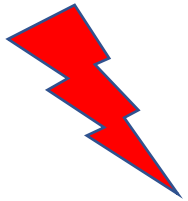
SOLAR STIK®

Mobile Surveillance Security Sensor (MS3) Hybrid Power System (HPS) Training

Terminal Learning Objective



Action: Operate the Solar Stik Hybrid Power System (HPS)

Condition: In a training environment given an HPS, a generator with Remote-operation Kit installed, and a load

Standard: Operate and maintain the Solar Stik HPS receiving a score of 80-100% on written final exam and a “GO” on the practical exam.

Introduction Topics

- **Introduction**
  - The Five Design Principles of the MS3 HPS
  - Four Component Categories
  - Dynamic Load
  - The Limits of Power Using the HPS
  - Principles of Operation
  - The Battery—The FOUNDATION of a High-efficiency System

Introduction Learning Objective

Action: Understand how components of the HPS work together to support the mission.

Introduction

The Five Design Principles of the HPS

Portable Adaptable Scalable Durable Autonomous

Introduction

Four Component Categories

There are usually four categories of equipment represented in a true high-efficiency HPS:

Power Generation

Energy Storage

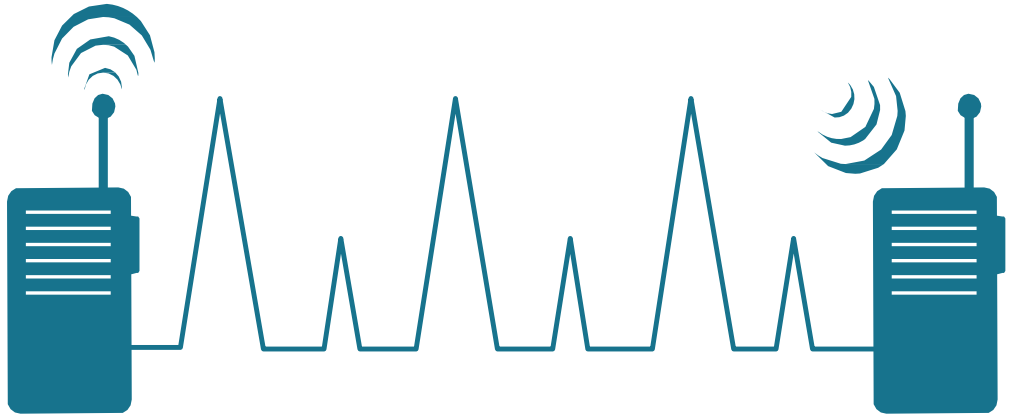
Power Management

Appliances (Load)

Introduction

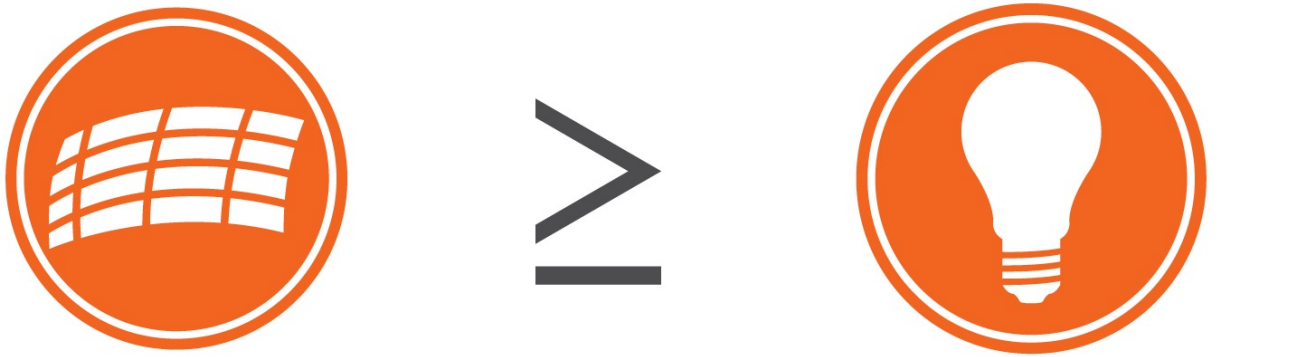
Dynamic Load

- “Dynamic” means that power is consumed at varying rates.
- In a non-hybrid power system, the generator MUST be running to provide ANY power, even if the load is negligible or intermittent.



Introduction

The Limits of Power Using the HPS

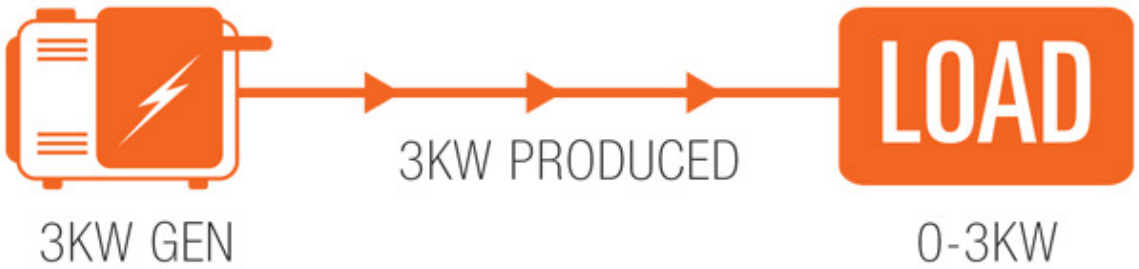


Power Generated must be greater than or equal to the Power Consumed by the Load!

The maximum continuous load placed on the HPS should/must NOT exceed the generator's maximum rated output when the generator is running.

The Battery—
The FOUNDATION of a High-efficiency System

LOW EFFICIENCY
TRADITIONAL POWER SYSTEMS



ENERGY WASTED

*ENERGY FROM FUEL IS **WASTED** IF NOT CONSUMED BY THE LOAD*

HIGH EFFICIENCY
HYBRID POWER SYSTEMS

NO ENERGY WASTED

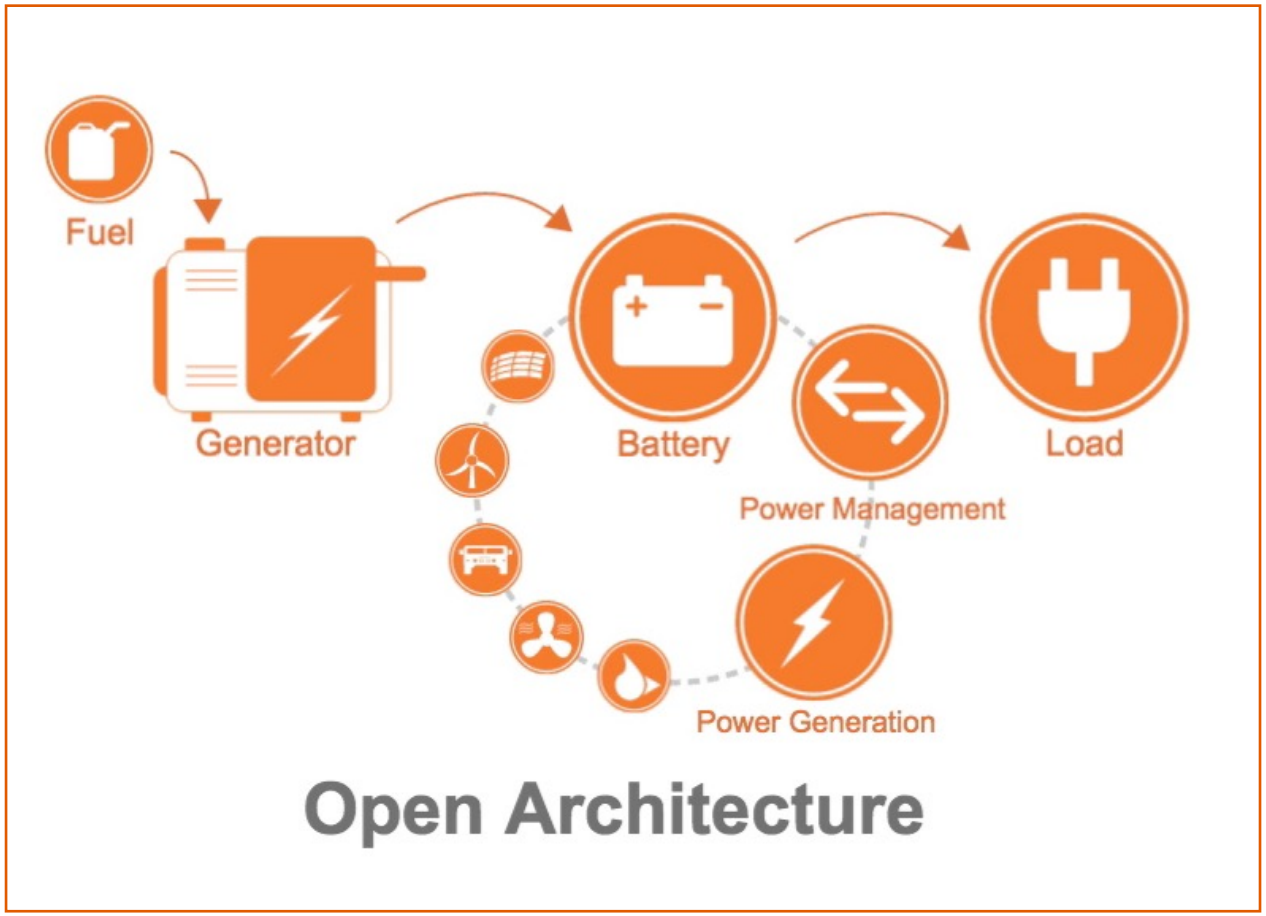
*ENERGY FROM FUEL IS CONSUMED BY THE LOAD OR **STORED** AS POTENTIAL ENERGY IN THE BATTERY*

Introduction

Hybrid Power Systems

Adding a battery:

- Increases Efficiency
- Opens Architecture to allow inclusion of multiple power generation sources



Questions and Discussion

1. What are the four categories of components in an HPS?
2. How does a battery increase HPGS efficiency?
3. List the benefits of using an HPS.
4. What component is the most important part of the HPS?

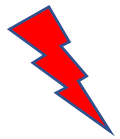
Environmental and Handling Precautions Learning Objective

Action: Understand the potential negative effects of allowing components to be exposed to unnecessary heat, water, dust/particulates, and impact.

Understand why it is necessary to minimize solar loading by shading components.

Environmental and Handling Precautions Topics

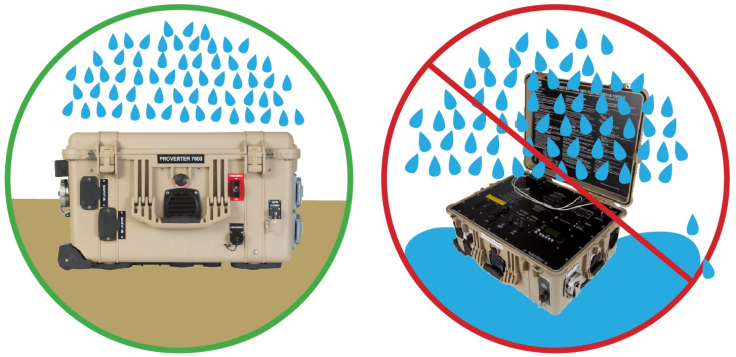
- **Environmental and Handling Precautions**
  - Handling Precautions
  - Environmental Impacts



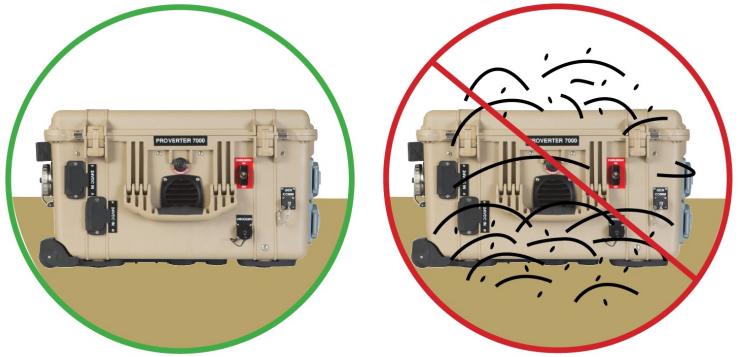
Environmental and Handling Precautions

Handling Precautions

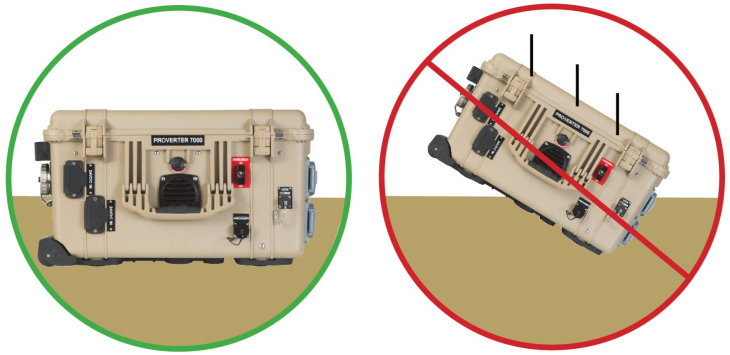
All Solar Stik components are ruggedized, yet there are a few things the operator can do to improve the performance, prevent failures, and prolong the operational life of the HPS.



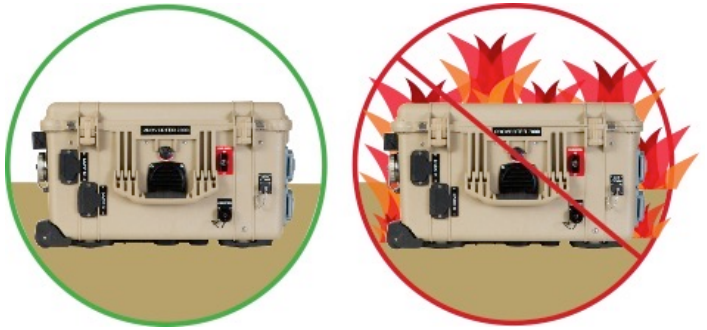
Water



Dust



Impact



Heat

Environmental and Handling Precautions

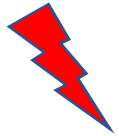
How to Reduce Environmental Impacts

- **Solar Loading** – Shade the components.
- **Water** – Keep the component lids closed and components off the ground.
- **Heat** – Clean the air intake filters and shade the components.
- **Dust/Particulates** – Keep the component lids closed, clean the air intake filters and keep components off the ground.
- **Impact** – Protect the components during transport and deployment.

Questions and Discussion

1. When should the lids of the components be closed?
2. What environmental conditions have the greatest impact on the operation of the HPS?
3. Which components should be shaded? Why?
4. How often should the air intake filters of the PRO-Verters and Power Hubs be cleaned?

Safety Learning Objective



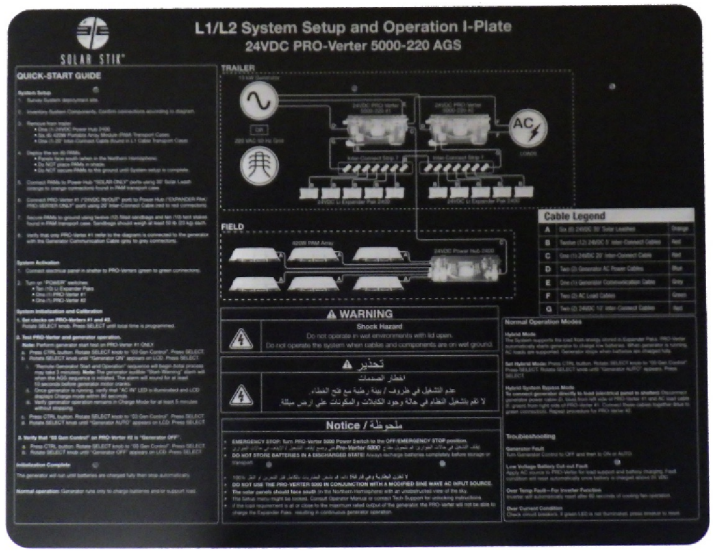
Action: Identify the location of all safety-related placards, I-Plates, and stickers and understand their meanings. Understand all safety-related information in all manuals. Be able to operate every component of the HPS with minimal risk of harm to people and equipment.

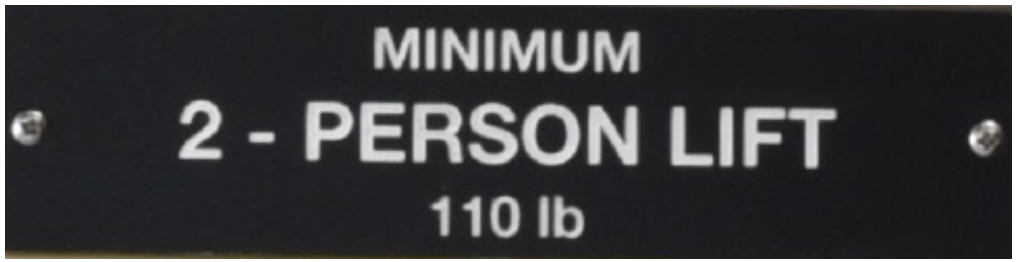
Safety Topics

- **Safety**
  - Placards, I-Plates, and Stickers
  - Technical Documentation
  - Fire and Electric Shock Hazards
  - Safe Component Operation

Safety

Placards, I-Plates, and Stickers





Safety

Technical Documentation

SOLAR STIK®

OPERATOR MANUAL FOR 24VDC PRO-VERTER 5000-220 AGS

P/N 20-0104022

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.
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Updated:20180420

Interactive

April 2018 | Solar Stik®, Inc. | 1

- Generator
- Solar Array
- PRO-Verter
- Power Hub
- Remote-start Enabling Kit
- Expander Pak

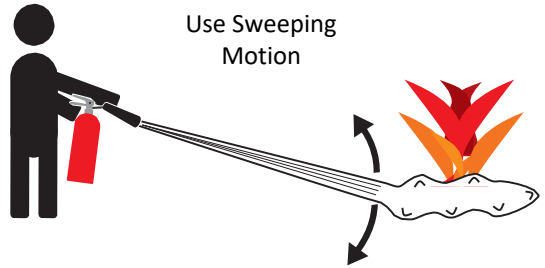
Safety

Fire and Electric Shock Hazards

Fire Hazard

WARNING

CO_2 (carbon dioxide) fire extinguishers are the best option for electric fires.



Electric Shock Hazard

DANGER

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

Safety

Safe Component Operation

- Operation in wet conditions requires extra attention.
- Always turn off everything before making any electrical connections.
- Always turn off the PRO-Verter before connecting it to the load.
- BE **VERY CAREFUL** WHEN WORKING WITH ELECTRICITY!

Questions and Discussion

1. What fire extinguisher type is best to use with the HPS?

2. Under what conditions is extra attention required when operating the HPS?

3. What must be turned off before making any electrical connections to the HPS?

4. ***True/False*** – The PRO-Verter must be turned off before connecting it to the load.

HPS Components Learning Objective

Action: Understand what components comprise the HPS and how they are connected.

