EXPEDITION™ 570
PORTABLE SOLAR ARRAY
OPERATIONS MANUAL
PART NUMBER: 225651

Nishati Expedition™ 570 is a 570-watt rated ruggedized portable solar array designed to provide power in remote locations and expeditionary conditions. Expedition™ 570 is fully optimized for power output, deployed footprint, ruggedness, transportability, complexity, and cost. The system is ideal for use with portable solar and hybrid power controllers and batteries as part of a complete solar power or charging system. Expedition™ 570 incorporates frameless, glass-free solar panels into an integrated case and racking system. The self-contained, integrated design enables simplified array deployment by one or two individuals in just minutes. This system is built to military ruggedization standards and is interoperable with commercial and government expeditionary solar and hybrid power systems currently in use within the U.S. Marine Corps and U.S. Army.

Nishati, Inc.
2200 E. Williams Field Rd., Ste 200
Gilbert, Arizona 85295
703-994-2339
www.nishati-us.com

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General Information

Part Number	225651
Contents	(4) Nishati Endurance™ 140 solar panels with Merlin™ Interconnect (1) Rugged transport case with integrated solar panel and racking (1) 35-foot Wire Harness Collector Cable (16) empty sandbags
Weight	88 lbs.
Outside Dimensions	43" x 38.37" x 6.75"
Stowage Volume	6.4 cubic feet (cu. ft.)
Max Deployed Footprint	22.9 ft^2 (@ 35° deployment angle)
Rated Solar Power Capacity	570 Watts
PV Efficiency	>19%
Open Circuit Voltage	79.6V DC (Solar Panels Wired in Series)
Short Circuit Current	9.0 Amps (A)
Operating Temperature	-4° to 140° F
Storage Temperature	-25° to 160° F
Weatherproofing	IP67: Protected from dust / water (to 1m immersion for 30 min)
Wind Certification	50 MPH for 30 minutes with 800lbs. (400 lbs. per side) Gust to 70 MPH when secured with 800 lbs. (400 lbs. per side)

Use of Special Text Boxes

WARNING

A procedure, practice, or condition that may result in injury or death if not carefully observed or followed.

CAUTION

A procedure, practice, or condition that may damage equipment if not carefully observed or followed.

NOTE

A procedure, practice, or condition that is essential to emphasize.

Background

The Nishati Expedition™ 420M Portable Solar Array, also known as the Advanced Integrated Solar Panel Case Assembly (AISPCA), replaced conventional glass solar panels in hardened transit cases that were originally fielded by military services. The 420-watt rated Expedition™ 420M/AISPCA dramatically improved transportability in expeditionary operations, reducing the system weight by 52% and the volume by 68%, while eliminating the more fragile and reflective glass and maintaining the solar performance. Since 2015, Nishati has delivered approximately 4,500 Expedition™ 420, and its 450-watt rated obsolescence replacement Expedition™ 450, to the U.S. Marine Corps, U.S. Army, and other government agencies to meet remote power requirements. Many of these kits continue to be deployed to overseas locations in support of military operations.

In 2017, Nishati introduced the Expedition™ 570 Portable Solar Array as a less complex, lower cost and more powerful alternative to the Expedition™ 420M / 450. This system maintains the man-movable, vehicle-transportable, and glass-free qualities, but delivers 570 watts of rated power in approximately one half of the Expedition™ 420M/450 footprint when deployed. The Expedition™ 570 is much easier to deploy and pack up and the simplified design improves manufacturability, field supportability and cost.

Overview

Expedition™ 570 (Figure 1) is a ruggedized portable solar array that is compatible with a range of ruggedized commercial-off-the-shelf (COTS) solar, renewable, and hybrid energy systems used by the U.S. Marine Corps, U.S. Army, and other military, government, and commercial systems. Expedition™ 570 is designed for the harsh operational and environmental conditions encountered in the field. This equipment is intended for transport by military ground, air, and sea vehicles and to be moved frequently by personnel.

Figure 1: Expedition™ 570 Deployed

Expedition™ 570 consists of 4 frameless glass-free rigid 142-watt rated Nishati Endurance 140 solar modules (Figure 2) within a ruggedized case, which also serves as the base of the portable ground-mounted rack/support system. Each of the four solar panels incorporate 3 bypass diodes to mitigate power-loss from partial shading and to protect the panel against reverse current flow for a total of 12 diodes per array.

Solar panels are joined in pairs by a hinge assembly and the pairs deploy side by side supported by the integrated rack and case system at a 35° fixed angle. In the standard system configuration, the four solar modules are connected electrically in series. An option to connect each pair in series and then connect the pairs in parallel is available for working with solar controllers that are unable to accept the series open-circuit voltage of 79.6V. Each module pair with racking folds down to fit within their respective case halves, which then clasp together to form the transport configuration. (16) sandbags (empty) and one 35-foot Export Power Cable are included with the standard kit. Tie down straps and stakes may be added to the kit as an option. The system is equipped with multiple carrying handles to permit single or two-person movement and two-person lift.

