



SOLAR STIK®

Operator and Maintenance Manual for the US Courts Hybrid Power System



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Revision History

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GENERAL INFORMATION, THEORY OF OPERATION, AND EQUIPMENT DESCRIPTION

The introductory parts of this Manual describe Hybrid Power Systems (HPS) composed of Solar Stik components. However, the Solar Stik architecture is modular and open allowing Operators to integrate non-Solar Stik components as part of a HPS solution. Please contact Solar Stik Technical Support for assistance in optimizing the integration of other components.

Introduction to Hybrid Power Systems

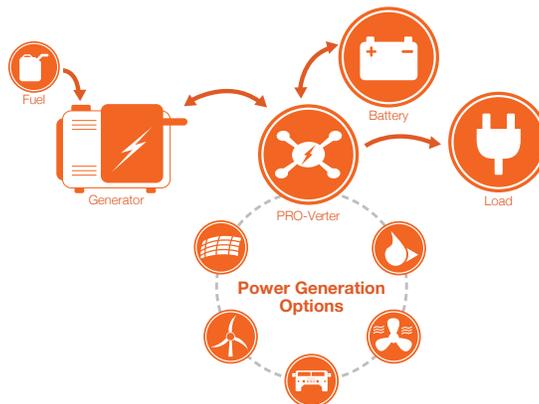
When a portable fuel-driven power generator is the primary source of power for an application, it must operate continuously to provide electricity to the load, even if the power requirements of connected loads are minimal or intermittent. Fuel energy is wasted in the production of electricity because neither the generator nor the load(s) can fully use the fuel's potential energy. This traditional power model is a low-efficiency system.

In the high-efficiency, Hybrid Power System (HPS), a battery bank supports the load. The power for the load is drawn from the batteries only as needed. Multiple sources of power generation can be used simultaneously to support the battery and ensure uninterrupted power to the loads. **The battery becomes the foundation of the HPS and the architecture is opened to allow multiple technologies to operate in concert.**



The Hybrid Power System Flexible Open Architecture

The System is comprised of modular components that integrate into a flexible architecture that is configured for an application's specific mission requirements. If the application changes, the modular System architecture can be modified or scaled to meet the new requirements.



HPS with Open Architecture

THEORY OF OPERATION

The System provides power surety for applications where Hybrid, UPS or Power Conditioning, functions are required. Expander Paks are also referred to as energy storage modules or ESMs throughout this Manual.

Universal “rules” for operation:

- Total power INPUT to the HPS must be greater than the power OUTPUT of the HPS.
- The HyPR requires the presence of battery (bus) voltage to operate fully.
- Based on the application, the user must configure the system so there is “balanced” operation between each individual component and the HyPR internal functions.

The following diagram illustrates where to connect power sources, 24VDC Li Expander Paks and loads to the HyPR. For normal operation, at least three (2) 24VDC Li Expander Pak 2400s must be connected.

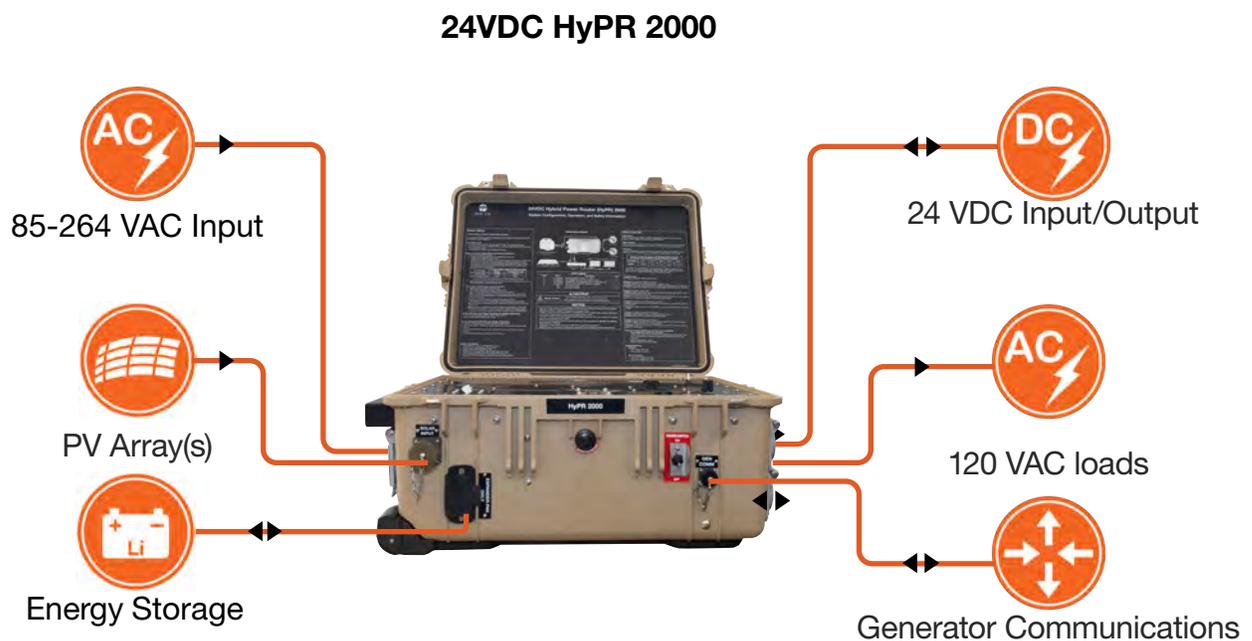


Figure 1. 24 VDC HyPR 2000 connections

Modes of Operation

There are several operational modes in which the HyPR may be configured, depending on the application,

Hybrid Mode—The hybrid mode allows the use of a smaller generator based on average, continuous total loads over a 24-hour period, versus a larger generator that will support “peak” loads, which are usually momentary or short in duration:

- AC power generation source (1 – 2 kW generator) with ESMs
- DC power generation source (PV) with ESMs
- AC and DC power generation sources (combinations of the above) with ESMs

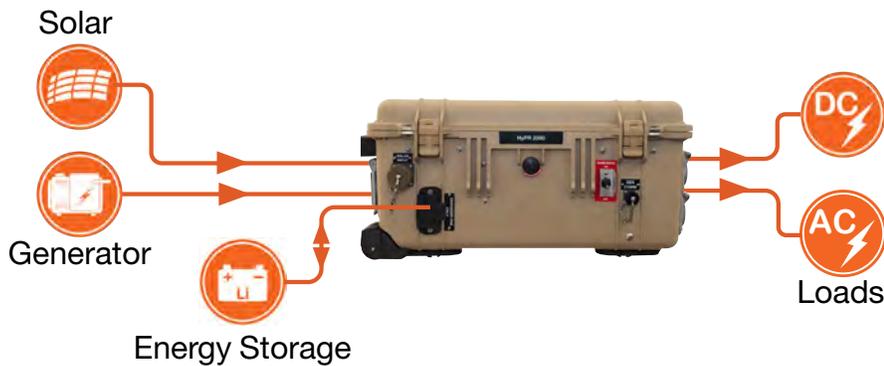


Figure 2. Using the HyPR 2000 in Hybrid Model

UPS Mode—The HyPR 2000 is capable of operating as an Uninterruptible Power Supply/Source, providing instantaneous emergency power to a load in the event that primary power source fails. In this mode, the HyPR 2000 will provide power to the load until it can be turned off safely or until primary power is restored. In this mode, power duration is limited to that contained in the ESM’s connected to the HyPR 2000.

- AC utility / grid power sources with ESMs
- ESMs do not cycle

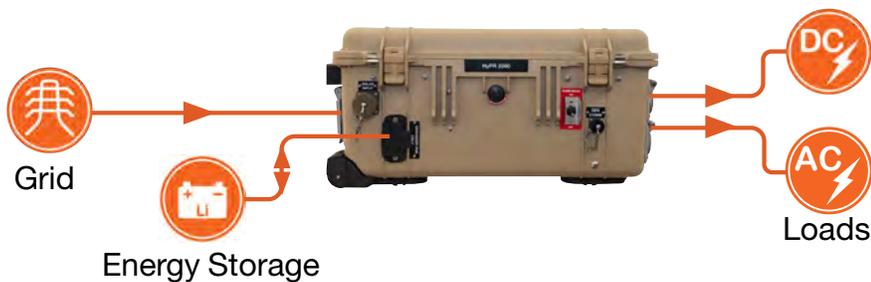


Figure 3. Using the HyPR 2000 in UPS Model

Power Conditioning Mode—The HyPR 2000 has a power conditioning mode that stabilizes output voltage and frequency from dirty AC power sources. The HyPR will convert AC power with voltage ranging from 120-264 and frequencies between 47-63 Hz into clean, pure sine wave 120 VAC, 60 Hz power providing protection for sensitive loads:

- HyPR with ESMs between AC power sources and AC and DC loads - eliminates overloading of small expeditionary generators and increases the HyPR power output stability over longer periods of time.
- HyPR without ESMs between AC power sources and AC and DC loads - eliminates AC power source voltage and frequency fluctuations that can cause problems with sensitive electronic loads.



Figure 4. Using HyPR in Power Conditioning Model

Inverter Mode – The HyPR 2000 may be used in inverter mode when no AC power generation sources are available. This allows the combined total input of DC sources (including ESMs) to be dedicated to AC loads. This mode may be used when renewable power generation is abundant and stable.



Figure 5. Using HyPR in Inverter Mode

Energy Storage—The Foundation of a System

Batteries in a Hybrid Power System are designed to “cycle”. A full cycle is defined as one complete discharge and recharge over a specific period of time. All batteries have a cycle life and therefore should be considered the “consumable” part of the System. The health of the battery can directly affect the function of the System over time, so proper cycling and cell-health management practices are strongly encouraged.

Energy Storage Requirements for Operation

The HyPR requires connection to an active 24 VDC battery to operate. There is a minimum energy storage capacity requirement for operation of the HyPR at its full rated power. Consult the I-Plate and subsequent sections of this Manual for specific information regarding minimum capacity necessary for a particular application.

The HyPR is compatible with lead-acid and lithium battery chemistries. However, battery chemistries should never be mixed within a System.

Battery Current Capacity Requirements for System Operation

Each 24VDC Li Expander Pak 2400 has a built-in 50 A circuit breaker that will trip at a value **less than** the maximum rated current that the HyPR 2000 can supply to an AC load. For this reason, at least two (2) Li Expander Pak 2400s must be connected to a HyPR 2000 for a System to function at its full, rated power.

Connecting an insufficient number of Expander Paks to a HyPR may result in a situation where the batteries are charged or discharged too quickly. Charging / discharging ESMs too quickly may cause the battery temperature to rise to a point that the battery management system (BMS) disconnects the batteries from the whole system.

Scaling Energy Storage Capacity

Plug & Play architecture allows expansion or contraction of battery capacity when conditions warrant.

Use Inter-Connect Cables to create a “bank” of Li ESMs. **Note:** Do not mix battery chemistries in a System battery bank.

If a System needs to be downsized, due either to reductions in the load or simply to reallocate energy storage resources to other locations, then Li ESMs can be removed from service in accordance with reductions in runtime requirements.

Selecting an AC Power Source

HyPRs can be used with grid-utility or generator AC power sources, and can easily be configured to work with the current limits of both the DC/AC power source circuits and the DC/AC load circuits. Once the input and output power limits are configured, the HyPR regulates how much power is delegated between these circuits, to prevent overload conditions.

Acceptable AC power sources for use with a single HyPR 2000 should provide the following:

- 1–3 kW of power
- Pure Sine Wave AC wave form output

When considering a fuel driven generator to pair with the HyPR, note that the maximum continuous AC load should not exceed the maximum continuous output of the AC power generator (i.e., maximum load AC power requirement \leq generator AC power output). Moreover, to use the HyPR in hybrid mode, a fuel-powered generator must be compatible with Solar Stik auto generator start/stop capabilities.

Temperature-dependent Power Processing

The performance of all electric and electronic equipment varies with temperature with the rated performance listed determined at standard testing conditions (77 °F; 25 °C). Generally performance declines or “derates” when the equipment is operating in ambient temperatures colder or hotter than STC; the hotter or colder the poorer the performance.

When the equipment itself generates heat, the temperature of the equipment will rise above ambient (and STC) in direct proportion to power being processed. This too results in derating. Internal thermostatic mechanisms are built into most equipment to reduce power processing in a heat-dependent manner to lower heat and prevent damage. Power processing vs heat curves vary widely.

The HyPR contains two (2) major subcomponents, a charger and inverter. Both of these derate at elevated temperatures but in a different manner. The inverter will provide full power up until a critical temperature and then turn off, dropping the AC load then resume support of the AC load after the inverter has cooled to a set point. The charger on the other hand, will reduce power processing at a critical, defined temperature but continue to charge the batteries at a lower rate.

Heat absorbed by the sun (solar loading) also increases the internal temperature contributing to temperature-dependent derating. Understanding how temperature-dependent derating affects HyPR power processing will enable the Operator to make adjustments to ensure continuity of operations in any environment.

Derating Specifications

The Inverter

- The inverter provides full power (2000 W) up to 86 °F (30 °C). It will decrease power output by 20% for each 18 °F (10 °C) increase over 86 °F (30 °C). The inverter will cease to process power at 176 °F (80 °C), to self-protect, and will resume providing AC power after it cools to operating temperature.
- Below 80 °F (27 °C), the HyPR can provide up to 2,000 W continuous while not charging.

The Charger

- The HyPR charger provides full power (2000 W) up to ~158 °F (70 °C). At 158 °F (70 °C) it will reduce power ~30% of full-rated power until it cools and resumes normal, full-rated output.
- Below 80 °F (27 °C), the HyPR can process around 2000 W continuous for battery charging (with no loads connected).

How to Minimize Temperature-dependent Derating

- Do not overload the HyPR. Manage power processing demand by paying close attention to what is “plugged in. Prioritize critical loads.
- Shade the HyPR 2000 to reduce solar loading. Solar Stik data indicate that solar loading of a Pelican case can increase internal heat by ~40 °F (~ 22 °C) above ambient.
- Do not block airflow into or out of the HyPR; give it space to breathe.
- Clean or replace the air intake filters regularly.

HyPR 2000 Circuits

The HyPR coordinates the support of AC and DC loads using power supplied from AC and/or DC sources. Both AC and DC power sources energize the HyPR internal DC circuitry (DC bus; AKA the “Inter-Connect” circuit). The presence of DC bus voltage (battery voltage) enables the full function of the HyPR 2000 internal circuits. System voltage and Expander Pak net current can be monitored on the DC User Interface.

A schematized illustration of the DC bus and its relationship to internal components, inputs and outputs is shown below. The arrows indicate the flow of current in the circuits.