HPS Components Topics

- **HPS Components**
  - ❑ Egypt MS3 Platform Overview for L0
  - ❑ Egypt MS3 Platform Overview for L1/L2
  - ❑ Color-coded Connections
  - ❑ Inventory L0
  - ❑ Inventory L1/L2
  - ❑ Components by Category and How They Are Connected
  - ❑ Information Plates (I-Plates), Faceplates, and Placards

HPS Components

Component Categories

Power Generation

420W Solar Arrays

13 kW Generator

5 kW Generator

Power Managemenmt

24VDC Power Hub 2400

24VDC PRO-Verter

Energy Storage

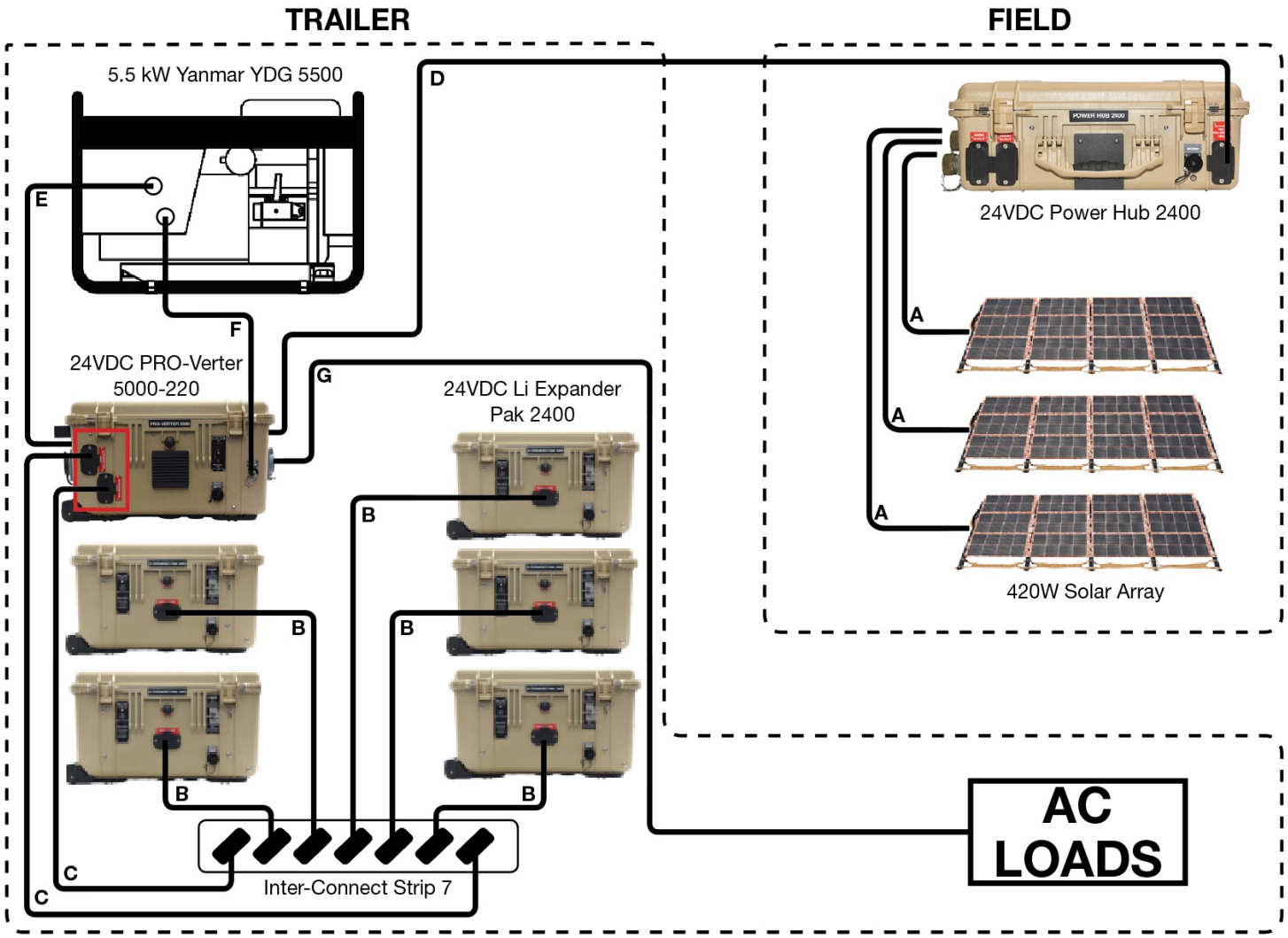
24VDC Expander Pak

Loads

L0
L1/L2

HPS Components

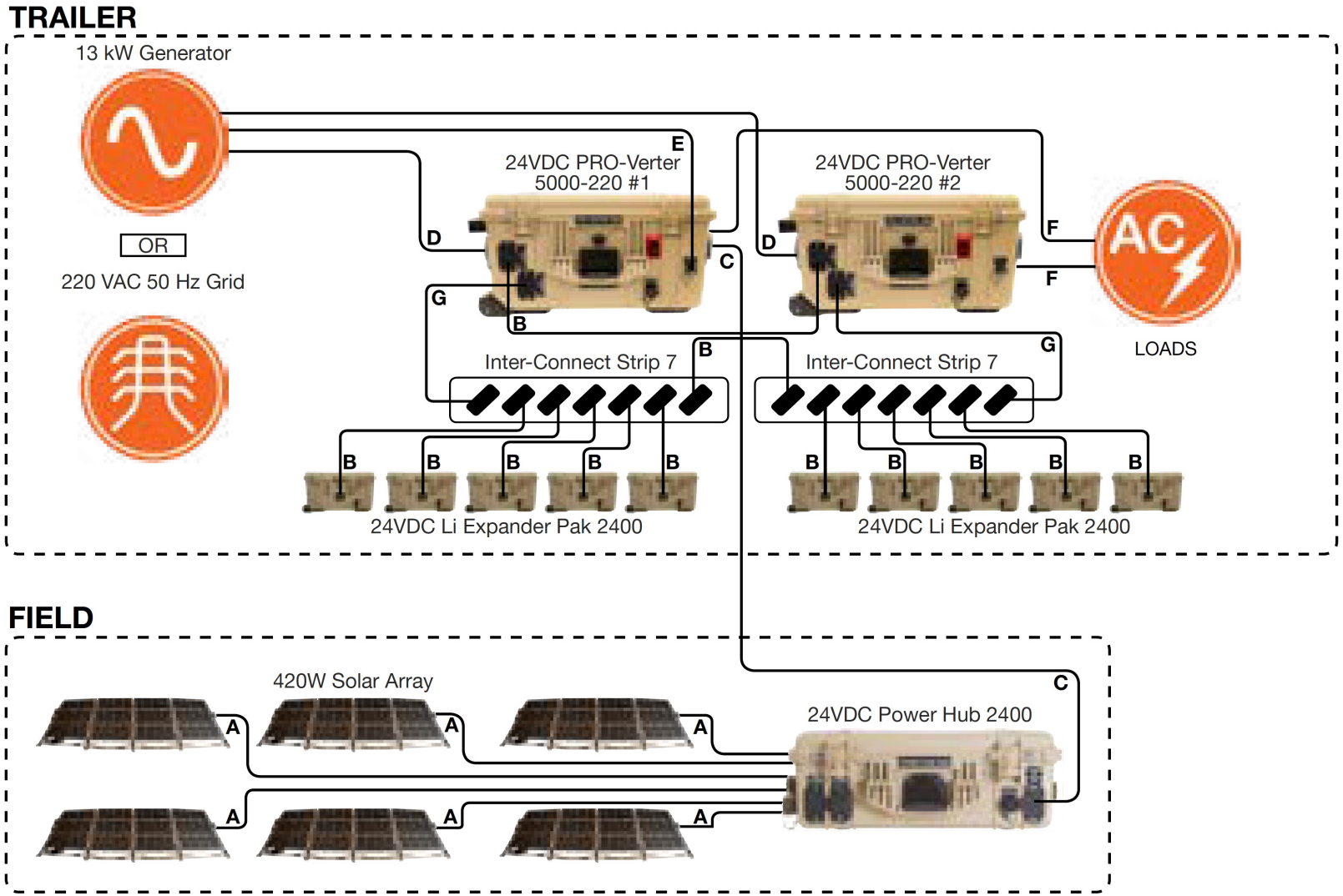
Egypt MS3 Platform Overview for L0



Cables	
A	24VDC 30’ Solar Leash
B	24VDC 5’ Inter-Connect Cable
C	24VDC 10’ Inter-Connect Cable
D	24VDC 20’ Inter-Connect Cable
E	Generator AC Power Cable
F	Generator Comms Cable
G	AC Load Cable

HPS Components

Egypt MS3 Platform Overview for L1/L2



Cables	
A	24VDC 30’ Solar Leash
B	24VDC 5’ Inter-Connect Cable
C	24VDC 20’ Inter-Connect Cable
D	AC Input Power Cable
E	AGS Cable
F	AC Output Power Cable
G	24VDC 10’ Inter-Connect Cable

HPS Components

Color-coded Connections

Cable Color

Orange: Solar Circuit Connection

Red: DC Circuit Connection

Example Ports

HPS Components

Color-coded Connections

AC Power Cable
15’ 230 V 50 Hz

Blue: AC Power Circuit Connection (from Power Generation to Power Management).

5’ Generator
Communications Leash

Gray: Communications Circuit Connection

AC Power Cable
15’ 230 V 50 Hz

Green: AC Power Circuit Connection (from Power Management to Load)

HPS Components

Unique and Polarized Connectors

Gen Comm

Inter-Connect

Solar

AC power in/out

HPS Components

Inventory L0

PAM Transport Case (x3)

Solar Array (x3)

Metal Stake (x10/array)

Sandbag (x12/array)

30’ Solar Leash (x3)

15’ MEP-802A Generator Communications Cable (x1)

15’ AC Power Cable 220 V 50 Hz (x1)

15’ AC Power Cable 220 V 50 Hz (x1)

24VDC 5’ Inter-Connect Cable (x5)

20’ 24VDC Inter-Connect Cable (x1)

10’ 24VDC Inter-Connect Cable (x2)

24VDC Inter-Connect Strip 7 (x2)

Cable Transport Case (x1)

HPS Components

Inventory L0

Yanmar YDG 5500 and Aux Fuel Tank (x1)

24 VDC Li Expander Pak 2400 (x5)

24VDC Power Hub 2400 (x1)

24VDC PRO-Verter 5000 AGS (x1)

HPS Components

Inventory L1/L2

PAM Transport Case (x6)

Solar Array (x6)

Metal Stake (x10/array)

Sandbag (x12/array)

30’ Solar Leash (x6)

15’ MEP-802A Generator Communications Cable (x1)

15’ AC Power Cable 220 V 50 Hz (x2)

15’ AC Power Cable 220 V 50 Hz (x2)

24VDC 5’ Inter-Connect Cable (x12)

20’ 24VDC Inter-Connect Cable (x1)

10’ 24VDC Inter-Connect Cable (x2)

24VDC Inter-Connect Strip 7 (x2)

Cable Transport Case (x2)

HPS Components

Inventory L1/L2

13 kW Generator (x1)

24 VDC Li Expander Pak 2400 (x10)

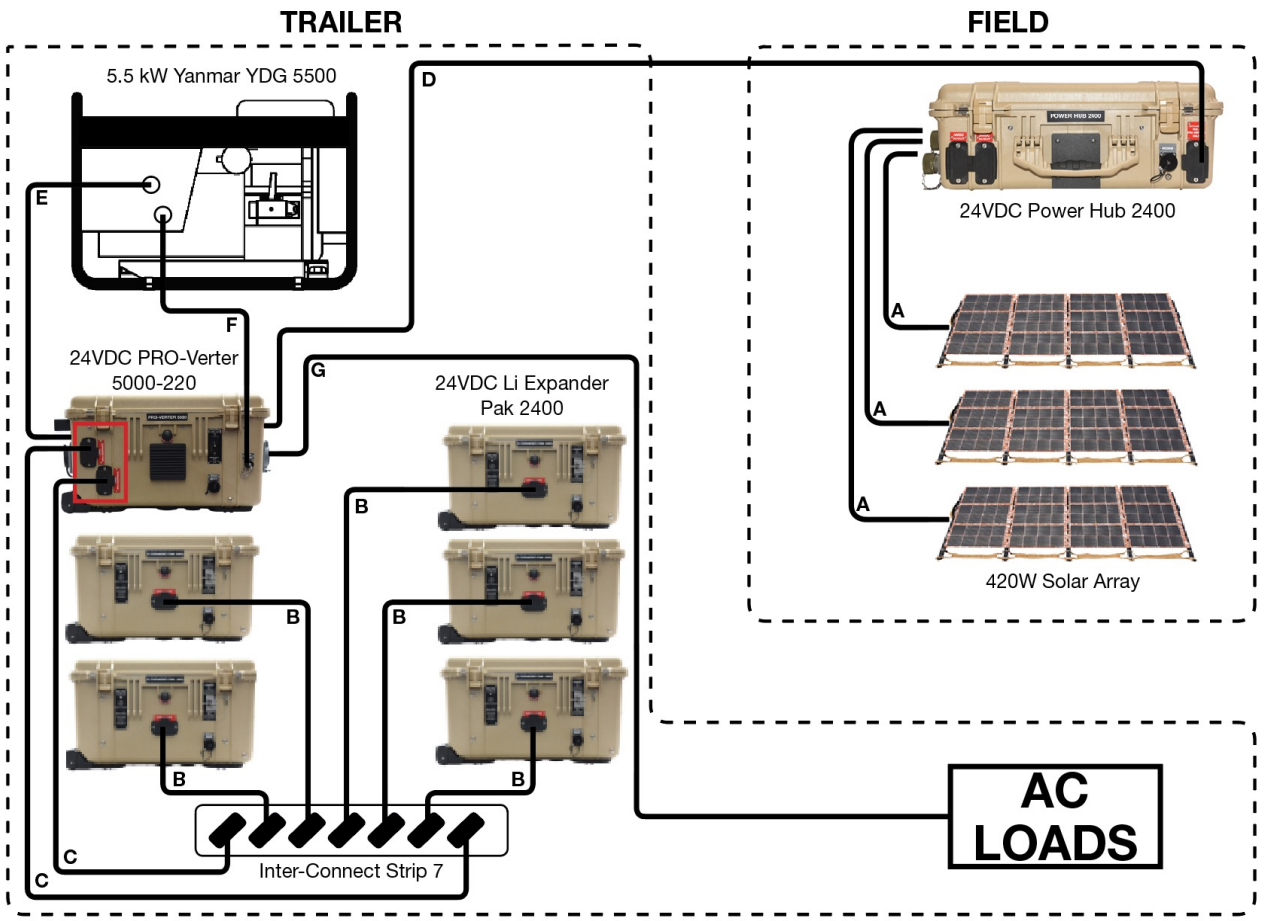
24VDC Power Hub 2400 (x1)

24VDC PRO-Verter 5000 AGS (x2)

HPS Components

Components by Category and How They Are Connected

- **Power generation:** Generator and solar panels
- **Power management:** PRO-Verter and Power Hub
- **Energy storage:** Expander Paks (batteries)
- Loads



HPS Components

Information Plates (I-Plates), Faceplates, and Placards

Please review all of the information on the I-Plates, Faceplates, and placards before setting up the HPS.

Questions and Discussion

1. Information about connecting the system is found on the I-Plate of which component?

2. What are the four categories of components in an HPS?

3. Why is it important to take inventory of the components?

4. What is the purpose of placards on the Inter-Connect ports of HPS components?

5. Why are the placards and cables color coded?

Expander Pak Operation Learning Objective

Action: Understand how to operate and maintain Expander Paks for optimal performance and life expectancy.

Understand the Expander Pak is a consumable part of the HPS.

Understand the Expander Pak is the FOUNDATION of the System

Expander Pak Operation Topics

- **Expander Pak Operation**
  - Battery Life Span
  - The HPS Energy Storage Module—Li Expander Pak 2400
  - Voltage and SOC
  - Battery Management System (BMS)
  - Battery Protection Circuits
  - Li Expander Pak Battery Status LED

Expander Pak Operation

Battery Life Span

Batteries are a **consumable** part of the HPS.

Primary factors that determine the life span of a battery:

- **Number of Cycles**
- **Abuse**
  - Storing in a discharged state
  - Storing in high heat
  - Transporting in a discharged state
  - Improper cycling

Expander Pak Operation

The HPS Energy Storage Module – Li Expander Pak 2400

Battery Chemistry – Lithium Iron Phosphate ($LiFePO_4$)

Battery Capacity

- 2400 watt hours (Wh)
- 100 amp hours (Ah)

Voltage

- 24 volts (nominal)
- 25.6 volts (actual when fully charged)

Current

- 50 amps (circuit breaker protected)

Expander Pak Operation

Factors Affecting Battery Capacity Requirements

Would you ever need to change the number of Expander Paks connected to the System?

Factors

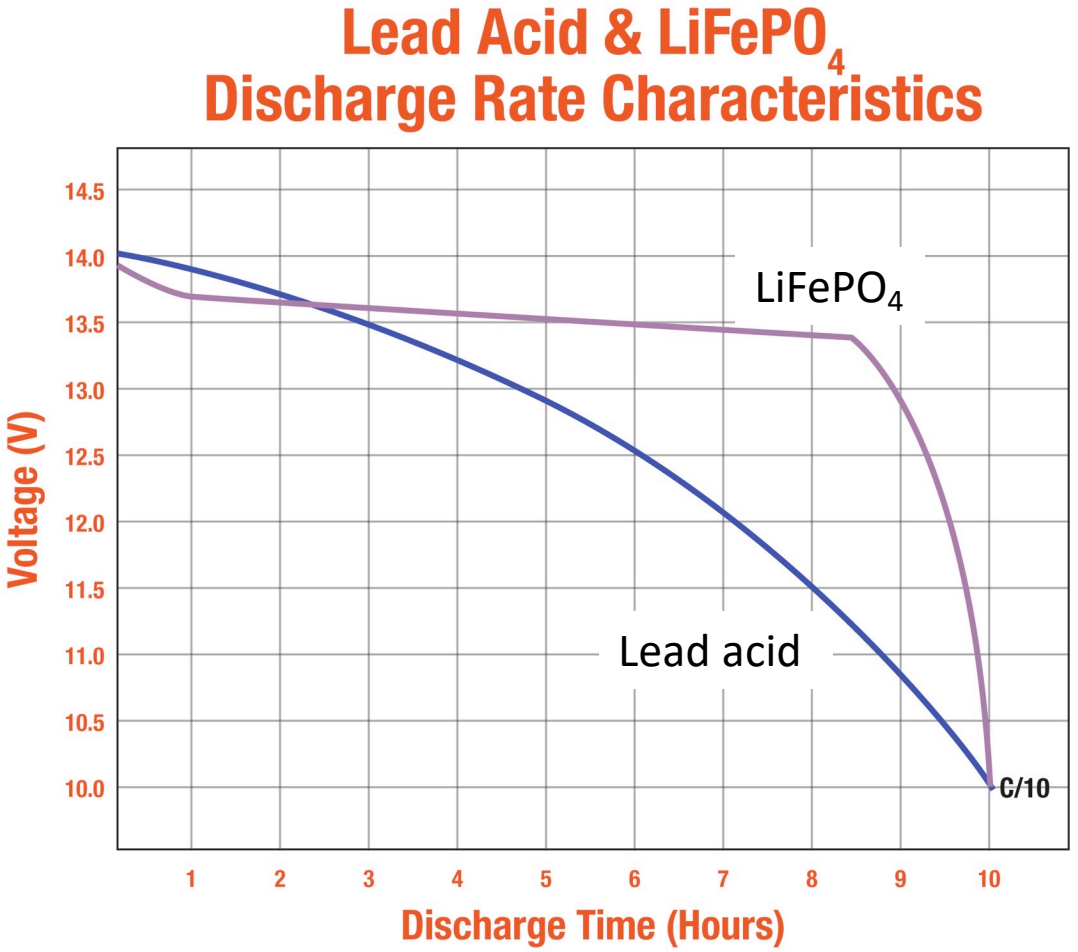
- Load sustainment (peak and continuous)
- Silent operation time
- Balanced operation between power generation and load
- Increased load

Expander Pak Operation

Voltage is not equal to SOC

The voltage of the $LiFePO_4$ battery does NOT indicate the state of charge (SOC).