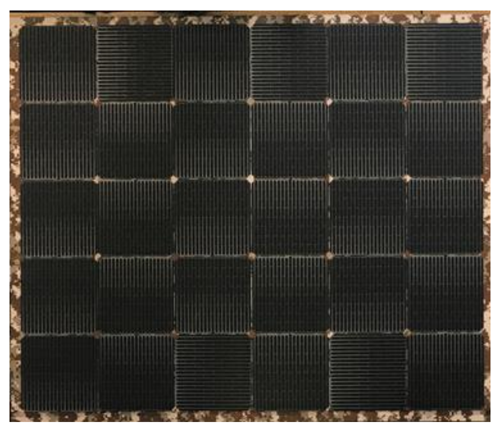


Figure 2. Solar Panel Sub-Assembly

The complete system measures 43.0” x 38.4” x 6.75” in the transport configuration and weighs 88 lbs. The system deploys in a surface area of less than 23 ft^2 (86” x 38.4”). Systems can be stacked up to eight high for palletized transport and can be stacked vertically on their edge for trailer or other space-constrained transport provided there is a means to secure them.

Figure 3: Five Expedition™ 570 Stacked on a Standard Commercial Pallet

Solar Energy Basics

Solar Photovoltaic (PV) Systems

PV systems are designed to harvest energy directly from sunlight. PV systems often include solar panels, batteries, power control electronics, and accessories that enable power applications.

Solar Insolation and Irradiance

Solar insolation is the amount of solar radiation received on a given surface area during a given timeframe. It is used as a measure of how much energy from the sun is striking a location on the earth's surface over a given time and, hence, available for harvesting. It is typically denoted as watts per hour per square meter. The amount of insolation received at the surface of the Earth is controlled by the angle of the sun, the state of the atmosphere, altitude, and geographic location. Solar irradiance is a measure of how much solar power is available at a specific location and time. On a clear day with the sun's rays directly perpendicular to a surface the solar irradiance is about 1,000 watts per square meter (W/m^2), which is also known as one 1.0 sun. Terrestrial solar panel power ratings reference standard test conditions (STC) of 1,000 W/m^2, 25°C and air mass spectrum 1.5 (AM1.5).

PV modules harvest solar radiation and produce direct current (DC) electricity. PV modules are most productive when the panels face directly into the sun (i.e. are as close to perpendicular to the sun's rays as practical). Two factors affect the angle at which the sun's rays strike a solar panel:

- Direction / azimuth
- Tilt angle

Diffuse and Direct Solar Radiation

As sunlight passes through the atmosphere, some of it is absorbed, scattered, and reflected by:

- Air molecules
- Water vapor
- Clouds
- Dust
- Pollutants
- Forest fires
- Volcanoes

The result is *diffuse solar radiation*, which contains less concentrated solar energy. The solar radiation that reaches the Earth's surface without being diffused is called *direct beam solar radiation*. The sum of the diffuse and direct solar radiation is called *global solar radiation*. Atmospheric conditions can reduce direct beam radiation by 10% on clear, dry days and by 100% during heavily clouded days.

Solar Panel Azimuth and Tilt Angle

Solar Declination Angle (δ), or *Declination,* is the angle between the equator and a line drawn from the center of the Earth to the center of the sun. *Declination* varies based on the time of year due to earth's tilt, oscillating between 23.45° north of the equator on June 21^{st} and 23.45° south of the equator on December 21^{st} (Figure 4). *Azimuth* is the angle along the horizon with zero degrees corresponding to North and increasing in a clockwise fashion (when viewed from above) such that 90° is East, 180° is South, and 270° is West. *Solar Azimuth Angle* is the sun's azimuth (Figure 5).

