



Power Pak user manual



Off-Grid System In a Box

3kW / 4kW / 10kW Models

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1 How to use this manual

This manual contains important information about how to install and operate your Power Pak. Before installing, please thoroughly read the Important Safety Information section and the Installation section. Please also read the Operating Instructions section before beginning to use the Power Pak.

The section entitled Components Description and Features contains detailed technical information that may not be of interest to most users. However, these technical details may be helpful if any troubleshooting is required.

This manual also includes a troubleshooting guide that provides recommended solutions to common problems.

A product specifications sheet is provided at the end of this manual, in Appendix 1.



This warning symbol appears throughout this manual. These warnings alert the reader that a particular action, or inaction, may result in damage to the Power Pak, damage to surrounding property, and/or risk of injury or death. These warnings must be heeded when installing or operating the Power Pak.

2 Power Pak Models

This manual covers the 3 available Power Pak Models. The features and functionalities are largely the same, the main differences being the AC power output rating, the battery voltage required, and the maximum charge that can be accepted from solar panels:

Power Pak MINI	Power Pak COMPACT	Power Pak GRANDE
3 KW max. output 120V AC and 12 V DC output Uses 12 V battery Max. 500 W solar input	4 KW max. output 120/240 V AC output Uses 24 V battery Max. 1000 W solar input	10 KW max. output 120/240 V AC output Uses 48 V battery Max. 4000 W solar input

MINI Power Pak



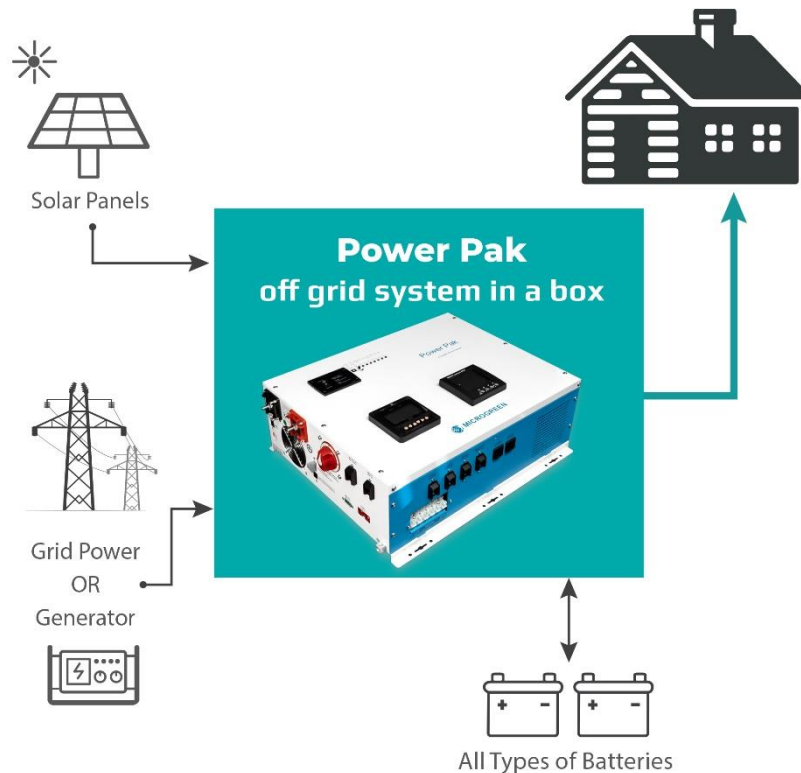
COMPACT Power Pak



GRANDE Power Pak



3 System Overview



The Power Pak is designed to be the *central piece* in a solar powered energy system. Its flexible design allows it to be used in a number of configurations:

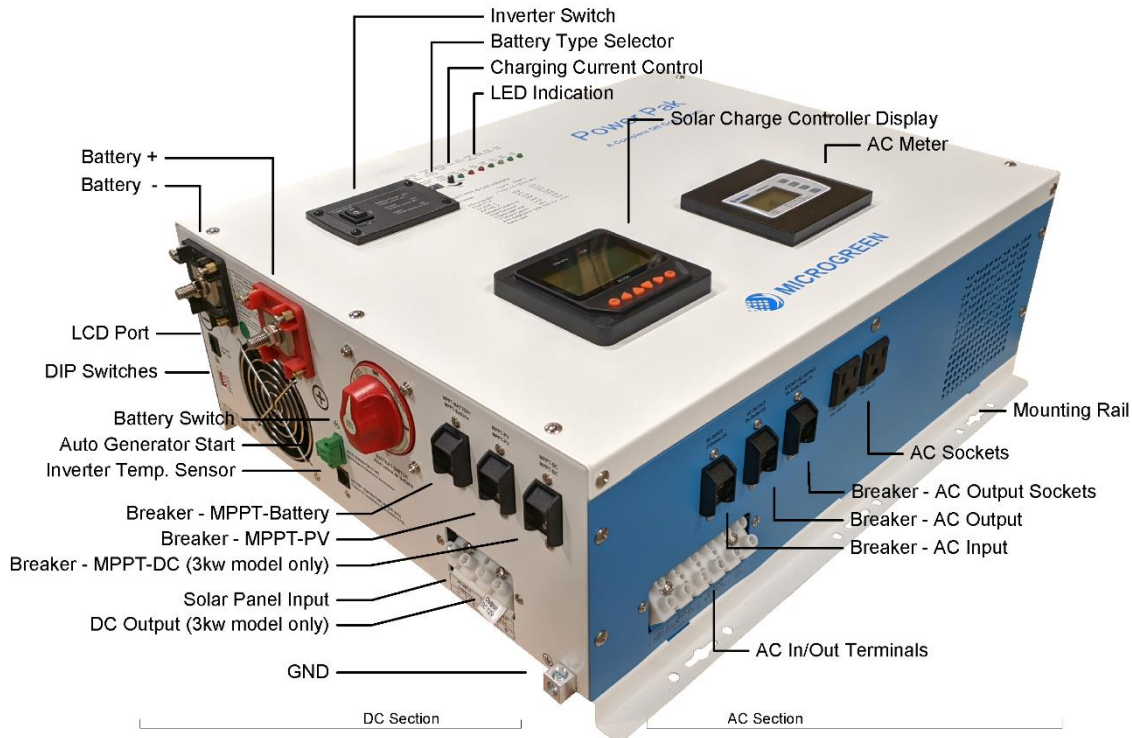
1. Solar-powered off-grid system - combined with solar panels, and batteries (for energy storage) to provide power for your household. No grid connection or generator is required.
2. Hybrid system - solar power to be used as the primary energy source, with grid power available as a back-up.
3. Hybrid system with no grid connection - solar power as the primary energy source, with a connected generator available as a back-up.
4. Multi-source off-grid system - solar power to be used as the primary energy source, with a secondary source available to charge the energy storage in parallel (such as a wind turbine).
5. Back-up power system - grid power to be used as the primary energy source, with the Power Pak and energy storage (with or without solar) available as a back-up in the event of a power outage.

Note: The Power Pak does NOT work as an “on-grid” system, where solar energy can be fed back to the grid for credit.

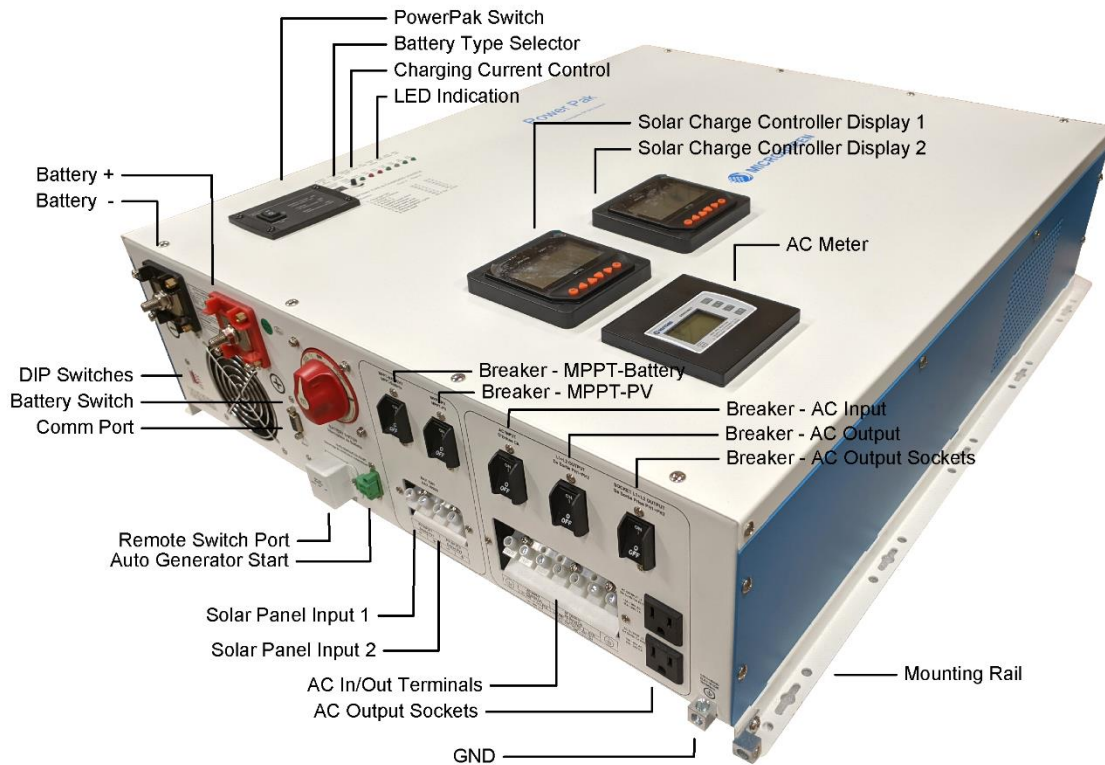
Before installing the Power Pak, please take a few moments to understand how it fits into your power system. The Power Pak is ULc certified. Please make sure that you understand all the safety precautions (see section 5).