Voltage is used to trigger events within a hybrid system (e.g., generator start/stop functions).



Expander Pak Operation

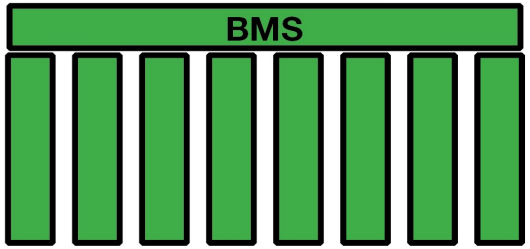
Battery Management System (BMS)

The BMS constantly manages and balances the cells, ensuring safe conditions as this occurs.

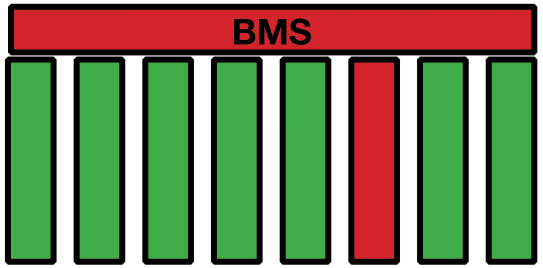
The BMS provides two critical functions for the 8 cells in an Expander Pak:

1. Supercell management
2. Protection circuits

Without a BMS, the supercells will become unbalanced and the battery will fail.



The BMS maintains equality among all of the supercells and allows current to flow into and out of the cells/battery.



The BMS will “turn off” the battery during conditions that make it unsafe for the battery to operate. This will protect the user *and* the battery.

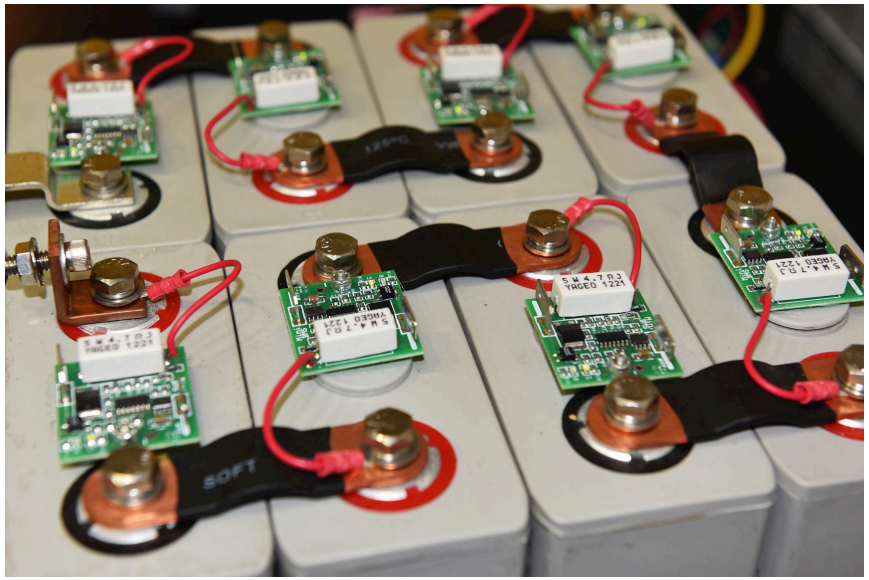
???

Expander Pak Operation

Battery Protection Circuits

When a lithium battery is in PROTECTION mode, it is either:

- Protecting the operator from an unsafe battery
  - Failed cell
  - BMS failure
- Protecting the battery from an unsafe operating condition (i.e., caused by the operator)
  - Overdischarged
  - Overtemperature
  - Overvoltage
  - Overcurrent



Expander Pak Operation

Li Expander Pak Battery Status LED

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	**Battery inoperative**

*Does not indicate that the Expander Pak is charged fully!

- Expander Paks must be charged fully before transporting.
- Expander Paks must be charged fully before storing.

Avoid Storing in HOT places

- Heat increases the electrochemical reaction that leads to overdischarge.
- When stored in hot places, INCREASE frequency of maintenance charging.
- Heat shortens battery lifespan

Questions and Discussion

1. What component is the foundation of the HPS?

2. ***True/False*** – $LiFePO_4$ battery voltage is used to determine the state of charge.

3. Which components should be shaded? Why?

4. What is the battery chemistry of the Expander Pak?

5. ***True/False*** – $LiFePO_4$ batteries can be stored and transported in a discharged state.

6. What are the two criteria (values and settings) that ensure an Expander Pak is charged fully?

7. Provide at least two conditions under which the battery BMS disconnects the cells from service.

Questions and Discussion

8. What happens to $LiFePO_4$ cells in higher temperatures during storage?

9. What environmental factor affects the maintenance-charging intervals of the Expander Pak?

10. What does a green-flash Battery Status LED mean?

11. What does a red-flash Battery Status LED mean?

12. What is the procedure when encountering an Li Expander Pak with a red-flash Battery Status LED?

13. What factors will decrease the life expectancy of a battery?

14. ***True/False*** – A battery cell's chemical reaction stops when the battery is turned off.

Questions and Discussion

15. Describe a battery cycle.

16. If all of the Expander Paks in the HPS have a red-flash Battery Status LED, what has likely occurred?

17. If all of the Expander Paks in the HPS have been disabled by the BMS due to low state of charge (SOC), what processes can be used to restore service (i.e., waking up the HPS)?

18. ***True/False*** – $LiFePO_4$ batteries are hazardous due to their toxicity.

HPS Setup Learning Objective

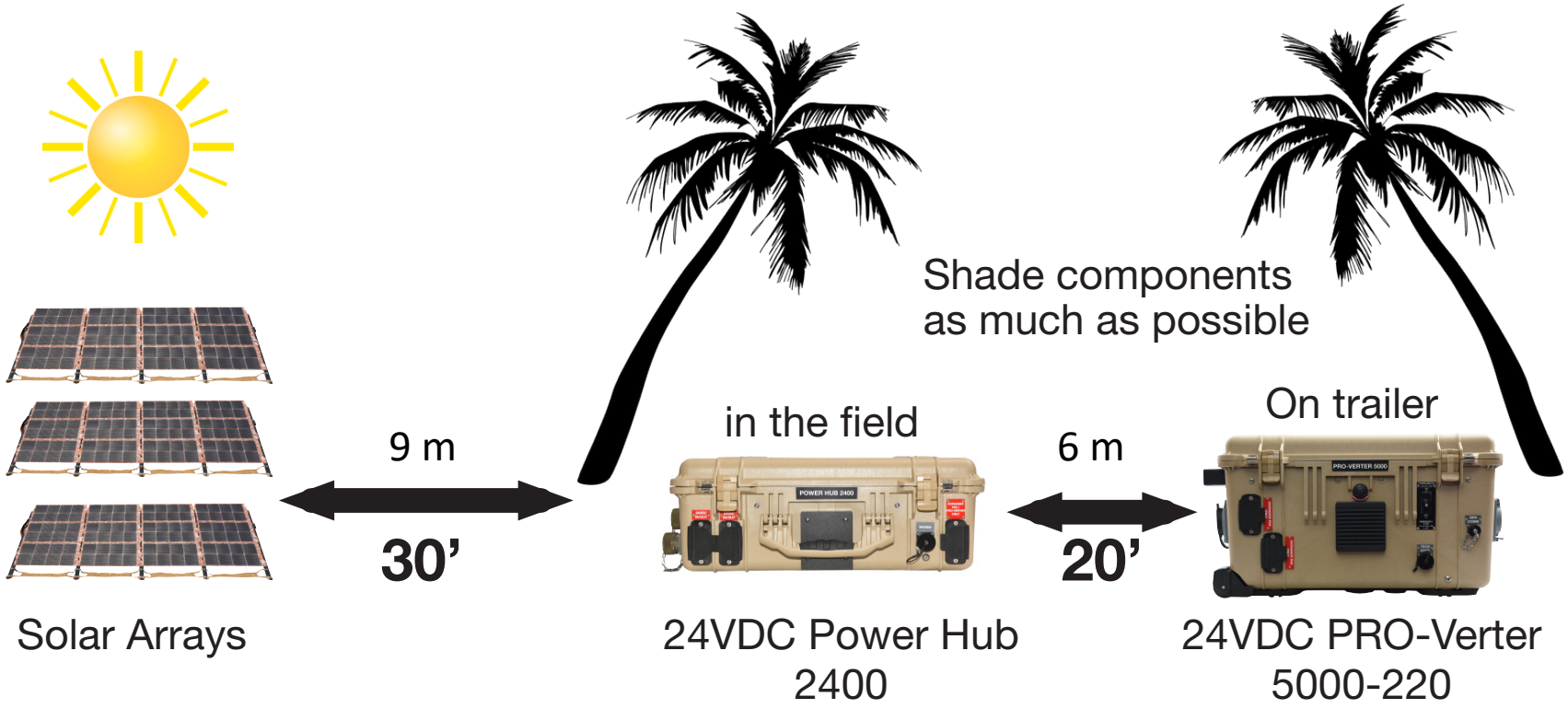
Action: Understand the proper setup and activation of the HPS.

HPS Setup Topics

- **HPS Setup**
  - ❑ Identify locations for System components.
  - ❑ Remove Solar Arrays, Power Hub, and 20’ Inter-Connect cable from trailer.
  - ❑ Inventory and connect System components.
  - ❑ Connect the Expander Paks to the PRO-Verter (L0 and L1/L2).
  - ❑ Connect the PRO-Verter to generator (L0 and L1/L2).
  - ❑ Connect the PRO-Verter to the load/service panel (L0 and L1/L2).
  - ❑ Ground the System*.
  - ❑ Deploy the Solar Arrays.
  - ❑ Connect the Solar Arrays to the Power Hub.
  - ❑ Connect the PRO-Verter to the Power Hub.
  - ❑ Secure the Solar Arrays to the ground.
  - ❑ Activate the System.
  - ❑ Initialize and calibrate the System.
  - ❑ Order of Operations

HPS Setup

Identify locations for System components.



15 m

The working radius is determined by the length of the cables; the PAMs could be up to 50’ from the PRO-Verter/trailer.

HPS Setup

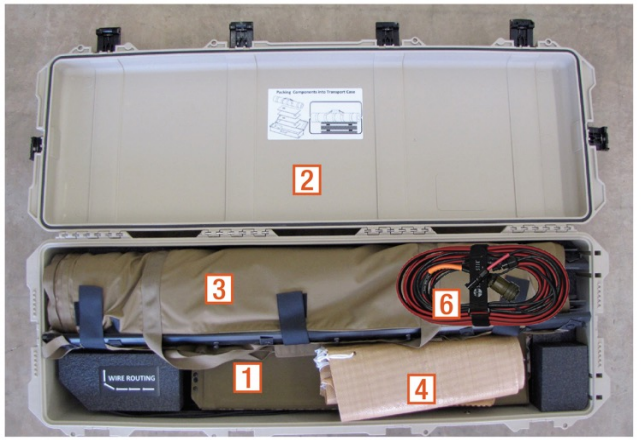
Remove Solar Arrays, Power Hub, and 20’ Inter-Connect Cable from trailer.

Locate and remove the following components from the trailer:

- One (1) 24VDC Power Hub 2400
- Three (3) 420W Solar Array transport cases for L0 and six (6) for L1/L2
- One (1) 20’ Inter-Connect Cable, located in the cable transport case

Inventory the contents of the Solar Array transport cases.

420W Expedition Solar Array-C Kit Inventory	
☐	Four (4) 105 W Photovoltaic (PV) Panels 1
☐	One (1) Transport Case 2
☐	One (1) Rollable Stand 3
☐	Twelve (12) Sandbags 4
☐	Ten (10) Stakes 5
☐	One (1) 30’ Solar Leash 6



HPS Setup

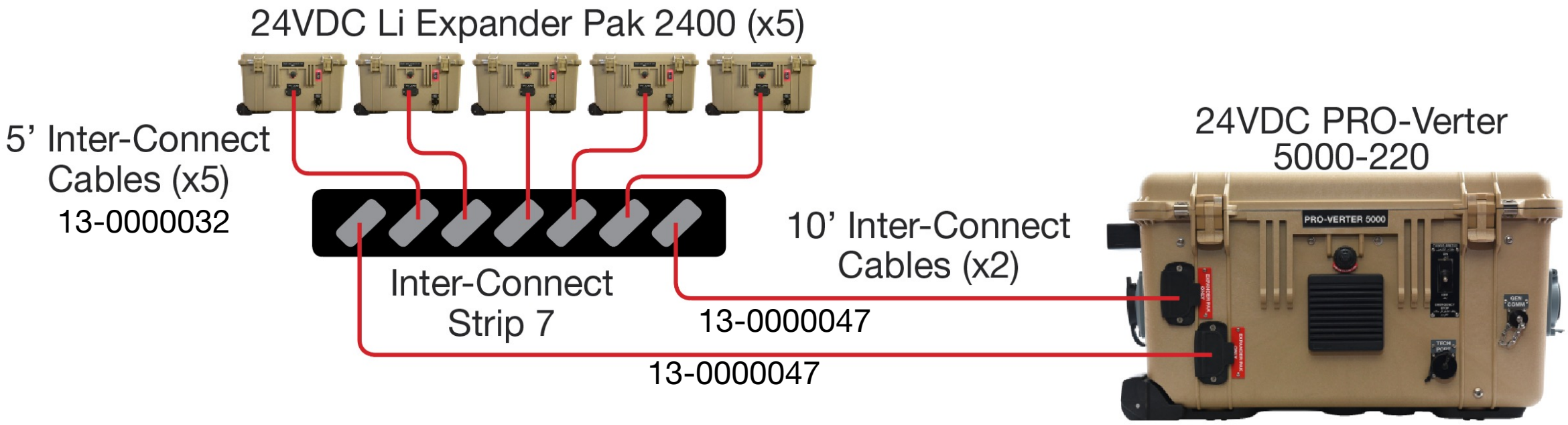
Inventory and connect System components.

- Inventory the System components using the list in the Trailer Inventory section.
- Connect the System components on the trailer according to the diagram on the PRO-Verter I-Plate and in the System Operator manual. The lines connecting the components in the diagrams on the following slides indicate the types of connections to be made.

HPS Setup

PRO-Verter to Expander Pak Connections (L0)

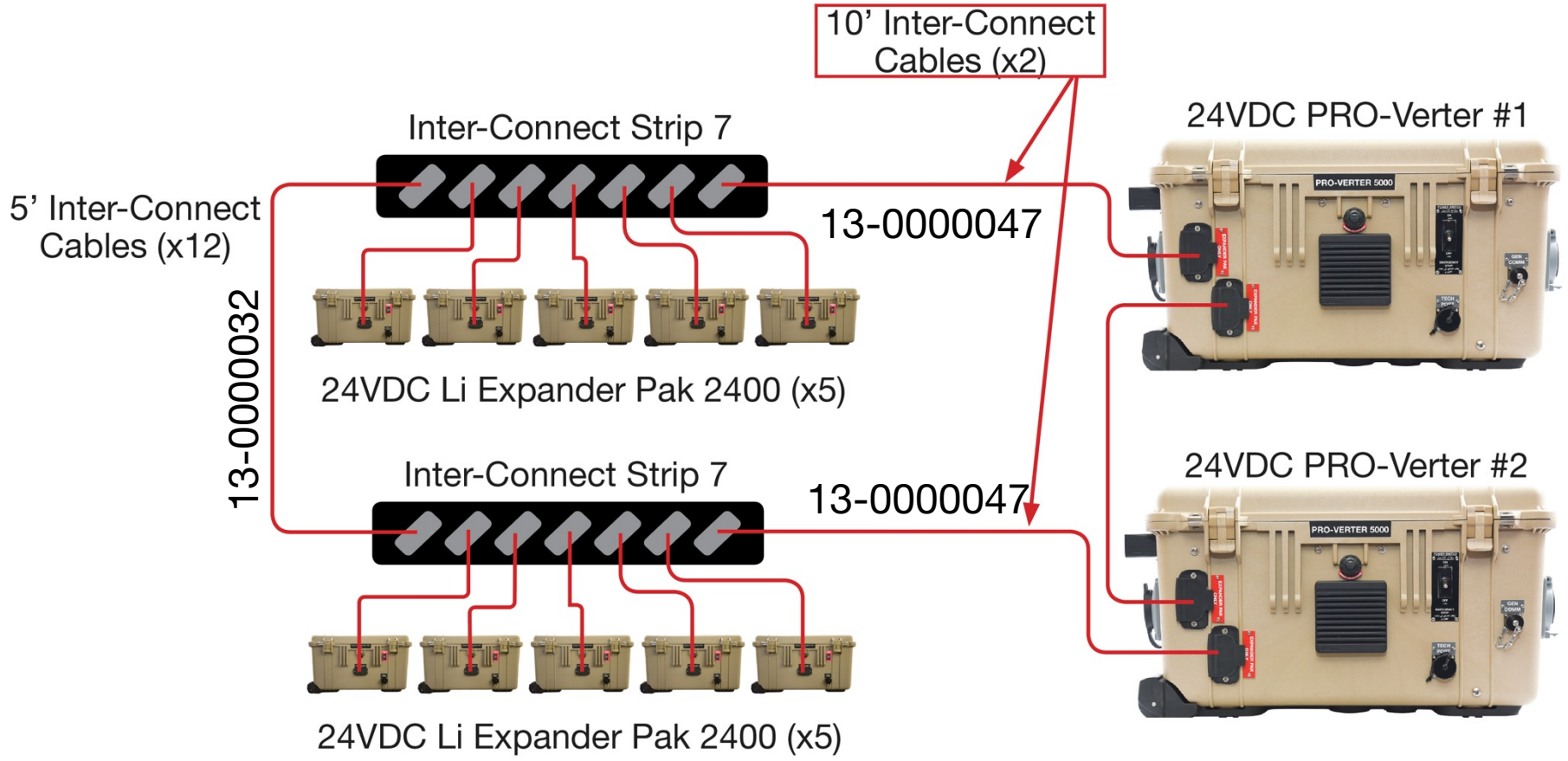
Connect the five (5) Expander Paks to the Inter-Connect Strip 7, and the Inter-Connect Strip to the PRO-Verter. All of these are red-to-red connections.



HPS Setup

PRO-Verter to Expander Pak Connections (L1/L2)

Connect the ten (10) Expander Paks to the Inter-Connect Strip 7s, and the Inter-Connect Strips to the PRO-Verters. All of these are red-to-red connections.