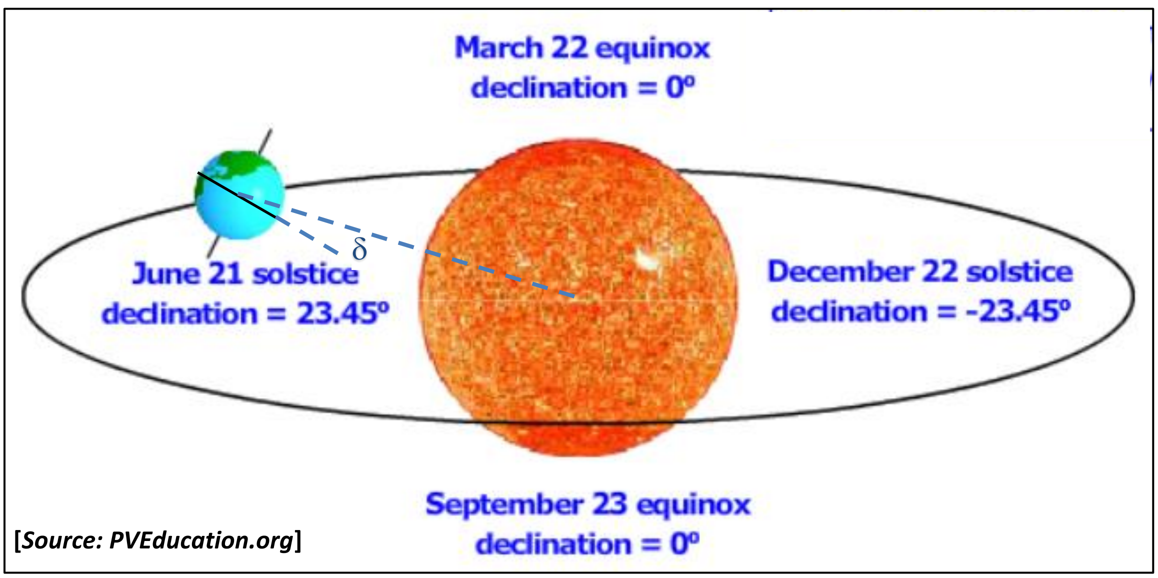


Figure 4. Solar Declination Angle Annual Variation

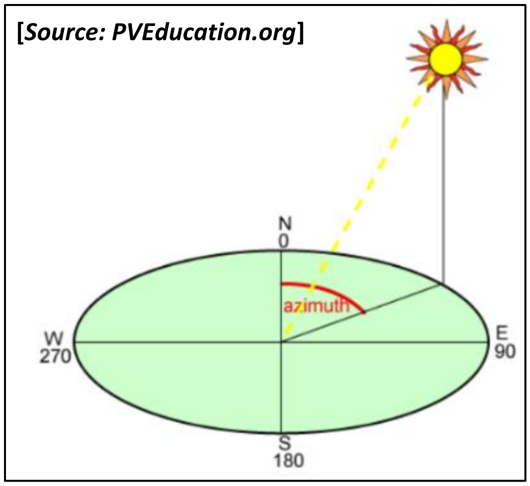


Figure 5. Solar Azimuth Angle

At latitudes north of the sun's *Declination* for a given day, the apparent *Solar Azimuth Angle* changes throughout daylight hours from east to west through true South. At latitudes south of the sun's *Declination*, the apparent *Solar Azimuth Angle* changes from east to west through true North. Since most Northern Hemisphere latitudes are north and most Southern Hemisphere latitudes are south of the sun's *Declination* for most of the year, a rule of thumb can be used for optimal fixed solar panel azimuth. That is, in *most* locations at *most* times of the year solar panels and arrays should be emplaced facing true (not magnetic) South in the northern hemisphere and true North in the southern hemisphere.

When using portable solar systems, it is possible to make fine adjustments to more closely track the sun based on location, time of year, and even time of day. It may also be helpful to compensate for local environmental effects. For example, in a valley with mountains to the west, facing solar panels slightly east of true South to collect extra power during the morning can compensate for losing power in the afternoon from the mountain shading.

NOTE

If the environmental effects and proper azimuth are uncertain, the system should remain facing true South (in the northern hemisphere) or true North (in the southern hemisphere).

Tilt angle refers to the PV panel's vertical angle relative to the ground. Optimum tilt angle is a function of the sun's elevation relative to the horizon at the location of interest on the earth at any given time. Once a panel is aligned to the proper azimuth, the tilt angle is determined. Optimum tilt angle is determined by latitude*, solar declination angle* (i.e. time of year) and time of day.

For a fixed solar panel system, a general year-round rule is to set tilt angle equal to the latitude. For example, at the north and south poles, the latitude will equal 90°. At 45° North or South latitude, the tilt angle of the solar panels should be 45°, and at the equator the solar panels should be laid flat. Figure 6 depicts this rule of thumb.

If the solar panels have an adjustable tilt angle, adjust as follows:

- Winter – latitude plus fifteen degrees
- Summer – latitude minus fifteen degrees

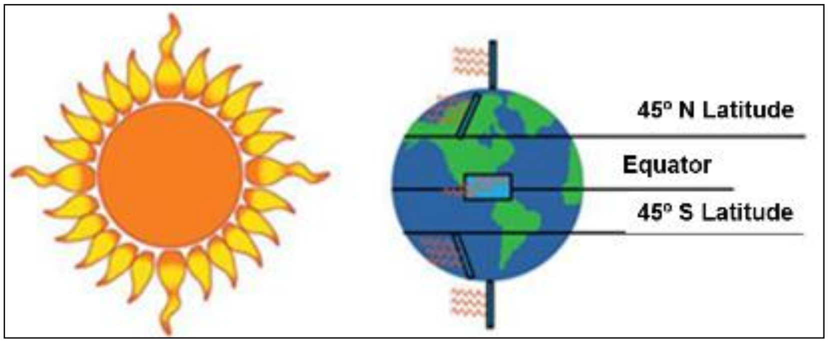


Figure 6. Tilt Angle Determination

Solar Panels and Arrays

Solar panels, also referred to as solar modules, are made up of multiple electrically connected solar cells. Solar arrays, in turn, consist of a several solar panels, which are electrically connected in series, parallel, or a combination of series and parallel circuits. Figure 7 shows linked solar panels in a solar array.

Most solar panels produce a relatively low amount of voltage and amperage. Depending on load requirements, multiple solar panels can be used together, creating a solar array, to reach the desired energy production. This allows tailored solar energy production to match load requirements.

