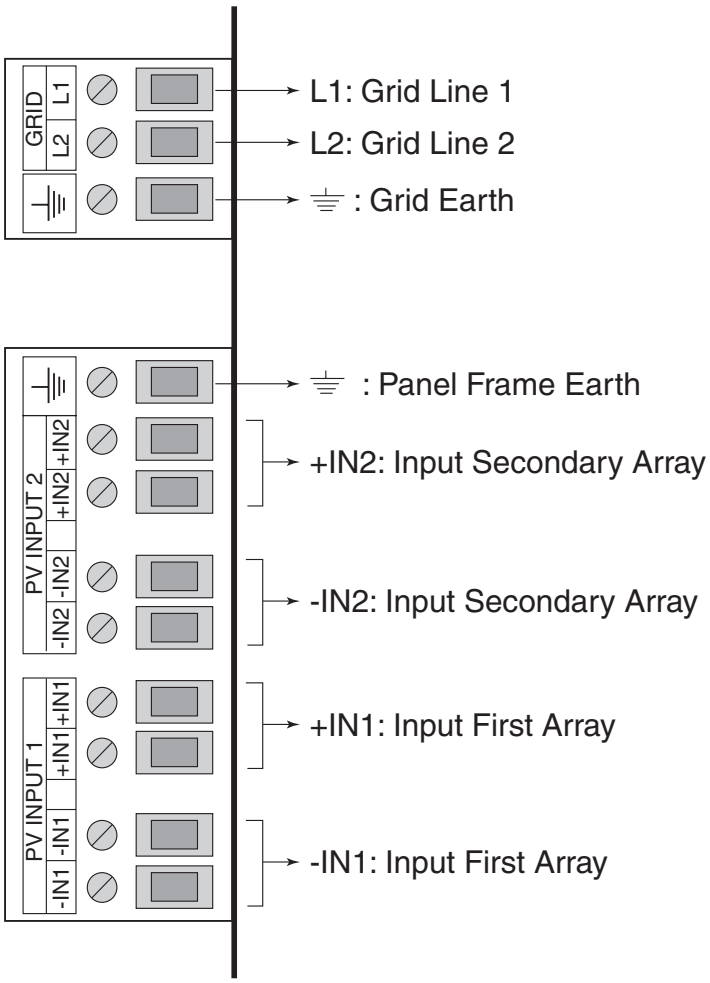


Fig 12: Screw terminal blocks

The conduit and the wire lengths depend on the distance between the unit and Ac and Dc disconnects. The wires must be inserted in the conduits and routed to the terminal blocks. Pay careful attention in bending the cables properly. The insulation at the end of the cable should be stripped back ½ “ (14mm). The maximum wire size that the terminal will accept is 12AWG.

WARNING: When making the electrical connections follow this exact procedure to avoid exposure to dangerous voltages. Each step of the procedure is explained in the following paragraphs.
To disconnect AURORA follow the connection procedure in the reverse order.

Step 1/7: Open the Ac disconnect or circuit breaker and lockout the Ac disconnecting means.

Step 2/7: Open the Dc disconnect and lockout the Dc disconnect.

Step 3/7: Verify there is no voltage on the connection terminals.

Step 4/7: Connect AURORA to the Main Ground (Protective Earth)

The plant must have a Protective Earth (Equipment main ground) connection according to the National Electric Code. See the National Electric code sections 690-40 and 690-42 for proper equipment ground conductor sizing. The Protective Earth cable must be connected to the AURORA chassis ground connection as shown in Fig.13 using the screw provided. Tighten the screw to a torque of 0.6 Nm (5.3 inlbs).

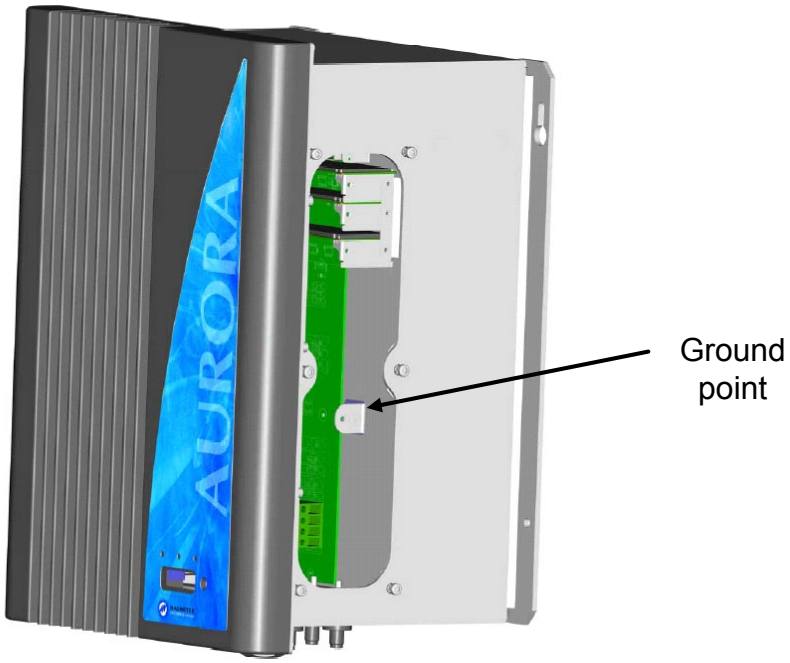


Fig.13: Location of Main Ground PE Screw

Step 5/7: Connect AURORA to the Ac Disconnect or circuit breaker

WARNING: Use proper, low impedance cables to connect AURORA to the Ac disconnect or circuit breaker, and between the disconnecting means to the grid. To ensure proper operation the impedance seen at the Ac output terminals of AURORA must be below 1ohm.

1) Mount the conduit between AURORA and the Ac disconnect
2) Connect the conduit to the AURORA by using suitable watertight conduit connectors
3) Insert three cables labeled L1 (phase ONE of the split-phase system), L2 (phase two of the split-phase system) and GND (Grid Ground) (in the conduit and run them to the terminal blocks of AURORA)
4) Connect the cable L1 to the terminal block labeled L1
5) Connect the cable L2 to the terminal block labeled L2
6) Connect the cable GND to the terminal block labeled ⏚
7) Tighten the screw with a torque of 0.6Nm (5.3 in-lbs)
8) Make the proper connections to the Ac disconnect. The L1 cable must be connected to Line side terminal 1, L2 must be connected to Line side terminal 2 and GND must be connected to ground terminal.
9) Verify that all connections have been executed properly and all the screws are properly tightened.

NOTE: In case your system has an additional kW-hour meter installed between the Ac disconnect and AURORA, please apply the Ac connection procedure to the terminals of the meter.

Step 6/7: Connect AURORA to the Dc disconnects

Your photovoltaic system may have one or two independent PV arrays when connecting to AURORA inverter.

NOTE: AURORA has two independent Dc input sections, each of them capable of handling a maximum power of 2000W and a maximum current of 10A. The recommended configuration of the PV system has two independent PV arrays wired to Aurora and connected separate to the two input sections. In case your photovoltaic system has one array only, and its current exceeds the current capability of one input section (10A) or the maximum power (2000W), you have to parallel the input terminal sections as shown in Fig.14. You can use the extra screw terminal block to wire a (14 AWG) jumper between the two sections. Moreover, you will need to configure the inverter to work with the two inputs sections wired in parallel (one array) by means of the communication software provided in the CD-Rom.

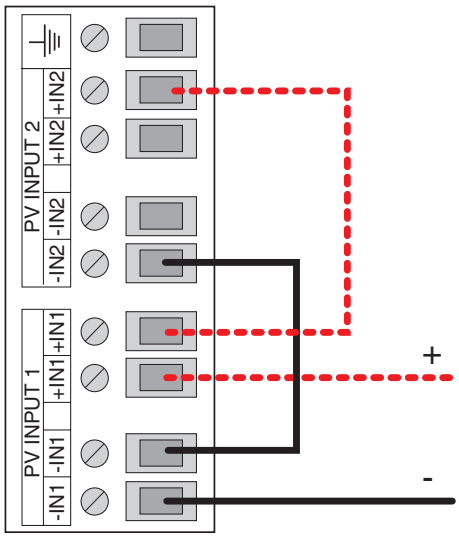


Fig.14: Paralleling the two input sections

NOTE: Paralleling the two input section may reduce the electro-magnetic compatibility performance of AURORA. Magnetek strongly recommends, whenever possible, to use two separate arrays each with a current capability compatible with the section limit of 10A and the maximum section power of 2000W.