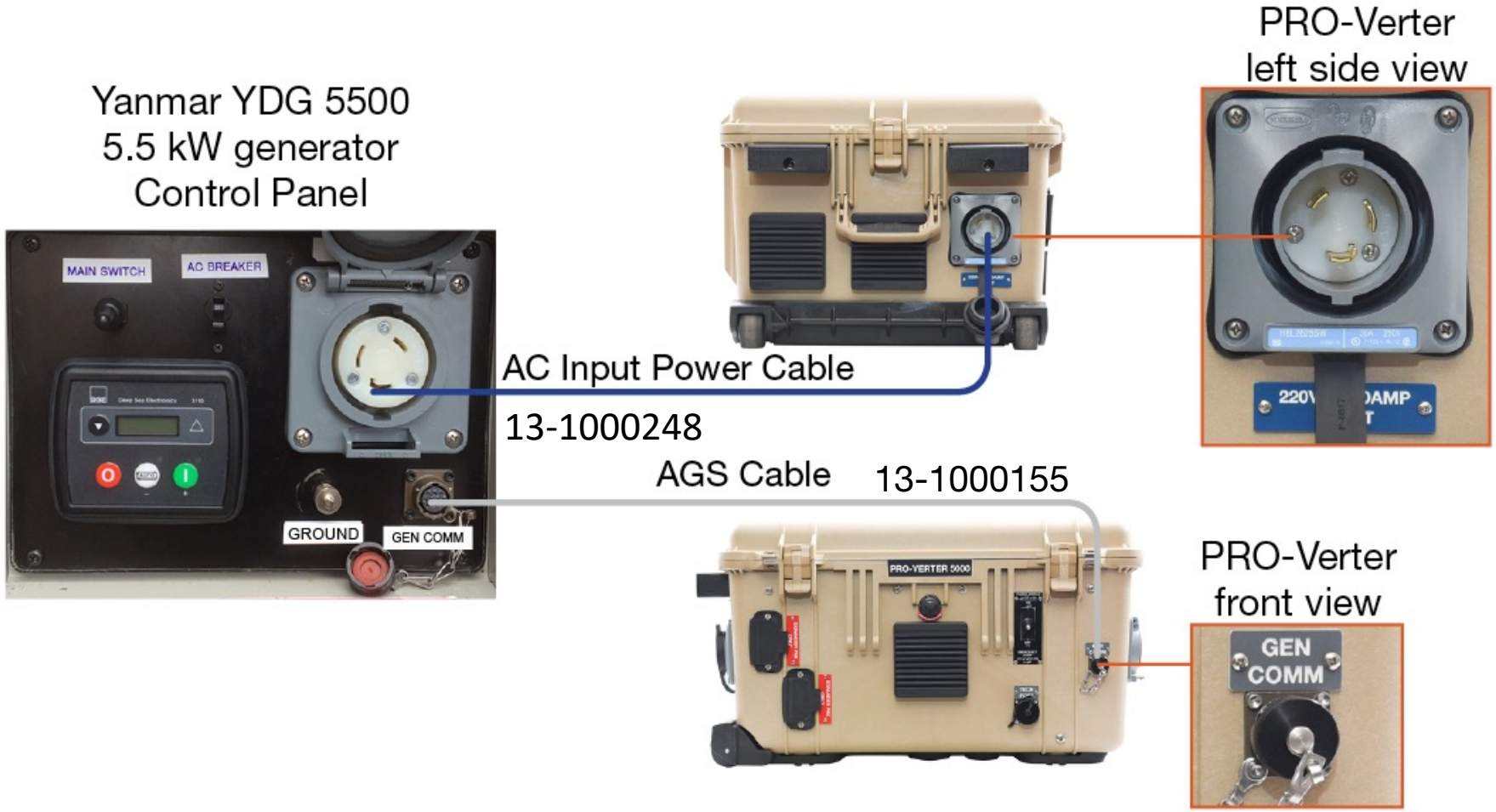


HPS Setup

PRO-Verter to Generator Connections (L0)

- **AGS Cable:** "GEN COMM" port on the 24VDC PRO-Verter 5000 and "GEN COMM" port on the generator using gray-to-gray connection

- **AC Input Power Cable:** AC power out on the generator to the "2200 VAC INPUT" port on the left-hand side of the PRO-Verter 5000 using blue-to-blue connection



HPS Setup

PRO-Verter to Generator Connections (L1/L2)

- **AGS Cable:** “GEN COMM” port on the 24VDC PRO-Verter #1 (Master PRO-Verter) and “GEN COMM” port on the generator using gray-to-gray connection

13.0 kW generator

13.0 kW generator
RsEK Control Panel

24VDC PRO-Verter **#1**

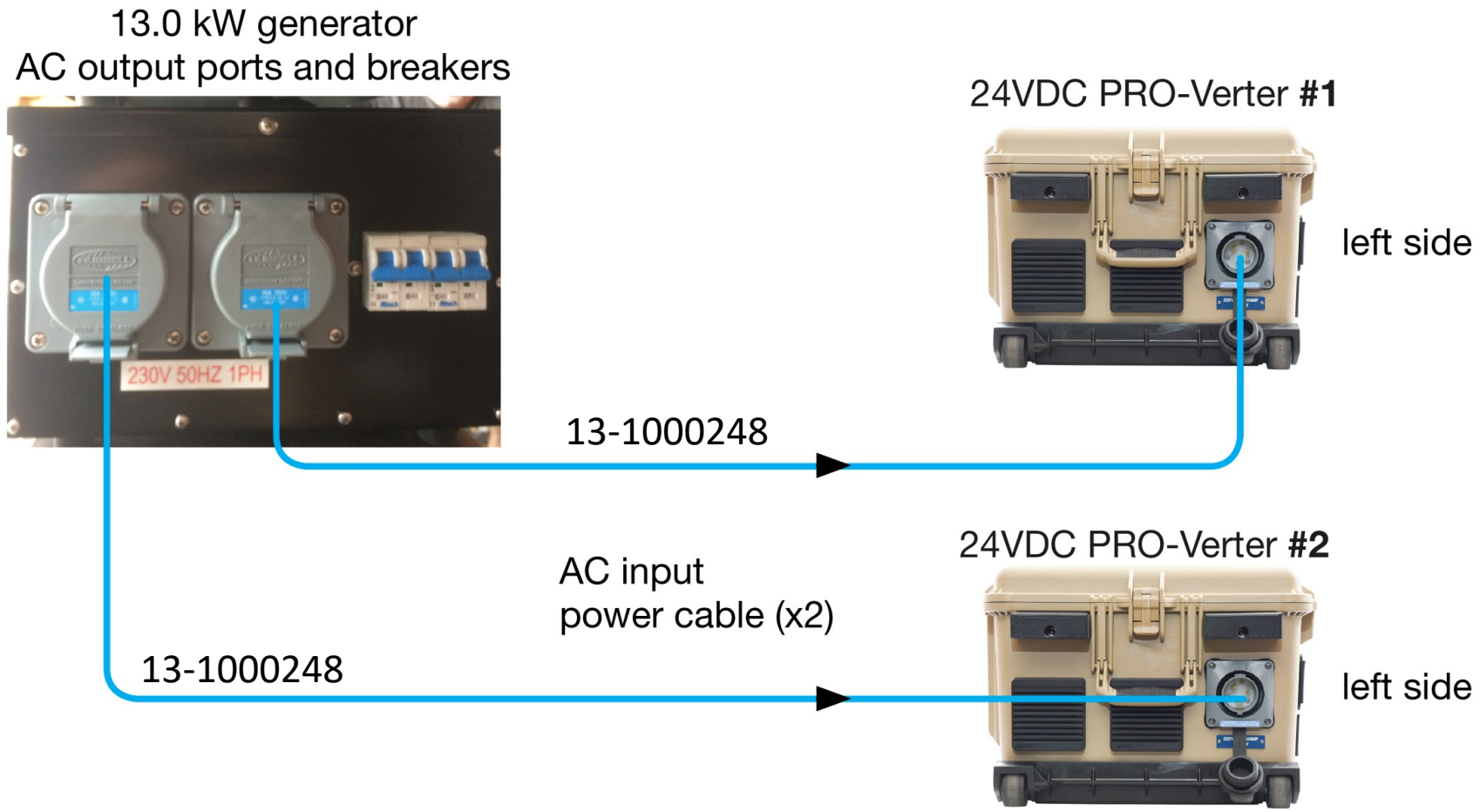
13-1000155

15’ AGS Cable

HPS Setup

PRO-Verter to Generator Connections (L1/L2)

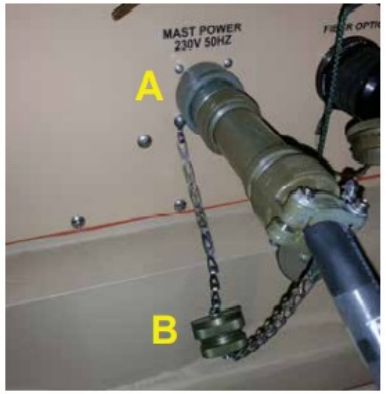
- **AC Input Power Cable:** AC power out on the generator to the “2200 VAC INPUT” port on the left-hand side of the PRO-Verter 5000 using blue-to-blue connection.
- These are twist lock connections.

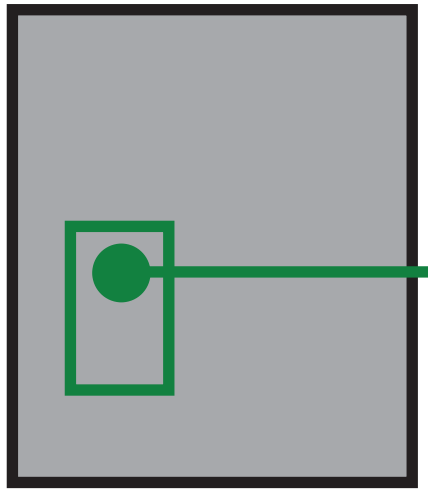


HPS Setup

PRO-Verter to Shelter Service Panel Connection (L0)

AC Output Power Cable – Connect the PRO-Verter (“220 AC OUT” port) to the shelter service panel (power socket to JPV-1 on the front side of the Shelter; green-to-green connection) using 15





Shelter/Conex
service panel

AC power cable
15’ 220 V 50 Hz

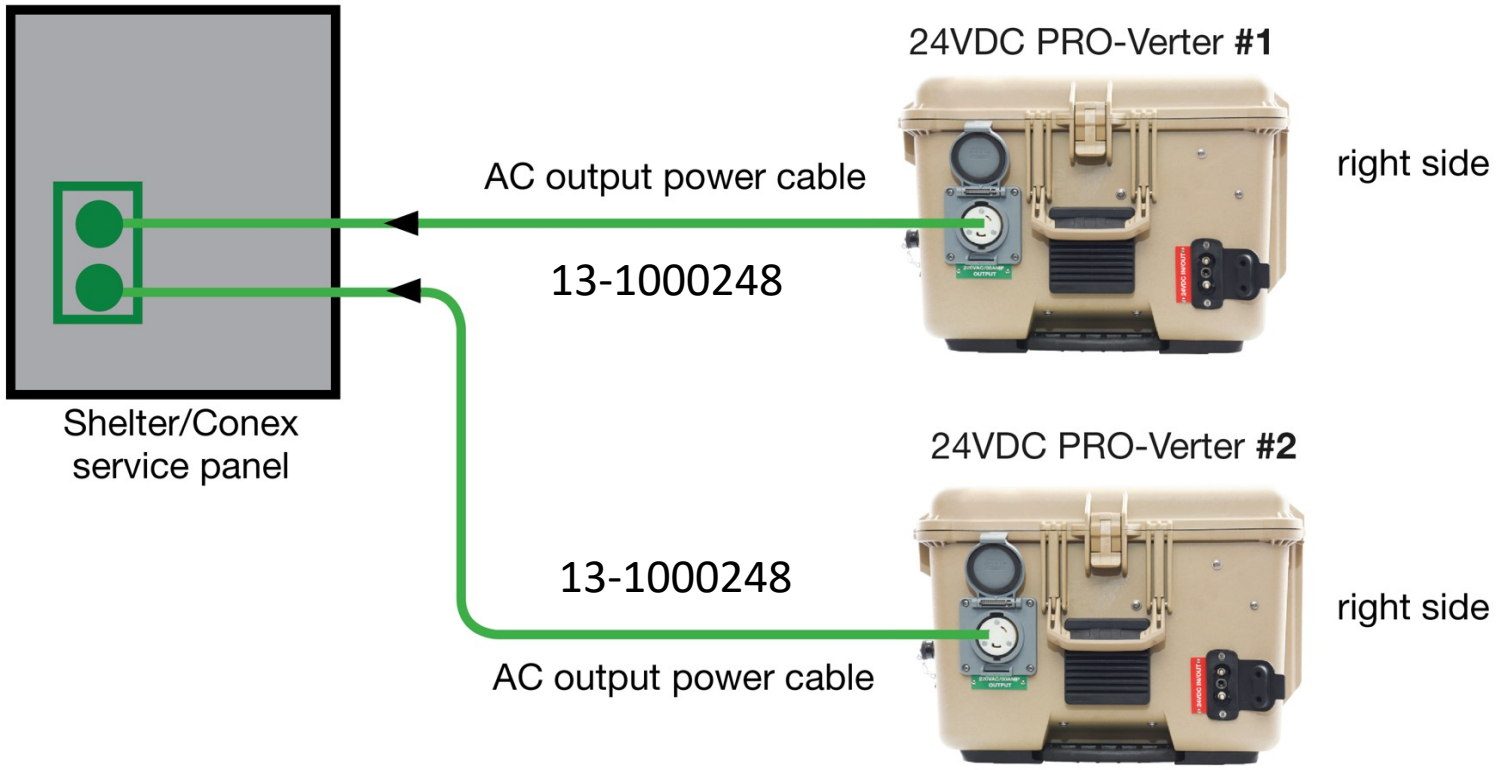
13-1000248

PRO-Verter
left side view

HPS Setup

PRO-Verter to Shelter Service Panel Connection (L1/L2)

AC Output Power Cable – Connect the PRO-Verter (“220 VAC/30 AMP OUTPUT” ports) to their respective loads using a green-to-green connection.



HPS Setup

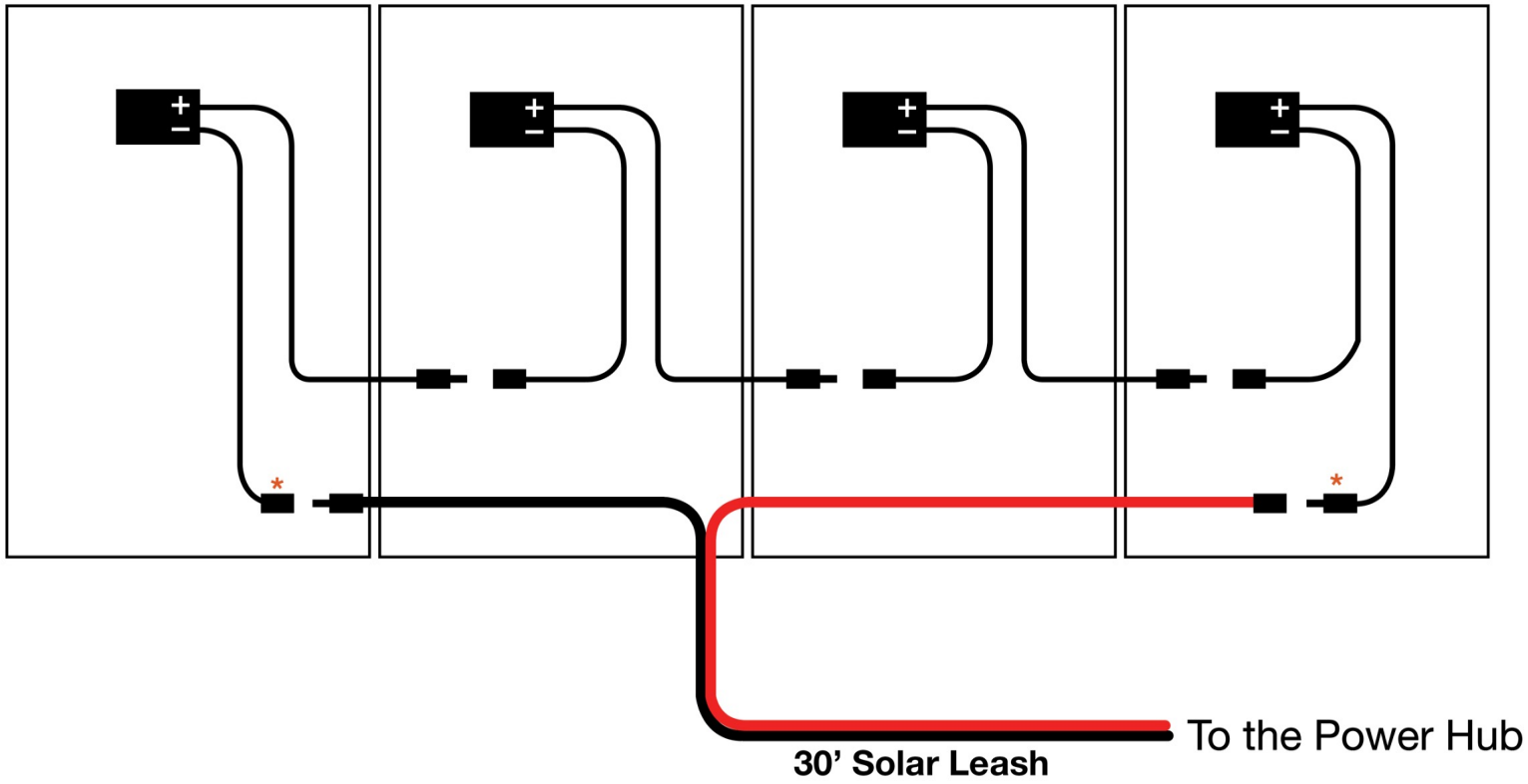
Ground the System.

- PRO-Verter and generator bonded to trailer equipment grounding conductor, which is connected to earth grounding rod
- When generator running, AC neutral and equipment ground automatically bond internally at generator
- When running off battery, AC neutral and equipment ground automatically bond internally at PRO-Verter
- No other neutral to ground bonds on trailer
- If HPS connected to grid power, neutral to ground bond at main breaker panel of grid power

HPS Setup

Deploy the Solar Arrays.

Connect the four (4) PV panels on a single rack in series using the wiring 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.



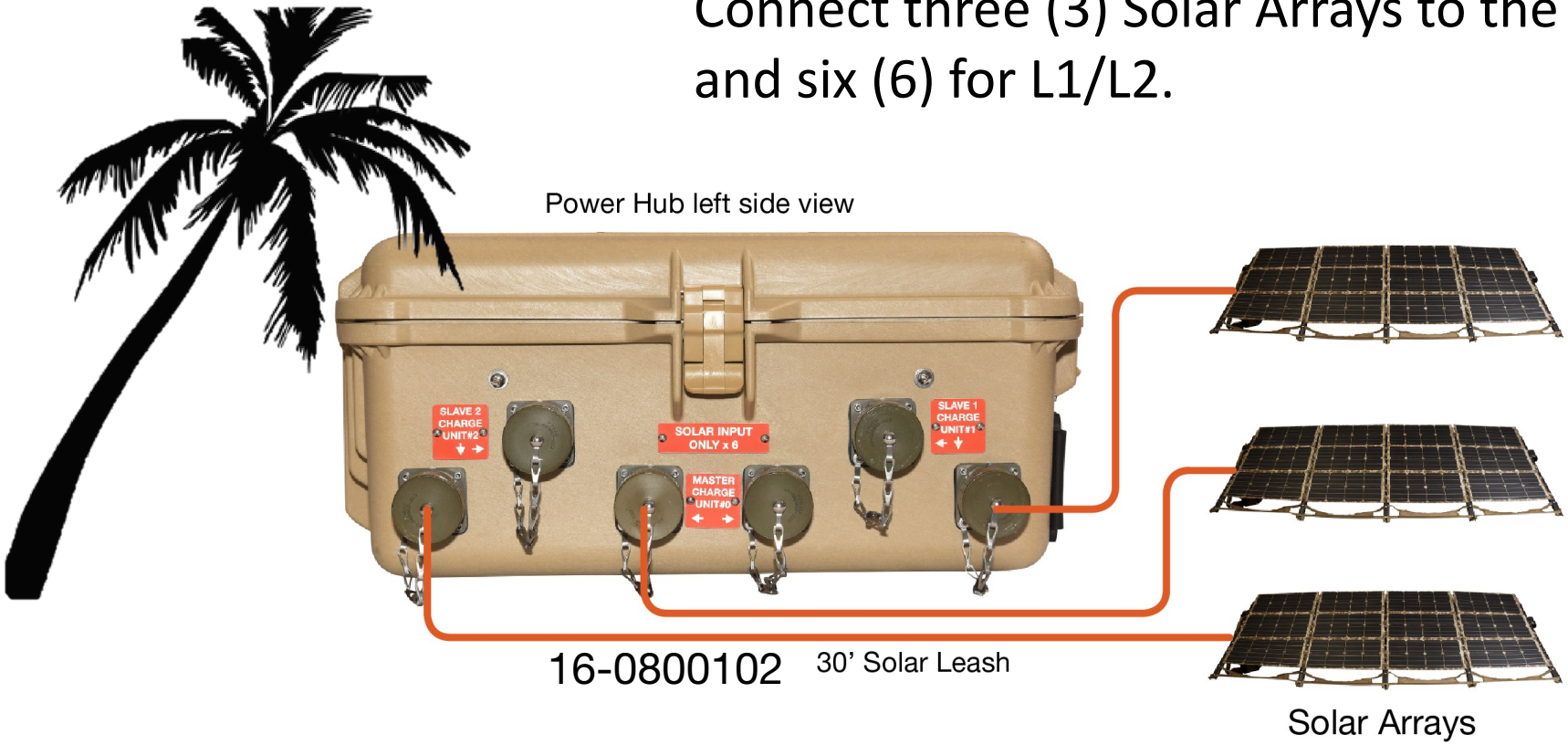
DO NOT secure the Arrays to the ground until the entire System is set up.