Figure 7. Four-panel Solar Array

Solar Array Location

Solar arrays shall be located away from flammable materials and away from tents or shelters. In very rare cases solar energy systems have been known to cause fires due to internal electrical failures. It is important to handle solar energy systems with care.

WARNING

Solar systems are silent energy systems. Always assume live voltage is present.

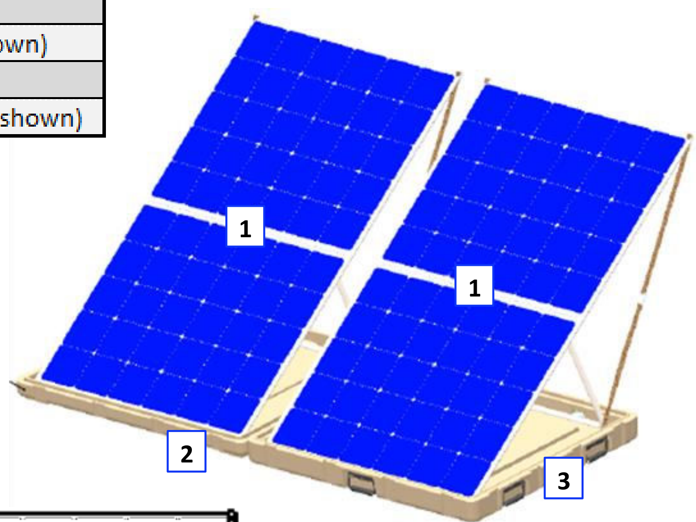
WARNING

Solar energy systems should be handled like other power generation equipment and shall not be located near flammable materials or close to tents or shelters.

Expedition™ 570 System Components

Expedition™ 570 is composed of the following components shown in Figure 8.

#	Description
1	(2) Solar Panel Assemblies
2	Case Top
3	Case Bottom
4	(2) Solar Panel Support Tube Assemblies
5	(4) Solar Panel Assembly Support Straps
6	Solar Panel Interconnect Cables
7	Solar Panel Storage Straps (not shown)
8	(16) Sandbags (not shown)
9	Wire Harness Collector Cable (not shown)



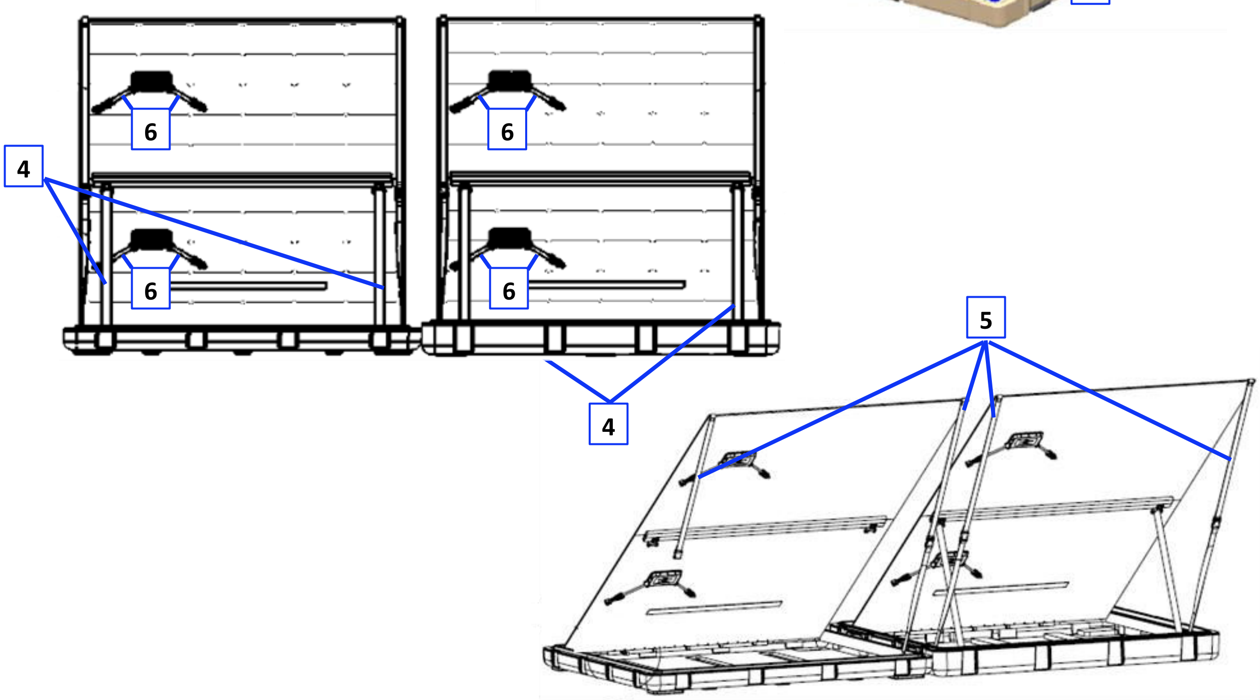


Figure 8: Expedition™ 570 Components

Solar Array Operation – Set Up

1. Opening the Case and Orienting the Solar Array

1a. Lay the Expedition™ 570 solar array on the ground or other flat solid surface with the Case Bottom to the ground side. The Case Bottom is slightly deeper than the Case Top and distinguished by carrying handles and butterfly latches around the case exterior perimeter.