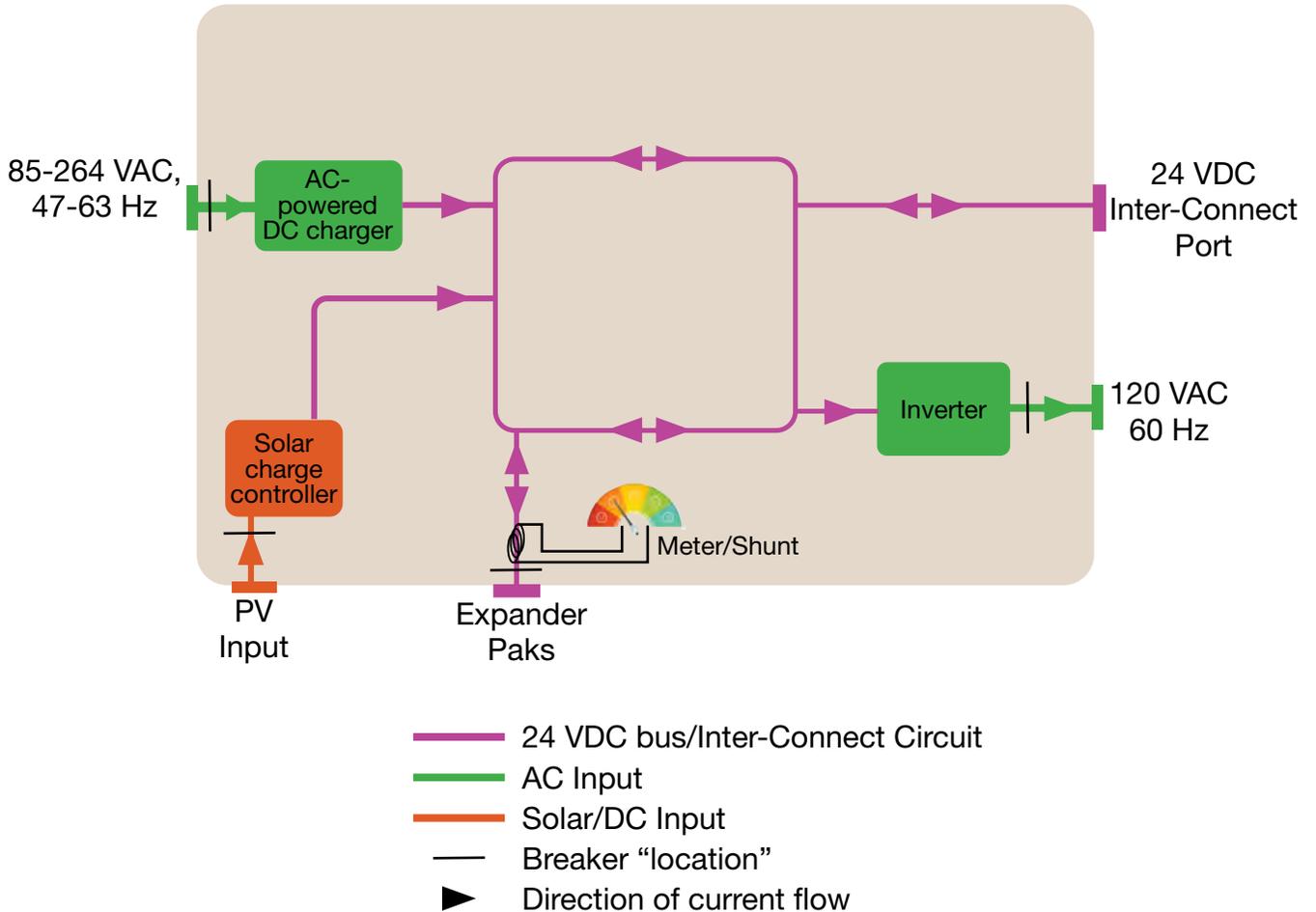


Figure 6. Schematized power flow from a top-down view of the HyPR 2000 interior.

AC Functions

The HyPR employs two (2) separate AC functions that operate on the DC bus:

Charging

AC>DC converter provides up to 70 A at 29.5 V DC to the DC bus (~2000 W).

Inverting

DC>AC inverter removes up to 84 A at 24 VDC from the internal DC bus (~2000 W).

When configuring the HyPR for use, it is important to understand how to establish balance between the power available from sources and the power required by the loads.

When using AC power sources in Hybrid or UPS models, the AC INPUT setting must be set for the following conditions:

- Continuity of AC load operation
- Battery charging
- Not to exceed the power output of the AC source

When small expeditionary generators are used, the HyPR can be used for dynamic loads that would normally cause overloading of the generator.

DC Functions

The DC bus is effectively the nervous system of the HyPR. All HyPR functions are regulated directly or indirectly by the DC bus voltage. The DC bus voltage is functionally equivalent to the System battery voltage. Direct connections to the DC bus can be made via the two (2) Inter-Connect ports. Ports for PV, AC Input and AC output ports are indirect connections to the DC bus (Figure 6).

DC power will flow into or out of the HyPR via the direct connections (Inter-Connect ports).

The indirect connections allow power to flow to the bus after being altered from its original form, for example:

- 30-57 VDC power from PV arrays converted by the solar charge controller to 29.0 VDC
- AC power converted to 29.5 VDC
- Inverter converts energy stored in batteries to 120 VAC power output.

Utilization of power sources to charge batteries and support loads is prioritized by voltage. Prioritizing PV power over AC power reduces reliance on fuel-powered generators.

Solar Power

The SOLAR INPUT port is the only port that may be used to connect PV power to the HyPR. Connecting a PV array to any other input port will damage to the HyPR.

Any PV array input must meet the following specifications: 450 W or less, voltage between 30 and 57 VDC, and a maximum current rating of 15 A at 24 VDC.

The HyPR converts incoming PV power to a 29.0 VDC charging current. When a PV array is present, all features of the HyPR DC INTERFACE are available.

Auto Generator Start / Stop

The HyPR Auto Generator Start/Stop (AGS) functions are controlled using the GENERATOR CONTROL switches on the Faceplate.

- The ON position turns on a connected generator regardless of the DC bus voltage.
- The AUTO setting automatically starts and stops a connected generator based on DC bus (battery) voltage.
- The OFF setting stops the generator(s) if it is running or prevents the generator from turning on.

Automatic Generator Start/Stop (AGS) voltages

The HyPR AGS is programmed to start and stop the generator(s) at voltages that allow the ESMs to charge and discharge over a safe and efficient voltage range.

- Generator start set point = 25.0 VDC
- Generator stop set point = 28.8 VDC

The generator start and stop voltage set points are programmable via a TECH PORT on the Faceplate. Contact Solar Stik Technical Support for assistance if reprogramming is required.

Battery Low-voltage Cut Off (LVCO)

AC loads

The HyPR is programmed, via the USER INTERFACE AUX circuit, to cease support of AC loads before the System battery voltage drops to a critical, overdischarged level.

- The HyPR will discontinue the support of AC loads when System battery voltage drops to 24.5 VDC.
- The HyPR will resume support of AC loads when System battery voltage is charged back up to 25.0 VDC.

The LVCO values are set in accordance with the battery's BMS specifications and will vary depending on the battery type and the total battery capacity in a System.

DC loads

The HyPR does NOT provide battery LVCO protections when supporting DC loads. DC loads connected to the HyPR may draw down battery voltage to the point that the battery's internal Battery Management System (BMS) will disconnect the battery from service to protect it from overdischarge.

Load Prioritization

In every operation mode, the HyPR will prioritize power to the load. It executes functions based on real-time operating conditions, which include:

- Total power available at the INPUTS
- Total power needed at the OUTPUTS
- Battery SOC
- Temperature
- User programming for special conditions

HyPRs can be used with grid-utility or generator AC power, and can easily be adjusted to operate within the current limits of both the AC load circuit and the external AC power source.

When operating a HyPR with multiple DC power sources connected (e.g., PV, Wind, vehicular, fuel cells, etc.), all incoming power will be prioritized to the load, reducing consumption of energy stored in the batteries, thereby extending battery-only runtime and the reducing need for AC power from a grid-utility or generator source.

When operating a HyPR with a fuel-driven generator, the AGS circuit can be used to start the generator when the battery SOC is low. Once the battery SOC reaches a user-determined point, the HyPR AGS circuit will start the generator, ensuring power to the load. In effect, the HyPR uses a connected generator as the last line of defense against mission failure.

With load prioritization, the load will always be the first to receive power. Any incoming power not consumed by the load is stored in the batteries. Stored energy is for use to support loads when these inputs are not available (e.g., grid failure, generator maintenance periods, etc.) and to reduce reliance on fuel-powered generators.

Scaling and Modifying a HyPR-based System

When expanding or modifying the architecture, scaling and stacking may be used to provide additional capabilities that may exceed the ability of any one component to handle.

Scaling

- Power generation and energy storage connected to the HyPR 2000 can be modified in accordance with changes in load requirements. Additional generation sources should be selected based on availability of resources, logistics, and the local environment.
- Additional energy storage modules can be of a different form factor but must be of the same chemistry and voltage and have compatible charge and discharge current capabilities.

Stacking

- Capabilities including inverters, advanced power distribution and management modules can be added (or removed).

Note: Scaling or modifying the System architecture should be done with all components in the System completely inactive and OFF.

The Inter-Connect System

A Solar Stik System is comprised of three (3) distinct types of technologies:

- Energy storage
- Power management
- Power generation

All of the individual components that operate in these categories utilize a unique connection architecture known as the Inter-Connect Circuit.

The Inter-Connect Circuit is the connection framework of the System's DC power network. It uses a simple, polarized, locking connection that is common throughout the architecture. All power management, energy storage, and power generation components are compatible with the Inter-Connect Circuit.

Using a common, polarized connector allows rapid "Plug & Play" scaling of components, adaptation of capabilities within the architecture, technology refreshment, and swapping of components when conditions warrant. It also ensures that there is no unsafe way to make connections.

Circuit Breaker Protections

The Inter-Connect network is protected from overloads and short circuits through a network of circuit breakers strategically placed throughout the circuit. It ensures the potential for a reverse polarity connection within the circuit is minimized. If a problem occurs in a leg of the Inter-Connect Circuit, the affected leg will disconnect from the primary network, leaving the other circuits functioning. If a major failure occurs in the circuit, then the entire network will shut down for System and Operator protection.

Operate with Voltage

The Inter-Connect Circuit communicates simple battery voltage to all components on the network, allowing them to independently coordinate their respective functions. Battery voltage is used to trigger actions such as Automatic Generator Start/Stop (AGS) function, power distribution timing, and more. Therefore, the proper setup of the Inter-Connect Circuit is critical to properly communicate voltage to all points in the System and to ensure all of the components operate together to provide seamless power to the load.

Optimize with Data

Data collection for a System occurs through the Inter-Connect network. Power management devices such as HyPR 2000 and PRO-Verters meter voltage, current and time through the circuit, providing critical real-time data the operator can use to troubleshoot and verify System performance. Data collection enables programming/architectural changes to optimize performance based on evolving conditions.

Important Safety Information and Instructions

This manual contains important instructions that must be followed during the setup and operation of a the HyPR 2000. Read all instructions and information contained in this manual.

Important information regarding the safe setup and use of the HyPR 2000 is contained in this Manual. DO NOT begin assembly or use of the HyPR 2000 without first reading and understanding this manual.

While the HyPR 2000 designed for indoor/outdoor operation, the DC Interface (control panels) must not be exposed to rain, snow, moisture, or liquids. Close and latch and/or lock the cases when the components are unattended.

Exercise caution when handling or operating the HyPR 2000. Live power may be present.

Safety Information Labels

Your safety and the safety of others is very important.

Many important safety messages have been provided in this manual and directly on the System components. Always read and obey all safety messages.



This is the safety alert symbol. This symbol is an alert to potential hazards that can cause death or injury. All safety messages will follow the safety alert symbol and the word “DANGER”, “WARNING”, or “CAUTION”. These words are defined as:

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

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

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

All safety messages will describe what the potential hazard is, how to reduce the chance of injury, and what can happen if the instructions are not followed.

Fire Hazard

Fire Types

Class A fire - Fires in ordinary combustibles such as wood, paper, cloth, trash, and plastics.

Class B fire - Fires in flammable liquids such as gasoline, petroleum, oil, and paint.

Class C fire - Fires involving energized electrical equipment such as motors, transformers, and appliances. Remove the power source and the class C fire becomes a class A or B fire.

⚠ WARNING

Only CO₂ (carbon dioxide) fire extinguishers should be used with this equipment.



Recommended Fire Extinguisher

NSN 4210-00-288-7219 Fire Extinguisher, Carbon Dioxide, 10 lb

Carbon dioxide is a liquefied gas, which is highly effective fighting class B and C fires. These extinguishers are ideal for areas where contamination and/or cleanup are a concern, such as data processing centers, labs, and telecommunication rooms.

Using the Fire Extinguisher

When using the extinguisher on a fire, remember PASS:

Pull the pin.

Aim the nozzle or hose at the base of the fire from a safe distance.

Squeeze the operating lever to discharge the fire extinguishing agent.

Sweep the nozzle or hose from side to side until the fire is out. Move forward or around the fire as the fire diminishes.

Watch the area for reignition until the cause has been fixed.

Electric Shock Hazard

⚠ WARNING

Standing water around the electrical equipment and/or intrusion of water into the System components can increase the risk of electrical shock.



HIGH VOLTAGE: System components, PV arrays, and generators may produce lethal line voltages. Extreme care should be taken to protect against electrocution. Always work with another person in case an emergency occurs. Disconnect power before performing maintenance. Wear safety glasses whenever working on any part of a system that requires exposure to mechanical or direct electrical contacts.

⚠ WARNING

The System is NOT GFCI protected.

Environmental and Handling Precautions

All Solar Stik components are ruggedized, yet there are a few things the operator can do to prevent failures and prolong the operational life of the Solar Stik System.

Wind

It is imperative to properly secure PV panels to the ground using sandbags so they do not become dangerous projectiles in high winds.



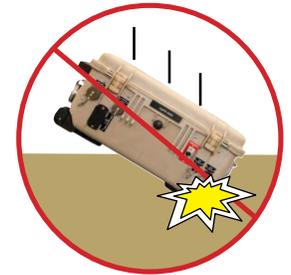
Water

If outdoor operation is necessary, the lids of all components should be closed and latched. During operation, cases should be placed upright, especially during inclement weather. Lids should be open only to access operator controls and closed at all other times.



Impact

Equipment should not be dropped onto hard surfaces at a height greater than one foot when transporting or during operation.



Dust/Foreign Object Intrusion

Air intake filters should be cleaned once per month, or more frequently when conditions warrant. As a general rule, minimize exposure to high levels of particulates and foreign object debris by exercising common-sense placement and protection during both operation **and** storage.



Heat

Heat and solar loading reduces efficiency and life expectancy. Shade components (except PV panels) to prevent the negative effects of heat.

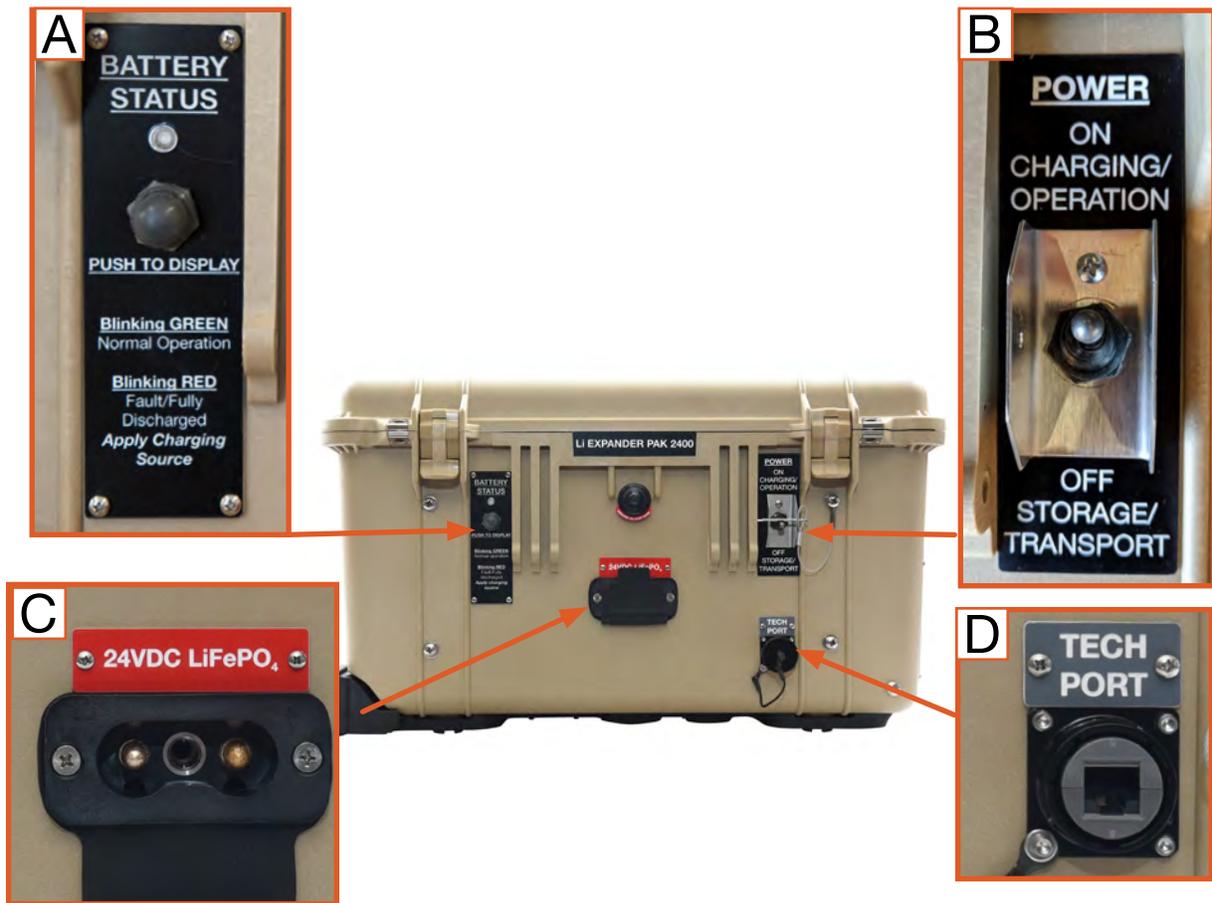


EQUIPMENT DESCRIPTION

24VDC Li Expander Pak 2400

The Expander Pak is the “heart of the Hybrid Power System”. Each of the two (2) Expander Pak has 100 Ah (2400 Wh) of storage capacity for 200 Ah (4800 Wh) total energy storage capacity.