4 Product Description

External Parts of Power Pak MINI (3 kW) and COMPACT (4 kW)



External Parts of Power Pak GRANDE (10 kW)



The Power Pak combines an *inverter*, *AC auto-transfer switch*, *battery charger*, and *solar charge controller* into one complete system with a peak overall conversion efficiency of 80% to 85%, with an inverter efficiency of 95%. It features power factor corrected, sophisticated multi-stage charging and pure sine wave output with unprecedented high surge capability to meet the demanding power needs of inductive loads without damaging the equipment.

It works by converting power from solar panels to power home appliances. Excess power is used to charge a battery bank, which can be used during periods of low sunlight.

The Power Pak can be optionally set up as a back-up power source for the grid or generator. This can be done by connecting it to an AC power source - either the electrical grid or a generator - and by setting it to AC Utility Priority Mode. When connected to the AC source, the batteries can be maintained at a high state of charge and can act as a backup power source. When utility AC power cuts out or falls below a certain threshold, an auto transfer switch automatically transfers the load to the Power Pak's output. Once the AC utility power is restored, and the load is automatically reconnected to AC utility power.

The Power Pak's settings can alternatively be configured to prioritize power usage from the battery over power from AC sources. This helps to extract maximum power from the battery in renewable energy systems. This is achieved by setting the Power Pak to Solar Priority mode.

For optimal performance the Power Pak must be installed and operated properly. Please read the instructions in this manual before installing and operating the Power Pak. Also refer to the Power Pak Installation Manual for additional details for battery and solar panel connections.

The Power Pak is fully certified to the UL standard and to the CSA standard, thus meeting rigorous safety and quality standards. All individual components, connections, and meters as well as the unit as a whole are thus UL certified.

The Power Pak does not require any routine maintenance. Associated system components, such as batteries, solar panels or generators, may require maintenance and their respective user manuals should be consulted.

4.1 Recommended Uses

The Power Pak is suitable for renewable energy systems, grid powered systems, RVs, cabins, marine applications and emergency appliances. Below are some examples of the types of appliances that can be used with the Power Pak.

- Power tools – circular saws, drills, grinders, sanders, buffers, hedge trimmers, air compressors.
- Office equipment – computers, printers, monitors, fax machines, scanners.
- Household items – vacuum cleaners, fans, fluorescent and incandescent lights, shavers, sewing machines.
- Kitchen appliances – coffee makers, blenders, ice makers, toasters.

- Industrial equipment – metal halide lamps, high-pressure sodium lamps.
- Home entertainment electronics – TVs, VCRs, video games, stereos, musical instruments, satellite equipment.

4.2 Features

- Easy to install & operate
- ULc certified for safest possible operation
- Designed to operate in harsh environments
- Compatible with both linear & non-linear loads
- Separate 15A fused AC output receptacles
- Low DC voltage supports home & office appliances (3kW model only)
- DC start & automatic self-diagnostic function
- AC charging (from grid/generator) and DC charging (from solar panels) available
- Powerful battery charge current, selectable from 20% - 100%
- High efficiency design & PowerSaver mode to conserve energy
- Battery priority mode to designate the UPS configuration
- Battery recover point, dedicated for renewable energy systems: 11.5 VDC (MINI), 21 VDC (COMPACT), 42 VDC (GRANDE)
- 8 pre-set battery type selector, plus de-sulphation (for flooded lead acid batteries)
- 4-step intelligent battery charging with power factor correction
- 8ms typical transfer time between utility & battery to ensure power continuity
- 15s delay before transfer when AC resumes to protect load when used with a generator
- Supports a wide range of batteries such as lead acid, AGM, deep-cycle, and lithium.

5 Important Safety Information



WARNING

This manual contains important instructions for all Power Pak models that must be followed during installation, operation and maintenance. Failure to follow these instructions may result in damage, fire, injury or death.

5.1 General safety precautions

All components and connections of the Power Pak are ULc certified; however safety precautions must be followed when handling any electrical equipment. Please read and understand the following section.

Do not expose the Power Pak to rain, snow, spray, bilge or dust. To reduce risk of hazard, do not cover or obstruct the ventilation openings. Do not install the Power Pak in a zero-clearance compartment. Overheating may result. Allow at least 30 cm (11.81 inches) of clearance around the Power Pak for air flow. Make sure that the air can circulate freely around the unit.

To avoid a risk of fire and electronic shock. Make sure that existing wiring is in good electrical condition; and that wires are not undersized. Do not operate the Power Pak with damaged or undersized wiring.

This equipment contains components which can produce electrical arcs or sparks. To prevent fire or explosion do not install in compartments containing flammable materials or in locations which require ignition-protected equipment. This includes any space containing gasoline-powered machinery, fuel tanks, or joints, fittings, or other connection between components of a fuel system.

Do not disassemble the Power Pak. It contains no user serviceable parts and disassembly will void the warranty. Attempting to service the Power Pak yourself may result in a risk of electrical shock or fire. Internal capacitors remain charged after all power is disconnected. See Warranty for instructions on obtaining service.

To reduce the risk of electrical shock, disconnect both AC and DC power from the Power Pak before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.



CAUTION - Equipment damage:

The output side of the inverter's AC wiring should at no time be connected to grid power or a generator. This condition is far worse than a short circuit. If the unit survives this condition, it will shut down until corrections are made.

Installation should ensure that the inverter' s AC output is, at no time, connected to its AC input.



WARNING – LIMITATIONS ON USE

The Power Pak should not be used in connection with critical life support systems as it is not a redundant power source.

5.2 Precautions When Working with Batteries

If battery acid contacts skin or clothing, wash immediately with soap and water. If acid contacts the eye, immediately flush the eye with running cold water for at least 20 minutes and get medical attention immediately.

Never smoke or allow a spark or flame in the vicinity of a battery or engine.

Do not drop a metal tool on the battery. The resulting spark or short-circuit may cause an explosion.

Remove metallic personal items such as rings, bracelets, necklaces, and watches when working with a battery. A battery can produce a short-circuit current high enough to weld a ring or other metallic items, causing a severe burn.

To reduce the risk of injury, charge only rechargeable batteries such as deep-cycle lead acid, lead antimony, lead calcium gel cell, absorbed mat, NiCad/NiFe or lithium ion batteries. Other types of batteries may burst, causing personal injury and/or damage.

6 Installation

Follow all local regulations when installing the Power Pak.

It is recommended to have at least 2 persons present during installation.

The Power Pak should be installed indoors in a location that is dry, clean and cool. Leave at least 12 inches of space around all sides of the Power Pak for ventilation. It is recommended to install the Power Pak near the building's electrical panel.

Working temperature: -10°C to 40°C

Storage temperature: -40 to 70°C

Relative Humidity: 0% to 95%, non-condensing

Installation can be completed in 3-4 easy steps:

1. Wall-mount the Power Pak
2. Install and connect the batteries
3. Install and connect the solar panels (optional)
4. Connect the Power Pak to the electrical panel (optional) and generator (optional)

6.1 Components Not included

The following components must be provided by the user:

- A plywood board – 2 x 3 feet for the MINI or COMPACT models; 2.5 x 3.5 feet for the GRANDE model.
- #12 pan head wood screws (1" min.) for mounting the Power Pak on the plywood. Will require at least 6 screws for MINI or COMPACT; 8 screws required for the GRANDE.
- A set of hardware for mounting the plywood board to the wall
- Appropriate cable to connect to the electrical panel - 3-wire for MINI, 4-wire for COMPACT or GRANDE.