WARNING: Take special care to ensure the photovoltaic voltage polarity corresponds to the symbols "+" and "-" labeled on the contacts of the photovoltaic field.
Before connecting AURORA with the photovoltaic field, Magnetek recommends checking, using a proper gauge, that the polarity value and the allowable voltage value between positive and negative contacts are correct.

Array connection: Follow this procedure for each array

1) Mount the conduit between AURORA and the Dc disconnect.
2) Secure the conduit to the AURORA enclosure by using suitable watertight conduit connectors
3) Insert the wires labeled + and – in the conduit and run them to the same input section terminal blocks of AURORA either Input 1 or Input 2.
4) Connect the cable + to the terminal block labeled +
5) Connect the cable – to the terminal block labeled –
6) Tighten the screw to a torque of 0.6Nm (5.3 in-lbs.)
7) Make the proper connections of the cables to the Dc disconnect. The + wire must be connected to the positive of the array, the – wire must be connected to the negative of the array
8) Verify that all connections have been executed properly and all the screws are tight.

The equipment grounding conductor from the photovoltaic field must be connected to the contact of the terminal block identified by the ground symbol ⏚

WARNING: The photovoltaic grounding shall be installed per the requirements of sections 690.41 through 690.47 of the NEC, ANSI/NFPA 70 and it is the responsibility of the installer

Step 7/7: Closing the side panel

WARNING: Tighten side panel screws with a torque of 1.5 Nm (13.2 in-lbs) to ensure watertight sealing.

4 START-UP

NOTE: do not lay any object on AURORA during operation.

WARNING: do not touch the heatsink during operation, some parts could be very hot and cause serious burns.

To turn on AURORA switch the Dc disconnect on the ON position.

1) Switch the Ac disconnect to the ON position.
2) AURORA will start operating and the green LED labeled Power on the front panels will start blinking while the grid is checked to make sure that voltage, impedance and frequency parameters are within operating range per UL 1741 requirements. The check can last several minutes depending on the conditions of the grid. During the check the LCD display will show a sequence of three screens, indicating:
   - Remaining time for next connection.
   - Grid voltage value and status (in or out of range)
   - Grid frequency value and status (in or out of range)
3) If the grid check is successfully completed the unit will perform a protective test on the unit. It's normal that the unit produces an audible sound during the test.
4) Then the AURORA will export to the grid and the green Power LED will be continuously lit (provided there is enough solar radiation to feed power to the grid).
5) If the grid check is not successful the unit repeats the check over and over again until acceptable grid parameters are found. During this procedure the green power LED keeps blinking. Measure the grid voltage and frequency and then verify the grid configuration of the unit.

5 MONITORING AND DATA TRANSMISSION

5.1 User's Interface Mode

WARNING: RS-485 cable must be rated to 600V or higher.

The AURORA inverter usually works automatically and is maintenance-free. When solar insolation is not high enough to provide power for export to the grid (during nighttime, for example) AURORA disconnects automatically, and enters the stand-by mode, waiting to start working again. The operational cycle is automatically restored as soon as the solar insolation is high.

AURORA inverter can provide operational data in the following ways:

- LED indicators
- Operational data on the LCD display
- Data transmission on a dedicated serial RS-485 line. The data can be collected by a PC or data logger equipped with a suitable RS-485 port or with the optional RS-485/RS-232 AURORA serial interface converter, or by AURORA Easy Control* data logger (* this accessory option is not presently released to the market).
- Data transmission on the Ac grid by means of a dedicated Power Line Modem (PLM). The data can be collected by a PC equipped with the optional PLM adapter, or by AURORA Easy Control data logger.

* Available starting Spring 2005. Please check web site www.alternative-energies.com for updated information

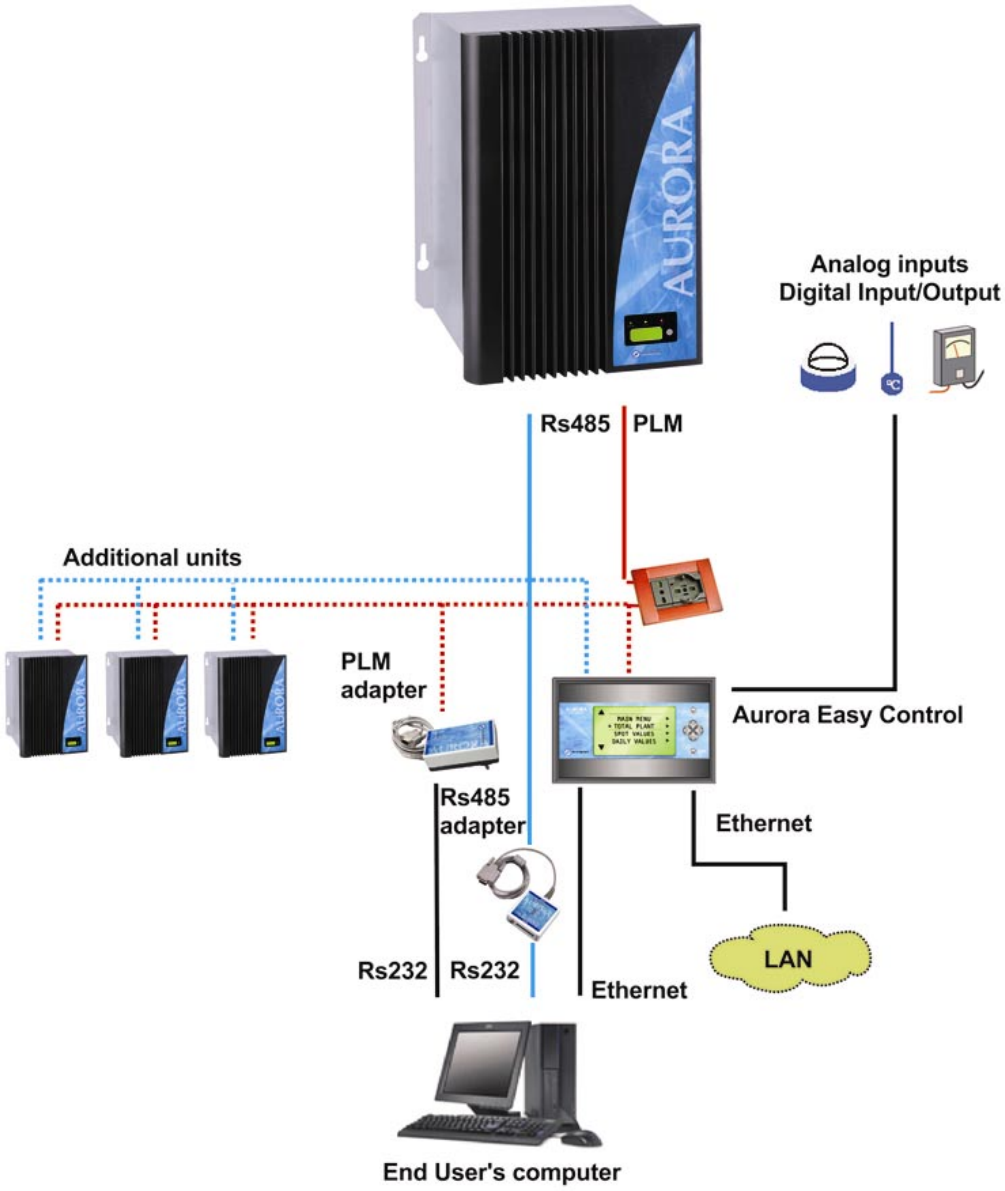


Fig. 15 Data Transmission Options

5.2 Available Data

AURORA provides two sets of data that are accessed using AURORA interface software.

5.2.1 Real time data

The real time operating data can be transmitted on request over the communication lines and is not recorded internally by the AURORA inverter. The AURORA interface software can be used to retrieve and store data on a PC computer. The following data is available:

- Grid voltage
- Grid current
- Grid frequency
- Power transferred to the grid
- Voltage of PV array 1
- Current of PV array 1
- Voltage of PV array 2
- Current of PV array 2
- Heatsink temperature
- Serial Number Part Number
- Manufacturing week
- Firmware revision code
- Energy produced so far in the day
- Leakage Current

5.2.2 Internally Logged Data

AURORA stores internally the following data:

- Lifetime counter of grid connection time
- Lifetime counter of energy transferred to the grid
- Energy transferred to the grid every 10 seconds for the last 8640 periods of 10 seconds (which on average cover more than 2 days logged data)
- Partial counter of grid connection time (the counter start time can be reset by using the AURORA software)
- Partial counter of energy (uses the same start time of the partial time counter)
- Last 100 fault conditions with error code and time stamp
- Last 100 variations to the grid connection parameters with parameter code, new value.