- A. Battery Status LED:** Displays battery operation status.
- B. Power Switch:** Enables Operation or Storage Modes; 50 A breaker.
- C. Inter-Connect Port:** Port for connecting the Li Expander Pak to the Inter-Connect Network.
- D. Tech Port:** Provides access to current and historical data from the Li Expander Pak BMS. A BMS reader (sold separately) is required to access information from this port.



	Description	Connector	Voltage	Amps	Watts
A	Battery Status LED and Momentary Switch				
B	50 A circuit breaker switch			50 A	1200 W
C	24 VDC LiFePO ₄ Port	Inter-Connect Port	24 VDC	50 A	1200 W
D	Tech Port	Ethernet - RJF21B	-	-	-

Figure 7. 24VDC Li Expander Pak features and functions

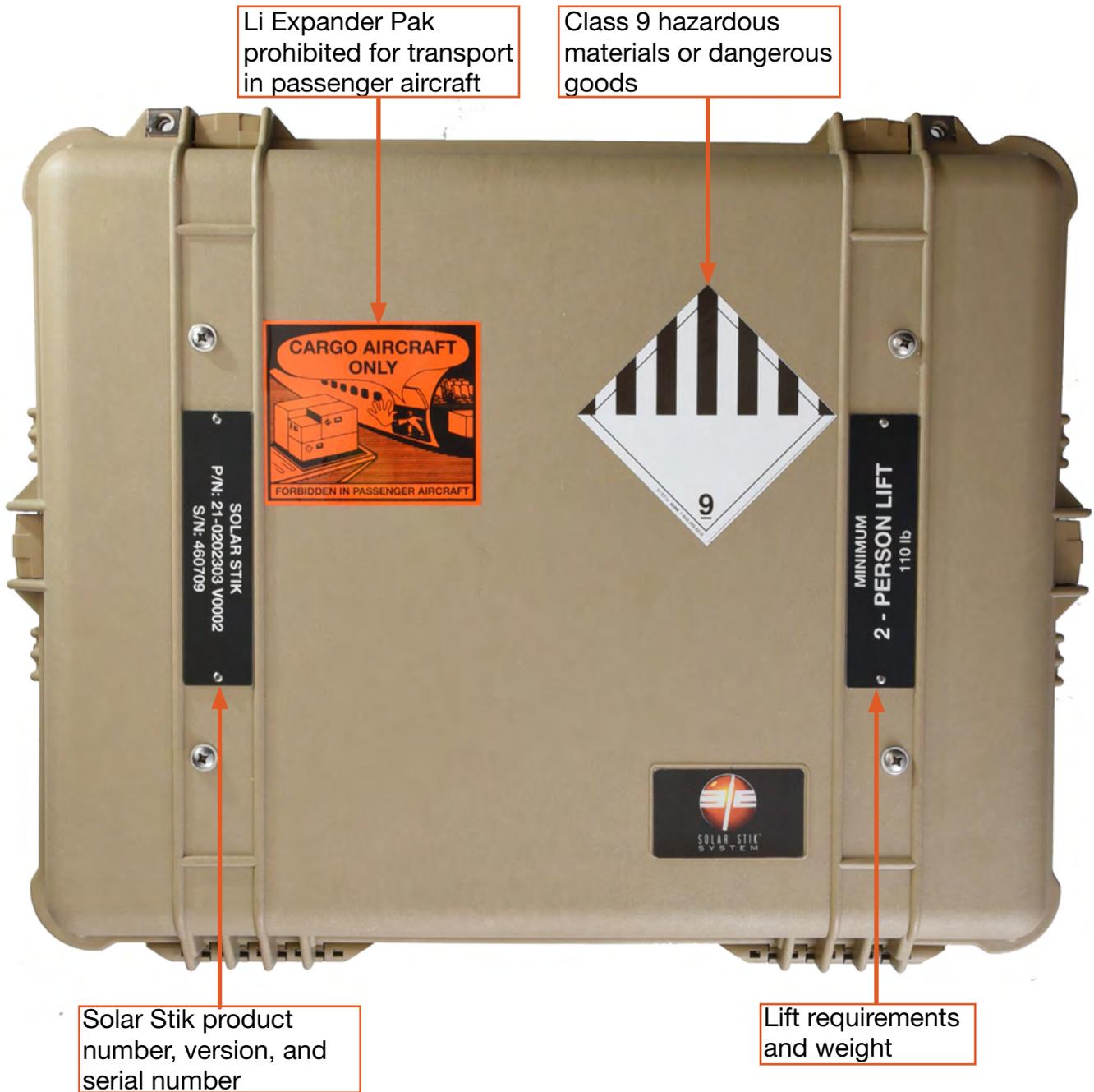


Figure 8. Labels on top of 24VDC Li Expander Pak 2400

Data Plate (D-Plate)



**24VDC Li EXPANDER PAK
2400**

Recommended Safety Equipment
10 lb carbon dioxide fire extinguisher
NSN 4210-00-288-7219

Battery Specifications
Chemistry: Lithium Iron Phosphate (LiFePO₄)
Capacity: 100 Ah (2.4 kWh)
Operating voltage: 24.0 VDC to 28.8 VDC
Maximum charge/discharge current: 50 A
Over voltage limit: 29.2 VDC
Under voltage limit: 21.6 VDC

Charging

- 1) Use a Solar Stik PRO-Verter that is configured for LiFePO₄ batteries.
or
- 2) A charger that is configured for LiFePO₄ batteries that **DOES NOT EXCEED 50 A.**

Environmental
Operating temp: -13 °F to 149 °F (-25 °C to 65 °C)
Charge temp: 41 °F to 113 °F (5 °C to 45 °C)
Storage temp: -22 °F to 158 °F (-30 °C to 70 °C)

Storage
Charge the Li EXPANDER PAK completely before storage and recharge fully every three months.

Transport
Class 9 hazardous material transportation restrictions.
UN3481 Lithium Ion batteries contained in equipment
See manual for SDS.

Technical Support
1-800-793-4364 Ext 102
tech@solarstik.com

Made in USA

Figure 9. 24VDC Li Expander Pak 2400 D-Plate

450W Solar Expedition Array

The Expedition Solar Array will produce up to 450 W of DC power under optimal conditions. During daytime hours, power from the Array will reduce generator run time.

Inventory of the contents of each Solar Array transport case prior to deployment.

450W Solar Expedition Array Kit Inventory	
<input type="checkbox"/>	Four (4) 140 W Photovoltaic (PV) Panels 1
<input type="checkbox"/>	One (1) Transport Case 2
<input type="checkbox"/>	One (1) Rollable Stand 3
<input type="checkbox"/>	Twelve (12) Sandbags 4
<input type="checkbox"/>	Ten (10) Stakes 5
<input type="checkbox"/>	One (1) 30' Solar Leash 6

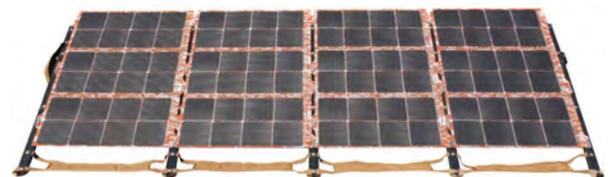
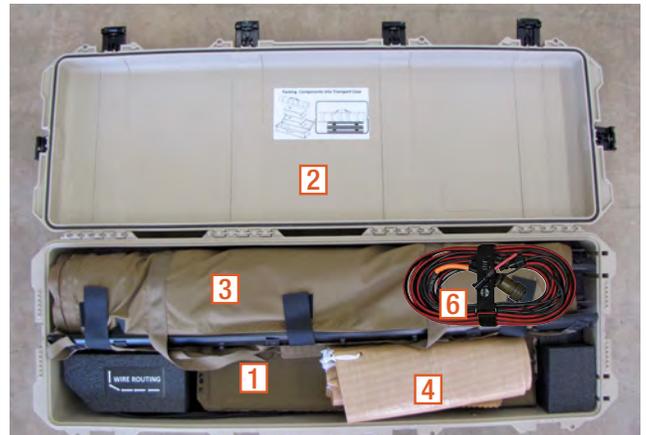


Figure 10. Solar Array transport case contents packed and unpacked

Generator with Remote-start Enabling Kit

The gasoline-powered generator has been modified with an automatic choke to enable starting and a Remote-start Enabling Kit (RsEK) that allows automatic start/stop control by the HyPR 2000. The generator runs only to charge Expander Paks.



Figure 11. 2 kW generator with RsEK

24VDC HyPR 2000

The HyPR 2000 manages power between power sources and loads. The HyPR 2000 provides both AC and DC mechanisms to charge Expander Paks while the system is operating or idle. The HyPR 2000 provides important System status information and therefore increased security for continuity of operations.

The following diagram illustrates an overview or where to connect power sources, Expander Paks and loads to the HyPR 2000.

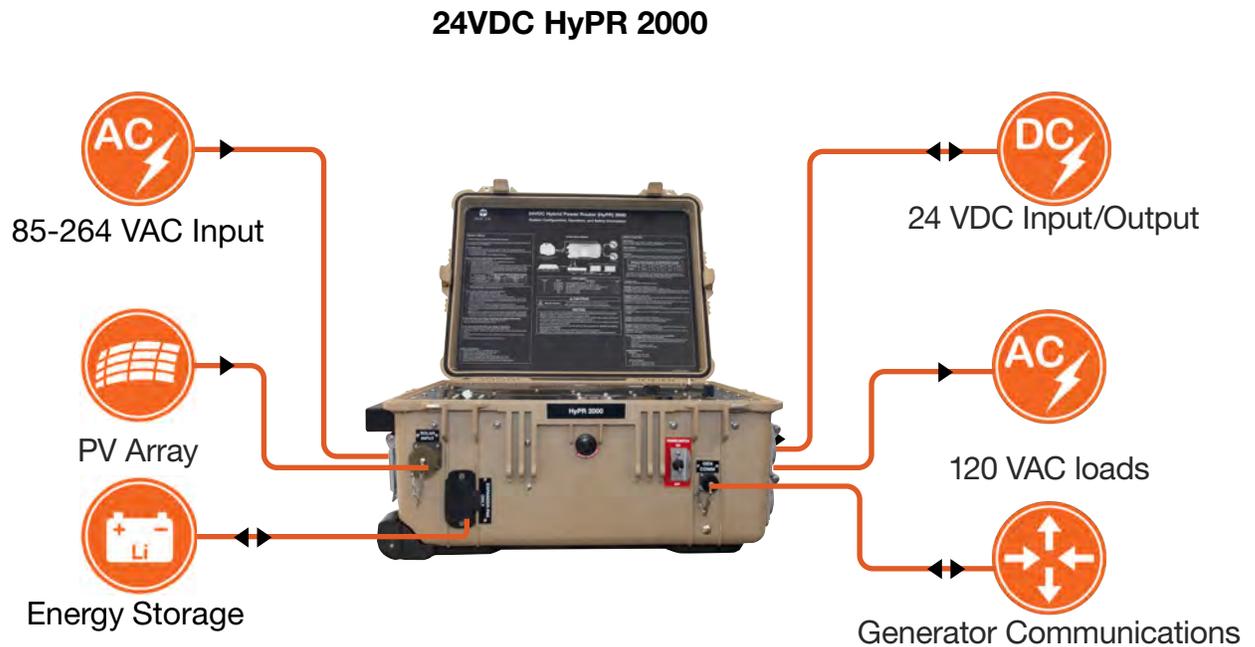


Figure 12. 24 VDC HyPR 2000 input/output overview

Exterior Features



Figure 13. HyPR 2000 exterior features

120-230 VAC Input Port

The HyPR 2000 can accept “universal” AC input. The label on the cover states 120-230 VAC but the true, tolerated range is 85-264 VAC and 47-63 Hz. The connector is a NEMA L5-15P.

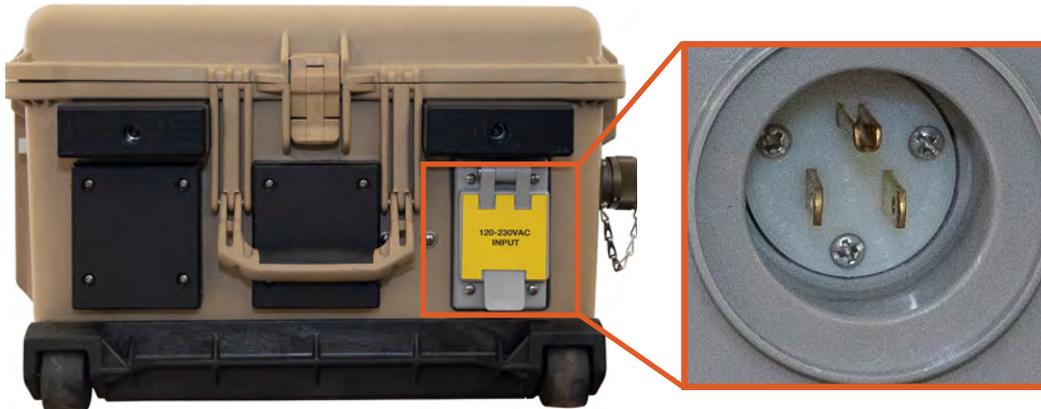


Figure 14. HyPR AC power input port

120 VAC Output Ports

These ports provide 120 VAC, 60 Hz, pure sine wave power. All four (4) receptacles may be used at the same time but the cumulative demand from all connected loads must not exceed 2000 W continuous. These connections are limited to 20 A by the breaker on the HyPR Faceplate.



Figure 15. HyPR 120 VAC output ports

Solar Input Port

The HyPR accepts power from PV arrays to charge connected ESMs. Specifications for the solar charge controller and compatible PV arrays are on the HyPR 2000 Faceplate. **Functioning PV arrays must be connected for the DC INTERFACE to calculate and report ESM state of charge (SOC).** Pins A and C are the current conductors, pin B is unused.

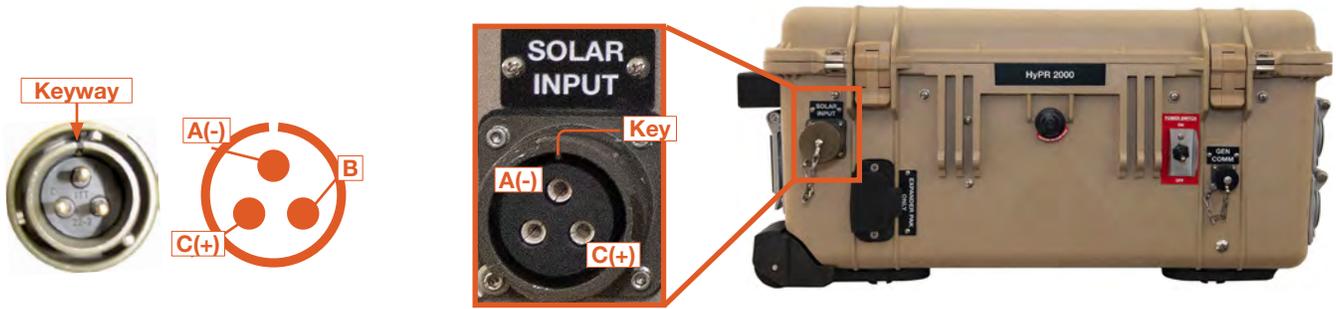


Figure 16. HyPR 2000 solar input port

Expander Pak Only Port

This Inter-Connect port is “metered” meaning that the HyPR measures the current that passes through the port, to and from the Expander Paks. In some System configurations, this metering can be used to calculate the SOC for the connected battery bank.



Figure 17. HyPR Expander Pak / ESM connection port

24 VDC IN/OUT Port

The Inter-Connect Port is a direct connection to the HyPR DC bus. This port is not metered and may be used to parallel HyPRs or to connect additional power management or power generation components.

