OPERATOR MANUAL FOR THE SOLAR VENTURE 350W PHOTOVOLTAIC ARRAY

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Revision History

Section	Page(s)	Description	Date
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GENERAL INFORMATION, THEORY OF OPERATION, AND EQUIPMENT DESCRIPTION

Introduction

The Solar Venture 350W Photovoltaic (PV) Array is designed to generate renewable power in expeditionary applications where weight, rugged design, and extreme portability are factors.

The Venture design can be deployed on any terrain, and the PV array can generate up to 350 Watts of power for applications where independence from traditional power sources is required:

- PV power generation for remote locations where fuel-driven generators are not an option
- Decreased fuel consumption in a Hybrid Power System (HPS)
- Peak-shaving to decrease reliance on power from utility or grid

The Solar Venture 350W PV Array is modular and scalable, allowing users to tailor power generation capability to load requirements.

Setup requires no tools and the 350 W Array is “Plug & Play” compatible with all Hybrid Power Systems.

The mono-crystalline cells in the high efficiency Venture-Series panels are laminated onto a carbon-fiber structure, which combines extremely high PV performance with incredibly light material for an extraordinary watt-to-weight ratio. The Venture offers a superior integration of technologies to provide the operator with highest power in the smallest renewable generator footprint available today.

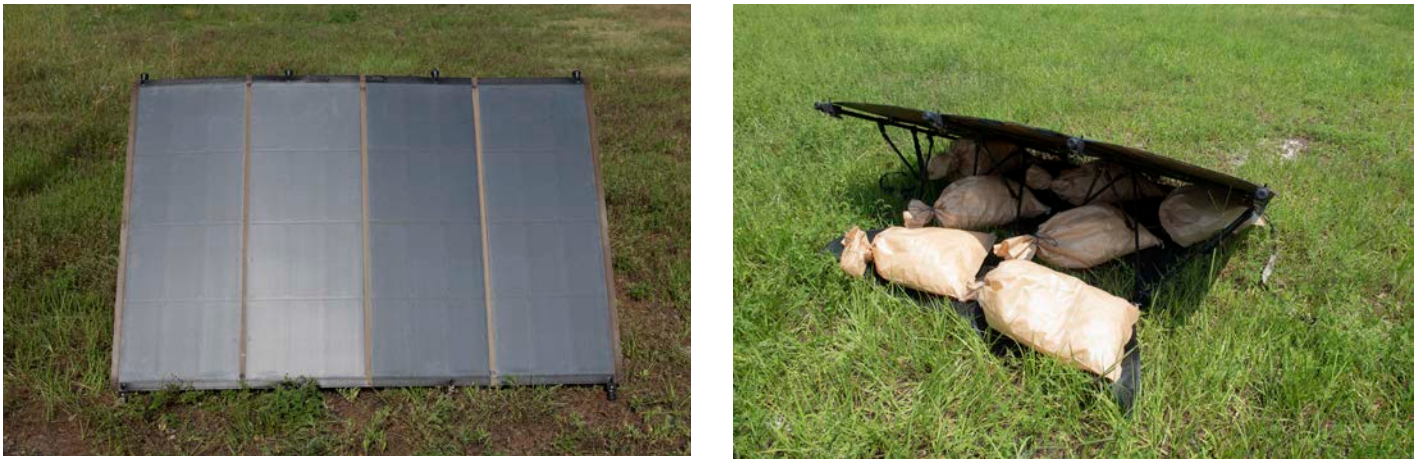


Figure 1. Solar Venture 350W PV Array with ground securing

Product Safety Information and Instructions

This manual contains important safety instructions that must be followed during the installation and operation of the PV array. Read all instructions and safety information contained in this manual.

Exercise caution when handling or operating equipment. Live power may be present.

Safety Information Labels

Your safety and the safety of others is very important. This manual provides guidance on safe operating practices and how to achieve maximum performance from the Solar Venture 350W PV Array. Always observe and follow all safety protocols outlined below:

This is the safety alert symbol. This symbol alerts you to potential hazards that can kill you or hurt you and others. 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 identify 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.

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.

⚠ WARNING

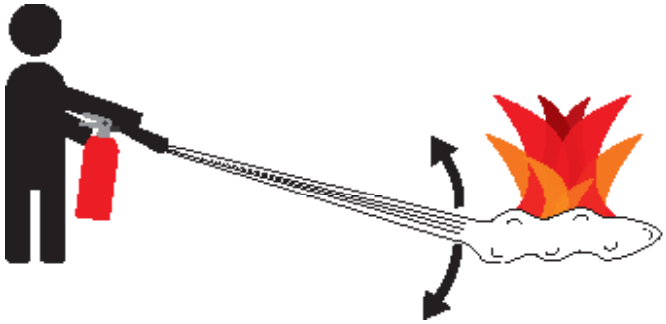
Only CO_2 (carbon dioxide) fire extinguishers should be used with this equipment.

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.



Use Sweeping Motion

Electric Shock Hazard Related to PV Panels

⚠ WARNING

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

- PV panels produce electricity when exposed to sunlight.
- Live power may be present at multiple terminals.
- Never route the cables through standing water.
- All cables and connections should remain dry and should be inspected regularly to ensure safe operating conditions.

DON'T LET THIS BE YOU!

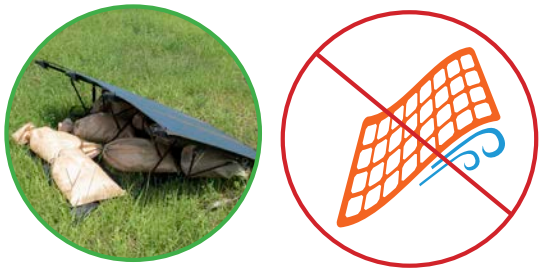
HIGH VOLTAGE: PV arrays, and generators produce potentially lethal line voltages. When servicing equipment, extreme care should be taken to protect against electrocution. Always work with another person in case an emergency occurs. Disconnect power before checking controllers or performing maintenance. Be sure the generator is properly grounded. Wear safety glasses whenever working on any part of the System that requires exposure to mechanical or direct electrical contacts.

Environmental and Handling Precautions

This equipment is ruggedized, yet there are a few things the operator can do to prevent failures and prolong the operational life of the product.