All data are available for transmission via the RS-485 link or PLM. In addition, the first two data of the list are displayed on the LCD.

5.3 LED Indicators

On the front panel of the AURORA inverter there are three LEDs, which give status indications:

1. A green LED labeled Power
2. A yellow LED labeled FAULT
3. A red LED labeled GFI (ground fault)

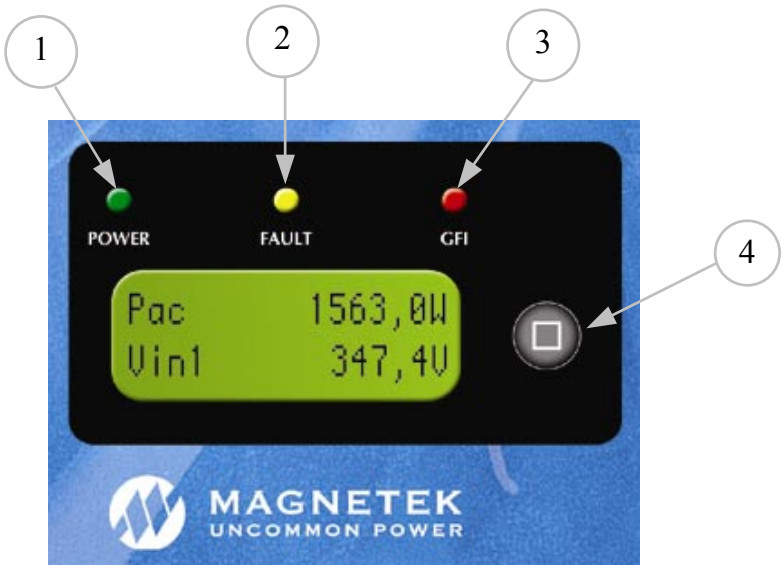


Fig.16 LED's location

KEY:

LED on

LED blinking

LED off

Any of the above conditions

	LEDs Status	Operational Status	Remarks
1	Power (Green): ☒ Fault (Yellow): ☒ GFI (Red): ☒	AURORA self-disconnection during nighttime	Input voltage below 90 Vdc for both inputs
2	Power (Green): ◪ Fault (Yellow): ☒ GFI (Red): ☒	AURORA initialization, settings loading and waiting for grid check	Input voltage above 200 Vdc also for one input only. It is a transition status while operating conditions are checked.
3	Power (Green): ■ Fault (Yellow): ☒ GFI (Red): ☒	AURORA is exporting to grid	Standard machine operation (search of max. power point or constant voltage).
4	Power (Green): □ Fault (Yellow): □ GFI (Red): ■	System insulation device faulty	Ground leakage found
5	Power (Green): ☒ Fault (Yellow): ■ GFI (Red): ☒	Malfunction – fault!!!	The Fault can be inside or outside the unit. See the alarm appearing on the LCD.
6	Power (Green): ☒ Fault (Yellow): ◪ GFI (Red): ☒	Installation phase: AURORA is disconnected from grid.	During installation, it refers to set-up of the address for RS-485 communication.

NOTE: All inverter statuses signaled by the corresponding LED coming on or blinking, are also identified on AURORA LCD by a message relating to the operation being carried out or to the defect/fault found (see following sub-sections).

G ☒
Y ☒
R ☒

1) Nighttime Mode

AURORA is in the nighttime disconnection phase; this happens whenever the input power is too low to export power to the feed grid and power the inverter control system as well.

G ◪
Y ☒
R ☒

2) AURORA Initialization and Grid Check

The unit is in the initialization phase: energy supply for the inverter control system is high enough. AURORA is also checking that starting conditions – such as input voltage, starting time, etc. - necessary for the initialization process, are satisfied. Grid check is then started.

G ■
Y ☒
R ☒

3) AURORA Under Production

Once all electronic and safety self-tests are over, the unit starts the exporting process.

As stated above, during this phase AURORA carries out an automatic search and analysis of the photovoltaic field max power point tracking (MPPT).

G □
Y □
R ■

4) Ground Insulation

The inverter signals a ground fault.

This can be due to an insulation defect on the photovoltaic field connection.

- *Insulation Defect*

  An insulation fault condition has been detected in the photovoltaic field or in the corresponding connection: a connection is conductive with the grounded potential.

WARNING: trying to remove the fault by yourself is extremely dangerous. The instructions below have to be followed very carefully. In case you are not experienced or skilled enough to work safely on the unit, contact a specialized technician.

What to do after an insulation defect has been found

Whenever the red LED comes on, press the special multifunction push-button next to the LCD side to reset it. If this fault can be reset, the AURORA will continue working. If the fault cannot be reset, there could be a water seepage due to condensation that is

causing a ground fault or there is some other insulation breakdown. Have the system inspected by qualified personnel.
If the signal cannot be reset, insulate AURORA on both Dc and Ac sides so as to reach a safe condition; then contact an authorized center for repairing the system or changing the fuse.

G ☒
Y ■
R ☒

5) Malfunction-Fault Signal

Every time AURORA check system detects an operative malfunction or fault, the yellow LED comes on and a message showing the type of problem found appears on the LCD.

G ☒
Y ◪
R ☒

6) RS-485 Address Setting Signal

During installation, the yellow LED will flash until the address is confirmed. For further information about setting the address, refer to chapter 6.3.

5.4 Messages and Error Codes

The system status is identified through message or error signals appearing on the LCD.
The tables below summarize the two types of signals that can be displayed.

MESSAGES identify the AURORA actual status; so they do not relate to faults and nothing has to be done. The message will disappear as soon as standard conditions are restored.

No.	Message type	Description
1	Waiting sun	Waiting for enough solar radiation or grid presence
2	PV low	PV input voltage too low to allow energy transfer to the grid

ERRORS identify a possible fault of the equipment or of the connected parts. The signal will disappear as soon as the causes are removed, except for the ground insulation fault. Usually, when an error signal appears, an action is needed. This action will be managed as much as possible by AURORA or, in case this is not possible, AURORA will supply all the necessary information to assist the person fixing the fault on the equipment or system.

No.	Error Type	Description
1	Input OC	Input overcurrent
2	Input OV	Panel overvoltage
3	Internal Error.	Internal error
4	Bulk OV	Internal overvoltage
5	Output OC	Output overcurrent
6	IGBT sat	Saturation of the IGBT power devices

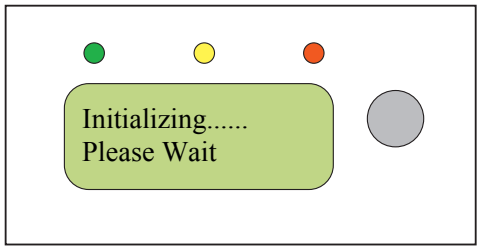
7	Bulk UV	Internal undervoltage
8	Internal Error	Software internal error
9	Grid Fail	Grid values outside the limits. Unit disconnected from the grid
10	Ramp fail	Internal failure in the Dc/Dc section
11	Over Temperature	Over temperature
12	Ground Fault	A ground fault condition of the photovoltaic panels is detected
13	IN not parallel	Input physically not in parallel
14	Bulk Cap. Fail	Failure of bulk capacitors
15	Start Timeout	Start timeout
16	Leak Failure	Leak current failure

5.5 LCD Display

The 2-line LCD display is located on the front panel and shows:

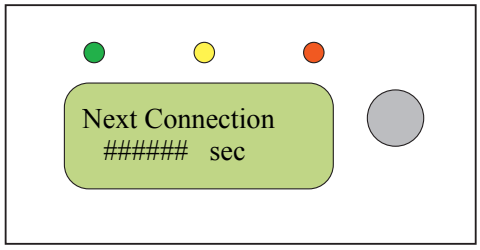
- ✓ the status of the inverter and statistical data;
- ✓ service messages for the operator;
- ✓ messages of faults or damages found.