HPS Setup

Connect the Solar Arrays to the Power Hub.

Connect one **30’ Solar Leash** to one (1) SOLAR ONLY port from each pair of ports (CHARGE UNIT #0, CHARGE UNIT #1, CHARGE UNIT #2). These are orange-to-orange connections.

Connect three (3) Solar Arrays to the Power Hub for L0 and six (6) for L1/L2.

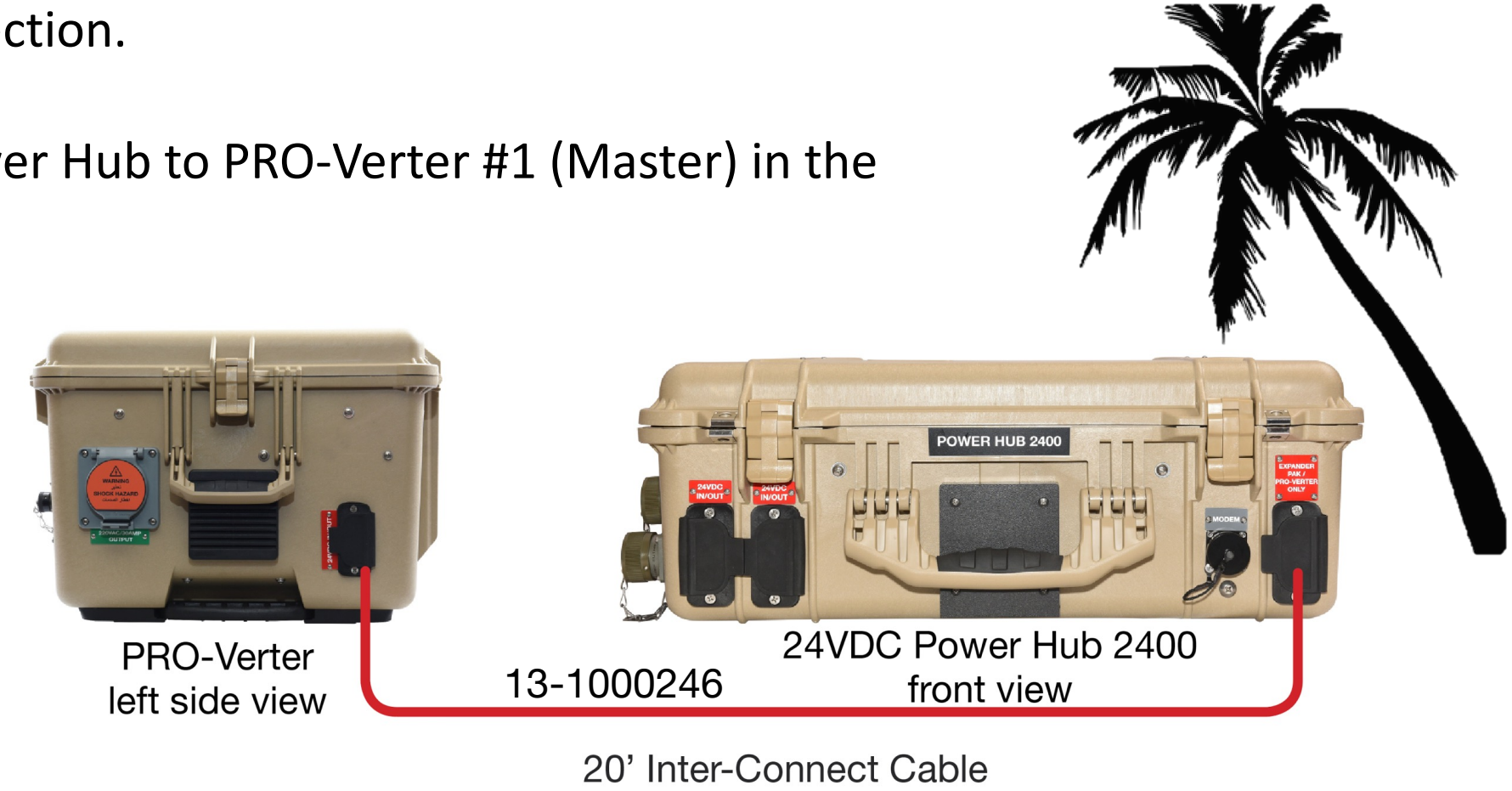


HPS Setup

Connect the PRO-Verter to the Power Hub.

20’ Inter-Connect Cable – Connect the PRO-Verter (“24VDC IN/OUT” port) to the Power Hub (“EXPANDER PAK/PRO-VERTER ONLY” port) using a 20’ Inter-Connect Cable. This is a red-to-red connection.

Connect the Power Hub to PRO-Verter #1 (Master) in the L1/L2 System.



HPS Setup

Secure the Solar Arrays to the ground.

Hard (impenetrable) surface
Securing the solar arrays with sandbags

Soft (penetrable) surface
Securing the solar arrays with tent stakes

⚠ WARNING

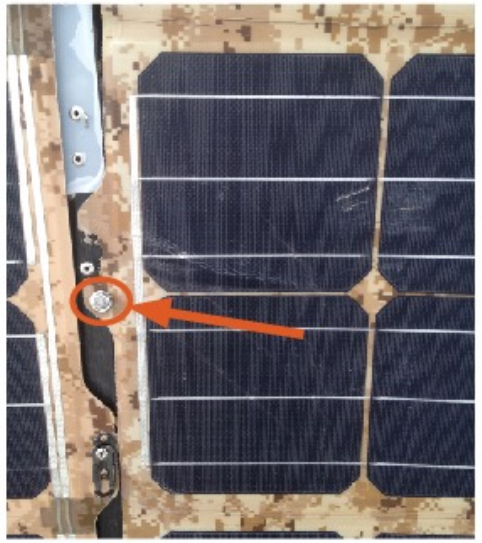
Failure to properly secure the Solar Arrays to the ground surface could result in solar panel damage, injury, or death in high winds. Tent stakes and/or sandbags should be used. Wind damage to panels can render them nonfunctional or significantly reduce their functional life expectancy.

HPS Setup

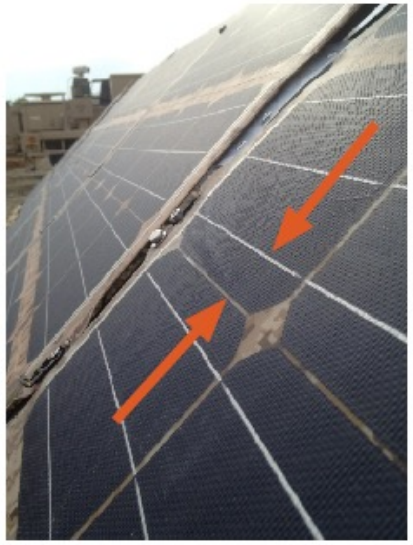
Inadequate Ground Securing: Solar Panel Damage

Arrays deployed without ground securing: No stakes and no sandbags

Bent or broken U-shaped catches and latches along the side of the solar panel



Improvised repair: Panel secured to stand with a bolt

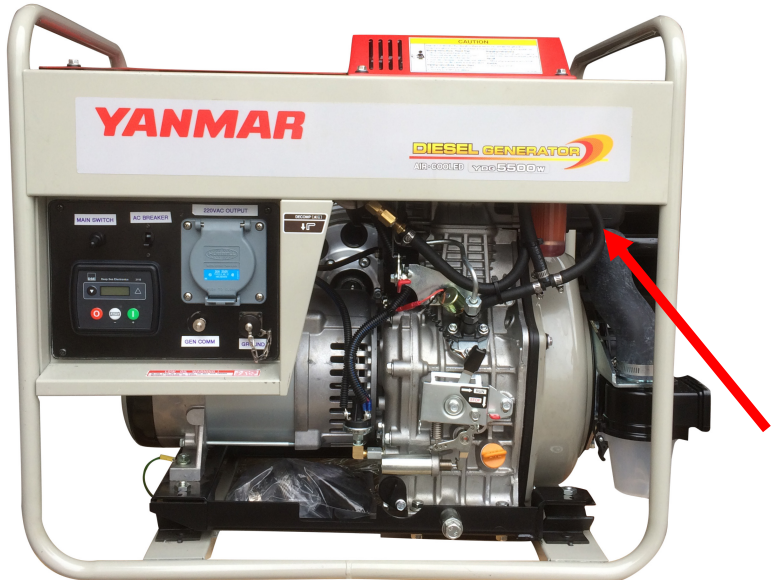


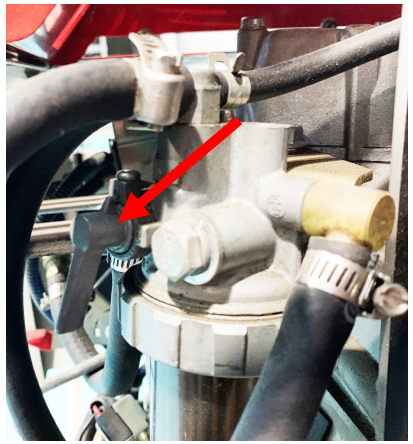
Solar panel bent and creased

HPS Setup

Activate the System
Prepare generators

L0 Generator

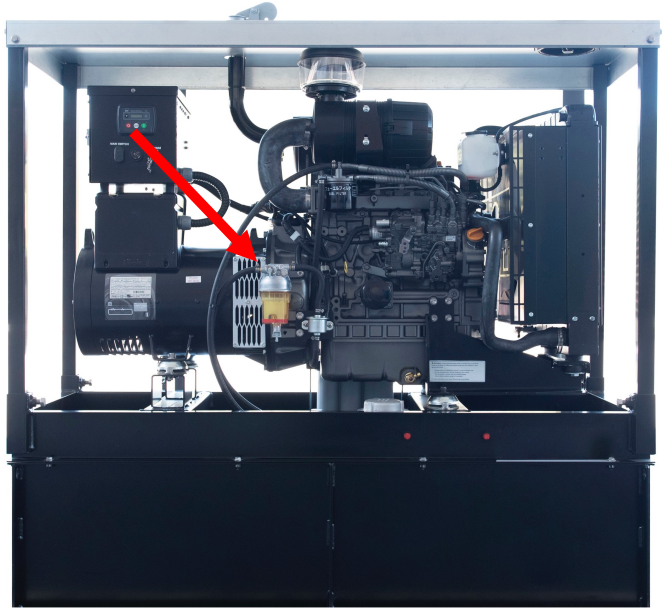




1. Verify the generator has fuel oil and coolant; verify the generator starter battery cables are connected.

2. Open fuel Line valves

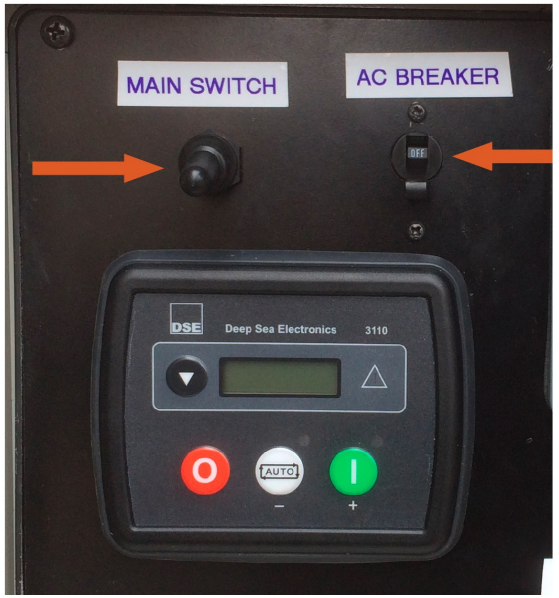
L1/L2 Generator



HPS Setup

Activate the System
Prepare generators

L0 Generator Control Panel



3. Toggle ON the MAIN SWITCHes to power up DSE Remote start control.
4. Toggle on AC BREAKER switches to ON.

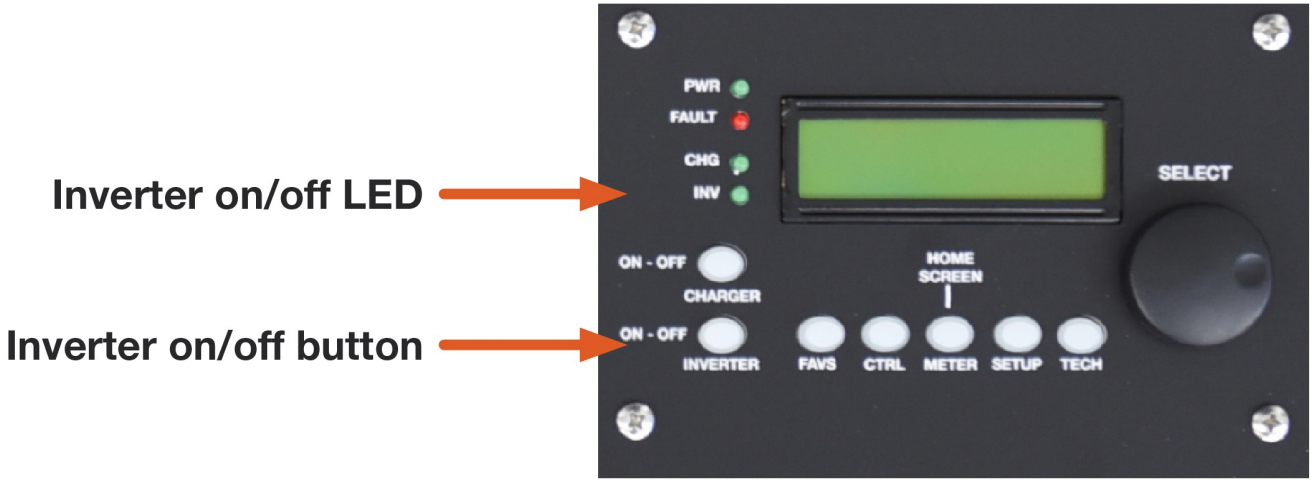
L1/L2 Generator Control Panel

HPS Setup

Activate the System.
Turn on generator from PRO-Verter

5. Turn on the main power switches on all Expander Paks and PRO-Verter(s).
   ~The Power Hub turns on automatically when connected to the battery bank via the DC Bus (Inter-Connect network).

6. The PRO-Verter “Inverter” function will turn on automatically. The LED next to “INV” will be illuminated when the inverter is operating.

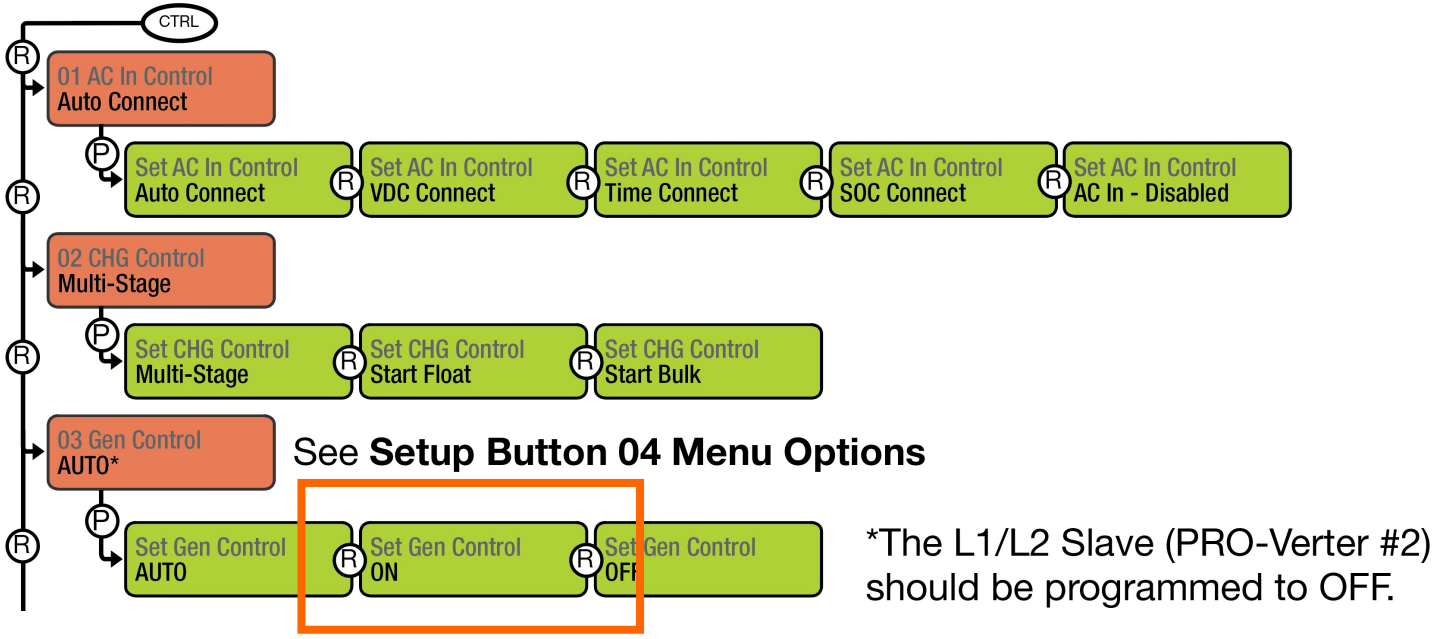


HPS Setup

Initialize and calibrate the System.

1. Set the PRO-Verter clock to local time.

2. Test the PRO-Verter and generator operation.
   Turn on the generator manually using the PRO-Verter (CTRL 03 ON > AUTO).



*The L1/L2 Slave (PRO-Verter #2) should be programmed to OFF.

Let the generator run until the batteries achieve full charge and then auto-stop.

Normal cycling will begin with the generator operating only as necessary for continuity of operation (keeping the batteries charged and the load functioning).

Initialization is complete.