1b. Unlatch the Case Assembly side latches by turning the butterfly handle of each latch counterclockwise until tension is released then folding the handle flush and rotating the latch and hand downward until flush with the Case Bottom.

CAUTION

Latch butterfly handles should remain flush with the latch and case except when being turned to open or secure the case. Failing to maintain the latch handles flush during use and movement may result in damage to the latch.

1c. Separate the Case Top from the Case Bottom by grasping the Case Top lip and lifting it free, and then rotating to place on the ground next to the Case Bottom with the stowed solar payload facing upward. The lower solar panel hinges that connect each set of joined Solar Panel Sub-Assemblies to the Case should be placed toward the intended solar panel azimuth. (Figure 9)

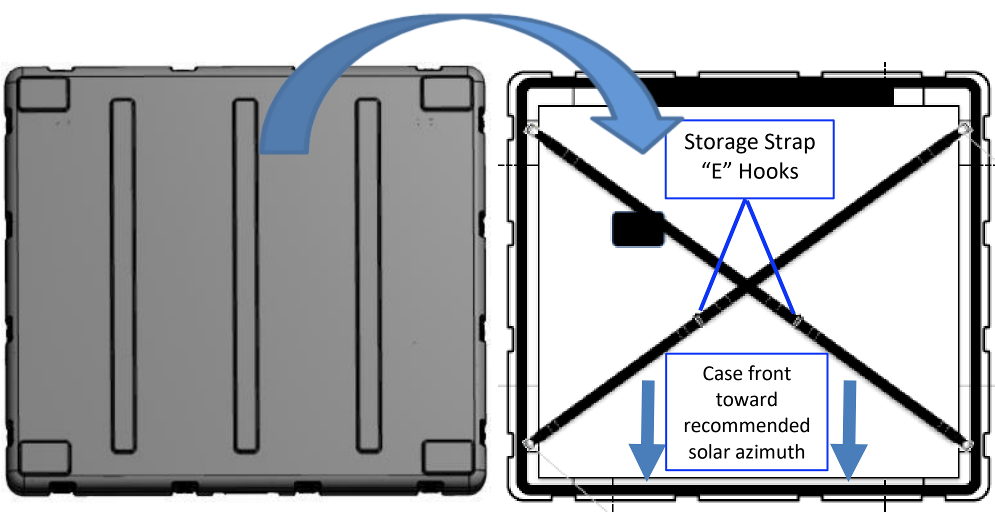


Figure 9. Unlatch, lay out and orient the Expedition™ 570 Case Top and Bottom

2. Erecting the Solar Panels

2a. Starting with either the Case Top or Bottom, unclasp the Solar Panel Storage Straps by slipping the strap loop of each of the front straps free from the rear strap “E” hooks. Raise the folded panels and grasp the Solar Panel Support Tube as it swings free. Pivot the bracket to the case rear, placing the bracket base against the back wall of the case. Repeat this step for the other Case half. (Figure 10)

2b. Starting with either the Case Top or Bottom, rotate the upper Solar Panel Assembly to a position in plane with the lower Solar Panel Assembly. Repeat for the other Case half. (Figure 11)

Figure 10. Un-stow Solar Panel Assemblies and lock the Solar Panel Support Tubes in

Figure 11. Rotate the solar panels into position.

3. Securing the Solar Panels

3a. Secure all four Support Straps by stretching the straps just enough to join them and sliding the upper strap loop over the open end of the opposing lower strap "E" hook. (Figure 12)

Figure 12. Secure the Solar Panel Assembly Support Straps

WARNING

Failure to secure solar panel Support Straps could result in damage, death, or injury.

3b. Secure each Expedition™ 570 Case Assembly with (16) 50 lb. sandbags using (8) sandbags per case half, as shown in Figure 13.

Figure 13. Sandbag the Case Top and Bottom

WARNING

Failure to properly secure solar array to surface with sandbags could result in damage, death, or injury in high winds.

4. Electrically Connecting the Expedition™ 570 Solar Array

4a. Prior to connecting any solar panels to power electronics or a load, electrically connect the four solar panels as required to remain within power electronics voltage limits. The standard system configuration is a four-panel string in series (4s) connection. An alternate configuration that connects the Solar Panel Sub-assemblies into series pair (2s) strings within each Solar Panel Assembly and then connects these two strings/Solar Panel Assemblies in parallel (2p) is also possible. The 2s/2p configuration requires a cable or controller with diode protection between parallel circuits to prevent electrical current feeding from one Solar Panel Assembly into the other in the event of a voltage mismatch between them caused by differential sun exposure or a malfunction. Nishati offers an optional diode-protected 'Y' cable for the 2s/2p configuration.