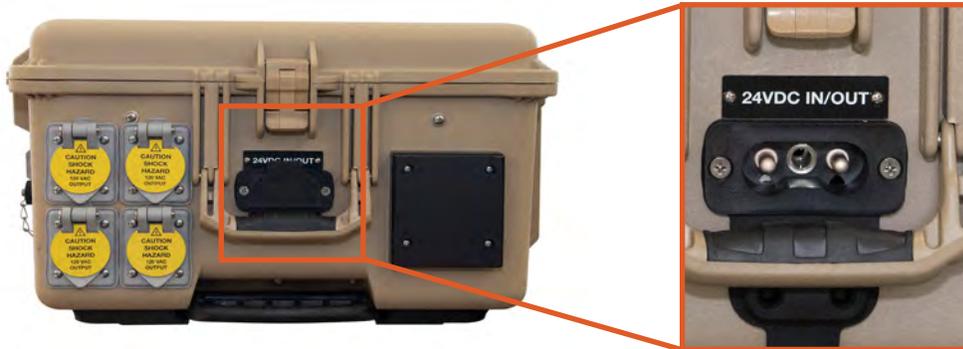


Figure 18. HyPR 24VDC IN/OUT port

GEN COMM Port

This connector provides the communication link between the HyPR and auto start/stop-capable generator.



Figure 20. HyPR 2000 generator communications port

Vents

Ambient air enters the case through the intake vents. Exhaust vents have fans to remove air from the case. **The intake vents have air filters that must be cleaned on a regular basis, especially when operating in dusty environments.**



Figure 19. HyPR 2000 air intake and exhaust vents

Faceplate Details

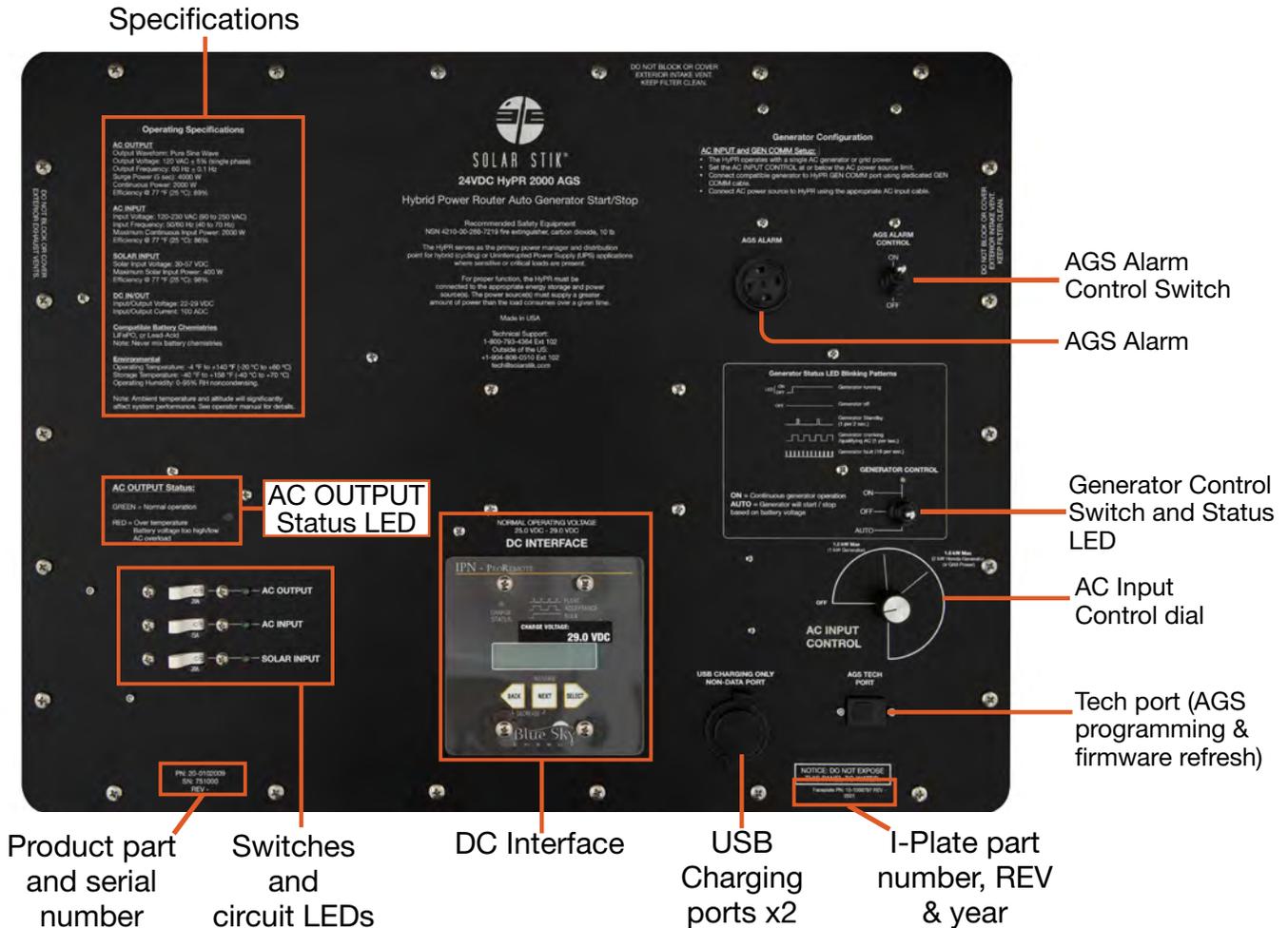


Figure 21. 24VDC HyPR 2000 Faceplate

DC INTERFACE – When operated with a battery, the HyPR 2000 backlit LCD DC User Interface provides data and control for battery and PV-related functions, including battery state of charge (SOC), DC bus voltage, net battery (charge/discharge) current, inverter low-voltage disconnect, and more. It contains a microprocessor that allows it to learn the battery’s behavior over time, increasing accuracy of reported metrics

GENERATOR CONTROL switch – The “ON” position manually turns on a generator; the “Auto” position automatically starts and stops the connected generator based on programmed battery voltage values. The “Off” position defeats the HyPR AGS communication with any connected genset.

Generator Status LED – Displays the current status of a connected generator. A legend correlating blinking pattern with status is immediately above the LED.

AC INPUT CONTROL dial – Allows selection of AC input current limit. This must be adjusted to match the maximum recommended current output limit of the AC power source. Recommended settings are found on HyPR 2000 I-Plate.

AC OUTPUT Status LED – Green indicates the HyPR inverter is operating normally and AC power is available from 120 VAC output ports. A red LED indicates an inverter fault.

AGS ALARM CONTROL Switch – Audible alarm indicates a connected generator is in the process of starting. This alarm may be defeated (toggle switch) when silent operation is required.

USB CHARGING Ports – The USB ports are for charging only; no data are transmitted via these ports.

Breakers / Switches – Breakers serve as switches to activate circuits and to deactivate circuits not in use. Circuit breakers also protect against overcurrent conditions. If too much current flows due to short-circuit, inadequate or improper loading, or component failure, these will protect the System and Operator. The green LED by each breaker will be lit if the circuit is active and the breaker is not tripped.

AGS TECH PORT – This port is used to program the Auto Generator Start/Stop module and to update firmware if/when necessary. Please contact Solar Stik Technical Support for further information.

Specifications – A list of performance metrics and limitations for the HyPR; provides guidance when configuring a System.

DC Interface

The DC Interface consists of an LED that reports the battery charging status, an LCD screen and three (3) menu navigation buttons. System voltage and net current are reported on the DC INTERFACE home screen.

There are some programmable settings that have been programmed for the US Courts application at Solar Stik and should not need to be changed. A description of these settings and their locations in the menu map are shown on subsequent pages. **Note:** the HyPR 2000 must be connected to an active Solar Array to access the full functionality of the DC INTERFACE.

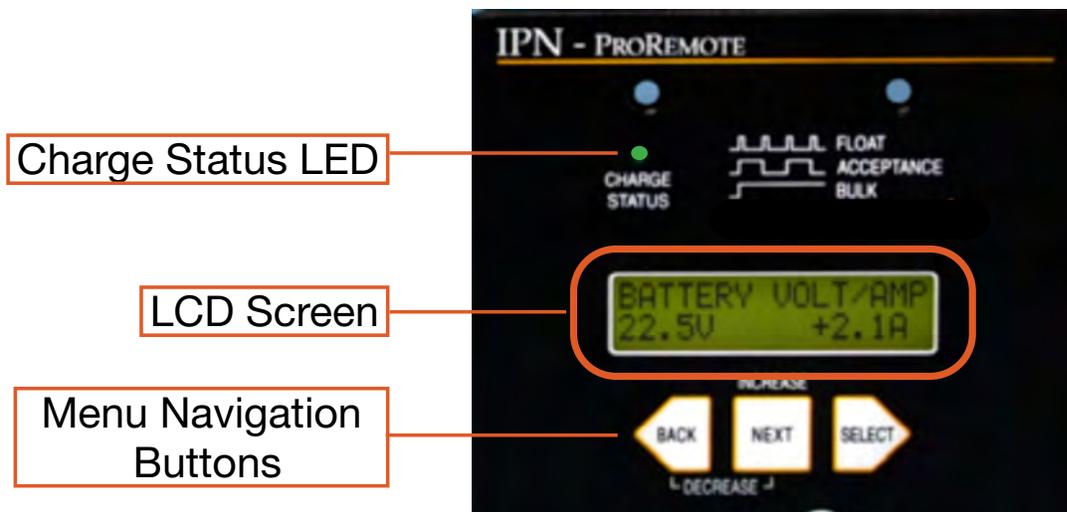


Figure 22. HyPR 2000 DC Interface

Solar Charging Status LED

The user interface charging status LED reports only solar charging.

AC Input Control Dial

This control may be thought of as the battery-charging rate limiter. Adjust this dial to match the maximum output of the AC power source connected to the HyPR. Properly setting this value will prevent overloading the AC power source.

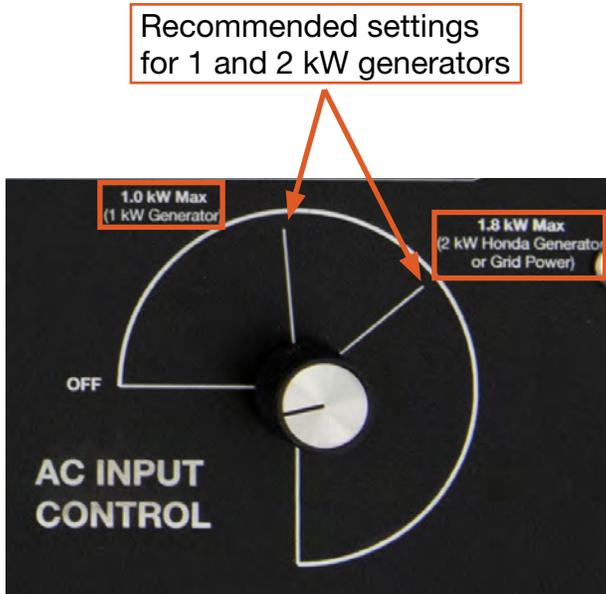


Figure 26. HyPR 2000 breakers

Figure 23. AC Input Control dial and recommended settings

Generator Control Switches

This switch provides manual and automatic control of a connected generator. The AUTO setting allows the System to operate autonomously; the generator running only to recharge System batteries.

Generator operating status is reported by the LED above the GENERATOR CONTROL switch (Figure 24; arrow). The LED blinks slowly when functioning in Auto mode, more rapidly when in manual On mode, and very rapidly when there is a generator fault. The LED does not blink when the switch is in the Off position. The chart above the GENERATOR CONTROL switches (Figure 25) illustrates how the LED blinks in each mode.

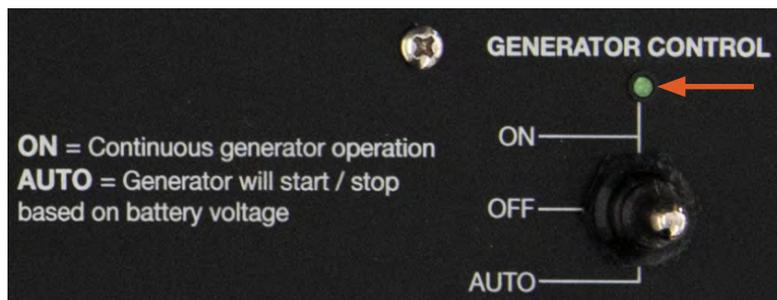


Figure 24. Generator mode control switch and LED

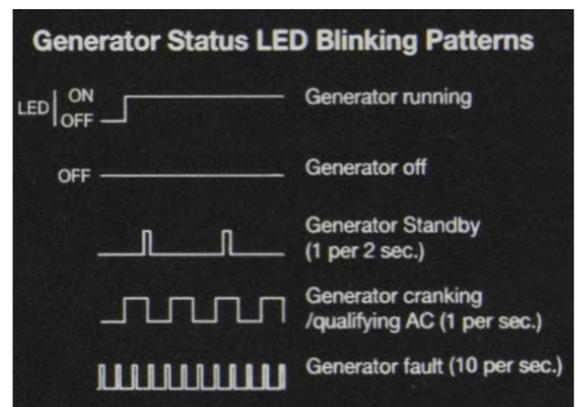
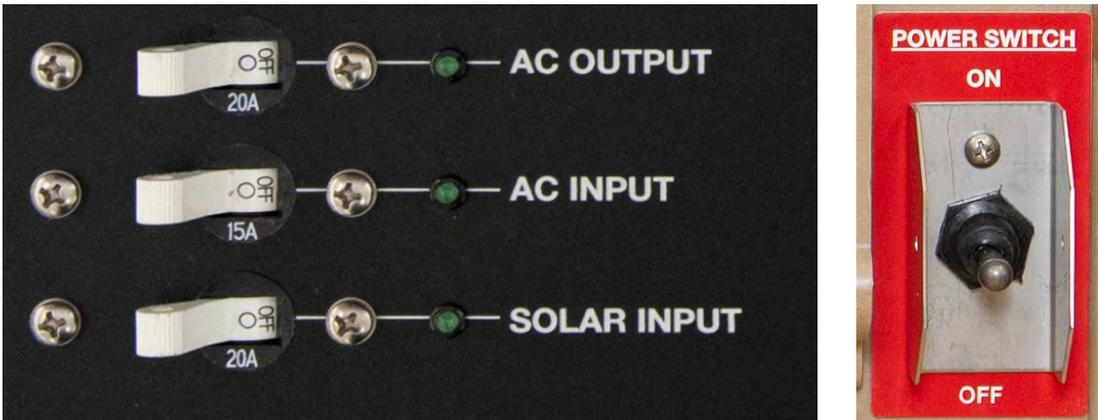


Figure 25. Generator Status LED blinking patterns

Breakers

The HyPR can be configured into a System in many ways. Understanding the function of each breaker and its associated circuit is critical to proper operation. Circuit breaker panel is only for IN / OUT circuit limit protections.



AC OUTPUT 20 A – Limits flow of power from the HyPR inverter to the four (4) AC output receptacles.

AC INPUT 15 A – Limits flow of power from AC power source into HyPR.

SOLAR INPUT 20 A – Limits flow of power from Solar Array into HyPR.

Power Switch 100 A – Limits flow to and from batteries to 100 A.

AC Output/Inverter Status

The LED under AC OUTPUT Status is green when the HyPR inverter is operating normally. A red LED indicates the inverter is in fault mode. The problem causing the fault must be corrected before inverter operation can return to normal.

Possible issues leading to inverter fault include loads exceeding the maximum power output of the inverter or overdischarged Expander Paks.

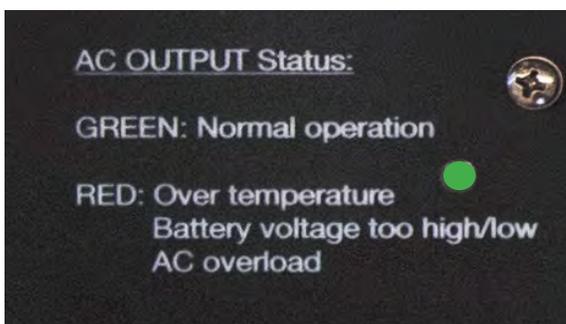


Figure 27. HyPR Inverter / AC OUTPUT status LED

HyPR 2000 Capabilities and Controls Summary

The HyPR features specific capabilities for the system in which it is employed and, while many of the circuits in the HyPR are fully automatic, outside user-established limits, not every HyPR feature may be used in every application.

Most functions and modes are controlled by programmable settings at the User Interface(s).