Data are shown cyclically, the screens change every 5 seconds. On the right of the display there is a button that when pressed freezes the screen. Pushing the button again unfreezes the screen. When AURORA is turned on the display shows the following screen for about 10 seconds:

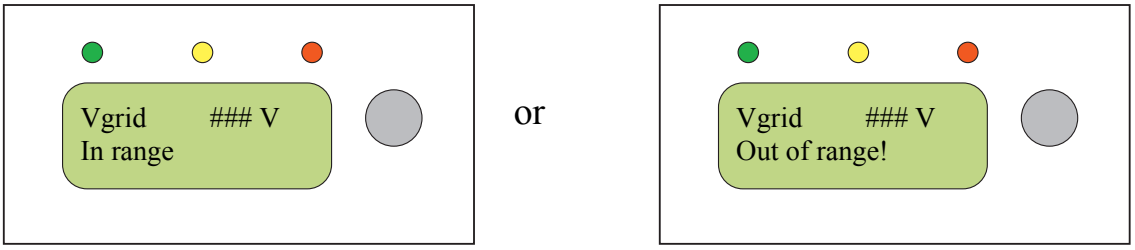


Afterwards it begins to check the grid. While checking the grid the display shows the three following screens cyclically:

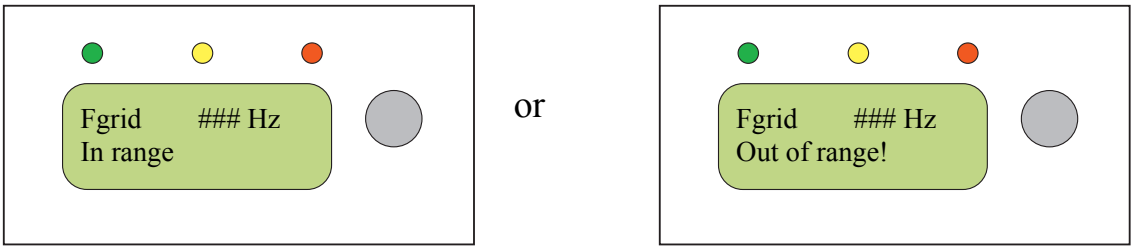
- ✓ This screen shows how many seconds are left before a new grid connection attempt will start.



✓ This screen shows the grid voltage and the related status (in range or out of range).

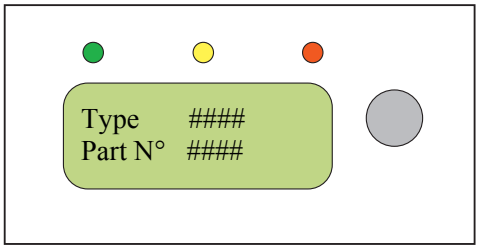


✓ This screen shows the grid frequency and the related status (in range or out of range, see section 9 for further details)

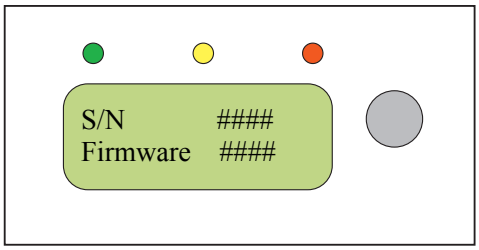


After AURORA is connected to the grid the display starts showing cyclically the following information screens, each for 5 seconds:

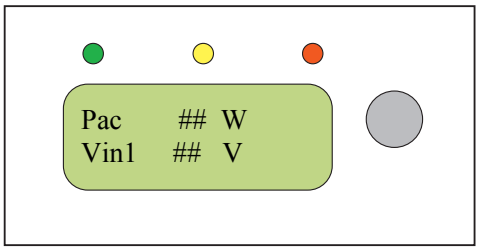
✓ First screen: Type and Part Number



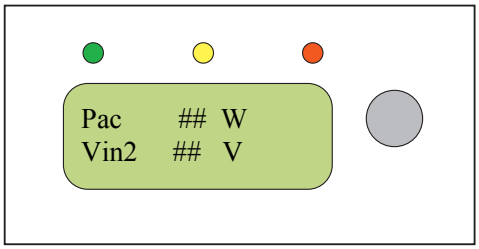
✓ Second screen: Serial Number and Firmware release number



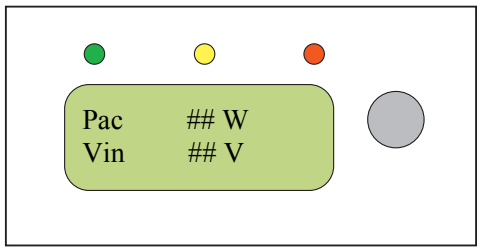
✓ Third screen: Output power and Voltage Input on the first photovoltaic array



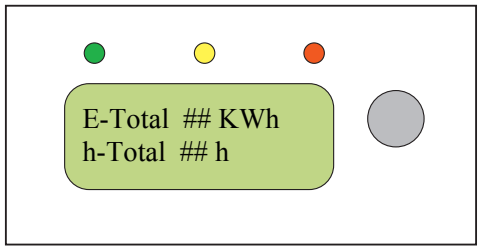
✓ Fourth screen: Output power and Voltage Input on the second photovoltaic array



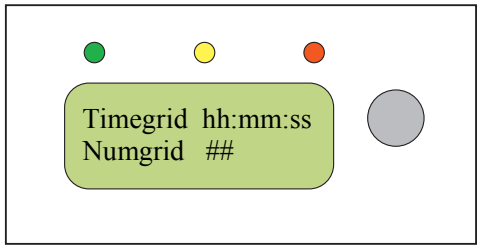
NOTE: In case your system works with just one array or with two arrays connected in parallel the screen shows this information:



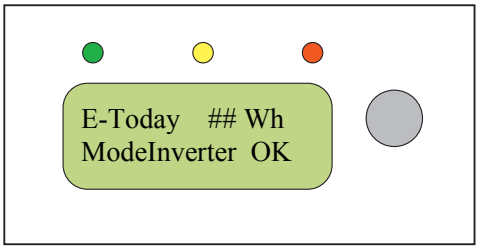
✓ Fifth screen: Total energy exported to the grid and total operating time (that is time during which the unit was active). Both data are measured since the unit was first operated.



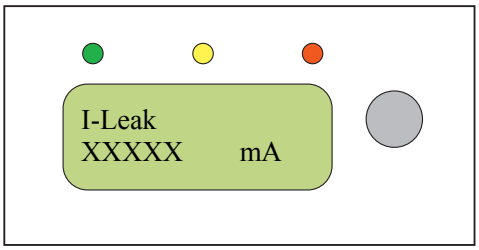
✓ Sixth screen: Time during which the unit exported energy to the grid, and number of times that unit connected to the grid.



✓ Seventh screen: Daily energy and mode of operation of the inverter

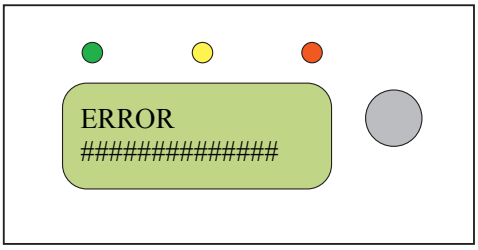


✓ Eighth screen: Leak current

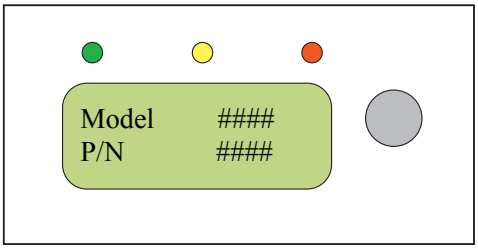


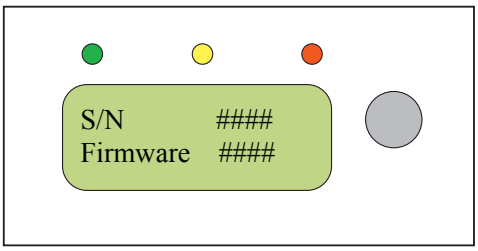
In case the inverter is not working properly the Fault or Ground Fault LEDs will turn on as described in paragraph 5.3, and the following three screens scroll on the LCD remaining on for 5 seconds. They contain important information that should be communicated to service personnel and will show cyclically on the LCD, each for 5 seconds:

✓ This screen shows the code of the error found, for further information refer to chapter 5.4.