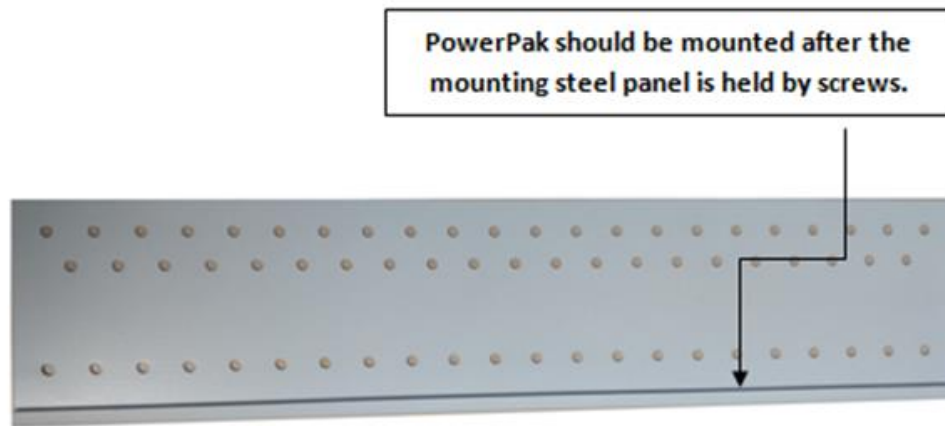
6.2 Tools required

- Drill or Power driver
- Screwdriver
- Multimeter
- Shovel (only if building does not have an existing electrical ground)

6.3 Wall Mounting

STEPS:

1. Securely mount a piece of plywood on the wall for the Power Pak to be installed upon.
2. Mount the Mounting Plate to the plywood. The Mounting Panel will support the weight of the Power Pak so it must be secure. Use at least 3 #12 pan head wood screws (1" min.) on the mounting plate of the MINI or COMPACT. Use at least 4 screws for the GRANDE.
3. Hook the bottom rail of the Power Pak onto the lip of the Mounting Panel. The Mounting Panel will support the weight of the Power Pak. Use 3 screws in the top rail to secure the Power Pak to the wall.



6.4 Battery Connection



WARNING

Failure to follow these instructions may result in sparking and damage to the batteries.

- Before connecting the batteries, ensure the battery bank is configured to provide the correct voltage for the specific Power Pak model being installed. *See Appendix 1 for specifications.*
- Do NOT let the black and red cable ends touch each other at any time. Ensure polarities are connected correctly.
- Do NOT let any metal object fall across the terminals during the installation.

STEPS:

1. Make sure the Battery Switch [1] is off.
2. Place the batteries close to the Power Pak (less than 10 ft) to reduce the energy lost in the cable.
3. Connect one end of the temperature sensor to the Power Pak and place the other end next to the batteries. The temperature of the batteries is used by the Power Pak to determine the correct charging voltage. This is very important if the Power Pak is used in cold temperatures.
4. Set the battery type using the Battery Type Selector switch located beside the On/Off switch. Choose 1 for Gel, 2 for AGM and 4 for flooded. See Section 8.2.1 for a complete list of choices.

Failure to select the correct type may result in damage, fire or explosion.

5. Connect the battery Positive (+) to the Power Pak's DC terminal Positive (+) and battery Negative (-) to the Power Pak's DC terminal Negative (-). Connect the battery bank to the Power Pak with AWG 2/0 cables.
6. Connect the batteries together to match the input of the Power Pak. MINI – 12V, COMPACT – 24V, GRANDE – 48V

6.5 Solar Panels Connection (optional)

This section describes how to connect a solar panel array to the Power Pak. This is optional. If solar panels are not connected, then another power source is required, e.g. electrical utility, diesel generator, etc.



WARNING

Before connecting the solar panels, ensure the solar panel array is configured to provide the correct voltage for the specific Power Pak model being installed. See Appendix 1 for specifications. Exceeding the voltage limit can damage the Power Pak.

STEPS to connect solar panels:

1. Make sure the MPPT-Battery and the MPPT-PV breakers on the Power Pak are off.
2. Before connecting the solar cables to the Power Pak, measure the voltage to ensure the polarities are correct.
3. Connect the solar panel Positive (+) to the PV Positive (+) on the Power Pak and the solar panel Negative to the PV Negative (-) on the Power Pak.
4. After the battery and solar panels are connected, turn on the battery switch, then the MPPT-battery breaker. WAIT for 2 seconds, and then turn on the MPPT-PV breaker. The Charge Controller Display will turn on and show the solar energy information.

6.6 Expanding the System: Additional Charge Controllers & Wind Turbines (Optional)

Some users may wish to provide additional power sources that exceed the Power Pak's built-in capabilities (see table below). For example, a very large solar array, a wind turbine, or a micro-hydro turbine.

Power Pak Model / max AC Output	Max solar input power
MINI 3 kW	500 W
COMPACT 4 kW	1000 W
GRANDE 10 kW	4000 W

To expand the system, the user will need to select an appropriate charge controller for their chosen power source and connect that charge controller to the battery bank. These additional power sources will not be directly connected to the Power Pak, but they will share the same battery bank via a parallel connection. This allows energy produced by these sources to be used by the Power Pak.

There is no limit to the number of charge controllers or different power sources that can be connected to the battery bank.

6.7 Grounding

The Power Pak system comes with a bare ground wire and a ground plate if required. If there is an existing ground for the building's electrical panel, do not install a second ground. ESA does not permit use of a second ground plate unless the first one is under another building at least 100 feet away, to prevent a ground loop.



Figure: Ground Plate

1. If there is an existing ground system in the building, connect the Power Pak to the ground connector (normally in the electrical distribution panel) using the ground wire.
2. If there is no existing ground for the building, install the ground plate outside. To do so, dig a hole 1.5 feet deep, and place the ground plate horizontally in the hole. Attach the bare ground wire to the ground plate with the brass lug at one end of the ground plate. Fill in and tamper the dirt over the ground plate.
3. Run the ground wire up to the Power Pak, and connect it to the grounding terminal on the Power Pak.

6.8 AC Connections - Input and Output (Optional)

6.8.1 AC Input Connections:

This section describes how to connect the Power Pak's input to a building's electrical panel and/or to a generator. This is optional, and applies in the case where an additional charging source is to be incorporated into the system as a back-up to the solar power.

The Power Pak is not designed to accept AC inputs from multiple sources simultaneously, i.e. either the electrical utility or a generator can be connected to the Power Pak's AC input, but not both at the same time. Please consult a qualified electrician if you want to connect to both.

STEPS to connect to AC Input

1. The Power Pak's AC Input can be connected to an external AC power source to charge the batteries. A generator or any power source providing the proper voltage may be used. The figure below shows a power source connected to the Inputs.
2. For the Power Pak MINI, use a generator/source that outputs 120 V AC. For the COMPACT and GRANDE, use a generator/source that outputs 240 V AC.

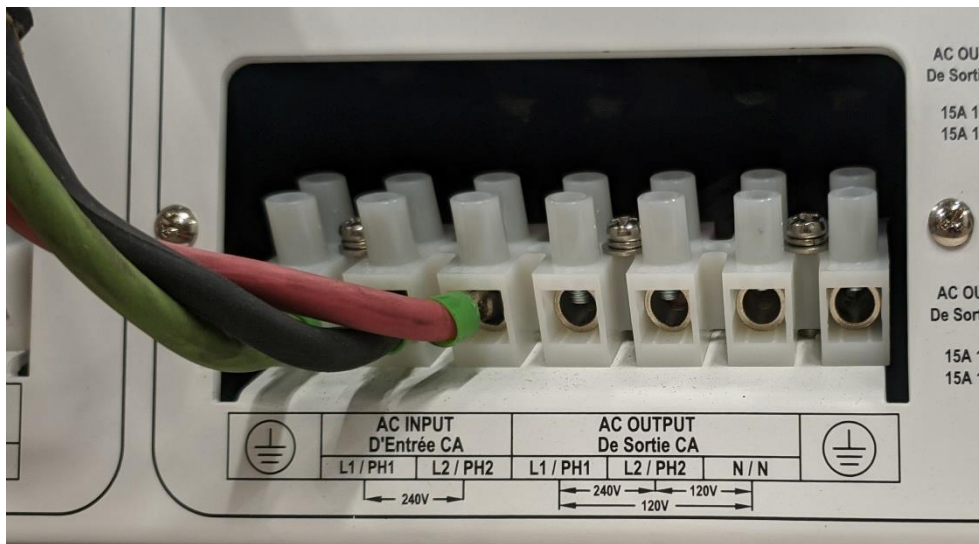


Figure: AC power source connected to the Power Pak AC Inputs. (COMPACT shown with 240V source, MINI is similar except 120V source is required)



WARNING

Turn off the Power Pak before connecting power to the AC Terminal.

Please refer to your local laws and regulations and guidelines when connecting to the electrical panel.

NOTE: Given the nature of the charging circuitry, more power is delivered by traditional generators. Thus, it is recommended to use a traditional generator, NOT an inverter-generator, as an AC power source. Note that

recent model generators may be inverter-based, which will not charge as efficiently as traditional non-inverter-based generators.

6.8.2 AC Output Connections:

The Power Pak comes with two AC Output Sockets [14], allowing it to be used as a stand-alone device by simply plugging appliances into these sockets. Each socket can operate up to 15 A at 120V AC.

Electrical Panel Connections:

The Power Pak's power output may also be optionally connected to an electrical panel. This will allow the Power Pak to provide power to the standard electrical outlets on the walls throughout the building/vehicle, provided those outlets are connected to the same circuit that the Power Pak is connected to. There are 2 types of electrical panels that the Power Pak can connect to, depending on the model:

The Power Pak MINI provides a single 3 kW 120 V AC output. This is designed for single-input 120 V electrical panels that are used in RVs, trailers and boats.

The Power Pak COMPACT and GRANDE have 2 separate lines of 120 V AC Output (L1 and L2), which are designed to connect to electrical panels that have split 120 V buses and a neutral connection. This allows the Power Pak to enable 240 V output via such electrical panels. NOTE: the total power that the Power Pak can deliver is equally split between L1 and L2. Therefore, to maximize the your AC power output you must distribute your load across the 2 lines. For the COMPACT, L1 and L2 each deliver 2 kW to provide the 4 kW total; for the GRANDE, L1 and L2 each delivery 5 kW to provide the 10 kW total.