- “Functions” are related to specific circuits or hardware in the HyPR.
- “Modes” refer to the operational employment of the HyPR circuits.

User Control Functions

The faceplate is divided into two interfaces; the AC and the DC control panels:

- The HyPR AC INTERFACE panel provides complete AC circuit input and output control.
- The HyPR DC INTERFACE panel provides complete DC control, including complete circuit data and metering.

When the main power breaker switch is turned on:

- The HyPR DC INTERFACE will power up and report DC bus voltage and amperage data on the home screen.
- The inverter (DC>AC) will be active, but AC power output is available only when the HyPR AC OUTPUT breaker is engaged.
- The converter (AC>DC; battery charger) will be active, but only operational once the HyPR AC INPUT breaker is engaged.
- The HyPR solar charge controller will be active, but only able to process PV power once the SOLAR INPUT breaker is engaged.

Data Management and Reporting

- **The DC INTERFACE provides complete DC circuit data only when an active PV array is connected.**
- The HyPR DC Interface provides basic DC circuit data, including ESM/bus voltage and net current only when active ESMs are connected.
- DC bus voltage is the only accurately-reported metric from the HyPR DC INTERFACE when ESMs are not connected.

Components listing



(x1) 24VDC Hybrid Power Router (HyPR) 2000
Item # 20-0102009



(x2) 24VDC Li Expander Pak 2400 (x1)
Item # 21-0202303



(x1) 450W Expedition Solar Array Kit
Item # 16-0800105



(x3) Cable, Power, Inter-Connect, 24VDC, 5', 2AWG
Item # 13-0000032



(x1) Cable, Gen Comm, 10-PIN/12-PIN, 10', 18AWG
Item # 13-1000288



(x1) Cable, Solar, MC4/Bayonet, 24VDC, 30', 6AWG
item # 16-0800102



(x1) AC POWER CABLE, 10', 5-15P to 5-15R
Item # 13-1000277



(x1) 24VDC Inter-Connect Strip 7
Item # 13-1000160



(x1) Honda 2KW Generator with RsEK
Item # 19-0401015

System Connection Diagram and Inventory

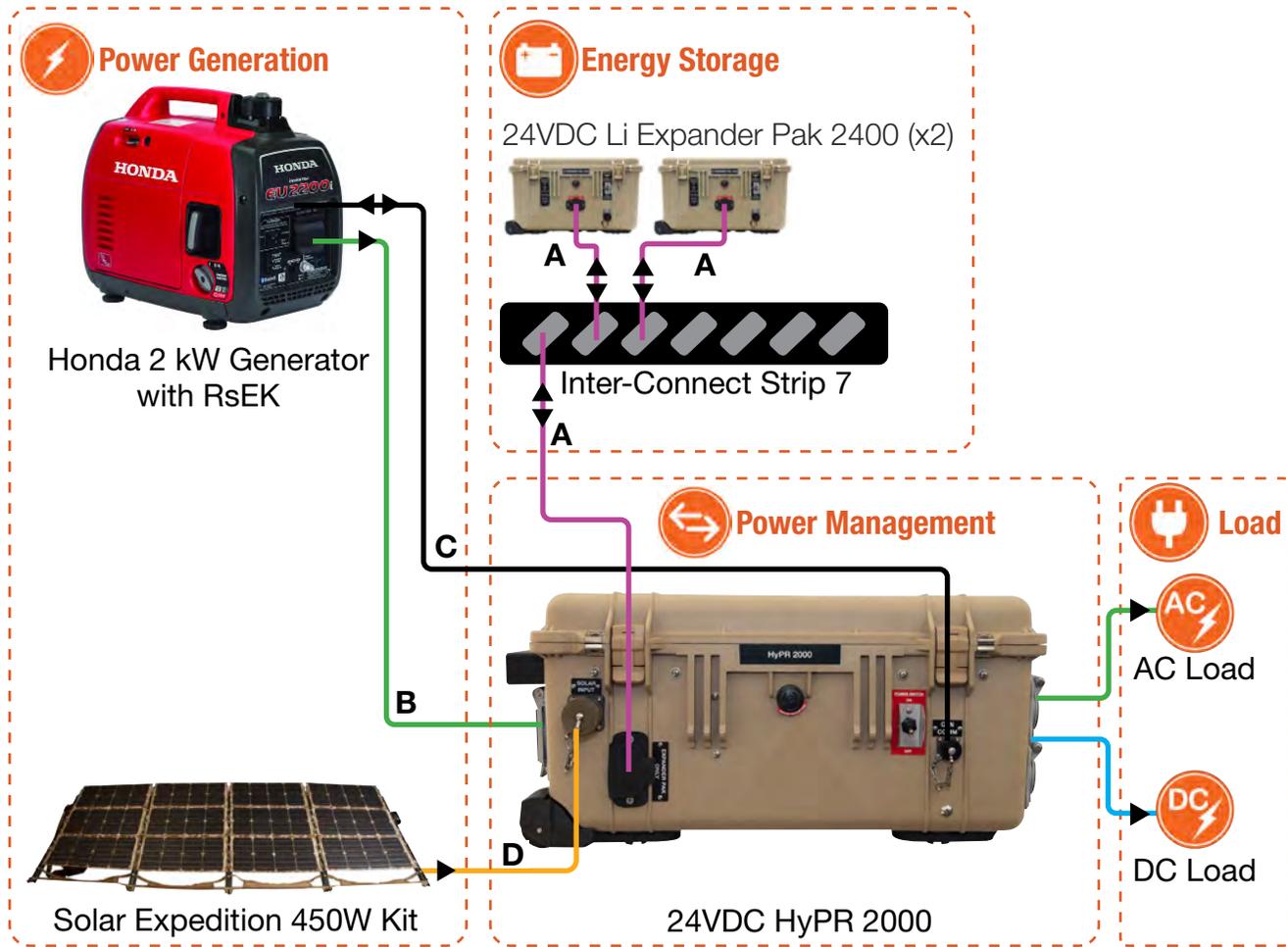


Figure 28. Hybrid Power System connection diagram

Item numbers are printed near the connectors of each cable to aid in assembly. However, each cable is unique and polarized so it is not possible to connect the System in an unsafe way.

Table 1. System inventory

Cable	Item #	Nomenclature	QTY
A	13-000032	CABLE, POWER, INTER-CONNECT, 24VDC, 5', 2AWG	3
B	13-1000277	AC POWER CABLE, 10', 5-15P to 5-15R	1
C	13-1000288	GENERATOR COMMUNICATIONS CABLE, 1kW and 2kW, 10'	1
D	16-0800102	CABLE, SOLAR, MC4/BAYONET, 24VDC, 30', 6AWG	1
-	20-0102009	24VDC HYBRID POWER ROUTER (HyPR) 2000	1
-	16-0800105	SOLAR EXPEDITION 450W KIT	1
-	19-0401015	HONDA 2KW GENERATOR WITH RsEK	1
-	21-0202303	24VDC Li EXPANDER PAK 2400	2
-	13-1000160	24VDC INTERCONNECT STRIP 7	1

Information Plate

The Information Plate (I-Plate) provides concise, abbreviated information for setting up and running a System. All system components should be connected as shown in the diagram on the I-Plate. The diagram illustrates component connections but not the actual physical arrangement of the components for a specific application.



24VDC Hybrid Power Router (HyPR) 2000

System Configuration, Operation, and Safety Information

System Setup

Configure System as shown in System Setup Diagram.

Ensure location of the equipment is in accordance with safety and operation protocols of United States Courts Operations.

Connecting Loads

- Connect AC loads to HyPR 120 VAC OUTPUT ports. The combined output of the four (4) ports should not exceed 2000 W continuous. See table below for maximum recommended AC loads.
- Connect 24 VDC loads to HyPR 24VDC IN/OUT port.

System Operation Hybrid Mode, see Modes of Operation)

- Activate the Hybrid Power System.
 - Toggle each LI Expander Pak 2400 POWER SWITCH to ON.
 - Toggle HyPR POWER SWITCH to ON.
 - Set HyPR AC INPUT CONTROL dial to match output limit of AC power source. The table below provides recommended settings for three (3) potential AC power configurations. Settings maximum. Expander Pak Energy Storage Modules, ESMs charging while protecting the AC source from overload fault ensuring continuity of operation.

Power Source	AC Input Control Setting	Maximum Recommended Continuous AC Load*
1 kW Generator	-0.9 kW	600 W
2 kW Generator or Grid	-1.8 kW	1200 W

* In Hybrid Mode, cycling batteries one (1) to two (2) times in 24-hours.

- Toggle appropriate HyPR switches, AC OUTPUT, AC INPUT, SOLAR INPUT, to ON. LEDs will illuminate, confirming active circuit.

- Initiate System calibration and cycling with generator.
 - Rotate generator ENGINE SWITCH to ON.
 - Rotate vent on generator fuel cap clockwise to ON.
 - Toggle HyPR GENERATOR CONTROL switch to ON position.

Note: Generator will start and stop before running continuously, as part of the warm-up process. Once generator is running continuously for five (5) minutes, proceed to next step.
 - Rapidly toggle HyPR GENERATOR CONTROL switch to AUTO.
 - Allow generator to run and charge ESMs until generator stops automatically.

Note: Charge function begins only after generator is running continuously for five (5) minutes.
 - Note: Generator operation will stop when ESMs are charged fully (-28.0 VDC). Automatic cycling begins. Loads are supported by ESMs until voltage reaches -33.0 VDC, at which point, generator will automatically start to recharge ESMs.

To Use With Solar Input (Solar Only Mode, see Modes of Operation)

- Connect Solar Expedition 450W Kit to HyPR SOLAR INPUT.
- Toggle HyPR SOLAR INPUT switch to ON.

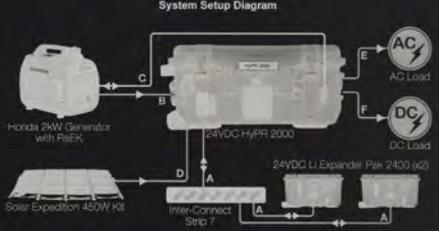
To Use With Grid AC Input Mode, see Modes of Operation)

- Connect AC power source to HyPR 120/230 VAC INPUT port.
- Set HyPR AC INPUT CONTROL to match output limit of AC power source (see table above).
- Toggle HyPR AC INPUT switch to ON. LED will illuminate, confirming AC power is present.
- Confirm charging operation begins after five (5) minutes.

System Deactivation

- Charge ESMs to 100% (-28.0 VDC and -0.6 A).
- Toggle all active HyPR power circuits to OFF.
- Toggle HyPR POWER SWITCH to OFF.
- Toggle each LI Expander Pak 2400 POWER SWITCH to OFF.
- Rotate generator ENGINE SWITCH and fuel vent cap to OFF.
- Disconnect System components and store/transport appropriately.

System Setup Diagram



Cable	Item #	Cable Name	QTY
A	13-0000332	INTER-CONNECT, 24VDC, 5', 2AWG	3
B	13-1000277	AC POWER, 120 VAC, 10', 5-15P to 5-15R	1
C	13-1000288	GENERATOR COMMUNICATIONS, 1AW and 2AW, 10'	1
D	16-0801102	SOLAR, MC4/BAYONET, 24VDC, 30', 6AWG	1
E	N/A	AC Power Output	0
F	N/A	DC Power Output	0

CAUTION

Do not operate with lid(s) open in wet environments.

Shock Hazard

Keep cables and other equipment out of standing water.

NOTICE

- DO NOT STORE ESMs IN A DISCHARGED STATE! Always recharge batteries completely before storage or transport. Regular maintenance charging is critical.
- Failure to connect System architecture in accordance with the System Setup Diagram will result in poor System performance and inaccurate metering of power flow.
- The bank of ESMs connected to System must be able to provide 100 A of current for the HyPR to function at its full rated power output.
- The HyPR can be programmed for use with lithium or lead-acid batteries. **DO NOT mix battery chemistries in a System.**
- High internal temperature will reduce HyPR power processing capabilities.
- SHADE System components (except solar array) from direct sunlight to reduce internal heat.

Modes of Operation

Hybrid Mode
Loads are supported by ESMs. The HyPR automatically starts / stops the generator based on ESM voltage and continuously cycles the ESMs.

Solar-only Mode
The HyPR uses solar input to power loads and charge ESMs. Power into the HyPR must be greater than connected loads over a given time for proper, continuous operation.

UPS Mode
Loads are supported by ESMs when primary AC power source fails. Transfer of load to battery support is instantaneous. The table below provides battery-only runtime.

Battery-only Runtime at Continuous Loads*					
Load Watts	100 W	200 W	300 W	400 W	500 W
Runtime	48 hrs.	24 hrs.	16 hrs.	12 hrs.	9.6 hrs.

* Load watts can be calculated by multiplying System voltage x amperage only when there is no external power input. Values in table above reflect a System with two (2) 24VDC LI Expander Pak 2400s at 100% state of charge.

Troubleshooting
See System manual for additional information.

Symptoms: No power with ESMs connected.
Possible cause: ESMs overcharged and in "block" mode.
Solutions: Connect AC or DC power source to HyPR to charge ESMs. Once ESMs attain charging voltage, they will return to service. Charge ESMs fully before placing on mission.

Symptoms: Generator fails to start.
Possible causes: Fuel issues, vent cap closed, generator ENGINE SWITCH OFF, HyPR GENERATOR CONTROL switch OFF.
Solutions: Once generator issues have been identified and resolved, a 15-minute manual generator run cycle (with no load) is recommended. See manual.

Symptoms: Generator runs continuously in cycling.
Possible causes: HyPR AC INPUT CONTROL setting too low; GENERATOR CONTROL in ON position.
Solutions: Increase HyPR AC INPUT CONTROL setting; toggle GENERATOR CONTROL to AUTO.

Symptoms: Generator overloads and turns off.
Possible cause: HyPR AC INPUT CONTROL setting too high.
Solution: Decrease HyPR AC INPUT CONTROL setting.

Symptoms: HyPR AC power output turns off.
Possible causes: Generator failed to start; load exceeded HyPR AC power output; battery low-voltage disconnect; HyPR overheated.
Solutions: Inspect generator, loads, and settings; allow HyPR to cool down; clean or replace air intake filters.

Monthly Preventive Maintenance Checks and Service (PMCS)

- Charge ESMs fully one (1) time per month.
- Inspect case, cables, and connections for visible damage and missing items.
- Clean excessive dust or dirt accumulation from the exterior, interior, and connectors.
- Close all unused port covers.
- Clean or replace all air intake filters.

Voltage Set Points

Generator

- Start voltage: 25.0 VDC
- Stop voltage: 28.0 VDC

AC Power Output

- Disconnect voltage: 24.0 VDC
- Reconnect voltage: 25.0 VDC

Figure 29. HyPR 2000 I-Plate

OPERATOR INSTRUCTIONS

1. Identify Location for System Components

Ensure location of the equipment is in accordance with safety and operation protocols of United States Courts Operations.

Component Shading

High temperatures result in derating, or diminished capacity and efficiency, of the components. The easiest way to effectively reduce heat buildup is to shade the components as much as possible.



Figure 30. Minimize solar loading

Minimize Potential for Water and Dust Intrusion

ALL Solar Stik equipment is designed for operation in adverse conditions; however, certain rules apply:

- If operating in wet environments, use common-sense placement to avoid water intrusion from flooding or precipitation.
- If operating in dusty environments, ensure good airflow by keeping air filters clean and placing unit in a location that minimizes exposure to particulates.

Solar Stik strongly encourages keeping power management or energy storage component off the ground. If no other placement options are available, preventive measures for water and dust intrusion should be taken. Consult the Maintenance section of this manual for additional details and component-specific Preventive Maintenance Checks and Service (PMCS).

2. Connect System Components

Turn all power switches and breakers to OFF position.

Each cable is unique to its function, point of connection and each connector is polarized. Taken together, these features ensure that the System can only be connected correctly and safely.

That being said, there are two (2) ports to which the Expander Paks could be connected; the one labeled “EXPANDER PAK ONLY” is the better of the two options as this port is metered. The System will operate normally if Expander Paks are connected to the 24VDC IN/OUT port but the USER INTERFACE will not report net battery current.

a. Connect Li Expander Pak 2400s to HyPR 2000.

Use Inter-Connect cables to connect multiple ESMs to an Inter-Connect Strip 7 and to the HyPR 2000 EXPANDER PAK ONLY port.