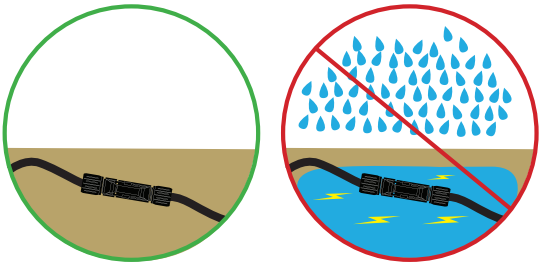
Wind

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



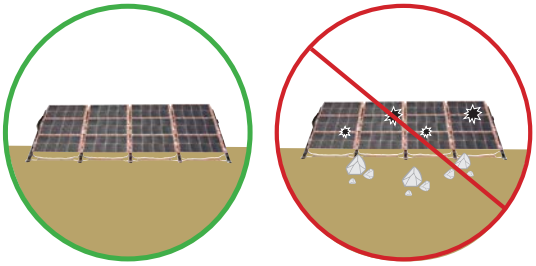
Water

- Do not operate equipment in or around standing water.
- Do not place cables that conduct electricity in or near standing water.



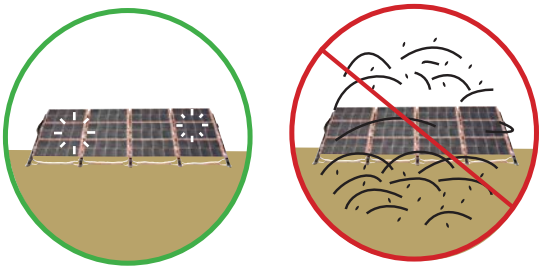
Impact

The PV panels should be protected from being struck by hard objects.



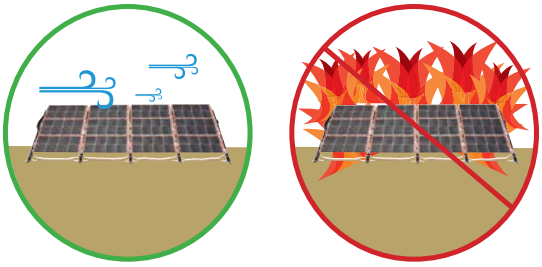
Dust

- This equipment is designed for operation in climates where high levels of dust or other particulates may exist.
- Clean the surface of the PV panels regularly to maintain maximum output. Dirty panels produce less power.



Heat

- Heat and solar loading reduce efficiency and life expectancy. Shade products (except PV panels) to prevent the negative effects of heat.
- PV panels should be placed so that they are exposed to adequate airflow.



GENERAL INFORMATION, THEORY OF OPERATION, AND EQUIPMENT DESCRIPTION

PV cells convert sunlight into electrical power. All PV cells are made of materials called semiconductors that absorb photons when sunlight strikes the PV cell. The absorbed photons then knock electrons loose within the PV cells, allowing them to flow, which produces an electrical current. PV cells contain one or more electric fields that force the direction of electron flow. Placing metal contacts on the top and bottom of a PV cell harnesses this current so it can power external appliances, much like a traditional power generator.

On their own, PV cells produce a limited amount of power, but when arranged and electrically connected in a PV panel, the power generated is directly related to how much cumulative current and voltage the PV cell arrangement is configured for. The panel's total output voltage and current will determine its "watt" rating.

The cell configuration of the Venture 350 Array generates up to 350W of DC power for an application.

Figure 2. Solar Venture 350W four-panel PV array with a small HPS

Equipment Description

Color-coded Connections

The cables and port placards are color coded to simplify making the proper connections. The ends of each cable type are wrapped with colored heat shrink that matches the color of the placard next to the port to which it connects.

Orange: Solar Circuit Connection

Solar Cable

Power Hub Solar Input Only Ports

Figure 3. Color-coded cable labels and case placards

Kit Components

Solar Venture 350W PV Array	
1	Hard transport case
2	4-section foldable PV array
3	Ground-securing mesh (large and small)
4	Support frame
5	Sandbags (12 ea)
6	Solar Cable (sold separately)

Figure 4. Solar Venture 350W PV Array components in transport case (top) and unpacked (bottom)

OPERATOR INSTRUCTIONS

Solar Venture 350W PV Array Setup

Position and Orient System Components

Identify the best location for each component of the System, keeping in mind the length of all cables that will be used to connect all of the components. The typical Solar Cable provided is 30’ long (other lengths are available).

The PV array can be deployed within a 30’ radius (the length of the Solar Cable) of the Power Hub. If the PV array must be deployed more than 30’ from the Power Pak or Power Hub, extensions are available.

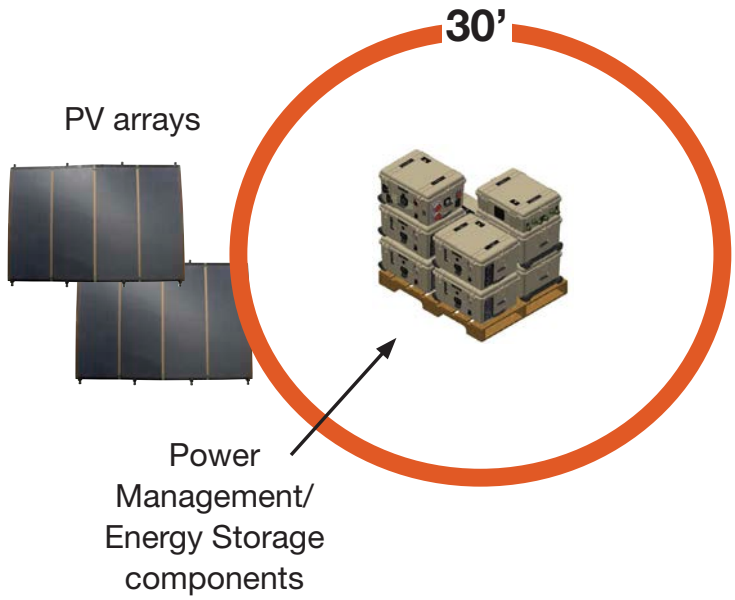


Figure 5. Working-space radius for the PV arrays and associated equipment

Deploy the PV Array Support Frame

Loosen the transport strap securing the foldable array support frame (Figure 6A). Remove the two locking pins (Figure 6B) to allow the frame to expand. Expand the support frame (Figure 6C) and install the locking pins in the “deployed” position (Figure 6D) after the support frame is fully extended (Figure 6E).