WARNING

The output voltage of this unit must never be connected to its input AC terminal. If connecting to an electrical panel, do not connect the Power Pak's input and output to the same circuit. Overload or damage may result.

Always switch the Power Pak on before plugging in any appliances to avoid damaging it.

Please refer to your local laws and regulations and guidelines when connecting to the electrical panel.

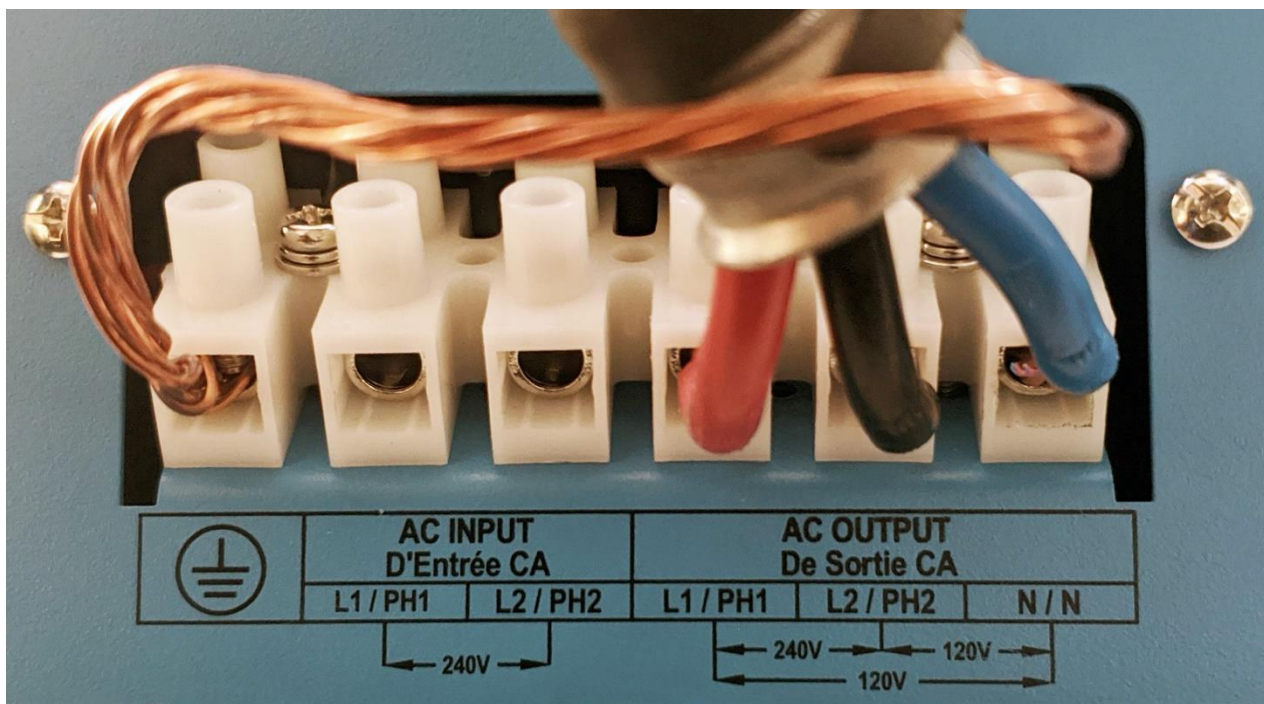
STEPS to connect to a single 120V bus electrical panel for MINI.

1. Simply connect the Power Pak's AC Output (Line and Neutral) to the electrical panel with 2 pieces of wire, size AWG 8. Also connect the ground.

STEPS to connect to a split 120V bus electrical panel for COMPACT and GRANDE.

2. Connect the Power Pak's AC Output (L1, L2, and Neutral) to the electrical panel with 3 pieces of wire, size AWG 8. Distinguish L1, L2, and Neutral spots when wiring. Also connect the ground. See Figure below: L1 (red), L2 (black), Neutral (blue), and Ground (copper).
3. The Power Pak's AC Outputs should each be connected to a 40A double breaker in the electrical panel for the COMPACT; for the GRANDE each AC Output should be connected to a 80 A double breaker in the panel.
4. The Neutral should be connected to the neutral busbar in the electrical panel.
5. There are two AC receptacles on the Power Pak that can be used independently from the electrical panel. Each receptacle can operate up to 15A at 120V AC.

Figure: AC Wiring connections for a 2-line electrical panel



When all the Input and Output connections have been completed, install the AC Cover. See Figure below.



Figure: AC Cover

7 Operating Instructions

7.1 General Operating Instructions

After the Power Pak has been installed and the solar panels (optional), batteries and AC input (optional) and AC output (optional) have been connected, the Power Pak is ready for use.



WARNING

Always switch the Power Pak on before plugging in any appliances, otherwise it may damage the unit.

STEPS to operate:

1. Turn the Battery Switch on.
2. Turn the Power Pak Switch on.
3. Check that the green INV Mode LED is on.
4. Check that the AC Display on the front of the Power Pak is on and shows 120VAC after 5 seconds.
Make sure that the AC breakers are on.
5. The AC output of the Power Pak is live now. Appliances can now be plugged into the outlets on the Power Pak.

7.1.1 Power Saver Mode

The Power Pak has an optional Power Saver mode. When Power Saver is off, the Power Pak consumes about 1,000Wh of energy per day. Power Saver can save approximately 800Wh per day. In Power Saver mode, the Power Pak will sleep when there is no significant AC load. It will wake up and operate when there is a constant AC draw of approximately 40W or more. It detects the presence of a load by sending out a pulse every 3 seconds.

To enable Power Saver, turn on the Power Pak Switch on the front of the Power Pak with Power Saver Mode.

7.1.2 Charging Batteries

When solar panels have adequate sunlight, they will provide power to any connected loads (i.e. appliances, lights, tools, etc.) and charge the batteries with any remaining power. When the Power Pak is drawing power from solar panels or batteries, the INV Mode LED will be illuminated.

If an AC input is connected and powered, the Power Pak will bypass the AC input to the AC output and charge the batteries at the same time with any remaining power - i.e. power to loads on the battery will get priority,

and only the remainder will be applied to charging. Therefore, if you want to optimize charging, make sure that all loads are switched off.

If a generator's auto start is connected to the Auto Gen Start on the Power Pak, the switch will activate and start the generator if the voltage of the batteries drops below a certain value. The triggering voltage levels for each model is as follows:

- MINI - 11.5 V
- COMPACT - 22.5 V
- GRANDE – 46.5 V

When AC input power is available, the Line Mode LED will be illuminated.

The Power Pak indicates charging status with the yellow LED labelled “Fast CHG” on the front panel. When the batteries are fully charged the green LED labelled “Float CHG” will illuminate. These LEDs will only illuminate when charging from an AC source, and will not be lit when charging from solar panels.

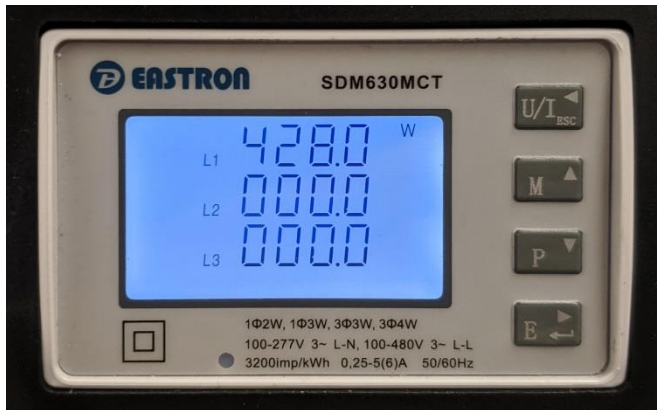
7.2 Monitoring

The Power Pak is equipped with two meters: a DC meter for the batteries and solar panels, and an AC meter for the AC power output to connected appliances. There is usually no need for the user to check these meters, but some users may find the information they provide to be helpful or interesting. Both the DC and AC meters come with a wide range of settings that can be customized by the user, but for the average user there is no need to ever adjust these settings.

This manual provides information only on how to read the displays on these meters. For detailed information on the meters and how to adjust all settings, please see the manufacturer's manual for each meter.

	DC Meter	AC Meter
Model	MT50	SDM630MCT
Manufacturer	Beijing Epsolar Technology Co. Ltd.	Zhejiang Eastron Electronic Co. Ltd.
Website	www.epever.com	www.eastron.com.cn
Manual	https://www.epsolarpv.com/upload/file/1903/MT50-SMS-EL-V2.1.pdf Note: subject to change without notice, current as of May 2021	Contact Microgreen or Eastron

7.2.1 AC Meter



The AC meter can be found on the lower right of the Power Pak's front panel. This meter provides accurate information on how much power is being used. This can be helpful in planning when or whether to use certain appliances, or when considering system upgrades. You can also use the power reading to determine how much power is being used by an individual device or appliance.