- **4 Series (4s) Connection** (Figure 14). At STC, the 4s connection provides a typical voltage of 79.7V_{OC} (open circuit) when not under load and 65.2V under load. In this configuration, the average current delivered by the array under load is 8.72A.
- **2 Series/2 Parallel (2s/2p) Connection** (Figure 15). At STC, the 2s/2p connection provides a typical voltage of 39.8V (open circuit) when not under load and 32.6V under load. In this configuration, the average current delivered by the array under load is 17.4A.

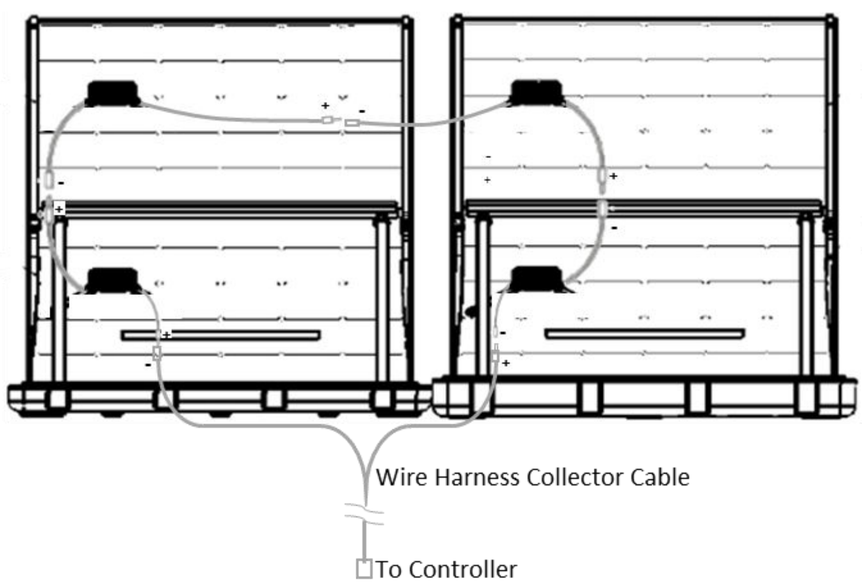


Figure 14. Four Series (4s) Electrical Configuration (Standard)

4b. As required for the desired configuration, connect the positive (male) and negative (female) H4 connectors between solar panels by joining the male and female ends until they click together securely. (Figure 16).

4c. Once the panel string is connected in series, connect the free positive and negative H4 connectors to the opposing male or female H4 connection of the Wire Harness Collector Cable.

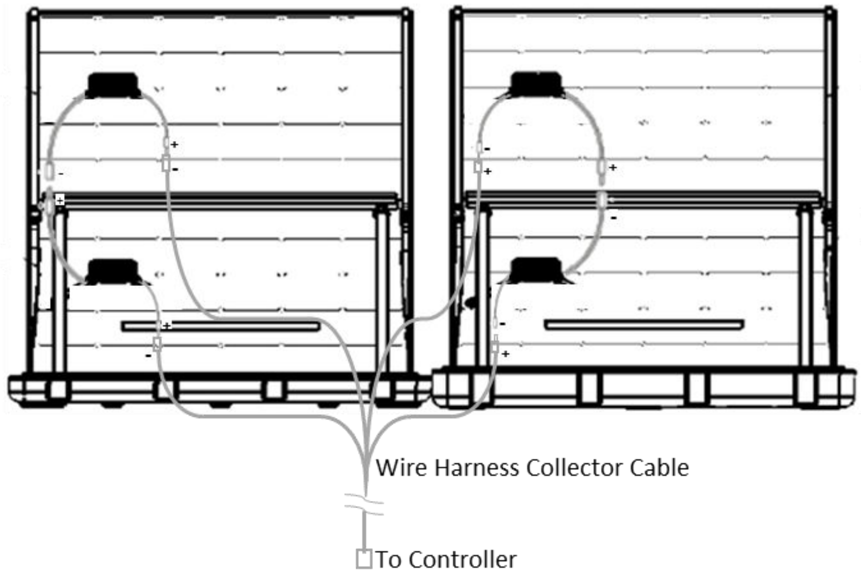


Figure 15. Two Series / Two Parallel (2s/2p) Electrical Configuration

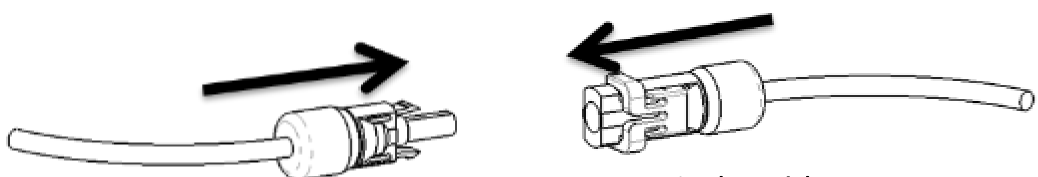


Figure 16. Making Electrical Connections

CAUTION

Prior to connecting the Expedition™ 570 to a solar charge controller or other power electronics, verify that controller/electronics are rated to accept at least the open-circuit voltage and short-circuit current for the selected wiring configuration. Solar array inputs that exceed controller power ratings may result in damage to the controller electronics.