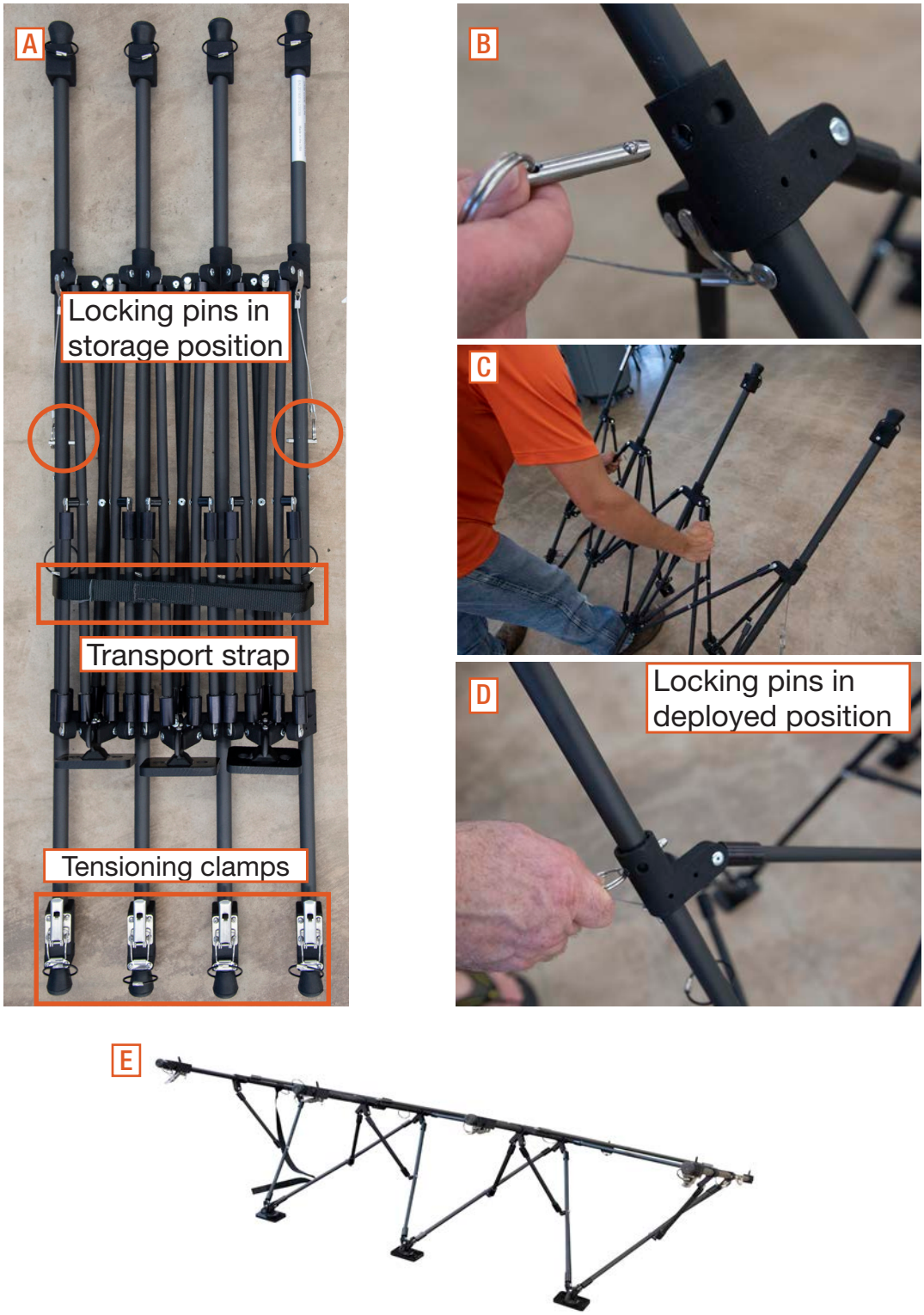


Figure 6. Deploying the PV array support frame

Install the Large Ground-securing Mesh

The large ground-securing mesh has three (3) clips on the short side and four (4) on the long side (Figure 7A). The clips on the short side connect to the rings on the three (3) cleats (Figure 7B) of the support frame. Connect the four (4) clips on the long side of the ground-securing mesh to the wire loops (Figure 7C) at the low end of the support frame bar (Figure 7D). The mesh will be stretched tight when all of the connections are made.