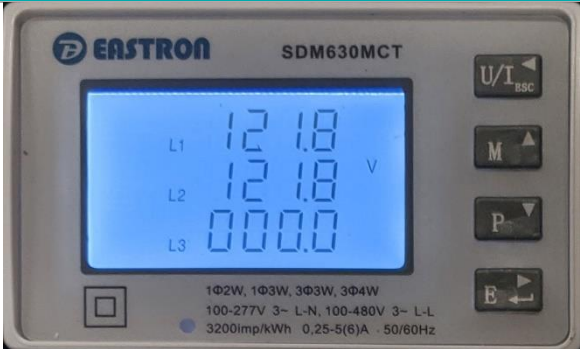
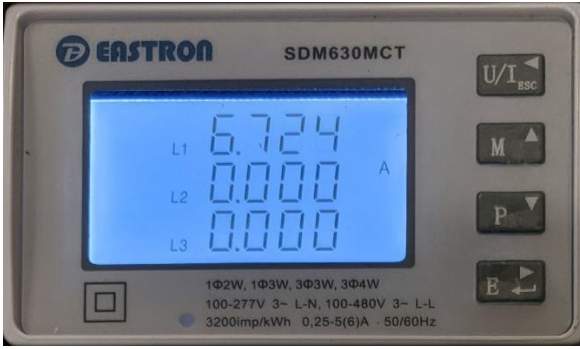

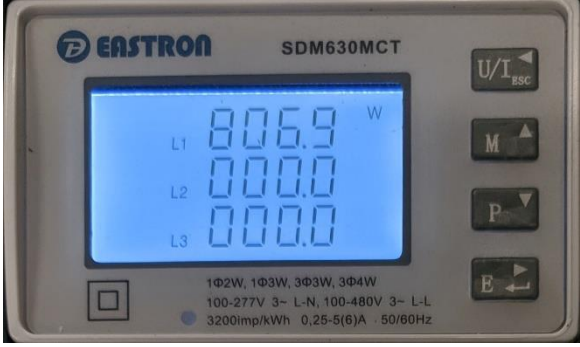

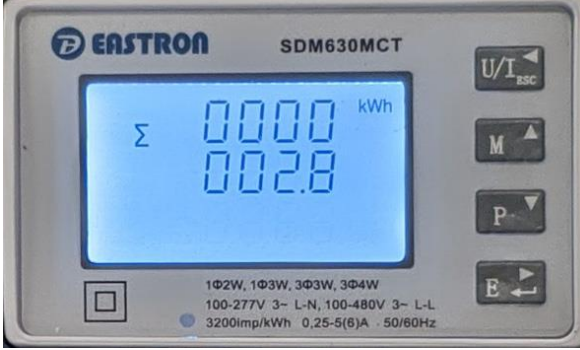
The AC meter is connected to the Power Pak's internal inverter and thus is meant to show power output from it, so is useful for Solar Priority mode operation.

When the Power Pak first is powered up the AC meter goes through a power test and the display will flash through a few different screens. Then the default measurement screen will appear.

The AC meter has different modes of display, which allow you to switch between a display of the voltage, current and power delivered by each line, as well as the total energy delivered.

NOTE: the MINI has a single line, so only the L1 values are meaningful. For the COMPACT and GRANDE, L1 and L2 values are meaningful.

7.2.1.1 Button Functions


Button	Display	Example
	Displays Voltage or Current in each line. Press this button until the V (volts) or A (amps) are displayed	 
	Displays power delivered in each line. Press this button until the W (Watts) are displayed	
	Displays total energy delivered in each line. Press this button until the kWh (kiloWatt hours) are displayed	

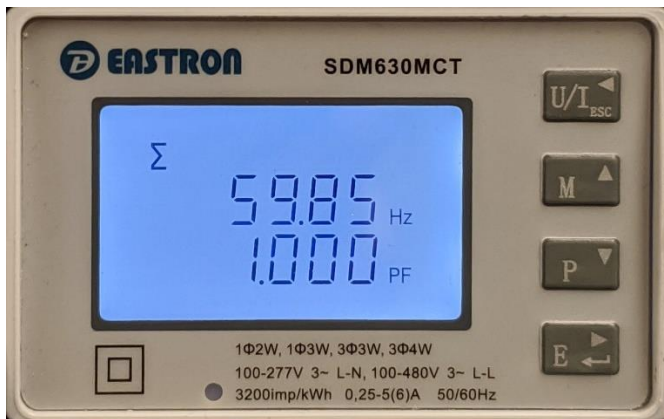
It is generally recommended that the user should not adjust the settings, and only do so after reading the manual provided by the AC meter's manufacturer. However, if the user wishes to reset the kWh reading, this is relatively simple and is described below.



WARNING

Some appliances may cause the Power Pak to operate with a lower Power Factor (PF).

Operating products with a motor, like a saw or water pump, may drop the PF to 0.8 or lower. Operating with a PF below 0.5 for many hours may reduce performance of the Power Pak. This is most common with failing motors or some motors manufactured outside of North America. Check the PF by pressing The Frequency and Power Factor and Demand button  until the Power Factor (PF) is displayed.



7.2.2 DC Meter



Note: the above photo is for illustration purposes only. It does not match the numbers referred in the Figure: “DC meter display elements” shown below.

The DC meter, also called the charge controller display, can be found on the lower left of the Power Pak’s front panel. This meter provides accurate information on how much power is being used. This can be helpful in planning when or whether to use certain appliances, or when considering system upgrades.

The default display screen is shown in the figure below. In the example shown, it is daytime and the solar panels are producing 15.2A of current at 17.5V. Of this current, 5.2A is being used to charge the battery, and 10.0A is being used to power the load. Note: the load value is only applicable to the MINI, for loads on its 12V DC output.

The battery level is also shown, as indicated by how full the battery icon is. NOTE: the battery level indicates the amount of usable charge left in the battery, rather than the actual charge percentage. For example, for AGM/lead acid batteries, the level would be empty at 50% and for lithium batteries, empty would be closer to 10%.

The icons on the screen are explained below.

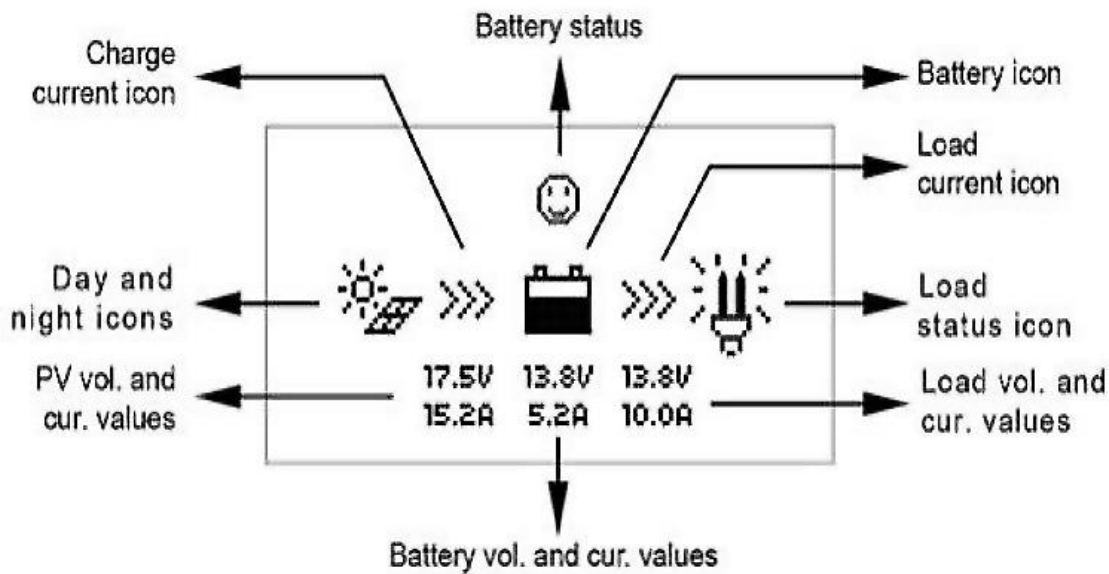



Figure: DC meter display elements

Day and night icons: when solar panel voltage is above 1V, this will automatically switch to day. When solar panel voltage is below 1V, it will automatically switch to night.

Charge current icon: dynamically displays charge current.