A single (1) Expander Pak 2400 is enough to power up the HyPR 2000 internal circuits and user interface as well as to support small loads. However, two (2) Expander Pak 2400s must be connected for the HyPR to operate at its full rated capacity.

Note: The total Ah capacity of all connected ESMs must be programmed into the HyPR, using the DC interface, for the HyPR DC interface to report battery SOC accurately.

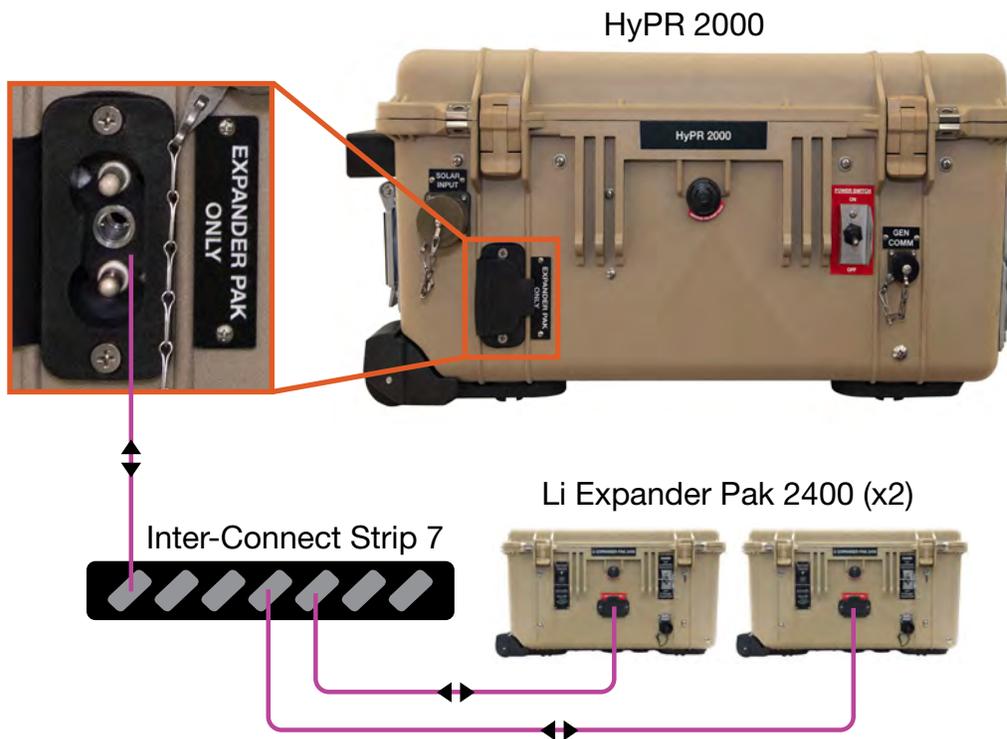
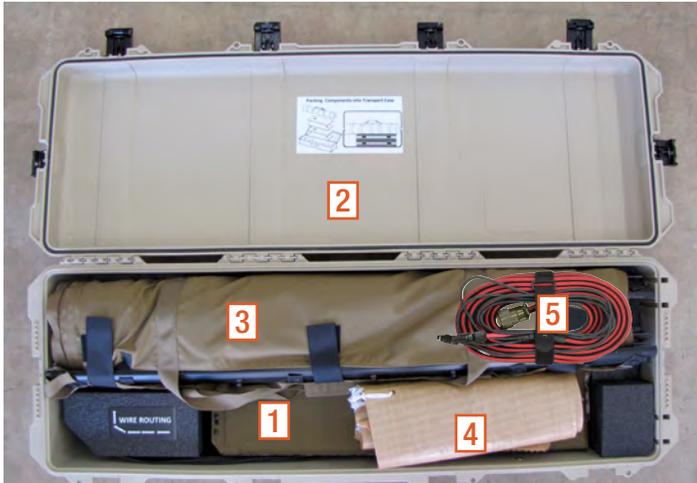


Figure 31. Connecting ESMs to HyPR 2000

b. Setup 450W Solar Array

This Manual provides abbreviated details on assembling the 450W Solar Expedition Array. It is critical to be familiar with the detailed information in the Array Manual to successfully assemble and integrate the Array in to the System.

Unpack and inventory the Array components.



Expedition 450 W Array Kit	
1	(4 ea) 112 W Trifold Photovoltaic (PV) Solar Panel
2	Transport Case
3	Rollable Stand
4	(12 ea) Sandbags and (10 ea) Tent Stakes (inside sandbag)
5	30' Solar Leash (sold separately)



Figure 32. Expedition components in transport case (top) and unpacked (bottom)



Figure 33. Sandbag (left) and tent stakes (right)

After assembling the Array, connect Panels in series using the diagram below. There will be one (1) free connector at each end of the rack of panels*. Connect these two (2) free ends to the appropriate connectors of the 30' Solar Leash.

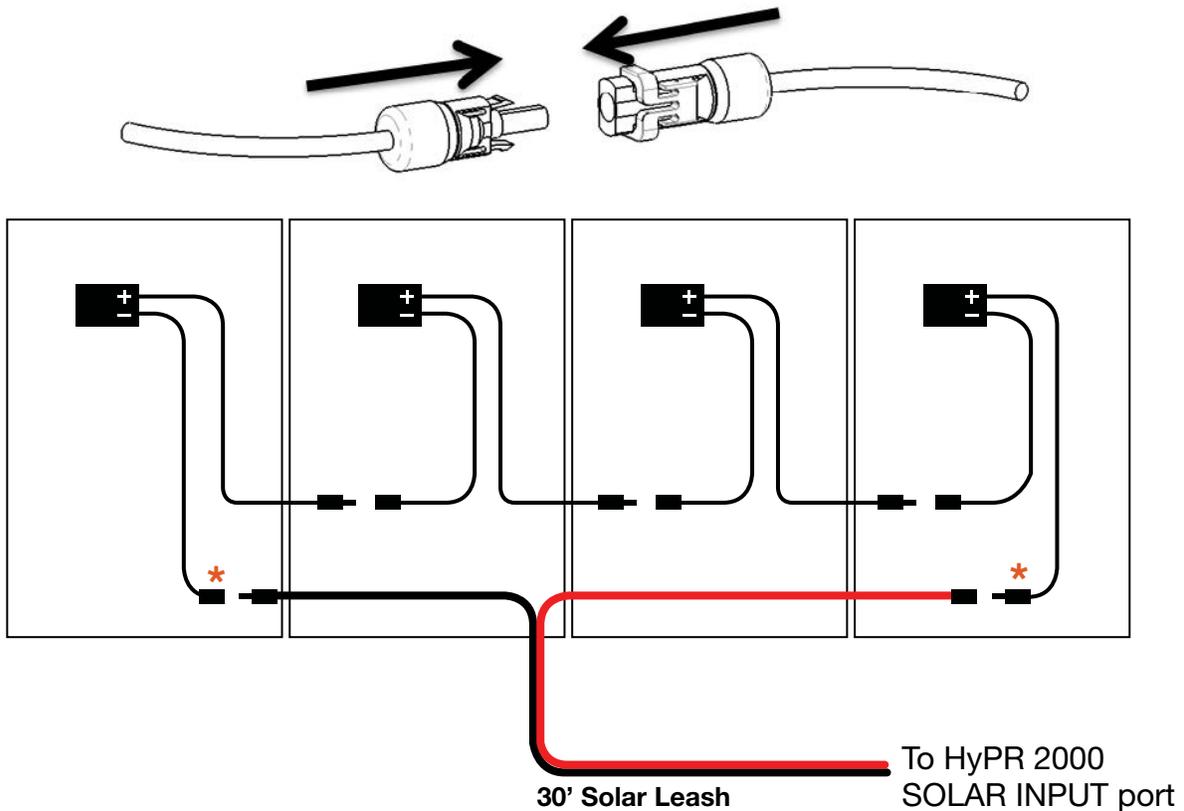


Figure 34. Solar Array series connection diagram

c. Connect Solar Array to HyPR

Connect Solar Expedition Array to the HyPR 2000 using the 30' Solar Cable.

Note: Solar array must be connected for the DC Interface to calculate and report ESM SOC. Disconnect arrays from HyPR when not in use.

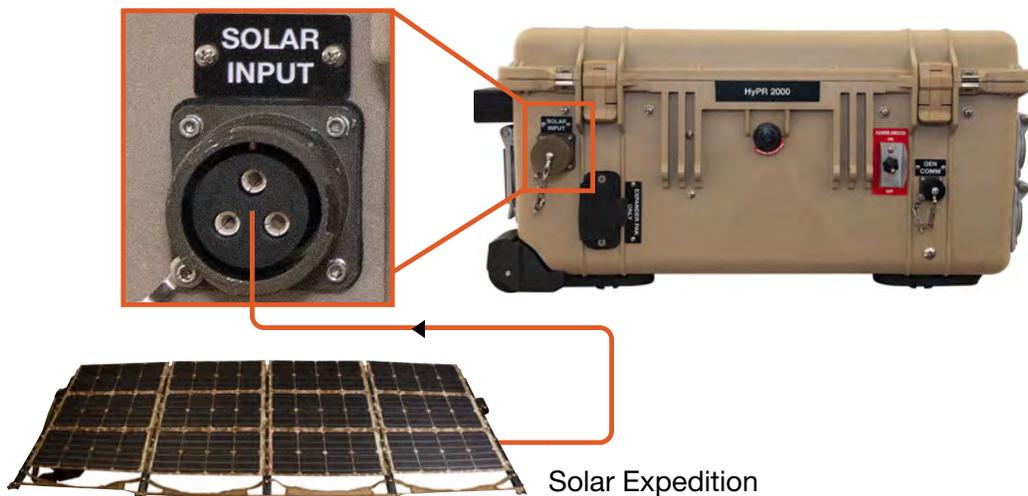


Figure 35. Connecting PV arrays to HyPR 2000

d. Connect Generator to HyPR: Power & Comms

Power: Connect power cable (13-1000277) to HyPR 120 - 230 VAC INPUT” port and one (1) of the two (2) generator AC OUT 120V 15A ports. **Comms:** Connect Generator Communications cable (13-1000288) to HyPR GEN COMM port and generator GEN COMM port.



Figure 36. HyPR-Generator connection

e. Connect AC Loads to HyPR

Connect AC loads to one (1) or more of the four (4) 120 VAC, 20 A receptacles. Loads connected to all of these ports should not exceed 2000 W continuous.

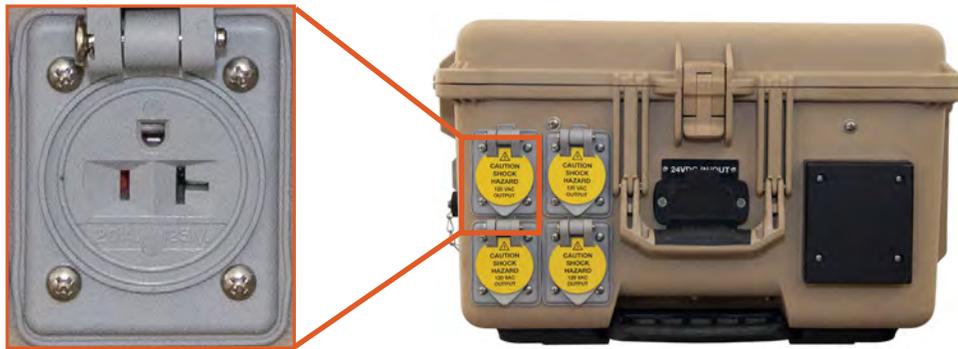


Figure 37. Connecting AC loads to HyPR 2000

3. Generator Setup and Operation

Note: This generator has been modified with an automatic choke mechanism. Moving the choke lever manually will not damage the mechanism and may be required when starting generator manually.

a. Before operating the generator:

- Check oil level. Fill or change as necessary.
- Check air filters. Clean or replace as necessary.
- Check fuel level. Fill as necessary.

b. Generator warm up and testing in manual mode.

- i. Toggle generator GEN COMM switch to MANUAL.
- ii. Toggle generator ECO THROTTLE switch to OFF.
- iii. Rotate generator fuel vent cap clockwise to ON.
- iv. Rotate generator ENGINE SWITCH to ON.
- v. Close choke.
- vi. Start generator with pull cord. Allow 15-minute warm up. Open choke, as appropriate, during warm up period.

c. Prepare generator for automatic operation with System.

- i. Toggle generator GEN COMM switch to AUTO.
- ii. Toggle generator ECO THROTTLE switch to OFF.
- iii. Rotate generator fuel vent cap clockwise to ON.
- iv. Rotate generator ENGINE SWITCH to ON.

Note: These settings must be maintained while the System is idle for normal, automatic System operation.

Generator is now ready to operate autonomously with the Hybrid Power System.



Figure 38. Prepping the 2 kW generator for operation

4. SYSTEM OPERATION

a. Activate the Hybrid Power System.

- i. Toggle each Li Expander Pak 2400 POWER SWITCH to ON.
- ii. Toggle HyPR POWER SWITCH to ON.
- iii. Set HyPR AC INPUT CONTROL dial to match output limit of AC power source. Table 2 provides recommended settings for three (3) potential AC power input/output configurations. Settings maximize Expander Pak (Energy Storage Modules; ESMs) charging while protecting the AC source from overload fault ensuring continuity of operation.
- iv. Toggle appropriate HyPR switches, AC OUTPUT, AC INPUT, SOLAR INPUT, to ON. LEDs will illuminate, confirming active circuit.

b. Initiate System calibration and cycling with generator.

- i. Rotate generator ENGINE SWITCH to ON.
- ii. Rotate vent on generator fuel cap clockwise to ON.
- iii. Toggle HyPR GENERATOR CONTROL switch to ON position.
Note: Generator will start and stop before running continuously, as part of the warm-up process. Once generator is running continuously for five (5) minutes, proceed to next step.
- iv. Rapidly toggle HyPR GENERATOR CONTROL switch to AUTO.
- v. Allow generator to run and charge ESMs until generator stops automatically.
Note: Charge function begins only after generator is running continuously for five (5) minutes.
Note: Generator operation will stop when ESMs are charged fully (~29.0 VDC).
- vi. Automatic cycling begins: Loads are supported by ESMs until voltage reaches ~25.0 VDC, at which point, generator will automatically start to recharge ESMs.

Table 2. HyPR AC INPUT CONTROL settings

Power Source	AC Input Control Setting	Maximum Recommended Continuous AC Load*
1 kW Generator	~0.9 kW	600 W
2 kW Generator	~1.8 kW	1200 W

Operational Considerations

Circuit breakers on faceplate are only for IN/OUT circuit limit protections. They are NOT “function controls” or “function protections”.

The internal DC Bus is limited to 100 A total current flow. This may restrict some HyPR functionality in certain operating modes.

Current flow on the DC bus is controlled by voltage. Power will always be prioritized to the loads and will only cease when the voltage drops to low-voltage disconnects controlled by the DC Interface AUX circuit, the battery’s internal battery management system (BMS).

System recovery from overdischarged batteries is possible using AC power or alternative 24 VDC power sources. System recovery using PV power is not an option.

AC power output fluctuates based on temperature (heat derating = efficiency loss).

System Monitoring

The DC Interface consists of an LED that reports **solar charging status** (see Table 3 for a functional description), an LCD screen and three (3) menu navigation buttons. **This LED does not report charging by the internal, AC-powered battery charger.**

- **The DC INTERFACE provides complete DC circuit data only when an active PV array is connected.**
- The HyPR DC Interface provides basic DC circuit data, including ESM/bus voltage and net current only when active ESMs are connected.
- Current (AMPS) value reported is only net current to/from ESMs.
- Current (AMPS) will be zero (0) when no ESMs connected.
- The Solar Charging Status LED report only solar charging status.
- The Solar Charging Status LED will not illuminate when the HyPR 2000 is using AC power to charge ESMs.

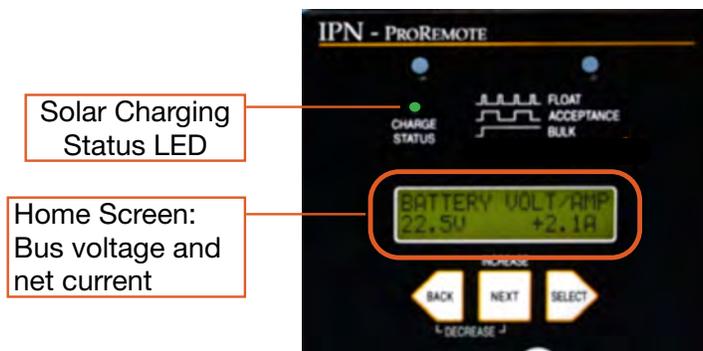


Figure 39. HyPR 2000 DC Interface

Note: the HyPR 2000 must be connected to an active solar array to access the full functionality of the settings and readouts in the DC Interface menus.