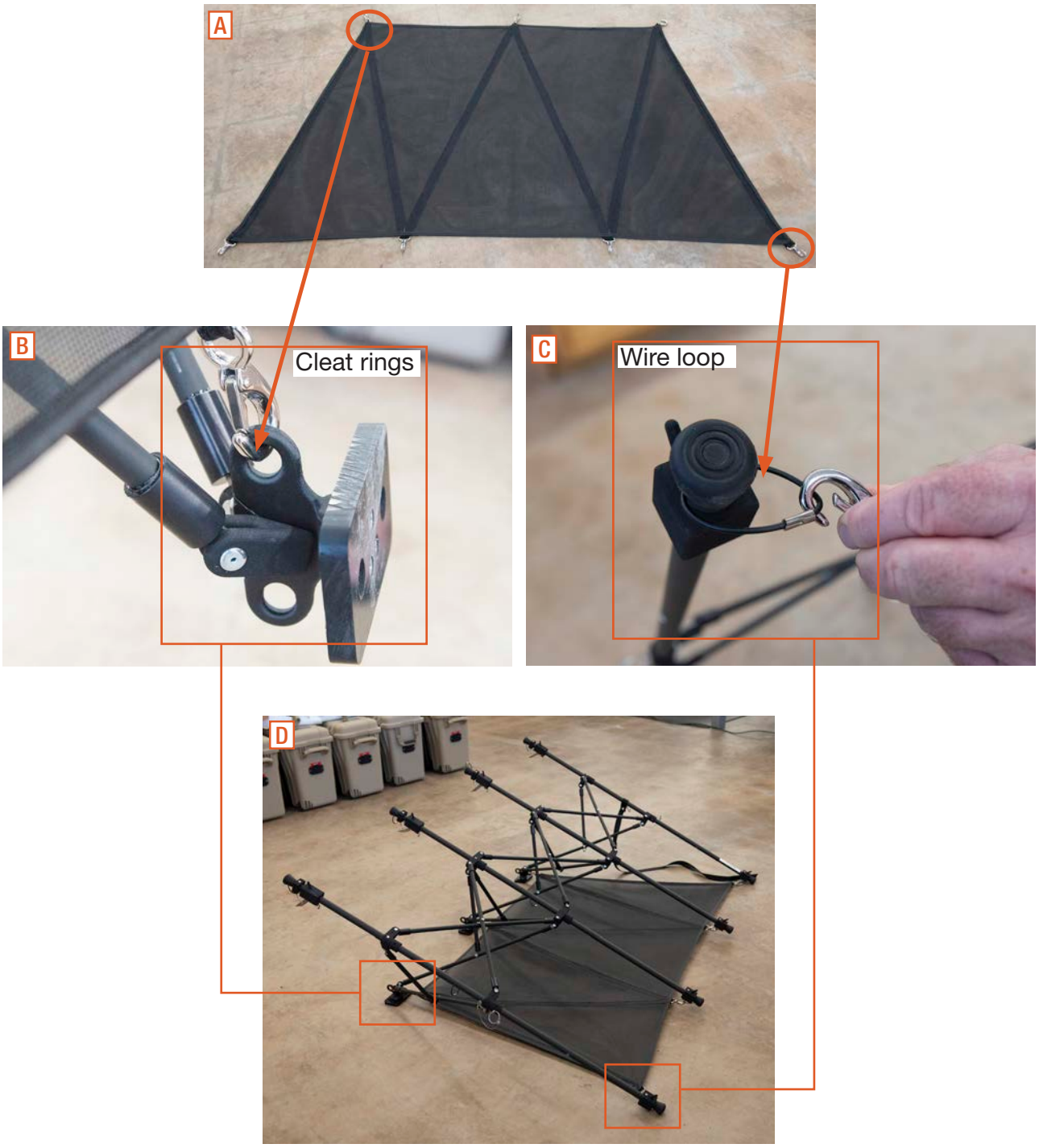


Figure 7. Large ground-securing mesh installation

Install the Small Ground-securing Mesh

The small ground-securing mesh has three (3) clips on the short side and four (4) on the long side (Figure 8A). The clips on the short side connect to the rings (Figure 8B) on the three (3) cleats of the support frame (Figure 8C).

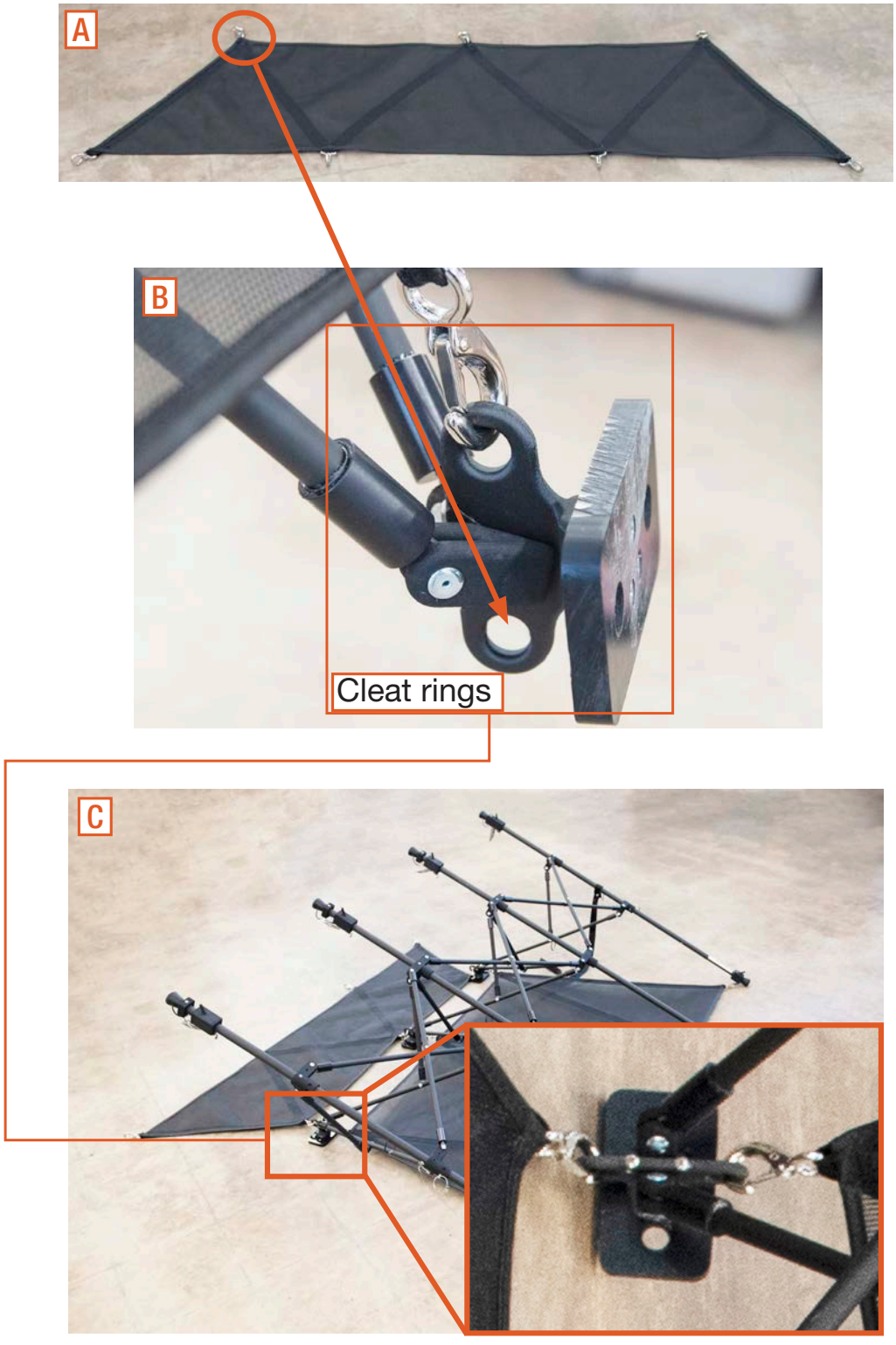


Figure 8. Small ground-securing mesh installation

Ground-securing Mesh Configuration for Low- and Steep-angle Deployments

Connect the large and small ground-securing meshes as shown in Figure 9 to deploy the PV array at 30º and as shown in Figure 10 to deploy the PV array at 60º.