CAUTION

The 2s/2p configuration requires adequately rated blocking diode protection between parallel solar panel circuits (strings). Connecting the array in a 2s/2p configuration without this protection creates a risk of panel damage and failure.

WARNING

Failure to properly secure electrical connectors could result in shock hazard to personnel.

5. Connecting Expedition™ 570 to a Solar Controller (Standard Configuration)

5a. After connecting the solar panel electrical connectors in a 4s configuration there will be two unconnected wires, one a positive (male) connector and one a negative (female) connector. A best practice for cable management is to make connections so that the free ends originate from the lower solar panels as shown in Figure 14.

5b. Connect the Wire Harness Collector Cable 'Y' end female and male H4 connectors to the male and female H4 connectors from the solar array. Figure 17 shows the Wire Harness connectors.

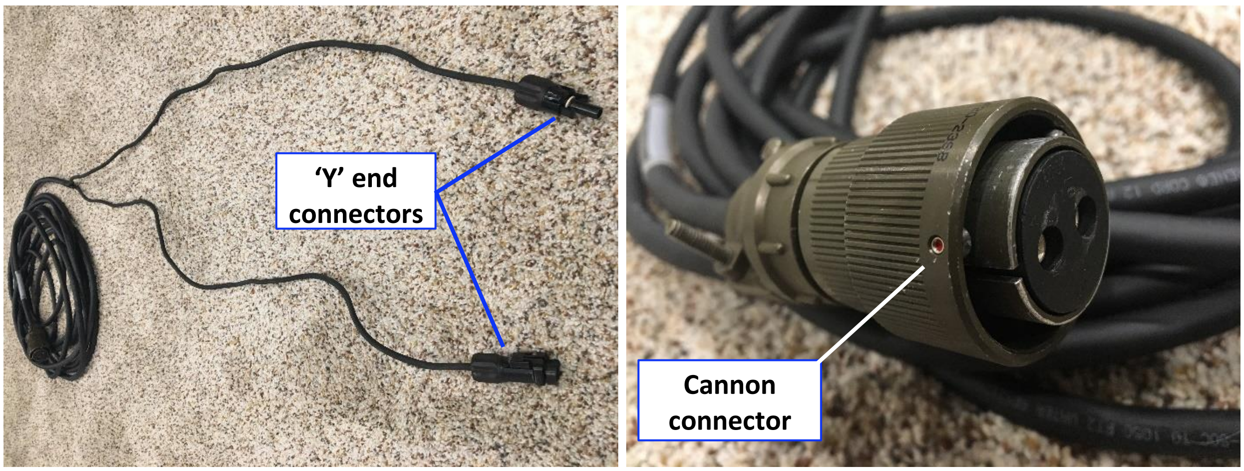


Figure 17. Wire Harness Collector Cable Ends

5c. Connect the Wire Harness to the solar controller. The standard Wire Harness terminates with an ITT Cannon 2 Contact Bayonet female connector (P/N CA3106F20-23SB) that is intended to mate with a male connector (CA3106E20-23SB) on the controller. The plug type can be modified at the factory or by qualified personnel in the field to adapt to other solar and hybrid controllers. To connect the standard harness, align the nubs on the Harness connector coupling nut with the slotted threads on the controller's solar input connector and twist clockwise until the connectors fully seat and lock together with a click.

5d. Connect additional Expedition™ 570 arrays in the same manner, as desired and as the controller permits. Figure 18 shows an example configuration with four Expedition™ 570 inputs.