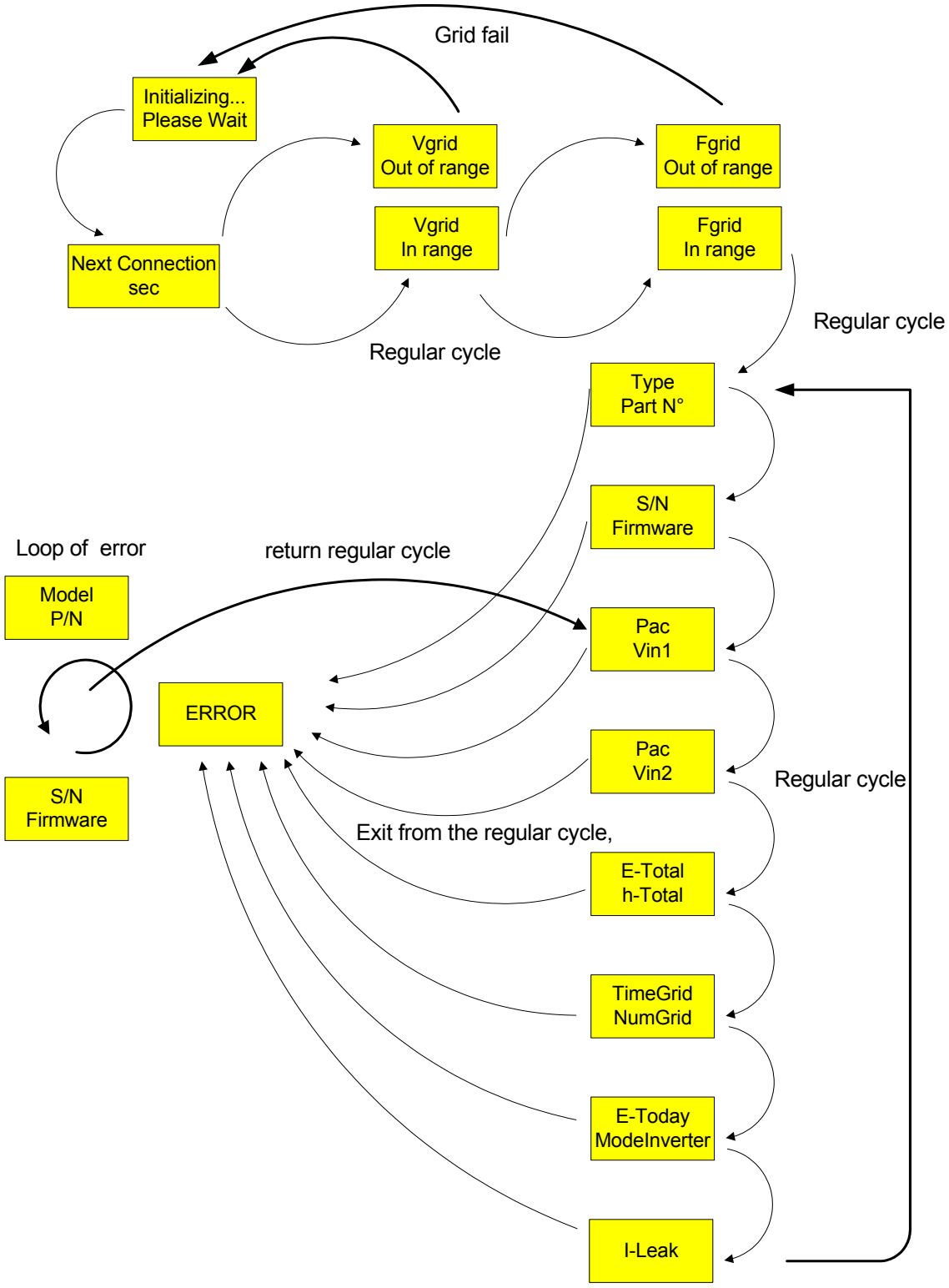


✓ These screens show the serial number and the firmware release number





The sequence of the screens is summarized in the following figure:



The values that can be displayed on the previous screens are summarized in the table below:

Data	Description
Vin1	Input voltage from photovoltaic array 1
Vin2	Input voltage from photovoltaic array 2
Pac	Output Ac power
E-Total	Total energy transferred to the grid since the unit was first operated
E-Today	Total energy exported to the grid today
h-Total	Total time since the unit was first operated
Type	Type of AURORA
S/N	Serial Number
Part N°	Part Number
Firmware	Firmware release number
TimeGrid	Time during which the unit exported energy to the grid
NumGrid	Number of connections to the grid
Leakage	Leakage current

6 DATA CHECK AND COMMUNICATION

6.1 RS-485 serial link

The RS-485 link uses two wires for signals plus a third wire for signal grounding, which is different from the equipment grounding of the unit. The wires must be run in a watertight conduit through the bottom of the unit as explained in paragraph 3.5 after removing the watertight cap and installing a suitable watertight conduit connector. The wires are then run to the RS-485 screw terminal blocks and connected as shown in Fig.17:

- Signal wires must be connected to +T/R and –T/R terminals
- Grounding wire must be connected to the RTN terminal

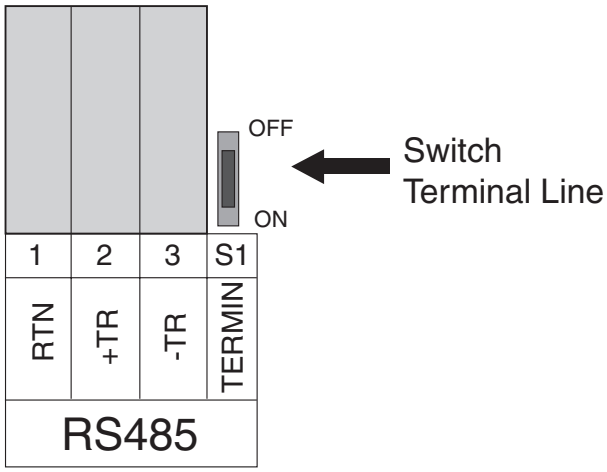


Fig.17: The RS-485 serial link terminal blocks

WARNING: RS-485 cable must be rated to 600V or higher.

The single AURORA has a default address is two (2) and the S1 dip switch is in the OFF position (pushed away from the side access panel). The RS-485 address does not have to be configured for the single AURORA inverter.
Up to 31 AURORA inverters can be connected on a the same RS-485 line. The maximum recommend RS-485 cable length is 1300 yards (1200 m).
In case multiple inverters are daisy-chained to the same RS-485 line, then the last unit must be identified by changing the position of the dip-switch shown in Fig.18 from OFF to ON. The default position of the switch is OFF. Also, each unit must have a different address. See par. 6.3 to change the addresses.

The following diagram shows how to connect multiple units on the same RS-485 bus.