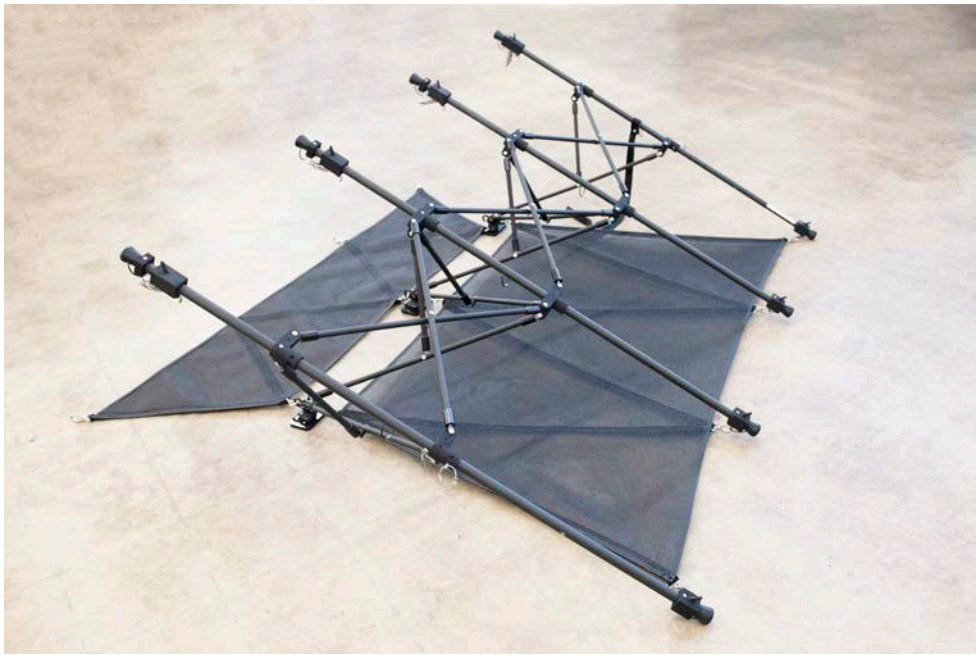


Figure 9. Ground-securing mesh configuration for 30º array deployment

Figure 10. Ground-securing mesh configuration for 60º array deployment

Install the PV Array on the Support Frame

The PV array has eight (8) grommet-reinforced holes, four (4) on the top and four (4) on the bottom (Figure 11A, orange circles). The support frame has eight (8) complementary panel mounting hooks (Figure 11B, orange circles). Connect the bottom of the PV array to the lower row of mounting hooks first and the top row of hooks second (Figure 11B).

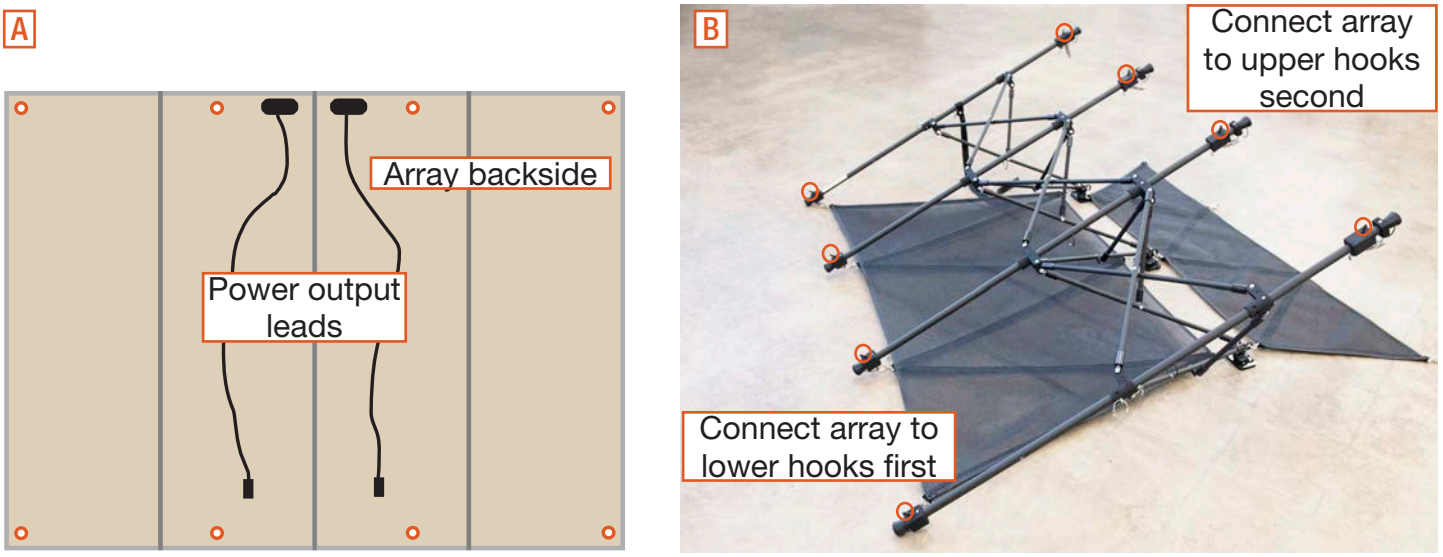


Figure 11. Connecting array hooks to support frame

The hooks on the upper row are part of a sliding tensioning clamp. Unlock and lift the clamp lever to allow the hook to slide down (Figure 12A). Place the hook into the hole, then tighten (Figure 12B) and lock the clamp (Figure 12C, arrow). Repeat for each of the four mounting holes until the array is secured to the support frame (Figure 12D).

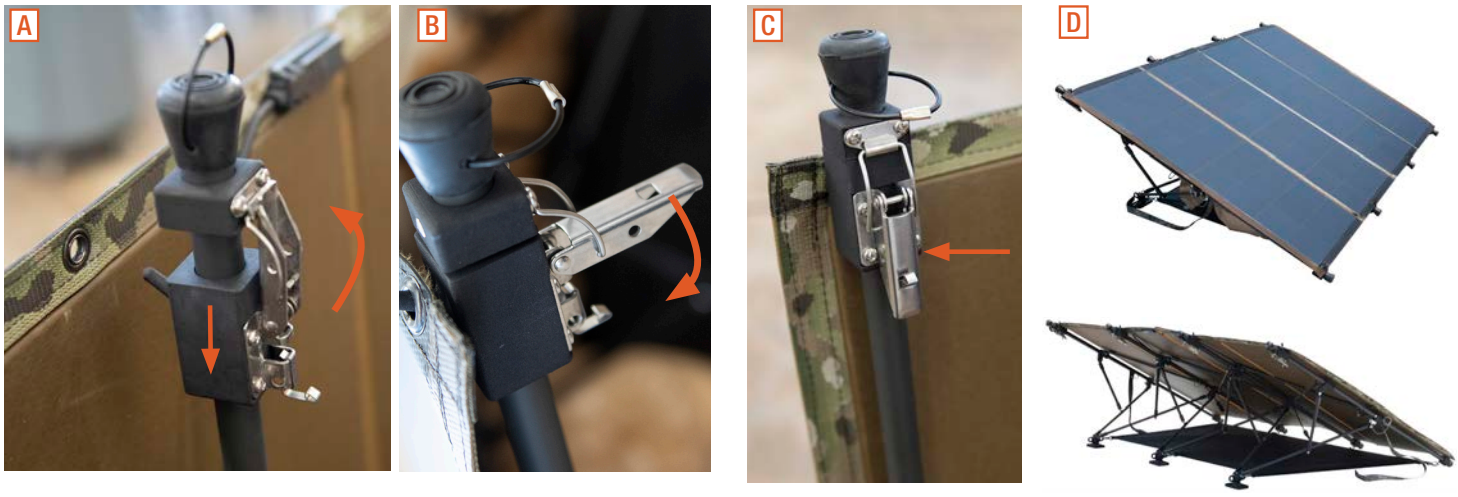


Figure 12. Locking the array into place on the support frame

Connect the Solar Cable to the PV Panel Leads

Connect the leads on the PV array (Figure 13A) to the Solar Cable (Figure 13B). The locking connectors are polarized (Figure 13C–D).