HPS Setup

Order of Operations
L0 and L1/L2

Check these to be sure

Activation Sequence

1. Charge System batteries.
2. **Turn off the generator (L0).**
3. Raise the mast.
4. Activate the shelter systems.

Deactivation Sequence

1. Charge System batteries**.**
2. **Turn off the generator.**
3. Deactivate all shelter systems.
4. Lower the mast.

Peak Loads

- Mast raising/lowering (**generator must be off for L0**)—The deployment of the mast requires up to 10 kW (43 A at 230 VAC) at peak load.
- Environmental control units (ECUs) (**soft starts installed**)—The ECUs require up to 8050 W (35 A @ 230 V AC) at peak load.

Questions and Discussion

1. Which components should be shaded? Why?

2. ***True/False*** The generator should be running when the mast is raised or lowered.

3. What two factors are the source of most faults and System failures?

4. What is the first step of the activation sequence?

5. What is the first step of the deactivation sequence?

6. Why is it important to secure Solar Arrays?

Questions and Discussion

7. ***True/False*** – The Power Hub regulates AC power from generator and grid sources.

8. How should the Solar Arrays be aimed when deployed?

9. ***True/False*** – It is ***safe*** to plug any Inter-Connect plug into any Inter-Connect port.

10. Which device(s) offers critical system operation information?

11. Which PRO-Verter menus provide quick access to commonly used settings?

System Operation Learning Objective

Action: Understand the HPS Inter-Connect network (DC bus) and its relationship to the flow of power and communication through the System.

System Operation Topics

- **System Operation**
  - ❑ Inter-Connect Network
  - ❑ Circuit Breaker Network in the HPS
  - ❑ Power Flow through the System

System Operation

Inter-Connect Network

- Enables “communication” (voltage) between components
- Provides the common DC circuit (bus) to which all HPS components are connected
- Enhances setup and safety through polarized connections

The Inter-Connect Plug

Plug & Play: All components in the HPS have placards located adjacent to Inter-Connect ports to indicate recommended setup connections. Failure to follow recommended setup connections may result in an inoperable condition or less than optimal metering of power, which will affect the ability to collect accurate operation data.

System Operation

Circuit Breaker Network in the HPS

The Inter-Connect system is protected from overloads and short circuits through a network of circuit breakers strategically placed throughout the circuit.

Note: Circuit breakers are **not** designed to protect equipment; rather, they are designed to prevent overheating of electrical conductors and connections in an electrical circuit.

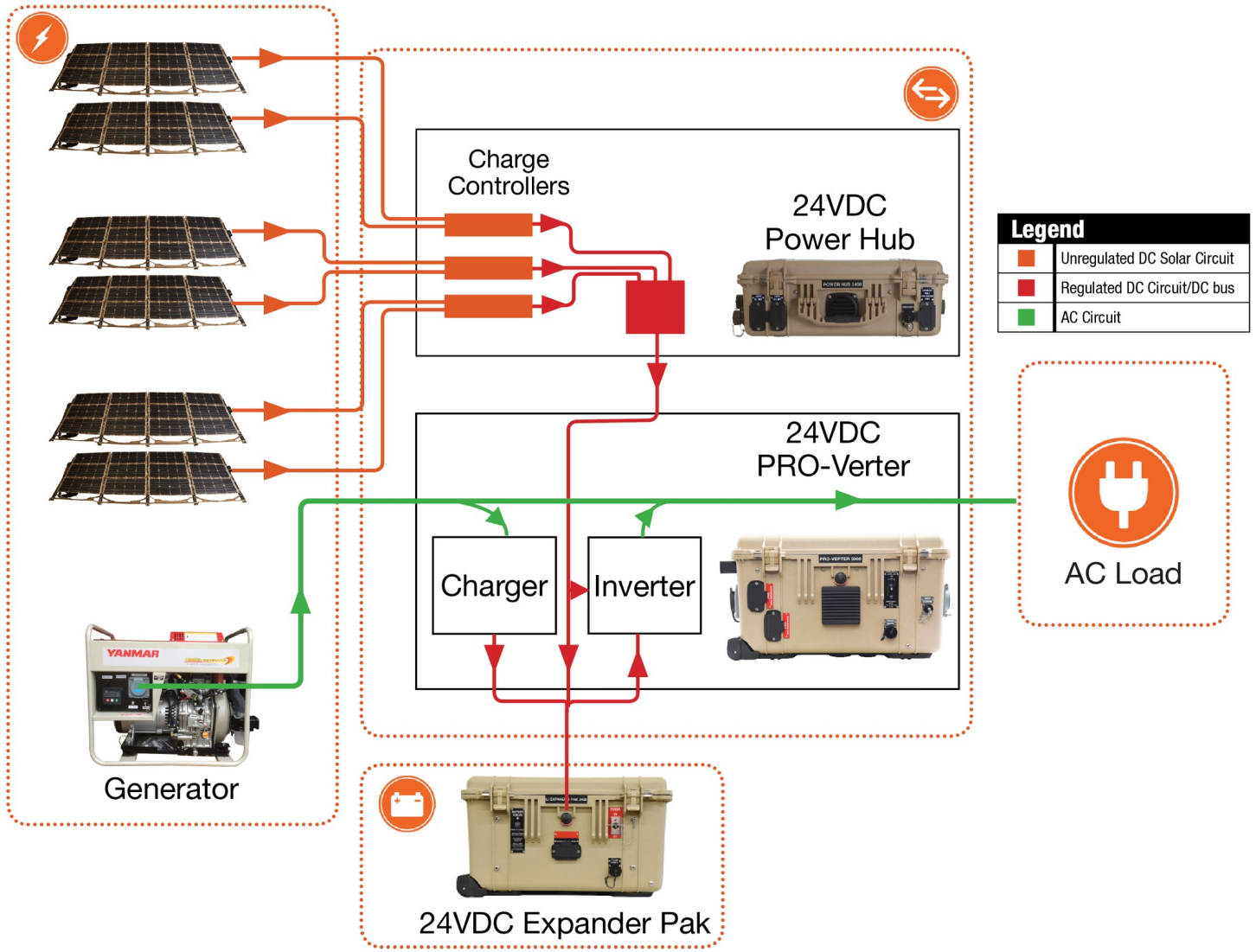
System Operation

Power Flow through the System

Cycling begins once the HPS batteries have reached full SOC.

The PRO-Verter AGS circuit will stop the generator and switch its internal function from CHARGING to INVERTING, providing power to the load.

PV power from the Solar Arrays (when it is present) is automatically prioritized over the generator.



Questions and Discussion

1. What is the connection framework of the HPS DC power network?

2. What component is considered the most important part of the HPS?

3. ***True/False*** – The HPS is protected by circuit breakers.

4. What two factors are the source of most faults and System failures?

PRO-Verter Operation Learning Objective

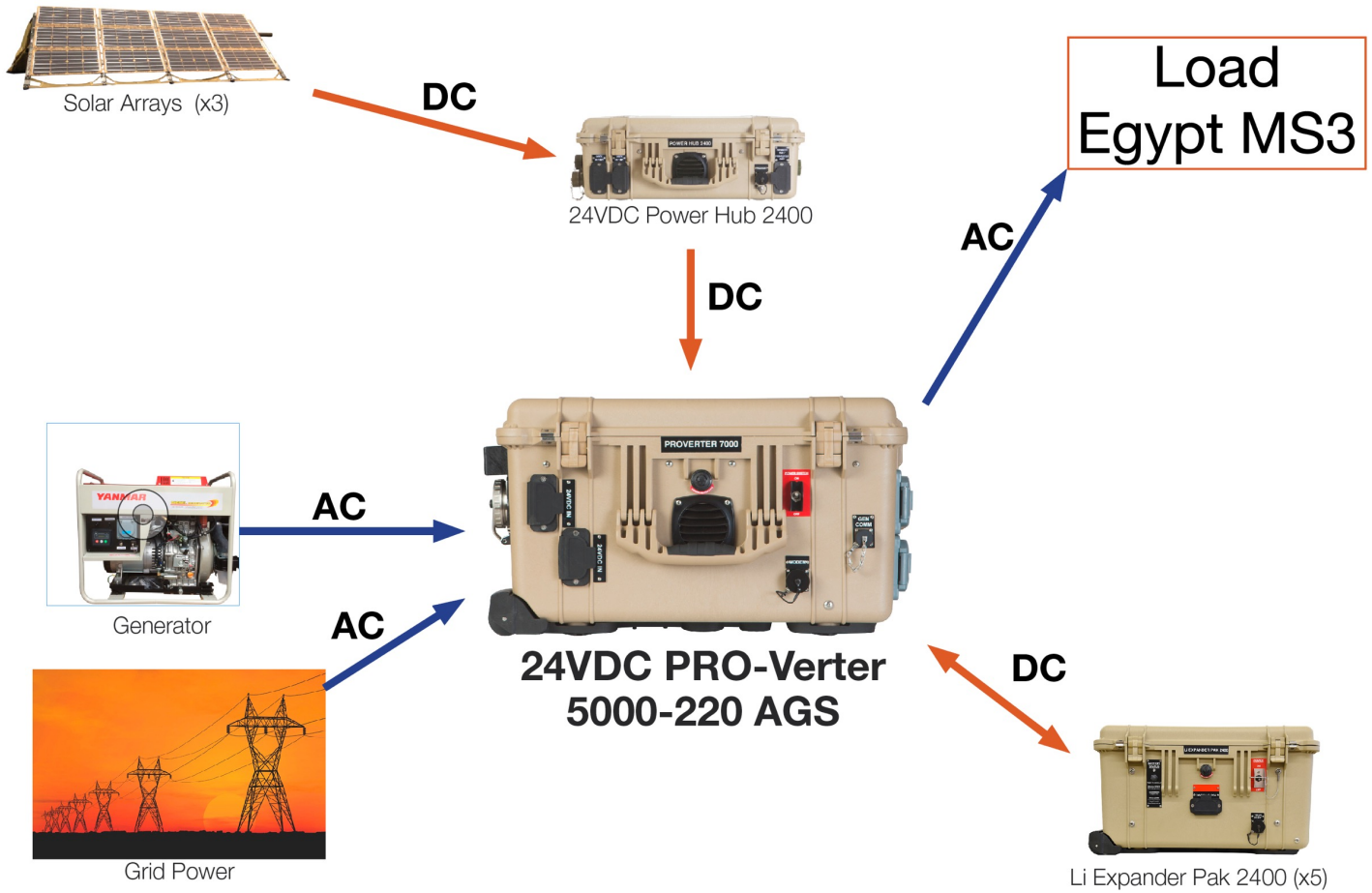
Action: Use the PRO-Verter to monitor and control the system function and state of health. Understand how to shade the PRO-Verter to reduce solar loading and thereby increase efficiency.

PRO-Verter Operation Topics

- **PRO-Verter Operation**
  - ❑ Function of the PRO-Verter in the HPS
  - ❑ LCD, Buttons, and Menu Items
  - ❑ Menu Buttons
  - ❑ LED Indicator Guide and Charger, Inverter Buttons
  - ❑ Programming for Three-stage Charging
  - ❑ Using One (1) PRO-Verter to Control the Generator
  - ❑ PRO-Verter 5000 Control Menu

PRO-Verter Operation

Function of the PRO-Verter in the HPS

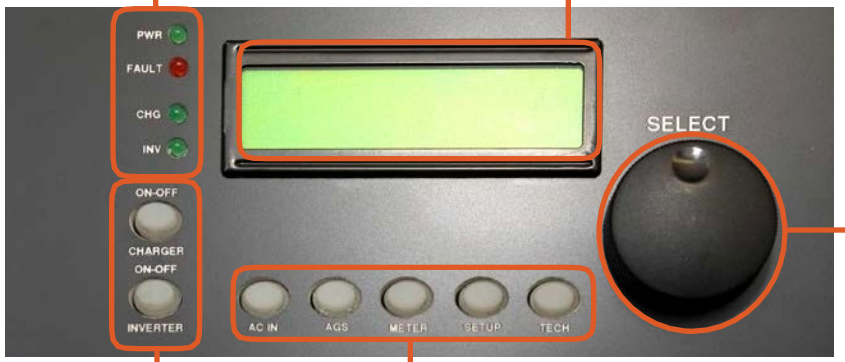


PRO-Verter Operation

LCD, Buttons, and Menu Items

System Status LED Indicators

LCD Screen



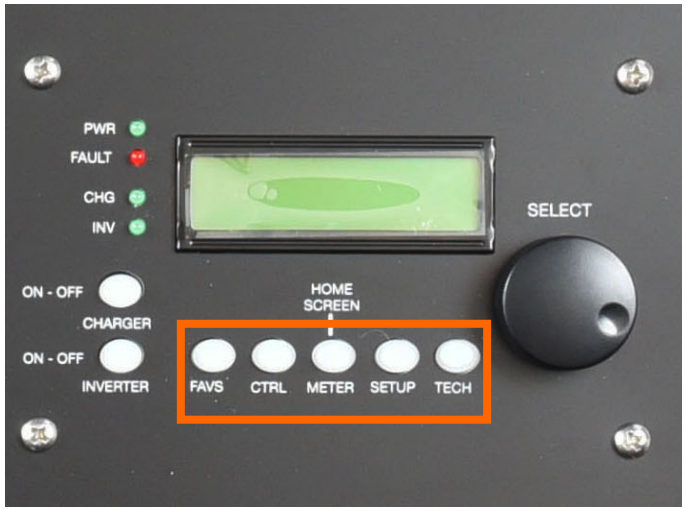
Rotary SELECT Knob

Inverter and Charger ON/OFF buttons

Menu Buttons

PRO-Verter Operation

MENU Buttons



FAVS

Stores the most commonly used settings, which aids in troubleshooting.

CTRL

Contains the menus for “AC In Control”, “CHG Control”, and “Gen Control”. Gives quick control of the main functions of the inverter/charger.

METER/HOME

Provides metering information on the PRO-Verter such as the AC, DC, or AGS meters. Brings the LCD back to the default HOME screen from any other menu.

SETUP

Allows the PRO-Verter to be configured to specific system preferences or to change the functions and capabilities. (Passcode may be required.)

TECH

Allows access to menu selections that can help service personnel with troubleshooting, historical data, revisions, and more.

PRO-Verter Operation

LED Indicator Guide and Charger, Inverter Buttons

Power Status LED (illuminates when powered)

Fault Status LED (illuminates when there is a fault)

Charger Status LED (illuminates when charging)

Inverter Status LED (illuminates when inverting)

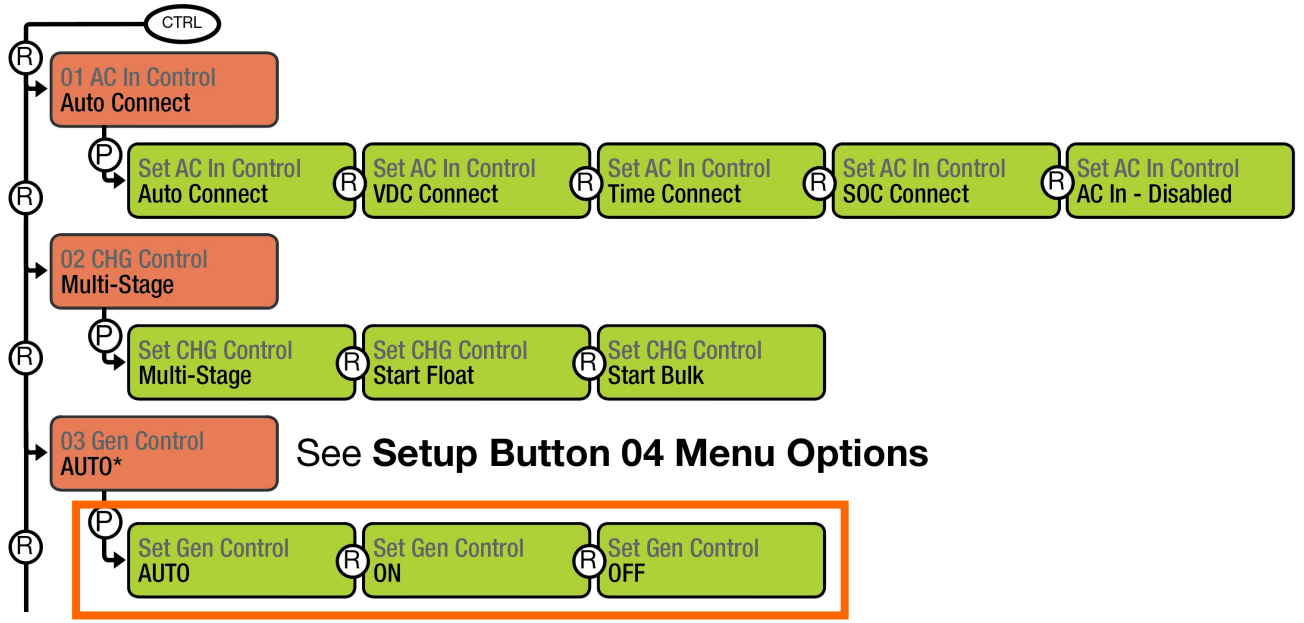
Charger Power Button

Inverter Power Button

Note: If there is no user activity at the PRO-Verter control for 15 minutes, the Status LEDs and the LCD backlight will enter Power-save mode. During this mode, all of the LED indicators and the screen backlight will NOT be illuminated. Press any button to on the control to “wake it up”.

PRO-Verter Operation

Using one (1) PRO-Verter to Control the Generator



L0

PRO-Verter = AUTO

L1/L2

PRO-Verter #1 (Master) = AUTO

PRO-Verter #2 (Slave) = OFF

PRO-Verter Operation

PRO-Verter 5000 Control Menu

SEE SUPPORTING DOCUMENT

Questions and Discussion

1. Information about connecting the System be found in which component?

2. When should the lids of the components be closed?

3. How often should the air intake filters of the PRO-Verters be cleaned?

4. ***True/False*** – It is ***safe*** to plug any Inter-Connect plug into any Inter-Connect port.