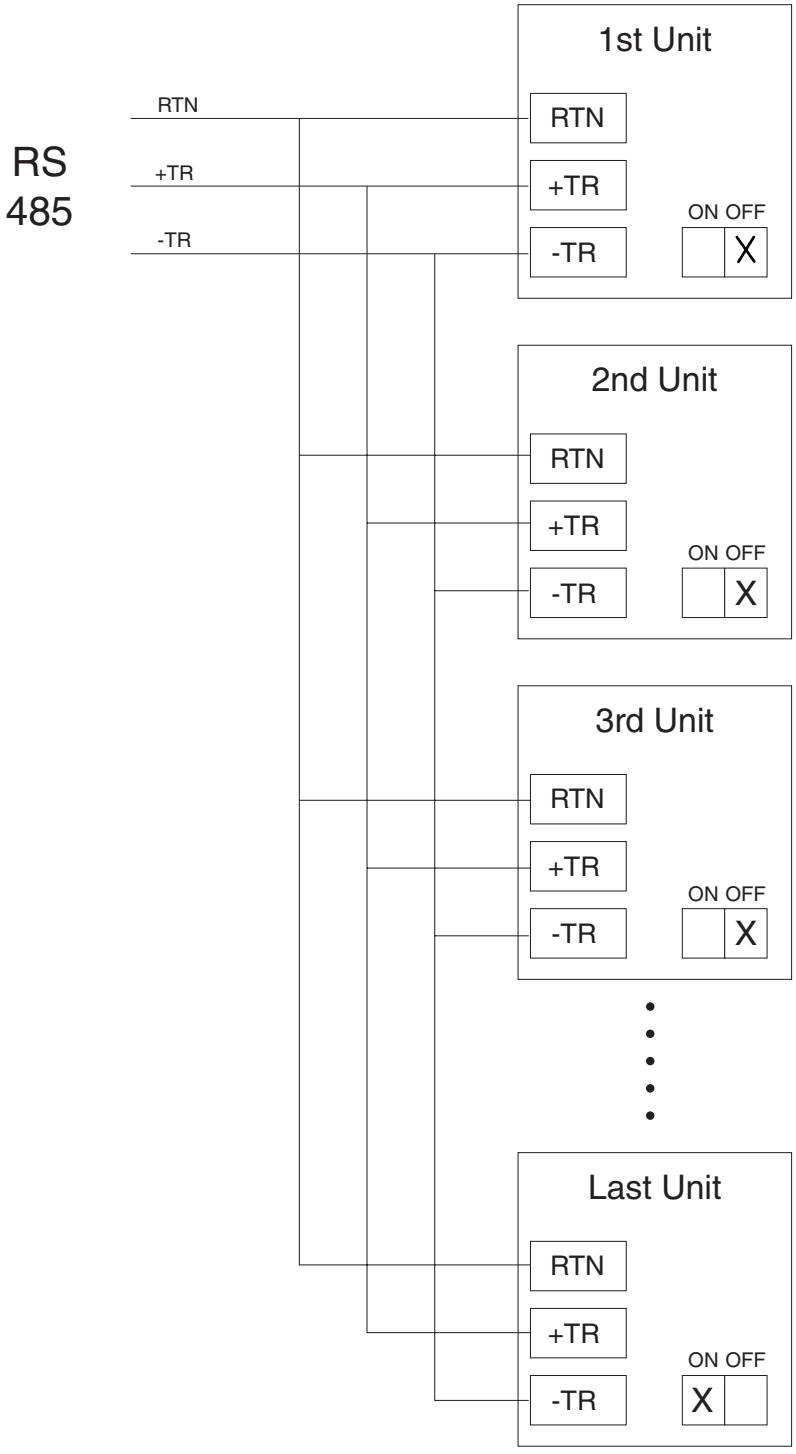


Fig.18 Multiple units connection

6.2 Power Line Modem (PLM)

AURORA comes with an integrated Power Line Modem using advanced algorithms to improve communication performance and increase reliability of data transmission over noisy electrical lines.
To collect the data transmitted over the PLM link two options are available:
• Use the AURORA Easy Control data logger, model number PVI-AEC
• Use a PLM/RS232 interface converter such as model number PVI-PLMREC-US to connect to a PC,
In either case no additional physical connections between the inverter and the receiver are needed, as the communication uses the power lines.
In case of installations in buildings wired with three-phase systems please make sure that the AURORA inverter and the receiving equipment are both on the same phase.
The nominal transmission range is 300yards (about 300m). However, the range may be limited in case of high electromagnetic interference of the power lines.
In case of extremely noisy power lines we recommend using a separate set of wires dedicated to the PLM communication, or to use the RS-485 serial link.
The maximum transmission rate of the PLM is 2400 bps.

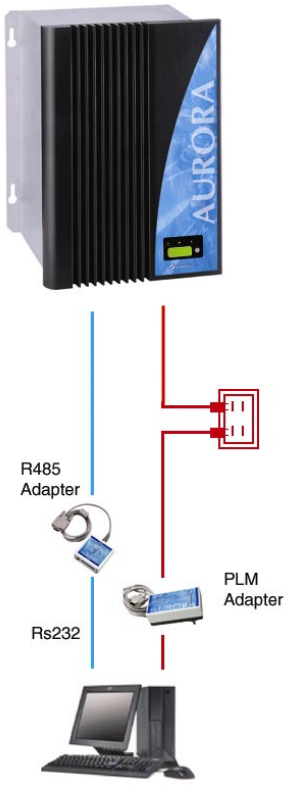


Fig.19: Data transmission to a PC

NOTE: the maximum number of inverters that can be connected via PLM is 63.

NOTE: It is not possible to have more than one receiving equipment such as AURORA Easy Control data logger or AURORA PLM/RS232 interface box connected to the same power line.

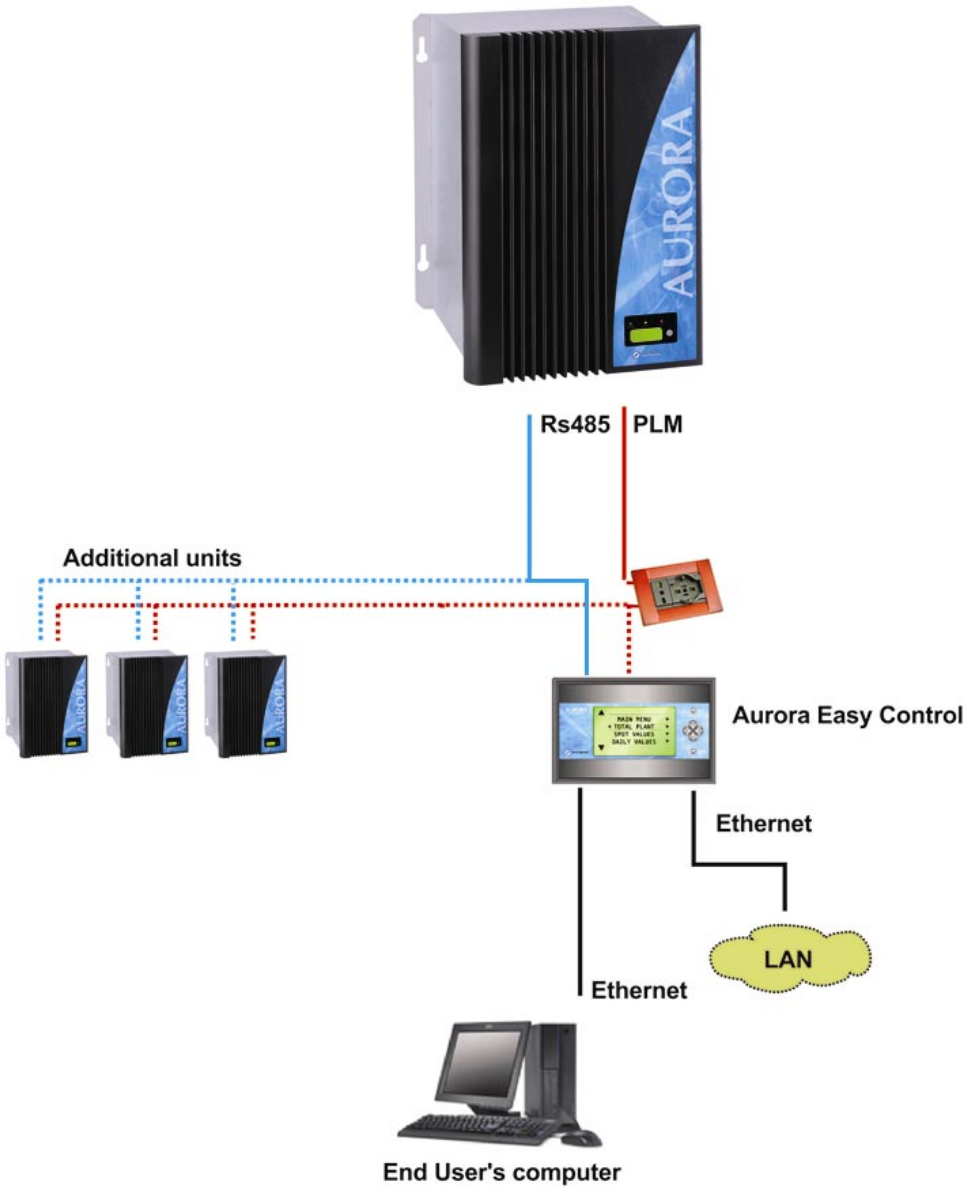


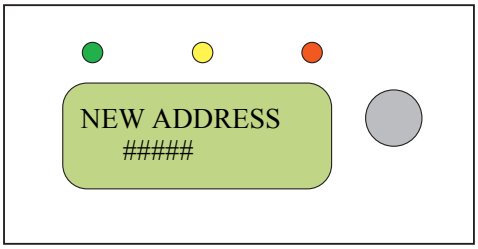
Fig.20: Data transmission to AURORA Easy Control

6.3 Address selection

When using PLM or the RS-485 serial link communication each unit must have a unique address. The default address of each unit is 2. When connecting multiple units on the same serial or PLM link a new address needs to be assigned to each unit to avoid communication errors.