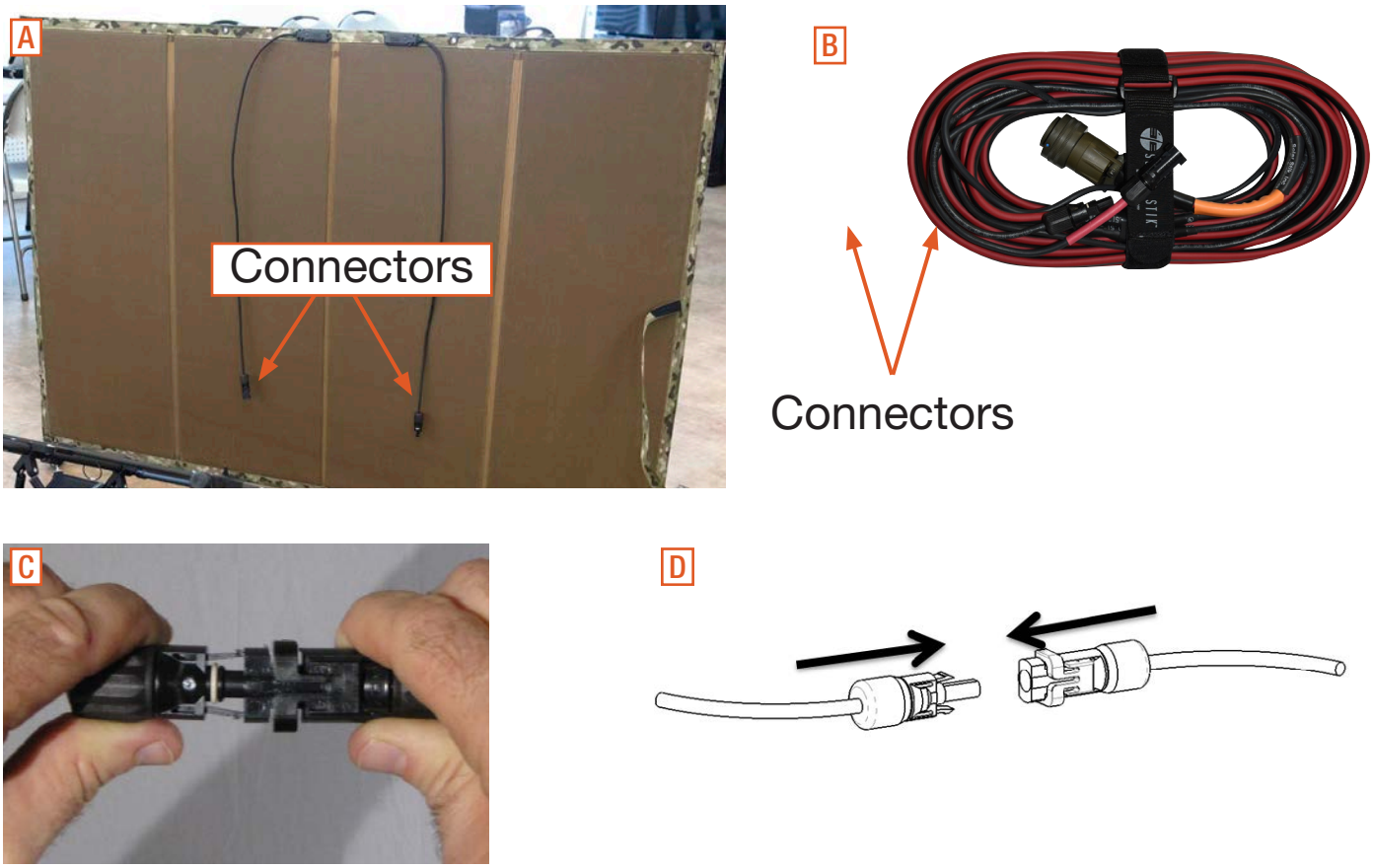


Figure 13. Connecting the PV array to the Solar Cable.

Connect PV Array(s) to Solar Only Input Port of Power Hub

Connect the Solar Cable(s) to the Solar Only Input ports on the side of the Power Hub. A maximum of six (6) PV arrays can be connected to the Power Hub.