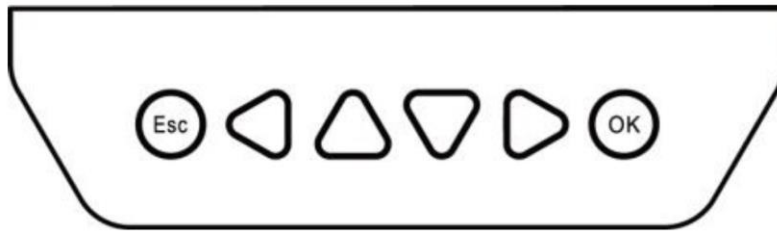
Battery status icon: normal voltage  under voltage  over discharged 

Battery icon: dynamically displays battery capacity remaining. If the battery is overdischarged, the icon will change to 

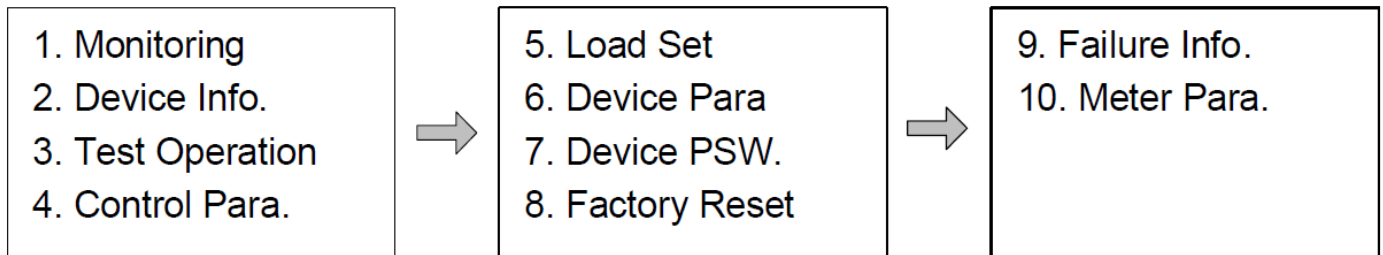
Load current icon: dynamically displays discharge current. (MINI DC output only)

Load status icon: load on  load off  -NOTE: this applies to the MINI only, and the load is switched on/off by the "OK" button on the display.

The AC meter has 6 buttons under the display screen, as shown in the diagram below:



From the default display screen, push ESC to enter the main menu. Use the Up and Down buttons to move the cursor and the OK and ESC buttons to enter or exit menu items. The main menu is shown below. For the average user, *Monitoring* will be the only item of interest. *Monitoring* provides more detailed information such as: charging and discharging energy today / this month / total to date; battery temperature and max/min voltages; solar power in W; and other parameters that may be of interest.



Use caution when accessing other menu items - improper changes to the settings may disrupt performance. It is recommended that users wishing to change the default settings first review the full manual provided by the manufacturer of the DC meter.

8 Components Description and Features

8.1 Topology

The Power Pak is built according to the following topology.

- Inverter: full bridge topology.
- AC Charger: isolate boost topology

By using high efficiency Mosfets, a 16bit, 4.9MHz microprocessor and heavy transformers, it outputs pure sine wave AC with an average Total Harmonic Distortion (THD) of 10% (min 5%, max 15%) depending on load connected and battery voltage.

The peak overall efficiency of the Power Pak is 80% - 85%, while the efficiency of the inverter is 95%.

8.2 Charging

The Power Pak is equipped with two chargers: a DC charge controller for charging the batteries from solar panels, and an AC charger for charging the batteries from the electrical grid or a generator.

The AC charger is an active PFC (Power Factor Corrected) multistage battery charger. The PFC feature is used to control the amount of power used to charge the batteries in order to obtain a power factor as close as possible to 1. Unlike other inverters whose max charging current decreases according to the input AC voltage, this charger is able to output max current as long as the input AC voltage is in the range of 95-127VAC or 164-243VAC and AC frequency is in the range of 58-64Hz or 48-54Hz.

There are 4 stages of charging, described below. The charger will automatically switch to the next stage without any input from the user.

1. **Fast Charging:** This is the initial stage of charging. While Fast Charging, the charger supplies the battery with controlled constant current and the battery voltage will gradually increase. The charger will remain in Fast Charge mode until the Fast Charge Voltage (determined by the battery type selection) is achieved. This stage is where most of the energy is added to the battery. Once the Fast Charge Voltage is reached, the battery can no longer be charged as quickly without reaching a dangerously high voltage, and charging progresses to the Absorb Charge stage.

During this stage, the LED labelled Fast CHG will be lit.

A software timer will measure the time from when Fast Charging starts until the battery charger reaches 0.3V below the Fast Charge Voltage, then take this time as T_0 . $T_0 \times 2 = T_1$.

2. Absorb Charging: During the second charging stage the charger provides the batteries with a constant voltage and reduces the charging current in order to maintain the Fast Charge Voltage setting. The purpose of this stage is to “top-up” the batteries to full charge while limiting the voltage to a safe level.

During this stage, the LED labelled Fast CHG will flash.

In this stage, the charger will start a T_1 timer equal to twice the duration of the Fast Charging stage ($T_1 = T_0 \times 2$) and output constant voltage until the T_1 timer has run out. The T_1 timer has a min time of 1 hour and a maximum time of 12 hours. Then the charger will move on to the Float Charge stage.

3. Float Charging: In the third charging stage the charge voltage is reduced to the Float Charge Voltage (determined by the battery type selection). The purpose of this stage is to keep the batteries fully charged and ready for use. A very small amount of current is trickled to the batteries to keep them fully charged at all times.

During this stage, the LED labelled Float CHG will be lit.

4. Reset: If the input power is reconnected or the battery voltage drops below 12/24/48V DC (depending on the model), the charger will reset the cycle above. If the charge maintains the float state for 10 days, the charger will automatically reset the cycle to protect the battery.

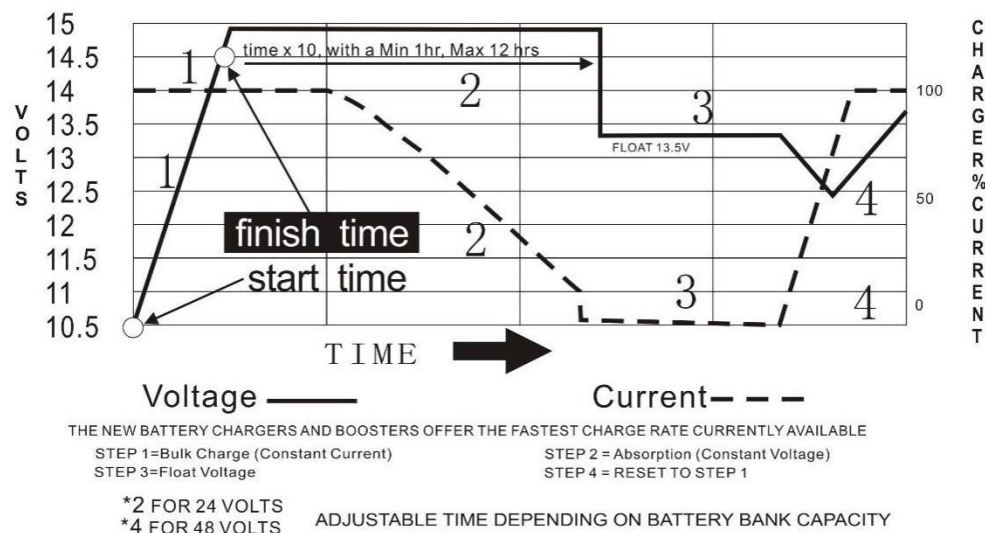


Figure: Battery Charging Processes

Note: the voltages shown in this graph are for an open lead acid battery. For different battery types, adjust using the voltages in the table 8.2.1 below.

8.2.1 Battery Type Selector

The Power Pak is compatible with many types of batteries. The table below shows a list of supported battery types and associated charge voltages. The battery type can be set by pushing the button to the left of the LEDs on the front of the Power Pak.



WARNING

Failure to select the correct battery type can result in reduced performance, fire or explosion. Selecting de-sulphation may result in battery damage, fire or explosion if used improperly.

Table 8.2.1

Battery Type Selector			
Switch Setting	Description	Fast Mode / VDC	Float Mode / VDC
0	Charger Off		
1	Gel USA	14.0	13.7
2	AGM 1	14.1	13.4
3	LiFePO4	14.6	13.7
4	Sealed Lead Acid	14.4	13.6
5	Gel EURO	14.4	13.8
6	Open Lead Acid	14.8	13.3
7	Calcium	15.1	13.6
8	De-sulphation	15.5 (4 Hours then Off)	
For 12VDC batteries (x2 for 24VDC, x4 for 48VDC)			

8.2.2 De-Sulphation

The de-sulphation cycle on switch position 8 is marked in red because this is a very dangerous setting if you do not know what you are doing. Before ever attempting to use this cycle you must clearly understand what it does and when and how you would use it. NOTE: this applies to lead acid batteries only.

What causes sulphation? It can occur with infrequent use of the batteries, or if the batteries have been discharged so low that they will not accept a charge. This can cause a sulphated crust to form on the electrode plates inside a lead acid battery, which can inhibit the plates' ability to accept a charge. This does not occur in lithium ion batteries, and the de-sulphation cycle should only be used with lead acid batteries.

The de-sulphation cycle applies a very high voltage charge to try to break down the sulphated crust. If successful this will clean the electrode plates and enable them to once again accept a charge .

8.2.3 Charging Depleted Batteries

The Power Pak is capable of starting up with depleted batteries.

For the 24VDC model, as long as the battery voltage does not drop below 20V, the Power Pak will be able to charge the battery once qualified AC or DC inputs are present. This will only occur if the following conditions are met once the battery voltage goes below 20 V:

- The Power Pak Switch on the front of the product is always kept in the "ON" position
- The Power Pak is always connected with the battery

Before the battery voltage goes below 18VDC, charging can be activated by turning the Power Pak Switch to "Off", then to "ON". Once the voltage goes below 18VDC, if the switch is turned to OFF or the battery is disconnected from the Power Pak, the Power Pak will not be able to charge the battery once again, because the CPU loses memory during this process. To resume using the battery with the Power Pak, the voltage will need to be brought back above 18VDC by other means, for example using a car charger.