Address Information
Addresses 0 and 1: are reserved for the host computers and monitoring accessories like the PLM modem and Easy Controller display unit.
The RS-485 serial link uses addresses 2 thru 32
The PLM link uses addresses 2 thru 64

Use the following procedure to set the new address:
1) Press the key on the side of the LCD display button for at least 5 seconds
2) AURORA disconnects from the grid, the yellow LED begins to blink and the display shows:



3) Press the key as many times as needed to select the address between 2 and 63. After the 63 the address starts back from 0.
4) Confirm the choice by pressing once more the key for at least 5 seconds. After the confirmation AURORA connects again to the grid.

NOTE: When using RS-485 link there can be no more than 31 inverters connected on the same link. Although you are free to choose any address between 2 and 63 it is recommended that you use addresses between 2 and 34 for the RS-485 serial link.

NOTE: When using RS-485 link, in case one or more inverters are later added to the system, please remember to switch back to the OFF position the dip-switch of the former last inverter of the system.

6.4 Measurement Accuracy

All measurement device have errors.
For each reading the following table shows:

- Description and Measurement Unit
- Resolution and Accuracy

Data	Description	Unit
Vpv1	Voltage of PV array 1	Vdc
Vpv2	Voltage of PV array 2	Vdc
Ipv1	Current of PV array 1	Adc
Ipv2	Current of PV array 2	Adc
Pac	Output Ac power	W
E-Total	Total energy	Wh
E-Today	Daily energy	Wh
h-Total	Total time	hh:mm:ss
TimeGrid	Total time energy exported to the grid	hh:mm:ss

Data	Resolution		Accuracy
	Display	Measurement	
Vpv1	1V	1/1000	2%
Vpv2	1V	1/1000	2%
Ipv1	0.1°	1/1000	2%
Ipv2	0.1A	1/1000	2%
Pac	1W	1/1000	2%
E-Total	1kWh	N/A	N/A
E-Today	1Wh	N/A	N/A
h-Total	1s	N/A	N/A
TimeGrid	1s	N/A	N/A

7 TROUBLESHOOTING

AURORA inverters comply with standards set for grid-tied operation, safety and electromagnetic compatibility.

Before being delivered by Magnetek, the product has been successfully subjected to several tests to check: operation, protective devices, performance and durability.

All these tests, together with the system ensuring Magnetek quality, guarantee AURORA optimal operation.

In case of any possible malfunction of the photovoltaic system, solve problems as follows:

- ✓ Working under safe conditions, as stated in chapter 3.5, check that connections between AURORA, the photovoltaic field and power distribution grid have been made correctly.

- ✓ Carefully observe which LED is blinking and read the signal appearing on the display; then, following the instructions given in chapters 5.3 and 5.4, try to identify the type of fault found.

If the malfunction cannot be removed by following these instructions, contact the service center or the installer (see following page).

Before contacting the service center, keep the following information handy:

INFO AURORA

NOTE: Information to be found directly on LCD

- ✓ AURORA model?
- ✓ Serial number?
- ✓ Week of production?
- ✓ LED flashing?
- ✓ Light blinking or steady?
- ✓ Signal displayed?

- ✓ Malfunction short description?
- ✓ Can malfunction be reproduced?
- ✓ If so, how?
- ✓ Does malfunction appear cyclically?
- ✓ If so, how frequently?
- ✓ Is malfunction present from installation?
- ✓ If so, has it worsened?
- ✓ Description of the atmospheric conditions when the malfunction appeared.

INFO on the Photovoltaic Field

- ✓ Make and model of photovoltaic panels
- ✓ System structure:
  - number of arrays and max. voltage and current values
  - number of strings for each array
  - number of panels for each string

8 TECHNICAL FEATURES

8.1 Input Values

WARNING: the Photovoltaic field and system wiring must be configured in such a way that the PV input voltage is less than the maximum upper limit independently from the type, the number and the operating conditions of the chosen photovoltaic panels.
As panel voltage also depends on working temperature, the number of panels per string shall be chosen according to the min. ambient temperature expected in that special area (see table A).

WARNING: The open circuit voltage of the photovoltaic panels is affected by the ambient temperature (the open circuit voltage increases as the temperature decreases). You have to make sure that at the minimum temperature estimated for the installation doesn't cause the panels to exceed the maximum upper limit of 600Vdc. As an example, the following table shows for typical panels of 36, 48 and 72 cells the maximum voltage of each panel as function of the temperature (assuming a nominal open circuit voltage of 0.65Vdc at 25°C and an increase of 0.0023V/°C for a decrease of temperature. The table shows, therefore, the maximum number of panels that can be connected in series as a function of the minimum temperature at which the system will operate. Consult the panel manufacturer for the correct temperature coefficient of V_{oc}, before calculating the voltage rating of the photovoltaic array.

NOTE: The inverter has a linear power derating related to the input voltage, starting from 530 Vdc (100% output power) to 580 Vdc (0% output power)

Minimum Panel Temp.[°C]	36 Cells Panels		48 Cells Panels		72 Cells Panels	
	Panel voltage	Max number of panels	Panel voltage	Max number of panels	Panel voltage	Max number of panels
25	21.6	27	28.8	20	43.2	13
20	22.0	27	29.4	20	44.0	13
15	22.4	26	29.9	20	44.9	13
10	22.8	26	30.5	19	45.7	13
5	23.3	25	31.0	19	46.5	12
0	23.7	25	31.6	19	47.3	12
-5	24.1	24	32.1	18	48.2	12
-10	24.5	24	32.7	18	49.0	12
-15	24.9	24	33.2	18	49.8	12
-20	25.3	23	33.8	17	50.7	11
-25	25.7	23	34.3	17	51.5	11

Table A

Description	Value PVI-3000-I-OUTD-US	
Nominal input voltage	360Vdc	
Input voltage range	90 Vdc to 600 Vdc	
Input voltage, MPPT operating range	90 Vdc to 580 Vdc	
Input voltage, MPPT range at full power	165 Vdc to 530 Vdc	
Max. short circuit current (of each array)	12 Adc	
Max. operating input current (of each array)	10 Adc	
Max. input power (of each array)	2000 W	
PV Ground fault protection	Ground fault detector and interruption provided	
Array configuration	One array	One or two array with common negative grounding and independent MPPT

8.2 Minimum Voltage of PV Generator

As stated above, AURORA carries out a search and analysis of the photovoltaic field max input Dc power point tracking.

NOTE: If the input current supplied by the photovoltaic field connected to the inverter is above the max. value and the input voltage is within the allowed range, the inverter is not damaged.

8.3 Output Values

Description	Value PVI-3000-I-OUTD-US
Nominal output power	3000 W
Grid voltage, maximum range	180 to 264 Vac
Grid voltage, nominal	240 Vac
Grid voltage, operating range	214 to 262 Vac
Grid frequency, maximum range	47 to 63 Hz
Grid frequency, nominal	60 Hz
Grid frequency, operating range	59.3 to 60.5 Hz
Nominal output current	12.5 Arms
Output over current protection	17 Arms

8.4 Grid protection characteristics

Anti islanding protection	According to UL 1741

8.5 General characteristics

Description	Value PVI-3000-I-OUTD-US
Maximum efficiency	> 93%
Internal consumption during stand-by	< 8 W
Internal consumption during night time	< 0.30 W
Operating ambient temperature	-25°C to +60°C (-13°F to 140°F)
Enclosure type	Nema 4X
Relative Humidity	0 – 100 % condensing
Audible Noise	< 30 dBA
Size (height x width x depth):	420 x 310 x 235 mm
Weight	29.5 kg