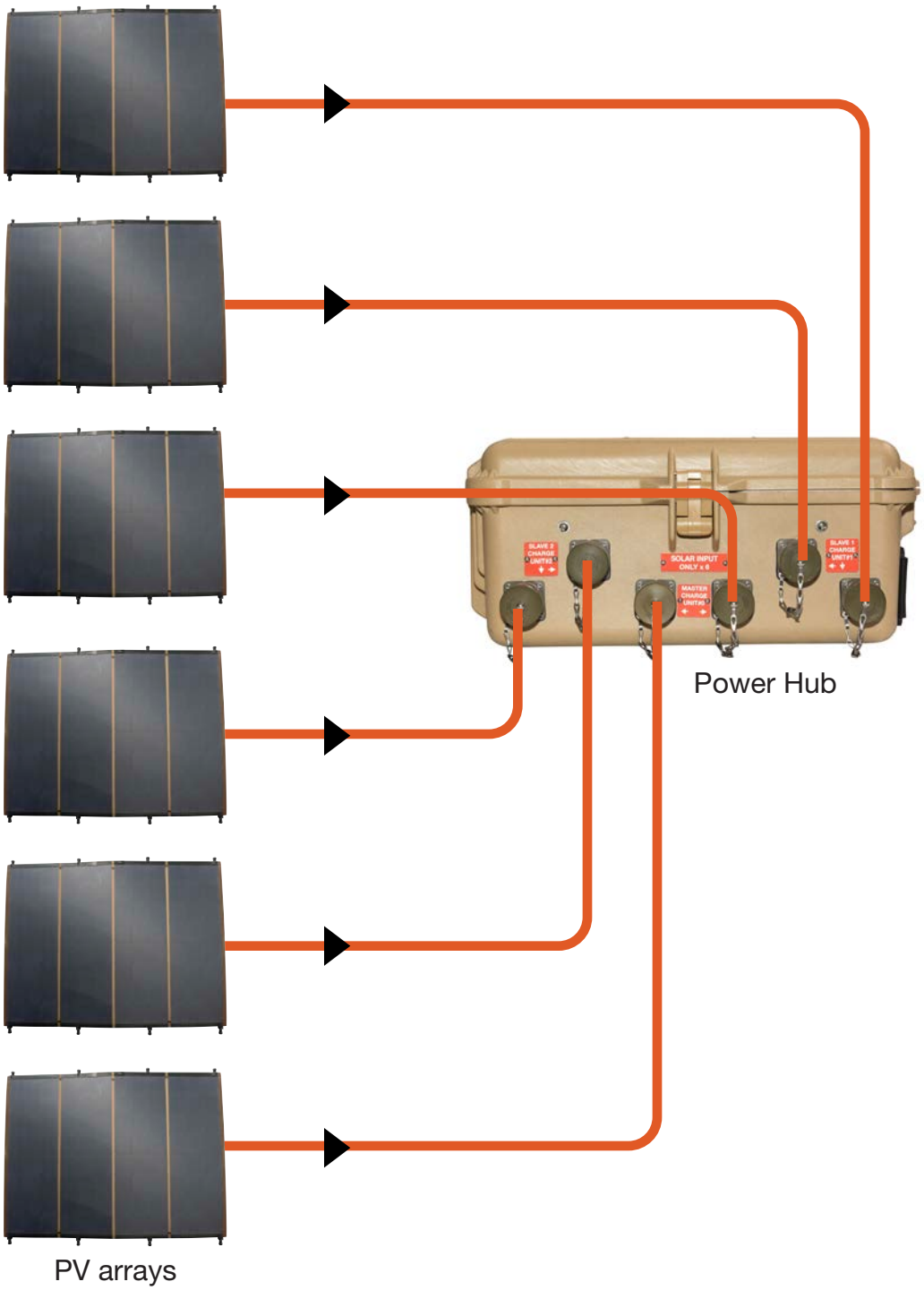


Figure 14. PV arrays connected to Solar Only Input ports of Power Hub

NOTICE

Do not secure the PV array to the ground until adequate cable length to the Power Hub has been verified and the arrays have been oriented optimally toward the sun.

Position the PV Arrays for Optimal Power Generation

NOTICE

The setup location should have good exposure to sunlight and be away from other structures or potential hazards such as moving-vehicle thoroughfares.

PV Array Orientation for Optimum PV Power Generation

PV generation requires direct sunlight for maximum performance. Optimal PV power generation is achieved by orienting all PV arrays in the same direction and at the same angle.

> **Note:** Harvesting PV energy will not improve by orienting subsets of PV arrays to capture morning, midday, and evening sun. In the Northern Hemisphere, the PV arrays should be positioned so that they face the noon sun, which is usually true South, true North if in the Southern Hemisphere. The PV arrays may be deployed flat, aimed straight up if at or near the equator.

Seasonal Adjustment of the PV Array Tilt to Improve Output

The PV array performance may be improved by adjusting the tilt and orientation of the panels seasonally. The angle of the array, relative to the sun, can be adjusted to 30° or 60° prior to securing to the ground. The sun is higher overhead during the summer and lower on the horizon during the winter.

Power output of the PV arrays can be monitored in real time on the Power Hub User Interface. (See the Power Hub Operator Manual for instructions.) Monitoring the power output while orienting and choosing the best tilt angle for the panels will assist in finding and maintaining optimum power output throughout the year.

Shading

The PV arrays must be positioned so they are not shaded. During periods of inclement weather or if the array is not positioned optimally, daily power generation levels may be reduced.

Derating, Solar Loading, and Airflow

Derating occurs when the power output of the PV arrays is diminished below their rated values. PV arrays may accumulate excessive amounts of heat due to solar loading and lack of airflow, resulting in derating.

Locate PV arrays where airflow is unobstructed to reduce the impact of solar loading–induced derating.

Secure the Array to the Ground

Do not secure the arrays to the ground before establishing proper location and orientation.

⚠ WARNING

Failure to properly secure the PV array(s) to the surface with sandbags could result in PV array damage, injury, or death in high winds. Wind damage can render arrays nonfunctional or significantly reduce their functional life expectancy. PV arrays must be properly secured to the ground even in low-wind environments.

The PV array must be secured with three(3) to six (6) sandbags (Figure 15) to reduce the potential for damage in high winds.

Sandbags should weigh a minimum of 50 pounds (23 kg) each. Place sandbags on the large ground-securing mesh under the PV panel and on the small ground-securing mesh behind the panel as shown below (Figure 15).

⚠ CAUTION

DO NOT DAMAGE THE ARRAY SUPPORT FRAME.
DO NOT DROP SANDBAGS ONTO THE PV ARRAY SUPPORT FRAME.

Figure 15. Ground-securing sandbag placement

Note: Before the arrays are secured to the ground, be observant and take care to ensure the support frame is not twisted. If the support frame is twisted, the array will be exposed to torsional strain, which can cause damage to the cells of the array panel(s).

Disassembling and Repacking the PV Array

Repacking the PV array is safe and simple when done correctly. Please follow the instructions below. Failure to follow the instructions may result in damage to the PV array and difficulty fitting all of the pieces back into the transport case.

- Disconnect the PV array from the Power Hub.
- Carefully clean the surface of the PV array.
- Remove the PV array from the support stand.
- Fold the PV array as shown in Figure 16 A.
- Place the folded PV array into the transport case and cover it with the case foam.
- Remove the locking pins (deployed position) from the PV array support frame, collapse/fold the support frame and return the locking pins to the storage position.
- Fasten the transport strap
- Place the support frame into the transport case on top of the case foam (Figure 16 B).
- Place the ground-securing mesh and the Solar Cable on the right and left sides of the interior (Figure 16 C).
- **The case lid should close without resistance when all components are stowed properly.**

Figure 16. Packing the Solar Venture 350W PV Array

MAINTENANCE

Preventive Care and Maintenance

- Ensure the PV panels are clean and positioned for maximum daily sunlight exposure.
- Secure the Solar Cables and provide strain relief at locations where the cables are stressed.
- Check the integrity of electrical connectors monthly.