Without solar input, use only home screen to monitor DC bus voltage and net System current.

Table 3. Charge Status Indicator—LED Status

Solar Charging Status LED	Charge Mode
Off	Charge Off
Continuously On	Bulk
Blinking – 1 second On / 1 second Off	Acceptance
Blinking – 0.2 second On / 1 second Off	Float

Bulk Charge: During bulk mode, the charge controller can deliver full output to rapidly recharge ESMs to the established acceptance charge voltage. This stage typically takes the battery to about 75% State of Charge (SOC) and at a rate not usually exceeding 25% of the battery’s amp hour capacity. This is also known as the “constant current phase”.

Acceptance Charge: In this stage, the charge current gradually decreases as the batteries obtain full charge. It is also known as the “constant voltage phase”. The Li Expander Pak 1300 does not require an acceptance charge.

Float Charge: This final charging stage compensates for the battery’s self-discharge and temperature.

Temperature and Power Output: The HyPR 2000 charge controller charge controller can deliver full output in an ambient temperature of up to 40 °C (104 °F). If an overtemperature condition exists, the charge controller will cycle on/off, reducing average power delivery to within safe limits. During thermal shutdown, the charge status indicator will display an OFF condition.

State of Charge (SOC) Calculation and Display

The HyPR 2000 calculates and reports battery bank SOC only after they are charged to float voltage (~29.0 VDC) with solar power. The HyPR will not report an SOC if ESMs are not charged to float with solar power. After the SOC is determined, the DC Interface will monitor and adjust the SOC value as power flows in and out of the ESMs.

Each time the HyPR power is cycled, the DC Interface is reset and it must “re-learn” the SOC.

Note: the total amp-hour (Ah) capacity of the bank of Expander Paks must be programmed into the DC Interface for the HyPR 2000 to accurately calculate battery bank SOC. Each Expander Pak 2400 has 100 Ah capacity. To determine total amp-hours, multiply the 100 Ah capacity by the number of Expander Paks in the battery bank of the System.

Expander Pak 2400 Status

Expander Pak status may be determined when connector or disconnected to the System and the Power Switch is ON (Figure 40). Press display button to illuminate LED (Figure 40). See Table 4 for interpretation of LED report.



Figure 40. Li Expander Pak power switch and Battery Status Indicator LED

Table 4. Battery Status LED Color and Corresponding Condition

Color	Frequency	Condition
Green	Flashing	Normal operation
Red	Flashing	Protection circuits engaged: 1. Cell overvoltage 2. Cell undervoltage 3. Overcurrent (charge or discharge) 4. Overtemperature (> 160 °F/71 °C) 5. An internal battery fault (such as a broken wire, etc.)
None	N/A	Expander Pak power switched off, battery inoperative

Generator Status LED

The LED above each HyPR GENERATOR CONTROL Switch on the Faceplate blinks slowly when functioning in **Auto mode**, more rapidly when in manual **On mode**, and very rapidly when there is a generator **fault**. The LED does not blink when the switch is in the Off position. The chart above the GENERATOR CONTROL switches illustrates how the LED blinks in each mode.

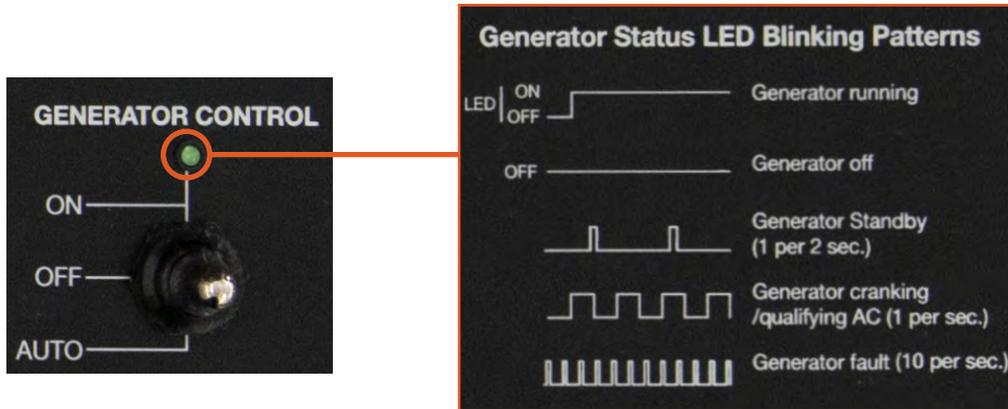


Figure 41. Generator Status LED and explanation of blinking patterns

HyPR Circuits Status LEDs

The status LEDs associated with each breaker are load-side indicators of circuit activity. None of these LED will be illuminated when associated breaker is in OFF position. An illuminated LED signifies output from the circuit is present.

AC OUTPUT - Illuminated when there is power to the 120 VAC OUTPUT ports and breaker in ON position. This LED will turn off when the HyPR inverter is in fault and the AC OUTPUT Status LED just above is red.

AC INPUT - Illuminated when there is AC power from generator or shore power connected to AC INPUT port and breaker in ON position.

SOLAR INPUT - Illuminated when there is power from Solar Array and breaker is in ON position.

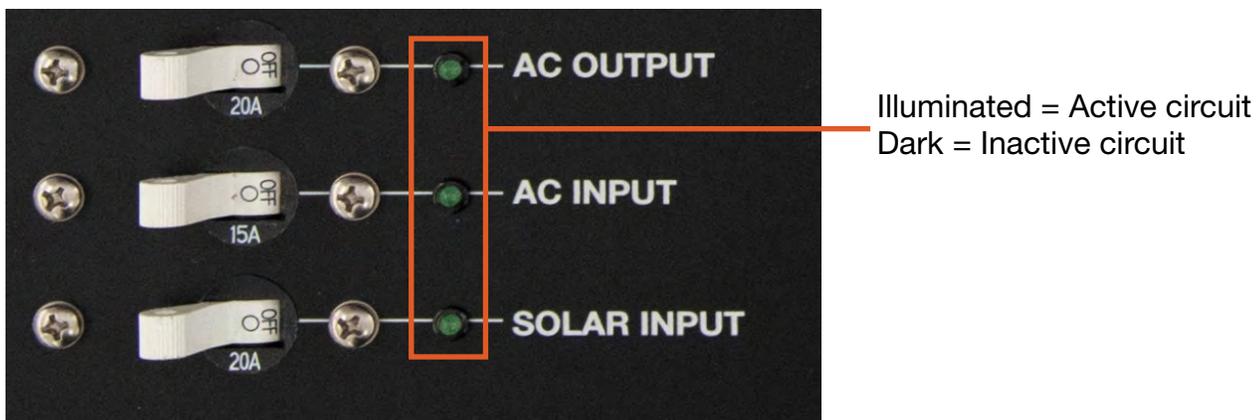


Figure 42. HyPR 2000 breakers shown in OFF position

Inverter Status: AC Output Status LED

The LED under **AC OUTPUT Status** is green when the HyPR inverter is operating normally. A red LED indicates the inverter is in fault mode. The problem causing the fault must be corrected before inverter operation can return to normal.

Possible issues leading to inverter fault include loads exceeding the maximum power output of the inverter or overdischarged Expander Paks.

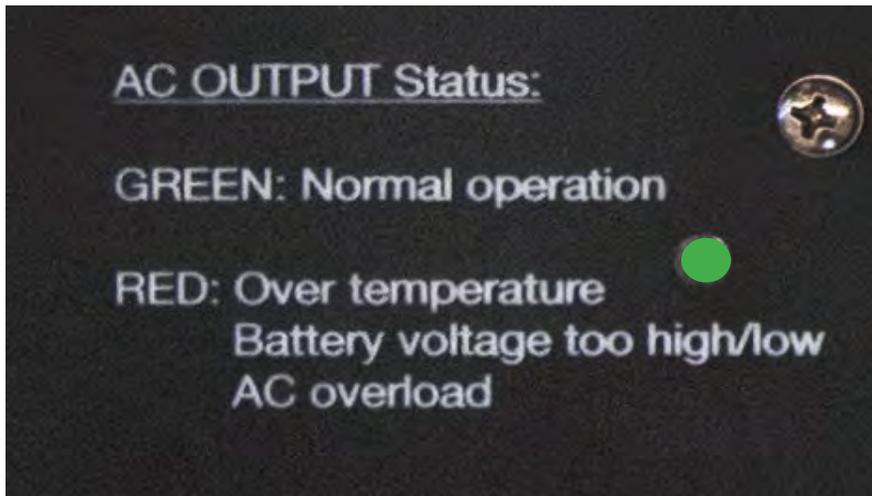


Figure 43. HyPR Inverter / AC OUTPUT status LED

System Deactivation

1. Charge ESMs to 100% (~29.0 VDC and ~1.0 A).
2. Toggle all active HyPR power circuits to OFF.
3. Toggle HyPR POWER SWITCH to OFF.
4. Toggle each Li Expander Pak 2400 POWER SWITCH to OFF.
5. Rotate generator ENGINE SWITCH and fuel vent cap to OFF.
6. Disconnect System components and store/transport appropriately.

To Use With Solar Input (Solar Only Mode, see Modes of Operation)

1. Connect Solar Expedition 450W to HyPR SOLAR INPUT.
2. Toggle HyPR SOLAR INPUT switch to ON.

To Use With Grid AC (UPS Mode, see Modes of Operation)

1. Connect AC power source to HyPR 120/230 VAC INPUT port.
2. Set HyPR AC INPUT CONTROL to match output limit of AC power source (see table above).
3. Toggle HyPR AC INPUT switch to ON. LED will illuminate, confirming AC power is present.
4. Confirm charging operation begins after five (5) minutes.

TROUBLESHOOTING

Issues most likely to be encountered

Symptom: AC circuit not operating as anticipated.

Cause: Circuit breaker not set properly.

Solution: Set circuit breaker properly.

Symptom: No power with ESMs connected.

Cause: ESMs overdischarged and in “protect” mode.

Solution: Connect AC and/or DC power source to HyPR to charge ESMs. Once ESMs detect charging voltage, they will return to service.

Symptom: Generator fails to start.

Cause: Fuel issues; vent cap closed; generator power switch off; generator starter battery overdischarged

Solution: Troubleshoot generator. Once generator issues have been identified and resolved, a 15-minute manual generator run cycle (with no load) is recommended.

Symptom: Generator runs continuously (no cycling)

Cause: AC INPUT CONTROL setting too low or; GENERATOR CONTROL in ON position.

Solution: Increase AC INPUT CONTROL setting; toggle GENERATOR CONTROL to AUTO.

Symptom: Generator overloads and shuts down

Cause: AC INPUT CONTROL setting too high

Solution: Decrease AC INPUT CONTROL setting.

Symptom: AC output turns off

Cause: Generator failed to start; load exceeds inverter output; low-voltage disconnect; inverter overheated,

Solution: Inspect generator, loads, and settings; allow inverter to cool down.

2 kW Generator Troubleshooting

Choke Fault LED

If CHOKE FAULT LED on generator illuminates, the automatic choke mechanism failed to engage or disengage fully. To reset choke mechanism and CHOKE FAULT LED, toggle GENERATOR CONTROL switch from AUTO to MANUAL (pause 5 seconds) then back to AUTO. For all other faults, consult Honda Generator OEM Operator and Maintenance Manual.

If generator starts and runs normally for ~10 minutes then unexpectedly stops running, check fuel cap vent to ensure it is open.

PREVENTIVE MAINTENANCE CHECKS AND SERVICE (PMCS)

24VDC HyPR 2000 PMCS

Table 5. HyPR 3000 Preventive Maintenance Checks and Services

Item #	Item to be Inspected	Interval	Procedures	Non-mission Capable
1	Visual inspection of 24VDC HyPR 2000	M	<ol style="list-style-type: none"> 1. Inspect case for visible damage and missing items. 2. Clean excessive dust or dirt accumulation from the exterior, interior and all connectors. 3. Close all unused connector covers. 	~If the case is broken or split or if connectors are damaged, do not place into service.
2	Air Intake Filters	M ¹	<ol style="list-style-type: none"> 1. Remove the two (2) air intake filters. 2. Wash with water and dry the filter. Reinstall. 3. If the filter is damaged or cannot be cleaned --replace it. 	~If the filter cannot be cleaned, is too damaged to function properly and a replacement is not immediately available, the unit is partially mission capable. Replace the filter as soon as possible to restore the unit to fully mission capable.

HyPR 2000 Air Intake Filter Maintenance`

There is one (1) air intake filter on the back of the HyPR 2000 (the vent on the left side of the HyPR is an exhaust fan and has no vent filter). Use a #2 cross tip screw driver to remove four (4) fasteners from vent cover (A). Removing these fasteners will remove vent cover and a metal grate that prevents ingress of small critters (B, C). The foam filter is attached to the case with adhesive tape (D). Carefully remove and clean or replace filter then reinstall vent assembly.

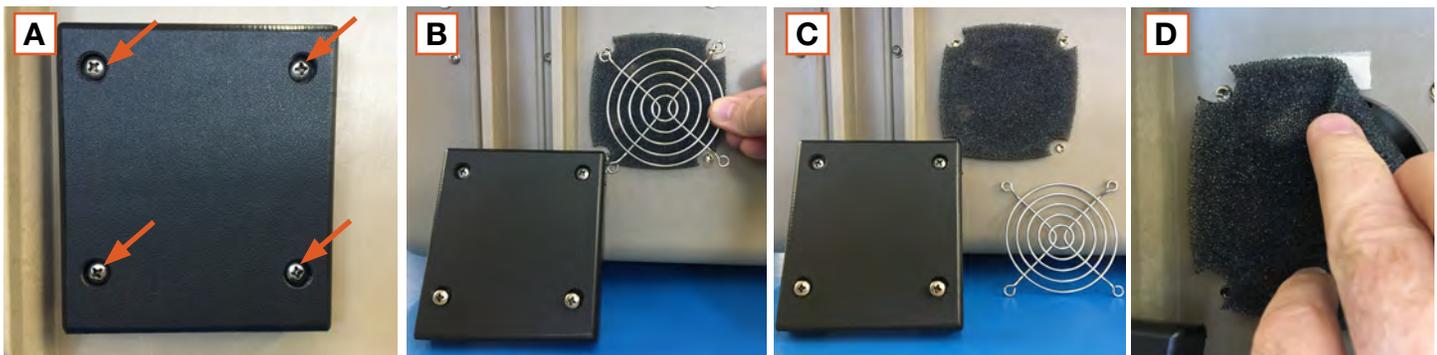


Figure 44. Cleaning/replacing HyPR 2000 air intake vent filter

Solar Expedition 450

The Solar Array does not require a complex program for PMCS. Following the Preventive Care and Maintenance protocol below and using common sense will ensure proper function and long lifetime. The Operator and Maintenance Manual for the Solar Expedition 450W provides additional information on troubleshooting and maintenance.

Preventive Care and Maintenance

- Ensure the solar panels are clean and positioned for maximum daily sunlight exposure.
- Use the Velcro straps to secure the Solar Leashes and provide strain relief at locations where the leashes are stressed.
- Check the integrity of electrical connectors on a monthly basis.

2 kW Honda Generator PMCS

Consult Honda Generator OEM Operator and Maintenance Manual for details regarding periodic maintenance checks and services (PMCS).

Preventive Care and Maintenance

Start generator manually each month and run for 15 minutes.

Two methods to manually start generator:

- Toggle HyPR GENERATOR CONTROL switch to ON.
- Toggle generator GEN COMM switch to MANUAL and start using pull cord. Manual choke closure may be required for starting.

24VDC Li Expander Pak 2400 In-storage PMCS

Failure to follow these instructions may result in permanent equipment failure and/or personal injury.

Required Tools

Solar Stik PRO-Verter or LiFePO4 battery maintenance charger.