5. Describe a possible cause of the PRO-Verter engaging high-temperature Auto Generator Start.

6. Which device(s) offers critical system operation information?

Questions and Discussion

7. Which PRO-Verter menus provide quick access to commonly used settings?

8. When troubleshooting the HPS, what two criteria must be verified before using the PRO-Verter menus?

Generator RsEK Operation Learning Objective

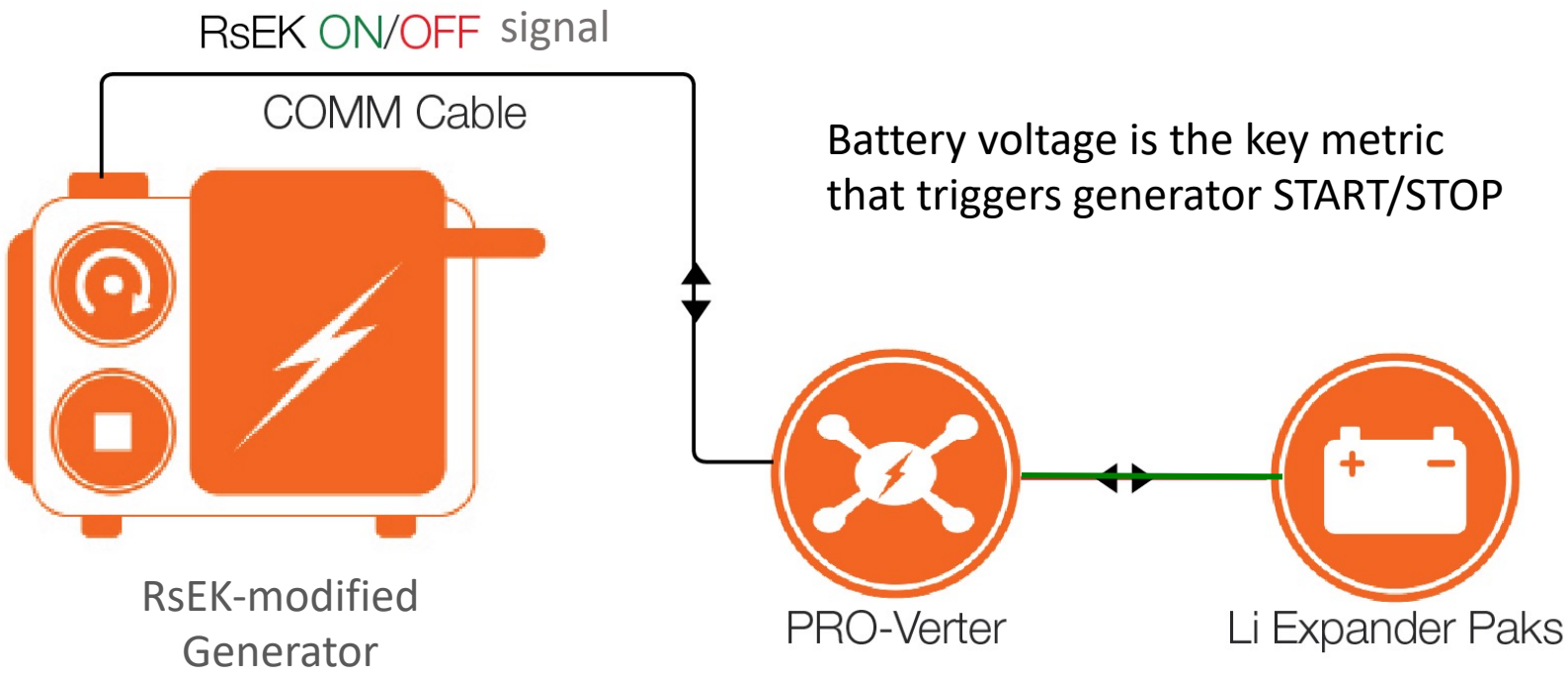
Action: Understand and demonstrate how to use the PRO-Verter to control the generator. Understand how to use the user interface of the generator remote-start controller to troubleshoot generator and system faults.

Generator RsEK Operation Topics

- **Generator RsEK Operation**
  - ❑ General Operation
  - ❑ How the RsEK Works with the AGS Control
  - ❑ RsEK User Interface
  - ❑ RsEK Operation in L1/L2

Generator RsEK Operation

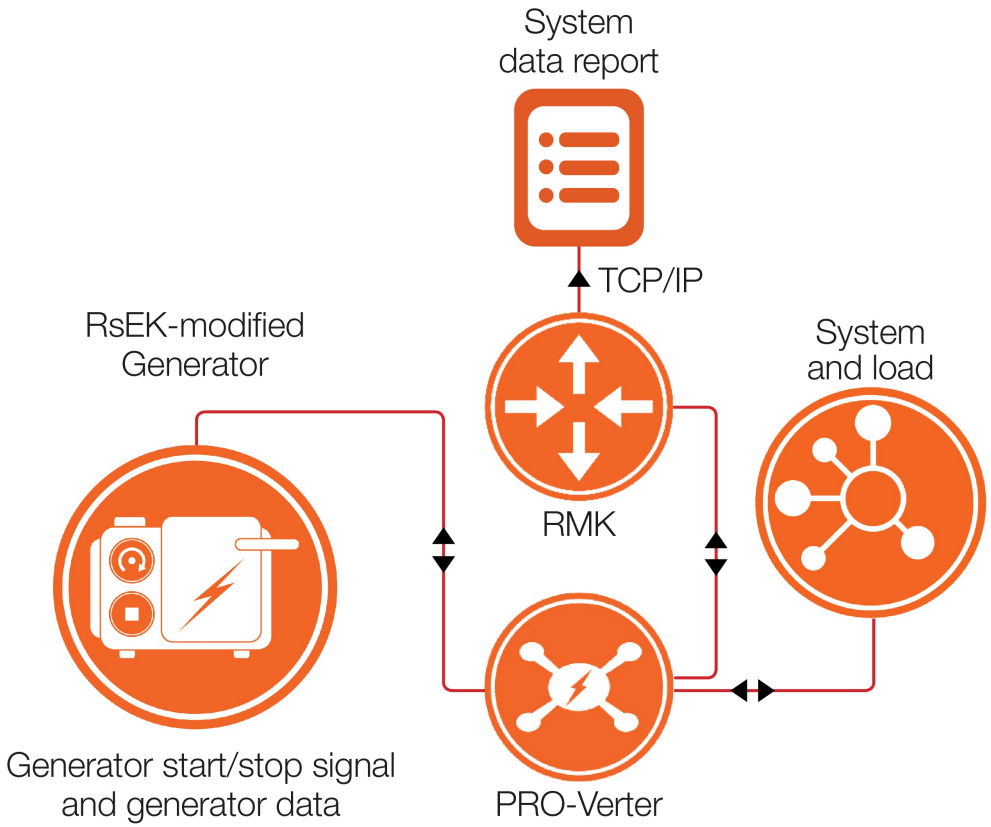
General Operation



Generator RsEK Operation

How the RsEK Works with the AGS Control

- PRO-Verter AGS control closes a contact to turn on the generator
  - Waits 90 seconds for generator to provide AC power to PRO-Verter
  - Repeats process up to four times before GEN RUN fault occurs
- PRO-Verter AGS opens the contact to stop generator



Generator RsEK Operation

RsEK User Interface

- Allows external mechanism to remotely toggle the generator control on and off
- Consists of a simple Auto-Start Module (DSE 3110) and a wire harness that overlays (duplicates) the generator's native electrical circuit

RsEK User Interface L0

RsEK User Interface L1/L2

Generator RsEK Operation

RsEK Operation in L1/L2

Only one of the two PRO-Verters controls the generator in L1/L2.

13.0 kW generator

13.0 kW generator
RsEK Control Panel

24VDC PRO-Verter **#1**

13-1000155

15’ AGS Cable

Genset/RsEK PRO-Verter Communication

Questions and Discussion

1. Describe how the PRO-Verter AGS functions.

2. Which of the two PRO-Verters in L1/L2 is connected to and controls the generator?

Power Hub Operation Learning Objective

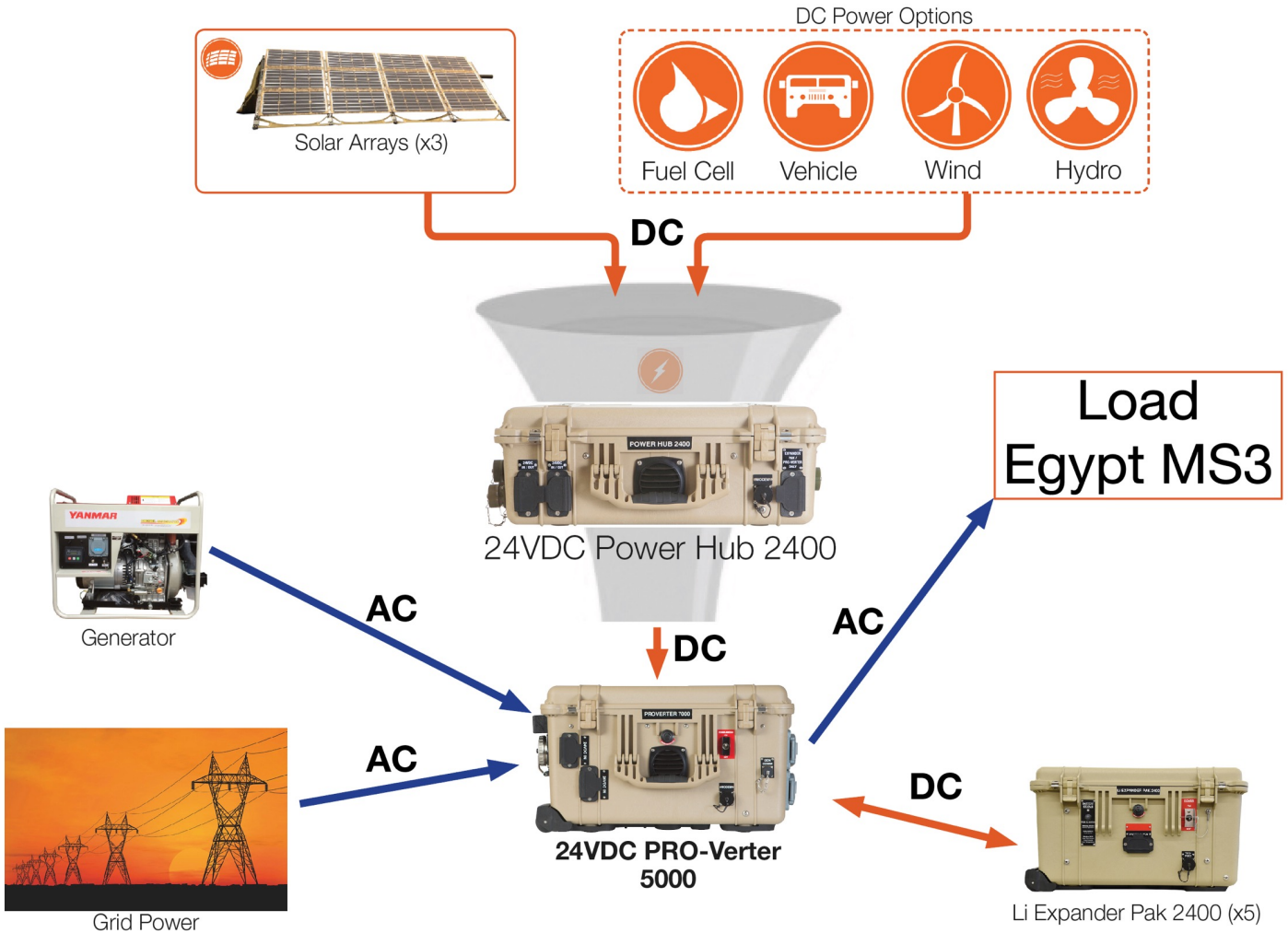
Action: Use the Power Hub to maximize and monitor energy produced by solar arrays. Understand how to shade the Power Hub to reduce solar loading and thereby increase efficiency.

Power Hub Operation Topics

- **Power Hub Operation**
  - ❑ Function of the Power Hub in the HPS
  - ❑ Power Hub Control Interface
  - ❑ Power Hub Control Menu
  - ❑ Shade the Power Hub

Power Hub Operation

Function of the Power Hub in the HPS



Power Hub Operation

Power Hub Control Interface

Monitoring the Photovoltaic Charging Status

Charge Status Indicator - LED Status	
Charge status indicator 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

NOTICE
The Equalize function in the Charge Controller has been disabled in the Power Hub 2400.

Blinking LED indicates charge control operation status

PV Charge Status LED

HPS Setup

Shade the Power Hub.

Power Hub Operation

Power Hub Control Menu

SEE SUPPORTING DOCUMENT

Questions and Discussion

1. What environmental condition has the greatest impact on the operation of the HPS?

2. Which components should be shaded? Why?

3. How often should the air intake filters of the Power Hub be cleaned?

4. ***True/False*** – The Power Hub regulates AC power from generator and grid sources.

5. Which component manages the power from the Solar Arrays?

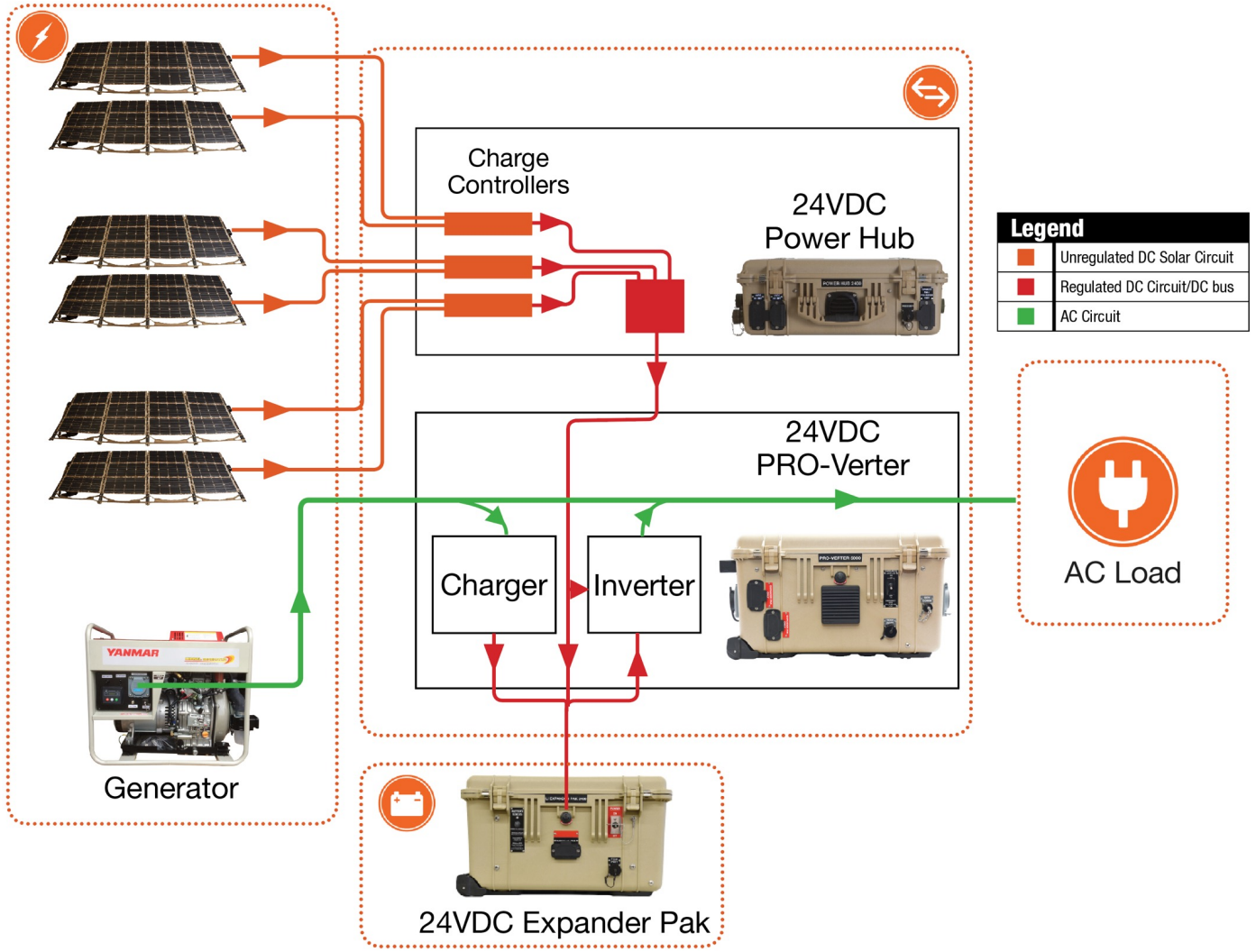
6. Will the Power Hub turn on when connected only to the Solar Arrays?

System Operation Summary

Action: Understand how power flows through the HPS.

System Operation Summary

Power Flow through the System



HPS Preventive Care and Maintenance Learning Objective

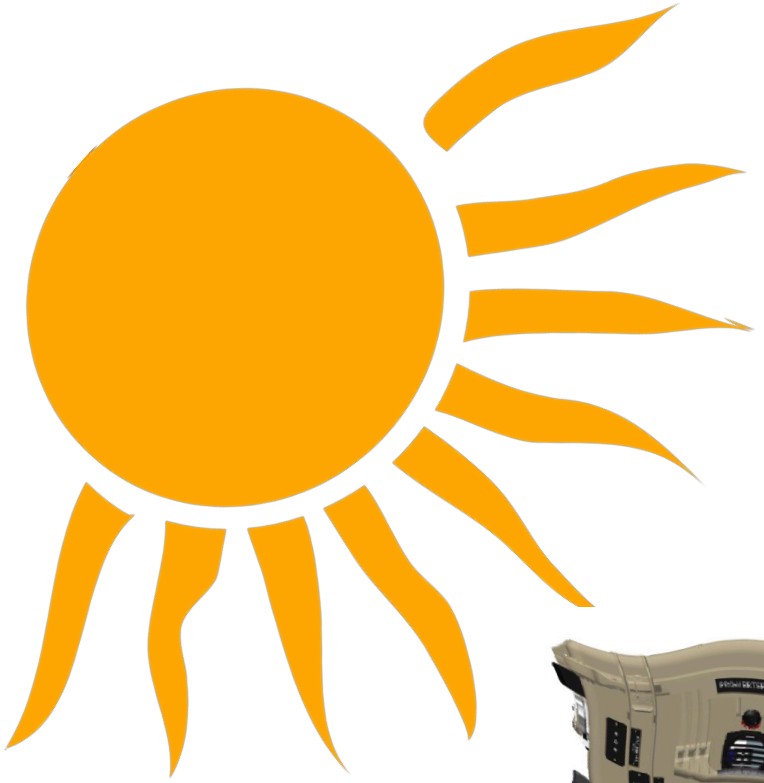
Action: Understand necessary System maintenance procedures and the interval for performing each.

HPS Preventive Care and Maintenance Topics

- **HPS Preventive Care and Maintenance**
  - ❑ Shade the HPS!
  - ❑ General Preventive Care and Maintenance
  - ❑ Water Intrusion Remediation
  - ❑ Cleaning the PRO-Verter Air Filters
  - ❑ Cleaning the Power Hub Air Filter
  - ❑ Cleaning the Solar Panels
  - ❑ L1/L2 13 kW Generator Maintenance
  - ❑ L0 5 kW Generator Maintenance

HPS Preventive Care and Maintenance

Shade the HPS!



Shade the HPS when possible!

HPS Preventive Care and Maintenance

General Preventive Care and Maintenance

- ❑ Cover and shade equipment (except for Solar Arrays) as much as possible.
- ❑ Check air filters monthly; keep them clean (see supporting document).
- ❑ Keep unused Inter-Connect Port covers closed.
- ❑ Check electrical connectors monthly.
- ❑ Ensure Solar Arrays are clean and aimed at the sun.
- ❑ Follow all generator maintenance procedures and intervals.
- ❑ Keep lids closed on PRO-Verter and Power Hub to prevent precipitation or particulates from damaging internal components.

HPS Preventive Care and Maintenance

Water Intrusion Remediation

Location of Drain Plug Screws in the Expander Pak (left), PRO-Verter 5000 (middle), and Power Hub (right)

There is a drain hole on the side, at the end of the strip (arrow).

HPS Preventive Care and Maintenance

Cleaning the PRO-Verter Air Filters

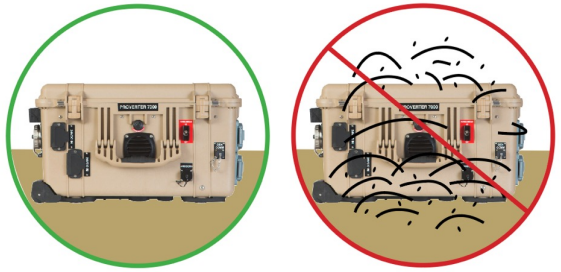
a. Squeeze the sides and pull away to remove the louvered vent cover..

b. The foam air filter sits on top of the filter assembly.

c. Remove the foam filter. Clean with water or compressed air.