8.2.4 Charging Current & Tips for Charging from a Generator

The charging power will peak around 3 seconds after charging begins. If charging from a generator, this may cause the generator's frequency to drop and cause the Power Pak to transfer to Inverter Mode, where power is drawn from the batteries rather than the generator.

It is suggested to gradually ramp up the charging load when charging from a generator, by gradually switching the Charge Current Control Switch, located next to the LEDs on the front of the Power Pak, from min to max. Together with the Power Pak's built-in 15s switch delay, this will give the generator enough time to spin up. This will depend on the size of the generator and rate of charge.

The maximum charging current can be adjusted from 0% - 100% via a liner switch to the right of the Battery Type Selector. Reducing the charging current may be helpful when charging a small capacity battery bank. The liner switch can effectively reduce the max charging current to 20% of its peak.

Table 8.2.4

AC Charging Current for Power Pak Model		
Power Pak Model	Battery Voltage	AC Charger Current Max.
MINI	12 VDC	60 ± 5 Amp
COMPACT	24 VDC	50 ± 5 Amp
GRANDE	48 VDC	80 ± 5 Amp

8.3 Power Transfer

While in Line Mode (aka Shore Power Model), the AC input is continually monitored. Whenever AC power falls below the trip voltage (154VAC, default setting for 230VAC, 90VAC for 120VAC), the Power Pak automatically switches to Inverter Mode to minimize interruption to connected appliances. This allows the batteries to act as a backup in case of a power outage for the grid or generator. The time to transfer from Line Mode to Inverter Mode is approximately 8 milliseconds. Though the Power Pak is not designed as a computer UPS system, this transfer time is usually fast enough to prevent a computer from shutting down.

When AC power is connected, there is a 15-second delay from the time the Power Pak senses that continuously qualified AC is present at the input terminals to when the transfer is made. This delay is built in to provide time for a generator to spin-up to a stable voltage and avoid relay chattering. The Power Pak will not transfer the load to a generator until it has locked onto the generator's output. This delay is also designed to avoid frequent switching when utility power input is unstable.

8.4 Alarms & Protections

The Power Pak is equipped with protection against various harsh situations or faults. Protections include:

- AC input over voltage / AC input low voltage
- Low battery voltage alarm / high battery voltage alarm and shutoff
- Over temperature protection / overload protection
- Short circuit protection (1s after fault)
- Back feeding protection

After the reason for a fault has been cleared, the Power Pak has to be reset to start working again. Do this by turning the Power Pak Switch on the front of the unit off and on again.

The low battery voltage trip point can be toggled using DIP Switch SW1.

An over temperature condition may be caused by overload (i.e. too many high-power appliances running from the Power Pak), inadequate ventilation or an external heat source.

To resolve an overload condition, connected appliances can be shut off / turned down / disconnected.

The back feeding protection which avoids presenting an AC voltage on the AC input terminal in Invert mode.

The Power Pak has a range of overload capacities for handling demanding loads. An audible alarm will indicate that the Power Pak is overloaded. It will automatically shut down if the overload condition is not resolved within a specific amount of time, according to the table below.

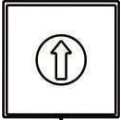








The table below describes the parameters associated with the Power Pak’s alarms and protections.

Table 8.4

Alarms & Protections	
Low Battery Voltage	INV Mode green LED lit; buzzer beeps for 0.5s every 5s.
High Battery Voltage	INV Mode green LED lit; buzzer beeps 0.5s every 1s. Shutdown after 60s.
Over Temperature	Heatsink temp. $\geq 105^{\circ}\text{C}$, Over Temp red LED lit; buzzer beeps 0.5s every 1s. Shutdown after 30s.
$110\% < \text{load} < 125\%$ ($\pm 10\%$)	No audible alarm for first 14 minutes, then buzzer beeps 0.5s every 1s on 15th minute. Shutdown after 15 minutes.
$125\% < \text{load} < 150\%$ ($\pm 10\%$)	Buzzer beeps 0.5s every 1s. Shutdown after 60s.
$\text{Load} > 150\%$ ($\pm 10\%$)	Buzzer beeps 0.5s every 1s. Shutdown after 20s.

8.5 LED Indicators

There is an LED display on the front of the Power Pak. The following display explains the meaning of each LED indicator.

<div>          </div> <div> <div>Battery Type Selector</div> <div>CHARGE CURRENT CONTROL</div> <div>Power Save On</div> <div>Over Load</div> <div>Over Temp</div> <div>Float CHG</div> <div>Fast CHG</div> <div>INV Mode</div> <div>Line Mode</div> </div>	
Power Save On GREEN LED lit	PowerSaver mode active (light flashes). Power Pak will sleep when no AC load present
Over Load RED LED lit	Power Pak is overloaded and will shut down if load is not reduced
Over Temp RED LED lit	Power Pak is overheated

Float CHG green LED lit	Batteries are fully charged, with a small amount of power keeping them topped up (Note: this LED will only be lit when charging from AC power, it will not be lit when charging from solar)
Fast CHG yellow LED lit or flashing	Batteries are being charged (note: this LED will only be lit when charging from AC power, it will not be lit when charging from solar)
INV Mode green LED lit	Power Pak is using power from the batteries
Line Mode green LED lit	Power Pak is using power from an AC source (e.g. grid or generator)

8.6 Fans

The Power Pak contains both AC and DC fans. The AC fan will only run when there is AC output from the Power Pak. In PowerSaver mode, the AC fan will turn on from time to time, when a certain temperature or load level is reached. The fans are designed to allow the Power Pak to safely operate in ambient temperatures up to 50°C.

Allow at least 30cm of clearance around the Power Pak for air flow. Make sure that the air can circulate freely around the unit. Failure to do so may result in overheating and automatic shutdown of the Power Pak.

8.7 DIP Switches

On the left panel of the Power Pak, there are 5 DIP switches which enable users to customize the Power Pak's settings. These are summarized in the table below, followed by a detailed explanation afterwards.

DIP Switch Settings				
DIP Switch NO.	Switch Function		Position: 0	Position: 1
SW1	Low Battery Trip Voltage		For Deep-Cycle Battery MINI: 11.0 V DC COMPACT: 22.0 V DC GRANDE: 44.0 V DC	For Standard Battery MINI: 11.5 V DC COMPACT: 23.0 V DC GRANDE: 46.0 V DC
SW2	AC Input Range / (AVR)	AC Source	Utility	Generator
		230VAC for the COMPACT or GRANDE model	184-253VAC / (176-276VAC)	140-270VAC / (150-276VAC)
		120VAC for the MINI model	100-135VAC / (92-144VAC)	90-135VAC / (78-144VAC)
SW3	PowerSaver Auto Setting		Night Charger function	Detect Load
SW4	Output Frequency Setting		50Hz	60Hz
SW5	Solar/AC Priority Setting		Utility/Generator Priority	Solar/Battery Priority

SW1: Low Battery Trip Voltage

This allows the user to toggle the low battery trip voltage, which will shut down the Power Pak when the batteries drop to this voltage. Position 0 is intended for a typical deep cycle lead acid battery. Position 1 is intended for a normal cycle battery, and uses a higher trip voltage to prevent this type of battery from over-discharging when there is only a small load applied. For Lithium batteries, use Position 1; in many cases the lithium battery will shut itself down before the trip voltage is reached, especially if it has its own BMS (battery management system).

SW2: AC Input Range

There are different acceptable AC input ranges for different kinds of loads. For some relatively sensitive electronic devices, a narrow input range of 184-253VAC for 230VAC nominal (100-135VAC for 120VAC nominal) is required to protect them. Use Position 0 for this type of load.

For some resistive loads a wide voltage range is acceptable. The input AC range can be toggled to 140-270VAC (90-135V for 120VAC nominal) to power these types of loads with the most AC input power without frequent switches to the battery bank. This setting can be useful when using “dirty” power from a generator as an AC input. Use Position 1 for this case.

SW3: PowerSaver Auto Setting

In PowerSaver Mode, when SW3 is switched to Position 0, the Power Pak’s inverter will stay in standby. No power from the batteries or solar panels will be supplied to power any AC loads that are connected. If a qualified AC input is present, it will be used to charge the battery and supply the load at the same time.

When the SW3 is switched to Position 1, the Power Pak’s inverter is initially in standby mode and sends a pulse to detect the presence of a load every 3 seconds. Each pulse lasts for 250ms. The inverter will remain in standby mode until a load has been detected. Then it will wake up from standby mode and start to invert electricity from the battery bank to power the load.

SW4: Output Frequency Setting

The output frequency of the inverter can be set at either 50Hz or 60Hz by SW4. When connected to an AC input, the Power Pak’s output frequency setting must match the AC input frequency. For reference, 60Hz is more common in North America and much of Central and South America, while 50Hz is more common in most of the rest of the world.

SW5: Solar/AC Priority Setting

When Position 0 is selected, power from AC input is prioritized over solar or battery power. The AC input will power any connected loads as well as charge the battery. Only once the AC input is stable, i.e. after the generator/source has stabilized for a continuous period of 15 seconds, the Power Pak will start a battery charging cycle to protect the battery. After 1 normal charging cycle, AC throughput will be restored and the load will be powered by the AC input.