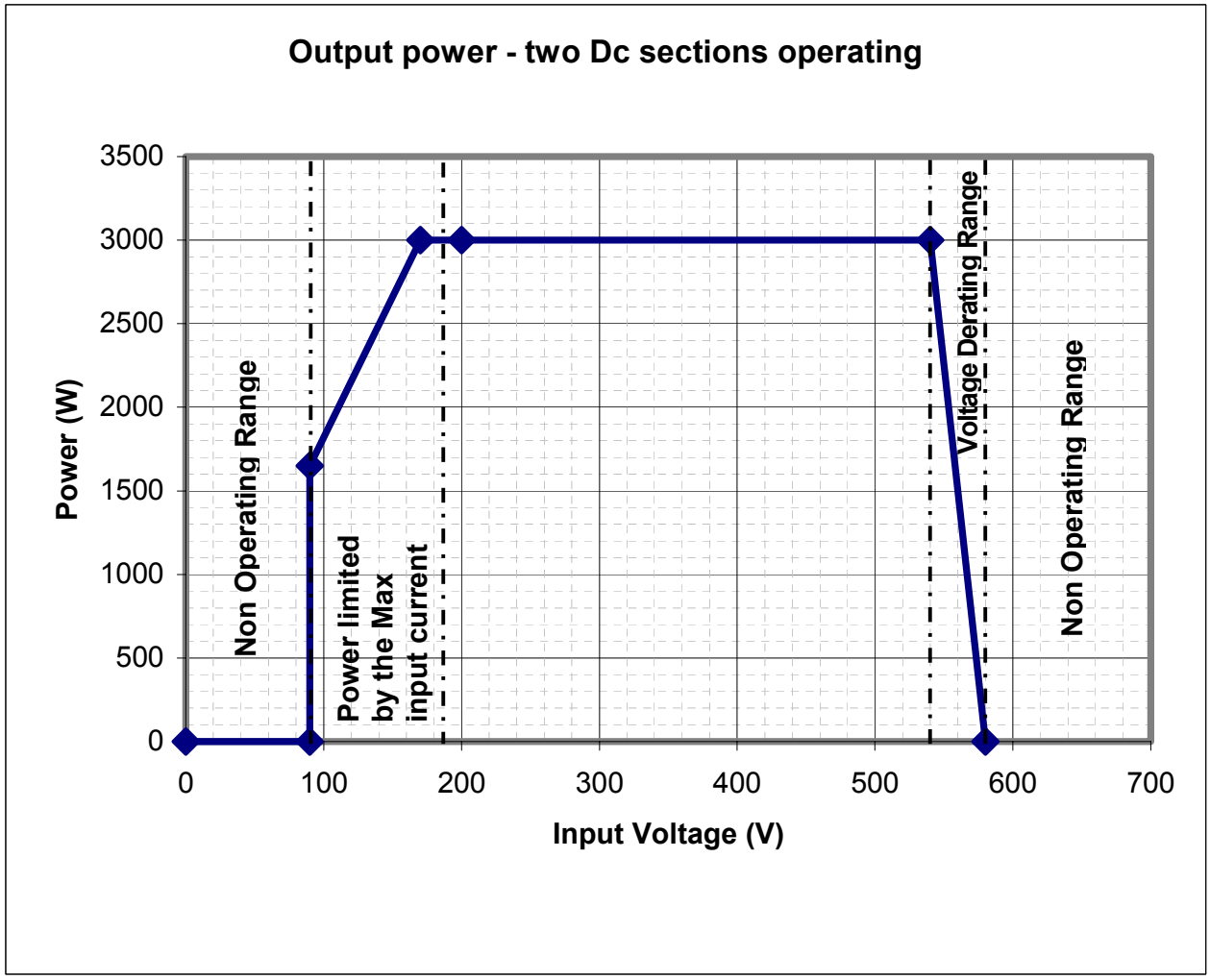
8.6 Power Derating

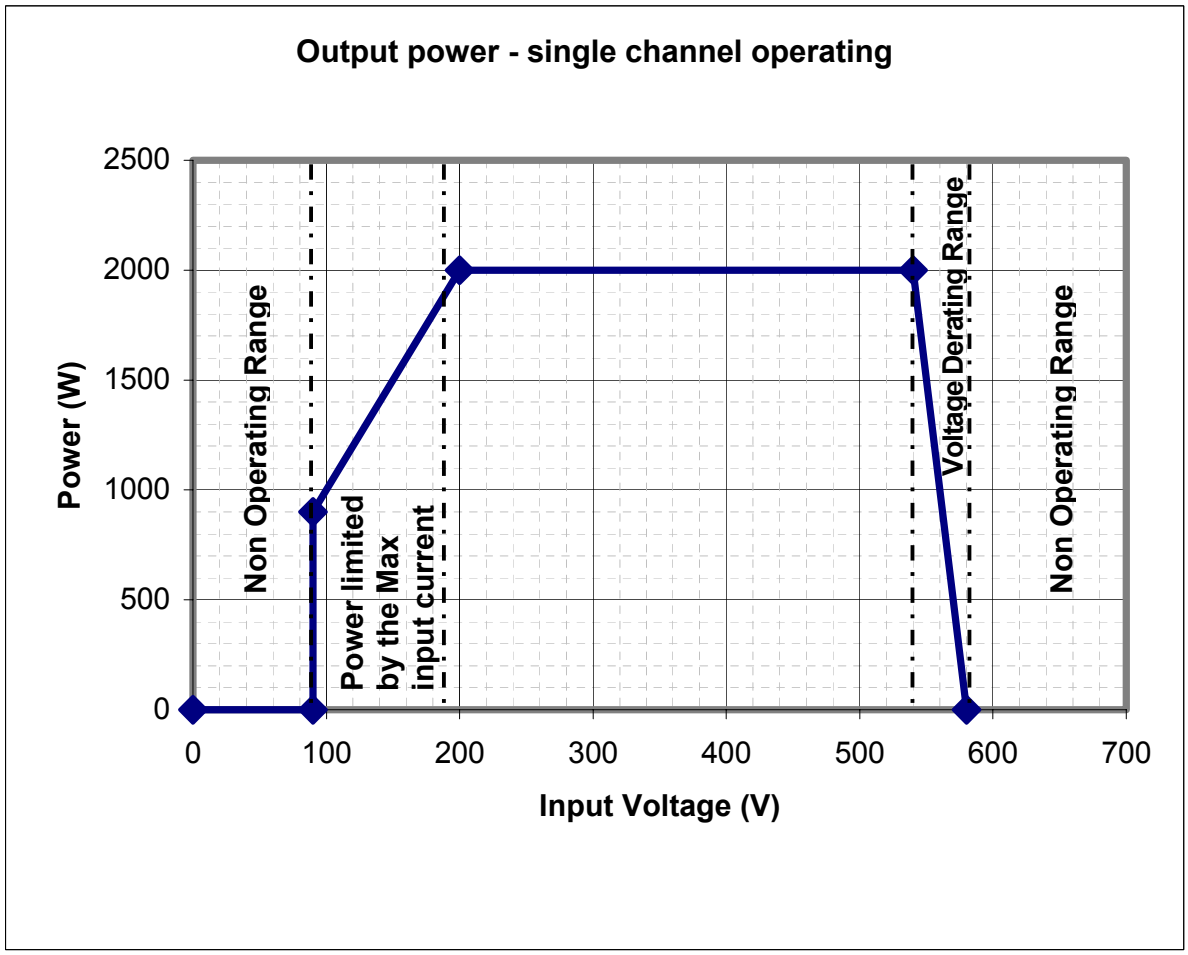
To ensure inverter safe operation under any temperature and electrical condition, the unit will automatically derate the power to be delivered to the grid.
Power derating can occur on one of the two following occasions:

Power Derating due to Ambient Temperature
Under certain operating conditions, AURORA automatically regulates the power to ensure that the components are always run well-within their operating temperature limits. Several environmental factors can influence the operating temperature of the unit, such as ambient air temperature, airflow, exposure to sun radiation, shadows, input voltage and power, orientation of the heatsink fins, etc. Therefore AURORA may or may not derate power during certain periods of the day. Field tests have demonstrated that for typical outdoor installations AURORA will not derate
power until the ambient temperature is higher than 35°C. Moreover, laboratory tests have demonstrated that even when there is no airflow and full power is supplied to the unit indefinitely, AURORA will not derate power until ambient temperature exceeds 25°C for at least 6 hours.

Power Derating due to Input Voltage

The graph shows the automatic derating of delivered power when input or output voltage values are too high or too low.





The two above cases, originating a power derating, can also occur at the same time, but the power derating will always correspond to the lowest value read.