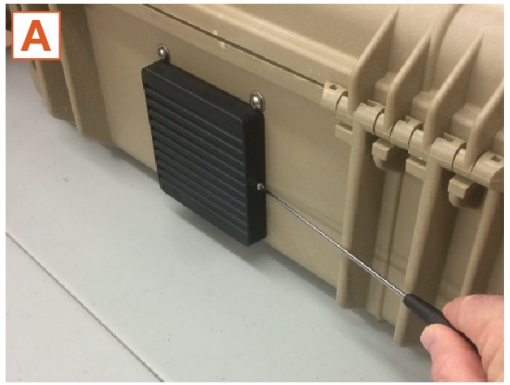
d. Reinstall the louvered cover in the proper orientation—leading edge of the baffles facing toward the ground.

Note: Only air intake vents have air filters. The exhaust vents do not. See Figure 5 through Figure 7 for vent type locations.



HPS Preventive Care and Maintenance

Cleaning the Power Hub Air Filters



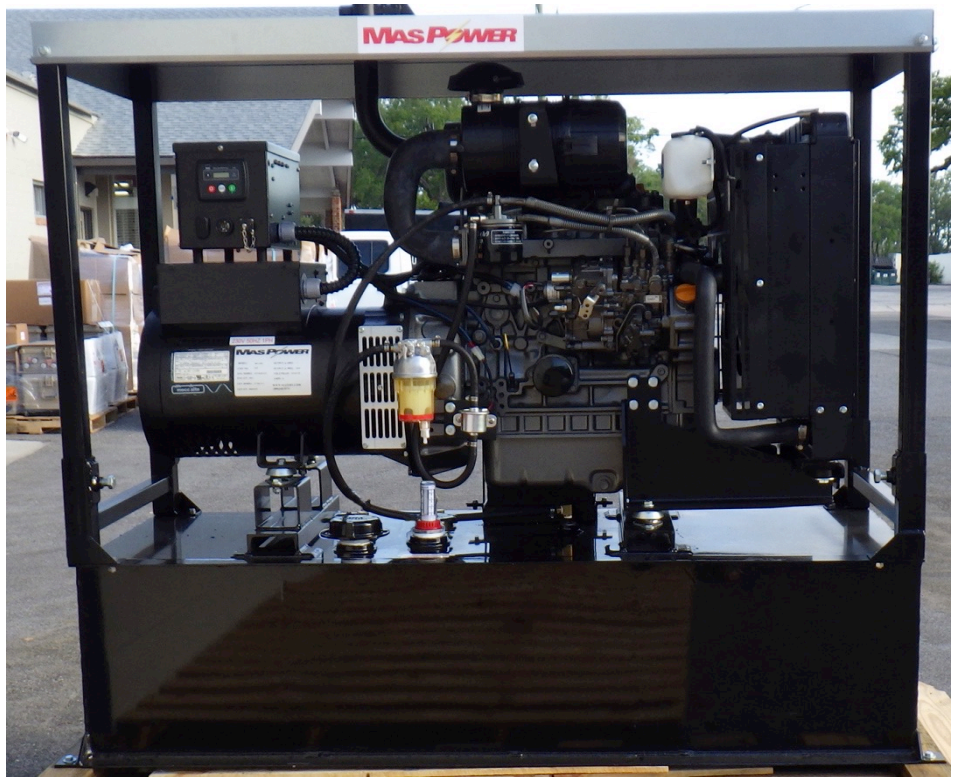
HPS Preventive Care and Maintenance

Cleaning the Solar Panels

Clean panels = more free power

HPS Preventive Care and Maintenance
L1/L2 13 kW Generator Maintenance

Engine Model: 4TNV88



Details in Generator Operator and Maintenance Manual

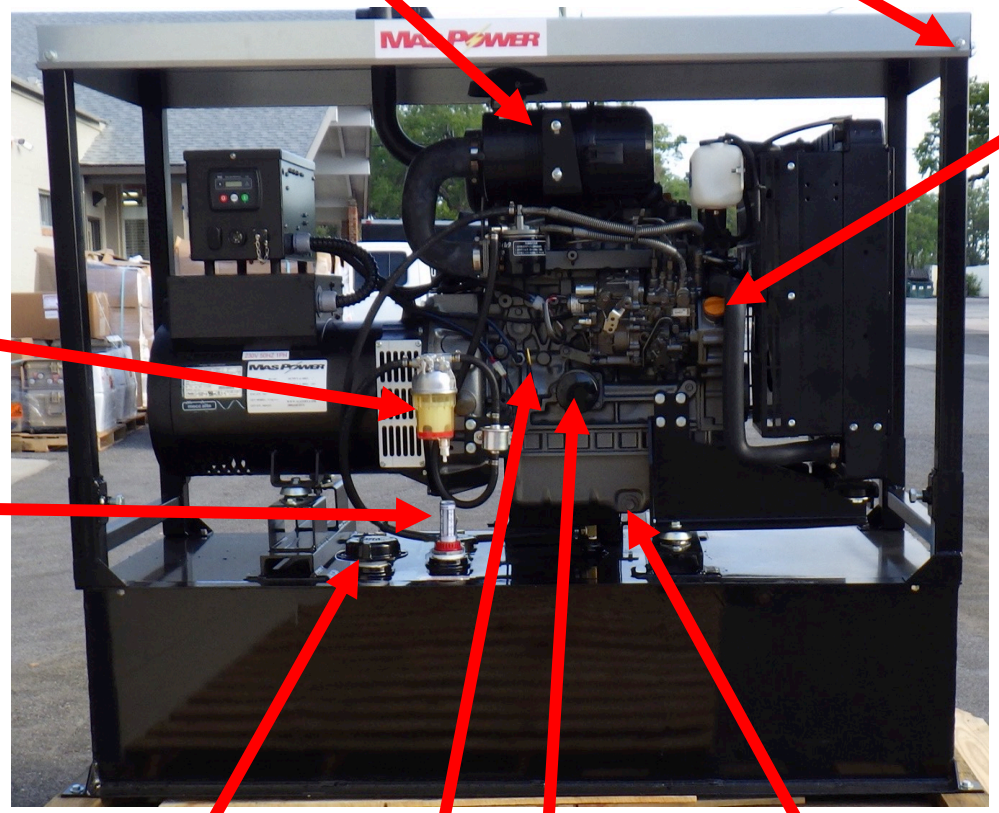
Periodic Maintenance Schedule

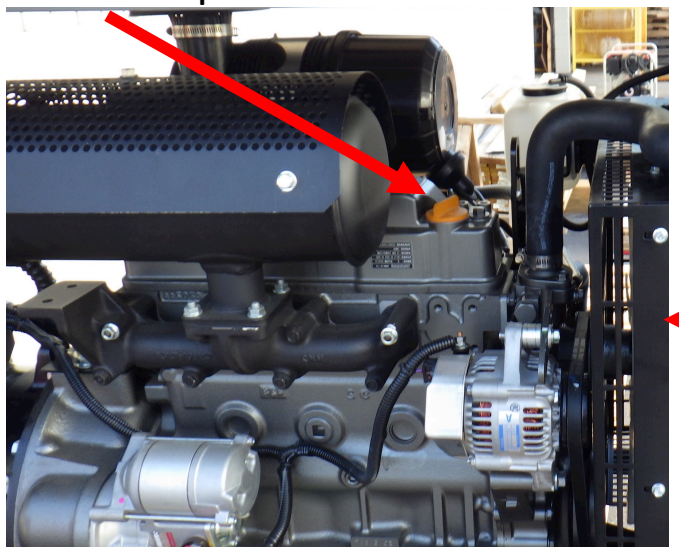
○: Check ◇: Replace ●: Contact your authorized Yanmar industrial engine dealer or distributor

System	Check Item	Daily	Periodic Maintenance Interval					
			Every 50 hours	Every 250 hours	Every 500 hours	Every 1000 hours	Every 1500 hours	Every 2000 hours
Cooling System	Check and Refill Engine Coolant	○						
	Check and Clean Radiator Fins		○					
	Check and Adjust Cooling Fan V-belt		○ 1st time	○ 2nd and after				
	Drain, Flush and Refill Cooling System With New Coolant					◇ or every 1 year whichever comes first		
Cylinder Head	Adjust Intake / Exhaust Valve Clearance					●		
	Lap Intake / Exhaust Valve Seats. If necessary							●
Electrical Equipment	Check Indicators	○						
	Check Battery		○					
Engine Oil	Check Engine Oil Level	○						
	Drain and Fill Engine Oil		◇ 1st time	◇ 2nd and after				
	Replace Engine Oil Filter							
Engine Speed Control	Check and Adjust Governor Lever and Engine Speed Control	○		○				
Emission Control Warranty	Inspect, Clean And Test Fuel Injectors						●	
	PL ENGINE Inspect Turbocharger (Blower Wash as Necessary) 3TNV84T, 4TNV84T, 4TNV98T, 4TNV106T, 3TNV84T-B, 4TNV84T-Z, 4TNV98T-Z						●	
	PL ENGINE Inspect, Clean and Test EGR Valve 4TNV84T, 4TNV98T						●	
	PL ENGINE Clean EGR Lead Valve 4TNV84T, 4TNV98T						●	
	PL ENGINE Clean EGR Cooler (Clean to Blow Water/Air Passages) 4TNV84T, 4TNV98T						●	
	Inspect Crankcase Breather System						●	
Fuel	Check and Refill Fuel Tank Level	○						
	Drain Fuel Tank			○				
	Drain Fuel Filter / Water Separator	○						
	Check Fuel Filter / Water Separator	○						
	Clean Fuel Filter / Water Separator				○			
	Replace Fuel Filter				◇			
Hoses	Replace Fuel System and Cooling System Hoses							◇ or every 2 yrs.

HPS Preventive Care and Maintenance

L1/L2 13 kW Generator Maintenance





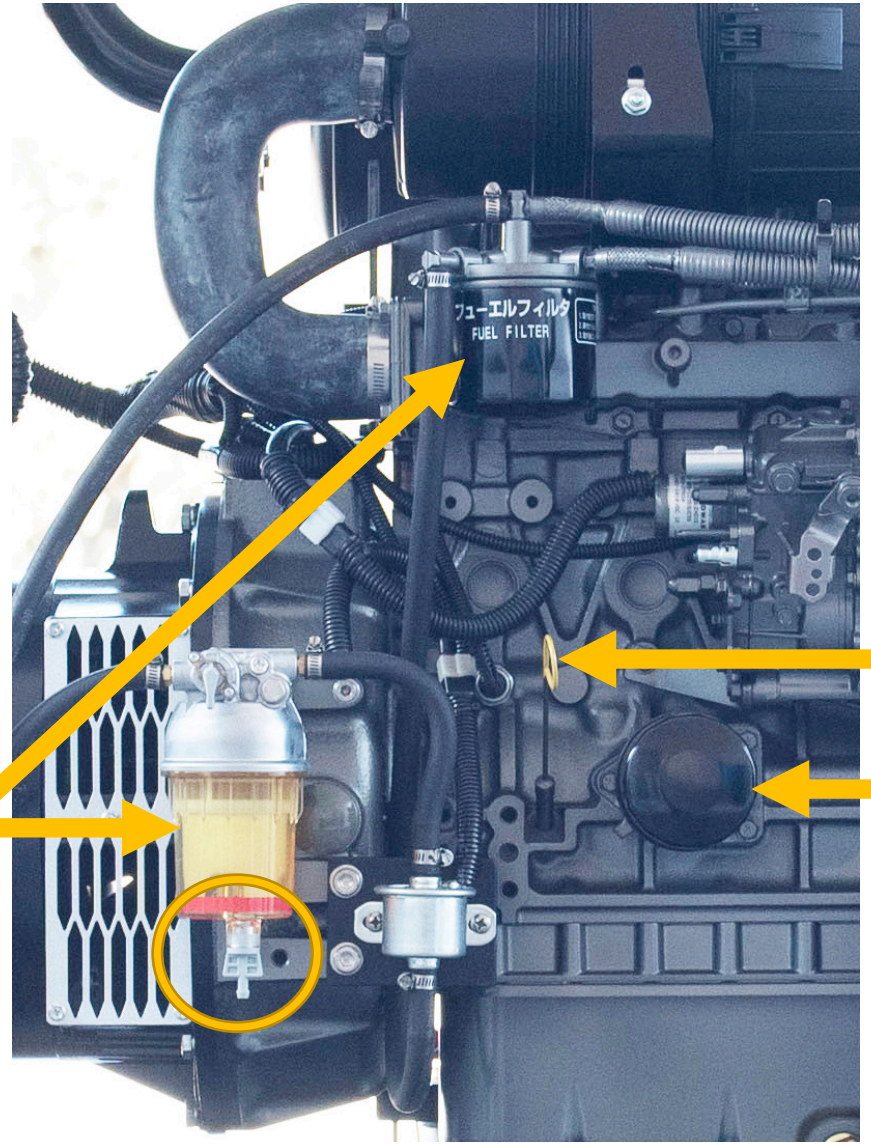
Engine Model: 4TNV88

HPS Preventive Care and Maintenance

13 kW Generator Air Filter Cleaning

HPS Preventive Care and Maintenance

13 kW Generator Oil and Fuel Filters



Fuel Filters

Oil dip stick

Oil Filter

HPS Preventive Care and Maintenance

L0 5 kW Generator Maintenance

Details in Generator Operator and Maintenance Manual

Periodic Maintenance Schedule

○: Check ◇: Replace ●: Contact your authorized YANMAR industrial engine dealer or distributor for these maintenance services.

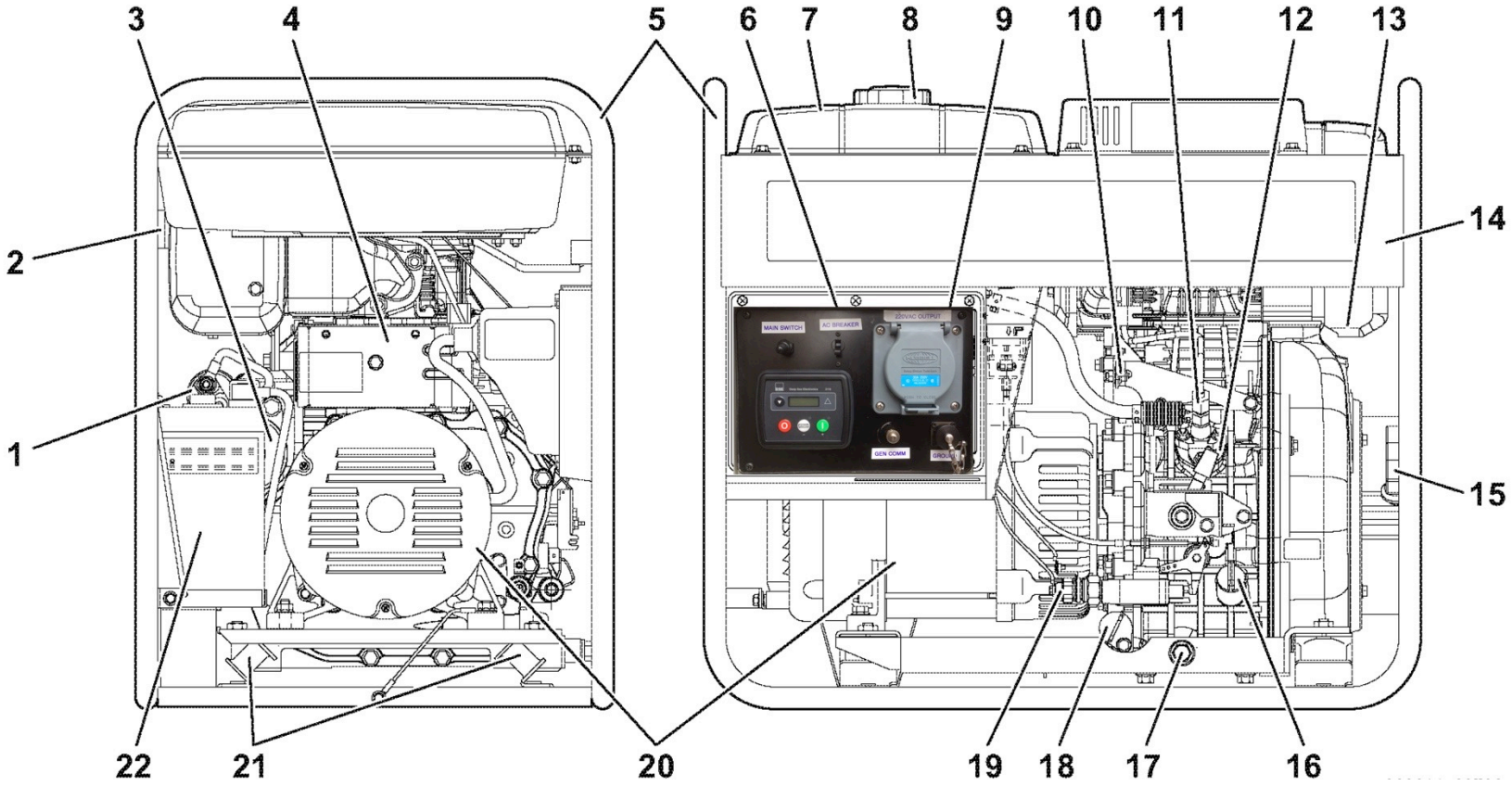
System	Check item	Daily	Periodic maintenance interval					
			Every 50 hours	Every 200 hours	Every 400 hours	Every 1000 hours	Every 1500 hours	Every 2000 hours
Air intake	Clean or replace air cleaner element - (may need more frequent service in dusty conditions)			○				
Cylinder head	Adjust intake/exhaust valve clearance				●			
	Check compression					●		
Electrical equipment	Check battery (if equipped) and add water as necessary	○ before operation						
	Check battery indicator (If equipped) and other driven machine indicators (if equipped)	○ when engine is started						
	Wiring harness				●			
	Voltmeter				●			
Emission control warranty	Inspect, clean and test fuel injection nozzle						●	
Engine oil	Check engine oil level and add engine oil as necessary	○ before operation						
	Drain and refill engine oil		◇ 1st time	◇ 2nd and after				
	Clean engine oil filter - replace if damaged				◇ 2nd and after			
	Check for engine oil leakage	○ before and after operation						
Engine speed control	Check for proper operation verify adjustment	○ 1st time		○ 2nd and after				

HPS Preventive Care and Maintenance

5 kW Generator Air Filter Cleaning

HPS Preventive Care and Maintenance

L0 5 kW Generator Maintenance



1 – Starter solenoid
2 – Muffler
3 – Starter motor
4 – Engine nameplate label
5 – Frame
6 – Control panel
7 – Fuel tank
8 – Fuel filler cap
9 – **AC Power Output**
10 – Compression release lever
11 – Fuel injection pump
12 – Engine control lever
13 – Air cleaner
14 – Generator set model and serial number label (behind upper frame rail)
15 – Recoil starter
16 – Oil filler cap/dipstick
17 – Oil drain plug (one located on each side of engine)
18 – Oil filter
19 – Oil pressure switch
20 – Generator unit
21 – Generator/engine damper mounts
22 – Battery

Questions and Discussion

1. When should the lids of the components be closed?
2. What environmental condition has the greatest impact on the operation of the HPS?
3. Which components should be shaded? Why?
4. How often should the air intake filters of the PRO-Verters and Power Hubs be cleaned?
5. What happens to $LiFePO_4$ cells in higher temperatures during storage?
6. What environmental factor affects the maintenance-charging intervals of the Expander Pak?
7. How should the Solar Arrays be aimed when deployed?

Questions and Discussion

8. Identify items that should be part of the HPS maintenance (PMCS).

9. What is an approved maintenance-charging procedure for the Li Expander Pak?