PV Array Conditional Maintenance

The Solar Venture 350W PV array(s) will typically be connected to a Power Hub to provide regulated power to an HPS. The Power Hub User Interface reports an extensive set of PV performance metrics including a daily and overall historical reports for each of the charge controllers in the Power Hub. These values should be monitored regularly during normal operation.

If an equal number of PV arrays is attached to each of the Power Hub charge controllers, the performance values reported by each charge controller on the Power Hub User Interface, both current and historical (Figure 18), should be approximately equal. This is an indication that all of the connected arrays are performing normally. If these values are not equal, one or more of the PV arrays may be underperforming.

If a disparity in performance is observed during normal operation, measure the voltage of each array independently using a handheld multimeter (Figure 17) or the meters provided in the Power Hub User Interface (See System Manual).

Note: The charging current from the PV arrays as reported by the Power Hub User Interface will be low, even in full sun, when the System batteries are near to or at a full charge. This is a normal operating condition. Consult the System manual for information about using a specific Power Hub for array maintenance monitoring.

Measuring PV Array Voltages: Background

Voltage “open circuit” (V_{oc}) is unregulated PV array voltage and measured directly from the leads of an array when not connected to a “load” such as a charge controller (Power Hub). The V_{oc} of the Solar Venture 350W PV Array is approximately 70.00 V under standard test conditions (STC).

When the array is connected to the Power Hub (i.e., the array is connected to a “load”), it is more likely the operator will see voltages around 50–60 V_{mp} reported on the User Interface.

The V_{oc} and V_{mp} should be measured for each PV array in “ideal” conditions if possible. This means the arrays should be oriented directly at the sun and unshaded on a clear day to identify the maximum V_{mp} and V_{oc}.

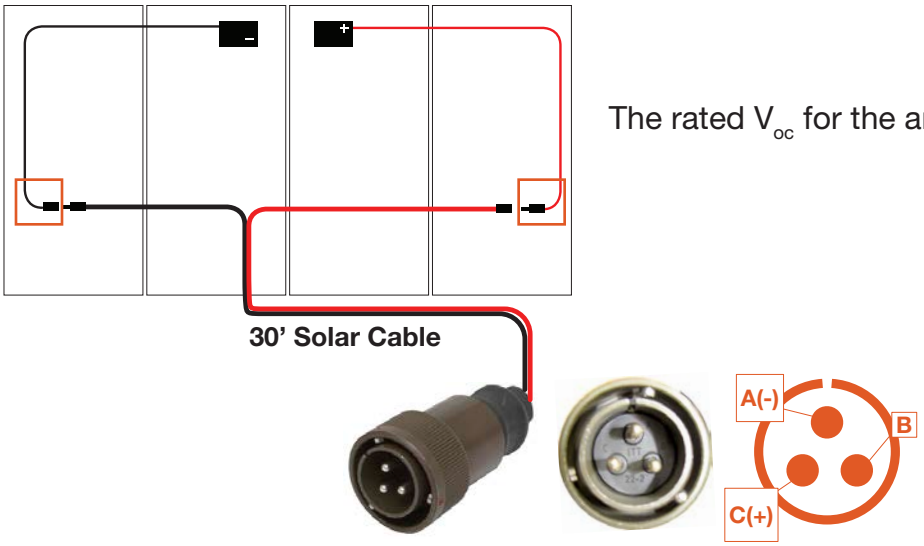
Procedure to Measure PV Array V_{oc} with a Multimeter

- Carefully place the leads of the voltmeter on pins A and C in the bayonet connector (Figure 17) at the end of the Solar Cable. Pin B is unused.

- Alternatively, disconnect the Solar Cable from the array leads and place the meter probes into the array lead connectors (orange boxes in Figure 17).

Under ideal conditions, the reading should be 60 V or more. If a normal voltage reading cannot be measured at pins A and B of the Solar Cable but CAN be measured at the PV array lead connectors, replace the Solar Cable.

Contact the FSR if a PV array voltage measurement indicates that a PV array is either not functioning or is performing very poorly.



The rated V_{oc} for the array is 70.00

Figure 17. Measuring PV array open circuit voltage V_{oc}

SUPPORTING INFORMATION

Technical Specifications

General	
Frame Construction	Anodized aluminum, stainless steel, and carbon fiber composites
Frame Adjustment Angles	30° and 60°
Solar Panel Construction	Tan fabric and carbon fiber
Ground Securing	Sandbags
Setup/Stowage Time	3.5 minutes
Transport Case	SKB iSeries 4719-8 waterproof utility case w/ wheels
Warranty	1-year materials and workmanship

Performance Specifications (@ 77 °F/25 °C)	
Array Voltage	59.5 V
Array Current	5.82 A
Array Power	346 W
Number of Solar Arrays	1 (4 sections)

Solar Array (@ 77 °F/25 °C)	
Max Power (P_{max})	346.4 W (86.6 W per section)
Rated Voltage (V_{mp})	59.6 V (14.9 V per section)
Open Circuit Voltage (V_{oc})	70 V (17.5 V per section)
Rated Current (I_{mp})	23.28 Imp (5.82 A per section)
Short Circuit Current (I_{sc})	24.44 A (6.11 A per section)
Cell Type	Monocrystalline silicone
Cell Efficiency (%)	> 25.1%

Connections	
Solar Array Connectors	MC4

Environmental	
Operating Temperature	-40 to 194 °F (-40 to 90 °C)
Storage Temperature	-40 to 194 °F (-40 to 90 °C)
Operating Humidity	0 to 95% RH up to 140 °F (60 °C)
Ingress Protection	MIL-STD-810 Method 512, Procedure I, Immersion MIL-STD-810 Method 510, Procedure I, Blowing Dust
Loose Cargo	MIL-STD-810, Method 514, Procedure II
Transit Drop	MIL-STD-810, Method 516, Procedure IV
Vibration	MIL-STD-810, Method 514, Procedure I, Category 20

Weights and Dimensions (L x W x H)	
Solar Array Weight	15.0 lb (6.8 kg)
Assembled Weight	23.6 lb (10.7 kg)
Transport Weight	45.6 lb (20.7 kg) 53.1 lb (24.1 kg) with 30 ft Solar Cable
Solar Array Dimensions	Assembled: 65 x 43 x 0.2 in (165 x 109 x 0.5 cm) Folded: 16 x 43 x 1.5 in (41 x 109 x 3.8 cm)
Assembled Dimensions	65 x 48 x 4 in (165 x 122 x 10 cm)
Transport Dimensions	Case external: 49.7 x 21.5 x 8.87 in (126 x 54.6 x 22.5 cm)