When Position 1 is selected, power from the solar panels and batteries will be prioritized over any AC input available. The AC input will only be used once the batteries are fully discharged. Once the batteries reach their low voltage setting, the Power Pak switches to the AC input and uses this to power the load and to charge the batteries until they are full once again. This setting is ideal for users that wish to maximize their use of solar power, and only use grid electricity or generators as a backup power source.

8.8 Other Features

8.8.1 Battery Voltage Recover Start

After a low battery voltage shutoff (10V for 12V model, 20V for 24V model, 40V for 48V), the Power Pak is able to restore operation once the battery voltage recovers to 13VDC / 26VDC / 52VDC (with power switch still in the “On” position). The built-in battery charger will automatically reactivate once a stable input voltage has been supplied for 15 seconds.



WARNING

In the event of a low battery shutoff, never leave connected loads unattended. When the system automatically recovers, these loads may turn on again and may present a hazard if left unattended, for example heaters may create a risk of fire.

8.8.2 Auto Gen Start

The Power Pak can be customized to start up a generator when battery voltage becomes low. It can send a signal to start a generator, and turn the generator off after battery charging is finished.

The auto gen start feature will only work with generators designed with this feature. There is an open/close relay that will short circuit the positive and negative cable from a generator. The input DC voltage can vary, but the max current the relay can carry is 16A.

9 Troubleshooting Guide

This section contains information about how to troubleshoot possible error conditions while using the Power Pak. The following tables are designed to help you quickly pinpoint the most common causes of failures.

Table 9.1

Indicators & Buzzers									
Status	Item	LED Indicator on Front of Power Pak							Buzzer
		POWER SAVER ON 1	OVER LOAD 2	OVER TEMP 3	FLOAT CHG 4	FAST CHG 5	INV MODE 6	LINE MODE 7	
Line Mode	Fast Charging					✓		✓	
	Absorb Charging					Flashing		✓	
	Float Charging				✓			✓	
	Standby							✓	
Inverter Mode	Inverter On						✓		
	Power Saver	✓							
Inverter Mode	Battery Low						✓		Beep 0.5s every 5s
	Battery High						✓		Beep 0.5s every 1s
	Overload On Invert Mode		✓				✓		Refer to "Audible alarm"
	Over-Temp On Invert Mode			✓			✓		Beep 0.5s every 1s
	Over-Temp On Line Mode			✓		✓		✓	Beep 0.5s every 1s
	Over Charge					✓		✓	Beep 0.5s every 1s
Fault Mode	Fan Lock								Beep continuous
	Battery High						✓		Beep continuous
	Output Short								Beep continuous
	Over-Temp			✓					Beep continuous
	Over Charge					✓			Beep continuous
	Back Feed Short								Beep continuous

The table below describes common problems and recommended solutions.

Table 9.2

AC Charging Current for Power Pak Model		
Symptom	Possible Cause	Recommended Solution
Power Pak will not turn on during initial power up.	Batteries are not connected, or connections are loose.	Check the batteries and cable connections. Ensure the battery switch [11], MPPT-battery breaker and MPPT-PV breaker [9] are set to ON. If it still will not turn on, call Microgreen support (it may be the DC fuse).
	Low battery voltage.	Charge the battery. The battery voltage may be too low for the Power Pak's built-in chargers to initiate a charge. An external charging source, such as a car charge, may be required to bring the battery voltage up to the minimum for the Power Pak to function. See Section 7.2.3 for more information.
No AC output voltage and no indicator lights ON.	Power Pak has been manually switched to OFF.	Toggle the Power Pak Switch on the front of the Power Pak.
AC output voltage is low and the Power Pak turns loads OFF in a short time.	Low battery.	Check the status of the batteries and recharge if possible.
Charger is inoperative, and unit will not accept AC power.	AC voltage has dropped out-of-tolerance.	Check the AC input source for proper voltage and frequency.
Charger is supplying a low charge rate.	Charger controls are improperly set.	Adjust the charging rate using the liner switch to the right of the Battery Type Selector on the front of the Power Pak.
	Low AC input voltage.	Ensure a qualified AC power source is properly connected to the AC input.
	Loose battery or AC input connections.	Check all DC /AC connections.
Charger turns OFF while charging from a generator.	High AC input voltages from the generator.	If possible, turn the generator output voltage down. Alternatively load the generator down with a heavy load, for example by turning on a heater.
Sensitive loads turn off temporarily when transferring between grid and battery power.	Low voltage trip may be set too low to sustain certain loads.	Set DIP SW2 to Position 0 to select a more narrow AC voltage range or install a UPS for sensitive loads.
Unusual noise from the Power Pak.	Applying certain loads, most commonly a hair drier.	Certain types of loads can cause internal components to rattle or vibrate. This will not harm the Power Pak or connected devices. The noise should stop when the load is reduced, for example by unplugging the hair drier.

10 Warranty

The Power Pak comes with a 2-year limited warranty. The following cases are not covered under warranty:

1. DC polarity reverse. The Power Pak is designed without DC polarity reverse protection. A polarity reverse may severely damage the Power Pak.
2. Incorrect AC wiring.
3. Water damage. The Power Pak is not waterproof.
4. Operating with an undersized generator or generator with unqualified wave form.

11 Power Pak Specs Sheet

		Power Pak		
	MODEL	MINI	COMPACT	GRANDE
AC Output	Continuous Output Power	3000W	4000W	10000W
	Surge Rating(20s)	9000W	12000W	18000W
	Output Waveform	Pure Sine wave/Same as input (Bypass mode)		
	Nominal Efficiency	88% (Peak)		
	Line Mode Efficiency	> 95%		
	Power Factor	0.9-1.0		
	Nominal Output Voltage rms	100-110-120VAC / 220-230-240VAC		
	Output Voltage Regulation	±10% RMS		
	Output Frequency	50Hz ± 0.3Hz/60Hz ± 0.3Hz		
	Short Circuit Protection	Yes (1s after fault)		
	Typical Transfer Time	8ms (10ms max)		
	THD	< 15%		
AC Input	Max Current	30 Amp	30 Amp	80 Amp
DC Input	Nominal Input Voltage	12 VDC	24 VDC	48 VDC
	Minimum Start Voltage	10 VDC / 10.5 VDC	20 VDC / 21 VDC	40 VDC / 42 VDC
	Low Battery Alarm	10.5 VDC / 11 VDC	21 VDC / 22 VDC	42 VDC / 44 VDC
	Low Battery Trip	10 VDC / 10.5 VDC	20 VDC / 11 VDC	40 VDC / 42 VDC
	High Voltage Alarm	16 VDC	32 VDC	64 VDC
	Low Battery Voltage Recover	15.5 VDC	31 VDC	62 VDC
	Idle Consumption-Search Mode	< 25W When Power Saver On		
Charger	Output Voltage	Depends on battery type		
	Max Charge Current	60 ± 5 Amp	50 ± 5 Amp	80 ± 5 Amp
	Battery Initial Voltage for Start Up	10-15.7Vdc	20-31.4Vdc	40-62.8Vdc
	Over Charge Protection Shutdown	15.7Vdc	31.4Vdc	62.8Vdc
	Remote Control	Yes. Optional		
Bypass & Protection	Input Voltage Waveform	Sine wave (Grid or Generator)		
	Nominal Voltage	100-110-120VAC / 220-230-240VAC		
	Max Input AC Voltage	150VAC for 120VAC LV Mode ; 300VAC for 230VAC HV Mode		
	Nominal Input Frequency	50Hz or 60Hz (Auto detect)		

	Low Freq Trip	47±0.3Hz for 50Hz, 57±0.3Hz for 60Hz		
	High Freq Trip	55±0.3Hz for 50Hz, 65±0.3Hz for 60Hz		
	Overload Protection (SMPS load)	Circuit breaker		
	Output Short Circuit Protection	Circuit breaker		
	Bypass Breaker Rating	25A	30A	80A
	Transfer Switch Rating	30A for UL & TUV	40A for UL	80A for UL
	Bypass without Battery Connected	Yes		
	Max Bypass Current	30A	30A	80A
	Bypass Overload Current	30amp:Alarm	40amp:Alarm	40amp:Alarm
Solar Charger	Rated Voltage	12V	24V	48V
	Solar Input Voltage Range	15-150Vdc	30-150Vdc	60-150Vdc
	Rated Charge Current	40A	40A	60A
	Self Consumption	< 10mA		
AVR Function	Input AC Voltage Range	78-144V±4%		150-276V±4%
	Stabilized Output Voltage rms	120VAC ±10% RMS	230VAC ±10% RMS	230VAC ±10% RMS
Mechanical Specifications (Power Pak Series)	Mounting	Wall mount		
	Dimensions (L*W*H)	484*328.2*192.2mm	505*447*178mm	588*415*200mm
	Weight	26 KG	35 KG	68 KG
	Shipping Dimensions (L*W*H)	630*525*265mm	630*525*265mm	846*731*259mm
	Shipping Weight	28 KG	37 KG	94 KG
	Display	Status LEDs / Status LED + LCD		
Warranty	Standard Warranty	2 Year		

12 How to Contact Us

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