Table 6. In-storage Preventive Maintenance Checks and Services

Item #	Item to be Inspected	Interval* at 91-140 °F (33-60 °C) Storage Temp	Interval* at 77-90 °F (\leq 25-32 °C) Storage Temp	Procedures	Non-mission Capable
1	Visual inspection of 24VDC Li Expander Pak 2400	M ¹	Q ²	<ol style="list-style-type: none"> Inspect case for visible damage and missing items. Clean excessive dust or dirt accumulation from the exterior and ports. Close all unused port covers. 	~If the case is broken or split or if ports are damaged, contact Solar Stik Technical Support for advice on how to proceed.
2	Battery Status LED color	M	Q	<ol style="list-style-type: none"> Push and hold the Battery Status LED button. Record the color of the Battery Status LED in the maintenance/service log If the Battery Status LED is flashing red on any Li Expander Pak, proceed to Item #3. 	~If the Battery Status LED emits no light, contact Solar Stik Technical Support or FSR.
3	In-storage maintenance charging	Q	S ³	<ol style="list-style-type: none"> Charge Li Expander Paks for 24 hours at 29.0 V. Follow the instructions for the lithium battery charger used. Charge until the Battery Status LED on all Li Expander Paks is flashing green (if flashing red to begin with). If the Battery Status LED flashes red on any Li Expander Pak after 24 hours, continue charging all Li Expander Paks for another 24 hours. 	~If any Li Expander Pak has a red-flash Battery Status LED after 48 hours of charging OR if the LED emits no light after charging, contact Solar Stik Technical Support.

¹Monthly (M)—every month ²Quarterly (Q)—every three months ³Semiannually (S) – every 6 months

Expander Pak Storage

There is a simple rule to remember about maintaining the Expander batteries:

Never store an Expander Pak in a discharged state! Charge the Expander Pak fully before placing it in storage.

Other than keeping the battery fully charged during storage, an LiFePO_4 -type of battery does not require any type of maintenance by the operator.

The Expander Pak has a relatively low self-discharge rate at 77 °F (25 °C) and can be stored for up to one (1) year at this temperature before it needs to be recharged. However, the self-discharge rate increases as the storage temperature increases. See In-storage Preventive Maintenance Checks and Services for complete specific charging instructions for a particular Expander Pak battery chemistry.

Note: If the Expander Pak is stored at temperatures above 91 °F (33 °C), then the time between maintenance checks and / or charges must be reduced to three (3) months.

In-Storage Charging Procedures:

Charge one—charge all. It is important to maintain an equal level of health between all Expander Paks in a System. If one (1) Expander Pak in a System needs to be charged during storage, it is likely that any/all others will also need to be charged. Charging all of the Expander Paks until they meet the criteria of being charged fully will maintain balance and equality among them.

CAUTION

Do NOT leave Li Expander Paks on a constant charge during long periods of storage. Cell damage may occur. Once the battery reaches 100% SOC during maintenance charging, the charging source should be removed until the next charging interval.

How to Charge Expander Pak 2400s

The HyPR 2000 can charge Expander Paks using DC and/or AC power sources. Expander Paks will charge to full more rapidly when all loads are either disconnected or turned off. The 85-264 VAC INPUT, SOLAR INPUT, and 24VDC IN/OUT. Battery charging rates among these connections will vary. The solar charge controller and the AC > DC converter/charger are programmed to charge batteries at 29.0 and 29.5 VDC respectively. Any DC charging source connected to the 24VDC INPUT/OUTPUT should have a ~ 29.0 VDC charging voltage set point. Connected batteries are charged fully when voltage is 28.8 - 29.0 VDC and current is less than 3 amps as reported on the DC Interface.

Charging from an AC power source provides 70 A (if the AC power source can provide that much current) at 29.5 VDC; charging from Solar power provides a ~14 A at 29.0 VDC. So, charging from an AC source will likely be faster, but charging using solar power is cheaper.

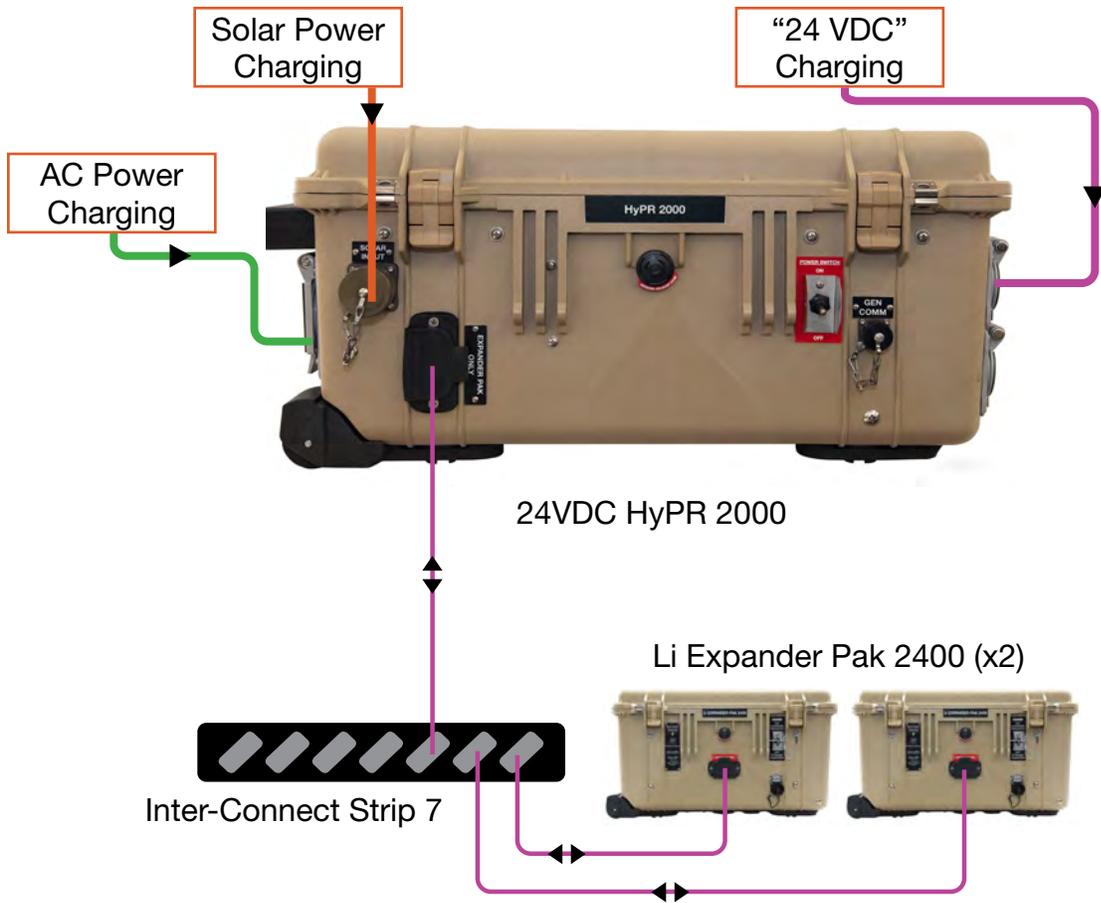


Figure 45. Charging Expander Paks with HyPR 2000

Water Intrusion Remediation

If water intrusion is suspected, and the System is still functional, disconnect power sources entering the HyPR 2000 from the most distant location possible, power down the System (turn off the power switches on all of the System components) and then disconnect the HyPR 2000 from the System. Do not move or relocate what may be a flooded HyPR 2000.



Figure 46. Drain plug screw located under the TECH PORT

Keep the HyPR 2000 as level as possible to prevent the water inside from accumulating at one end or the other and submerging the internal electronics. Remove the screw from the drain hole at the bottom edge of the case. If water flows out of the drain hole after removal of the plug, let it flow until it stops. Then slightly and slowly tilt the case toward the drain hole to remove any remaining water. Continue to increase the angle of the HyPR 2000 slowly until no more water drains from the hole. After the water has been drained, remove the Faceplate. Place the HyPR 2000 in the driest environment possible for a period sufficient to ensure full evaporation of any remaining water. When the HyPR 2000 is completely dry, reconnect it to the System and test to determine if it is still functional.

Transporting the HyPR 2000

The HyPR 2000 transports like a briefcase or rolls on wheels when transport handle is extended. It is safe for all modes of transportation, including land, sea, and air. There are no transport restrictions.



Figure 47. HyPR transport wheels and pull-handle

SUPPLEMENTAL INFORMATION

Navigating DC User Interface Menus

The user interface has four main menus:

1. General Information
2. Advanced Information
3. Operation Setup, and
4. Battery Charger Parameter Setup.

The Home screen is in the General Information menu.

To move forward through screens in a menu, press NEXT. It is only possible to move forward through the menu items.

To move to the top of a menu, press BACK. Pressing BACK does not move “back” one menu screen. Instead, it moves to the top of the current menu or to the top of the higher menus when BACK is pressed repeatedly.

To move to the “next” menu, press and hold SELECT for 4 seconds.

To change settings/parameters in the Operation Setup and Battery Charger Parameter Setup menus, move forward through the menus (using the steps above) to the menu window that contains the desired parameter. Then do the following:

*Press and hold SELECT for 4 seconds. “SETTING” blinks.

*Change the value.

- To increase a value, press NEXT. (The word “Increase” is above the NEXT button on the interface.)
- To decrease a value, press and hold NEXT, then press and tap or hold BACK. (The word “Decrease” is below the NEXT and BACK buttons on the interface.)

To exit the selected menu screen, press and hold SELECT for 4 seconds

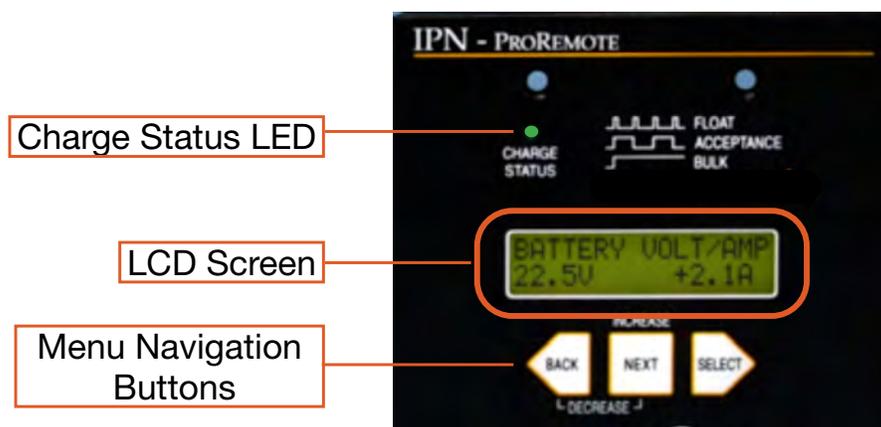


Figure 48. Navigating the DC Interface

Programmable Parameters

These settings are programmed by Solar Stik in accordance with the intended application. If changes to the intended application are required, please contact Solar Stik Technical Support for assistance with these settings. Please consult the Operator and Maintenance Manual for the HyPR 2000 for a detailed description of all HyPR User Interface Menu options.

Parameters that may need to be set or confirmed are (orange outline windows Figure 49):

SET BAT AMP-HRS – The value in this window should be the cumulative Ah capacity of the battery bank connected to the HyPR.

SET AUX OUT OFF/ON – The “OFF” value is the battery low-voltage cut off (LVCO). These values are set to protect the battery from overdischarge. The “ON” value is the voltage at which the HyPR resumes battery support of loads.

SET ACCEPT CHG and SET FLOAT CHG – These values will vary depending on the System battery type.

Read-only Parameters

The first screen under General Information Menu is the Home Screen. It displays the DC bus voltage (battery voltage in the absence of a charging source or load) and the net current. A detailed description of each menu item may be found in the Operator and Maintenance Manual for the HyPR 2000.

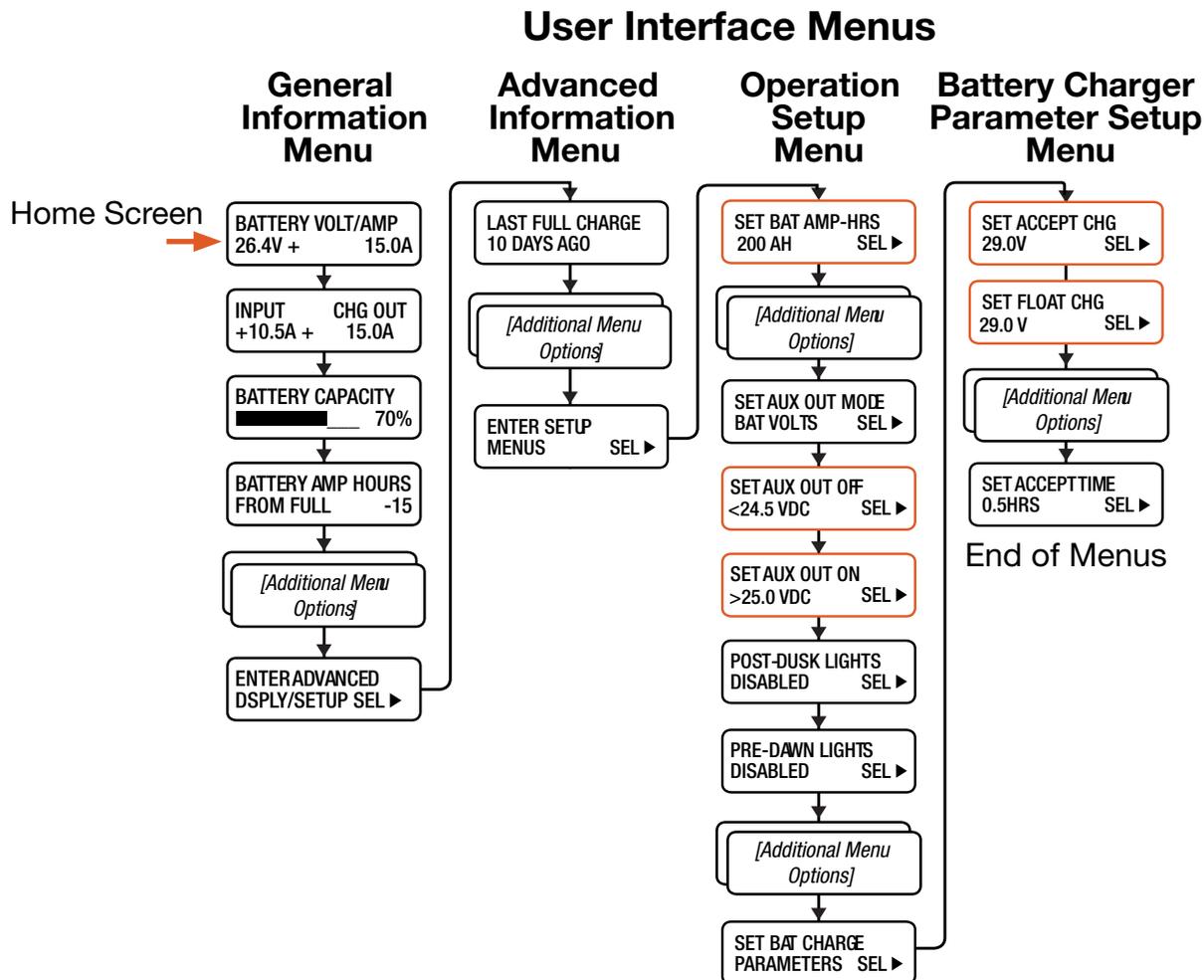


Figure 49. Abbreviated HyPR DC Interface Menu Map

ABOUT SOLAR STIK, INC.



SOLAR STIK®

Mission Statement

Using American-made components and constant innovation, Solar Stik creates portable power solutions that enable self-sufficiency for the soldier, the sailor, and beyond. In doing so, we save lives, change lives, and help revive American manufacturing.

STIKopedia

[STIKopedia](#) is a compilation of everything you would ever want to know about portable Hybrid Power Systems, including the philosophy and mechanics of high-efficiency circuits, and the individual technologies used to create them.

Solar Stik Training and Education

- **Solar School (St. Augustine, FL)** provides an introduction to the design and support of small-scale, renewable-energy, power generation systems, with detailed explanation of system components. Advanced configuration options with hands-on deployment of actual systems will enhance student understanding.
- **Solar Stik New Equipment Training (on site)** teaches Hybrid System configuration options with hands-on deployment of actual systems to enhance student understanding.

Solar Stik Training Courses are tailored to the specific needs of the students. To schedule Solar Stik Training or to learn more about the curriculum, please contact us.

Contact

Technical Support:

1-800-793-4364 Ext 102

Outside of the US:

+1-904-808-0510 Ext 102

tech@solarstik.comAddress

Solar Stik, Inc.

13 North Leonardi Street

Saint Augustine, Florida 32084

Website

www.solarstik.com

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