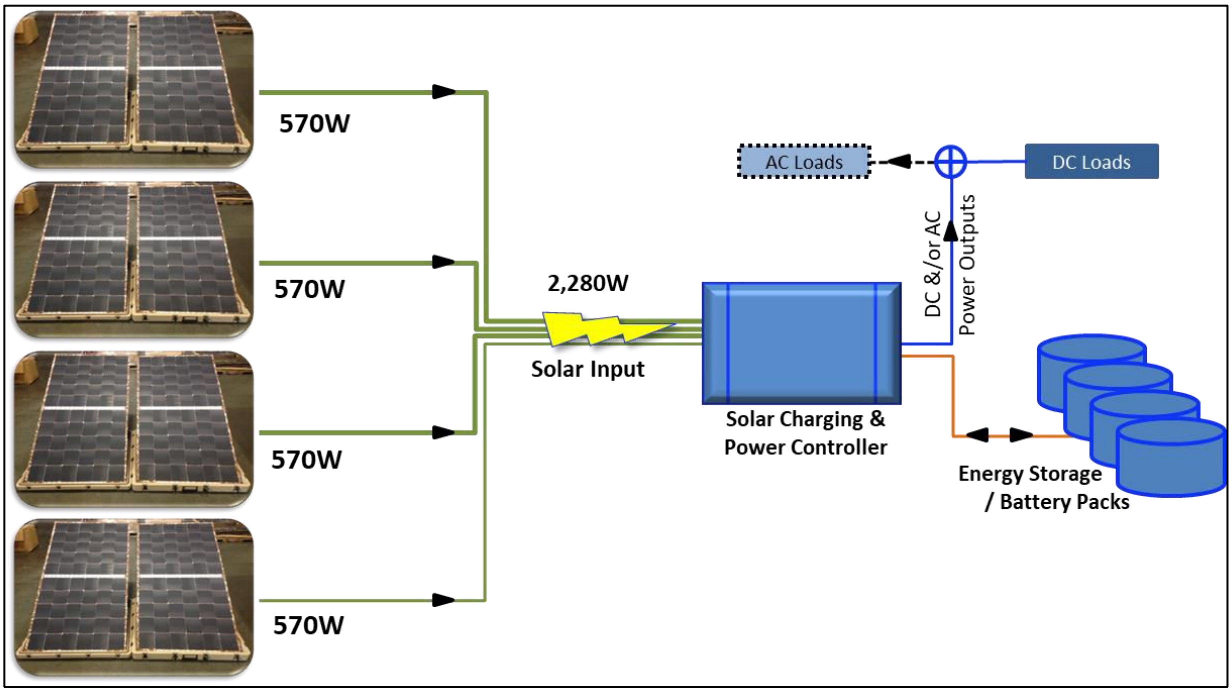


Figure 18. Example Expedition™ 570 Configuration with Power Electronics and Energy Storage

Solar Array Operation – Stowing and Packing for Transport

1. Disconnecting Solar Array from Charge Controller

WARNING

Do not disconnect solar panel electrical connectors under load, disconnecting under load could cause damage, death, or injury.

1a. On the solar controller, turn off solar panel circuit breakers to stop the flow of electricity from the solar panels into the controller prior to disconnecting any cables. If the solar controller does not include this feature, then fold down the upper panels to cut off power. Next, proceed to carefully disconnect the collector cable from the solar controller.

1b. Disconnect the Wire Harness Collector Cable by twisting the connector coupling nut counterclockwise until free.

2. Electrically Disconnecting Solar Panels

2a. Prior to disconnecting the solar panels be certain they are not connected to the charge controller and generating power.

2a. Disconnect wires interconnecting the solar panels (total of 3 connections). To disconnect solar panel H4 connectors, squeeze together the PIO tabs on both sides of the negative H4 connector and gently pull the two sides of the connector apart as shown in Figure 19.

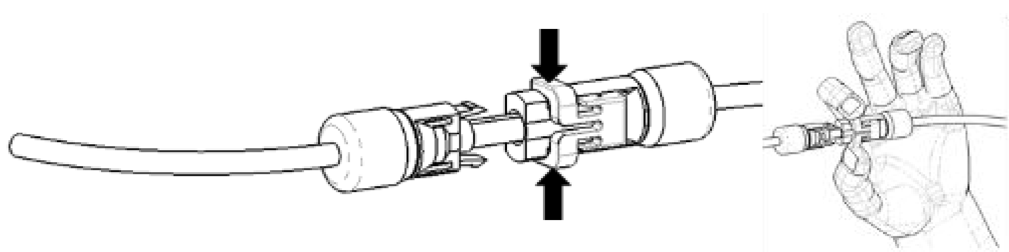


Figure 19. Disconnect Solar Panels by Squeezing the PIO tabs

3. Remove Sandbags (and Empty) and Tent Stakes, if Used

3a. If the Case Assemblies are secured with stakes, pry the stakes from the ground and remove excess dirt and debris.

3b. Remove and empty the sandbags, fold all the empty sandbags except one.

3c. Place all empty, folded sandbags and stakes into the remaining unfolded sandbag for storage.

4. Fold Down Solar Panels and Stow Cables

4a. Disconnect all four Support Straps by unhooking from E-Hook clasp and lay the Lower straps outboard on the ground and clear of the panel stowage area within the case. (Figure 20)

Figure 20. Disconnect the Solar Panel Assembly Support Straps

4b. Rotate each upper solar panel downward carefully until the upper and lower panel faces meet.

4c. If empty sandbags and the Wire Harness Collector Cable are to be stowed inside the case, place them under the Case Bottom solar panel. Storing items behind Case Top solar panels, between upper and lower solar panels or in between case halves is not recommended.

4d. Starting with either the Case Top or Bottom and with solar panel wires coiled neatly against the backside of the upper and lower solar panels, respectively, lift (rotate) the folded Solar Panel Assembly and rotate the Solar Panel Support Bracket under the lower panel. Then lower both panels and the bracket into the Case Assembly. (Figure 21). Repeat for the other Case half.

4e. Secure both Solar Panel Assemblies by slipping each front strap loop onto the open “E” hook end of the rear strap that is diagonal from the front strap. Straps form an ‘X’ when both are secured, as in Figure 22.

CAUTION

Stowing ancillary equipment between behind the Case Top solar panels, between upper and lower solar panels or in between case halves may result in damage to the solar panels or support hardware during transport.

Figure 21. Stow Solar Panel Assemblies

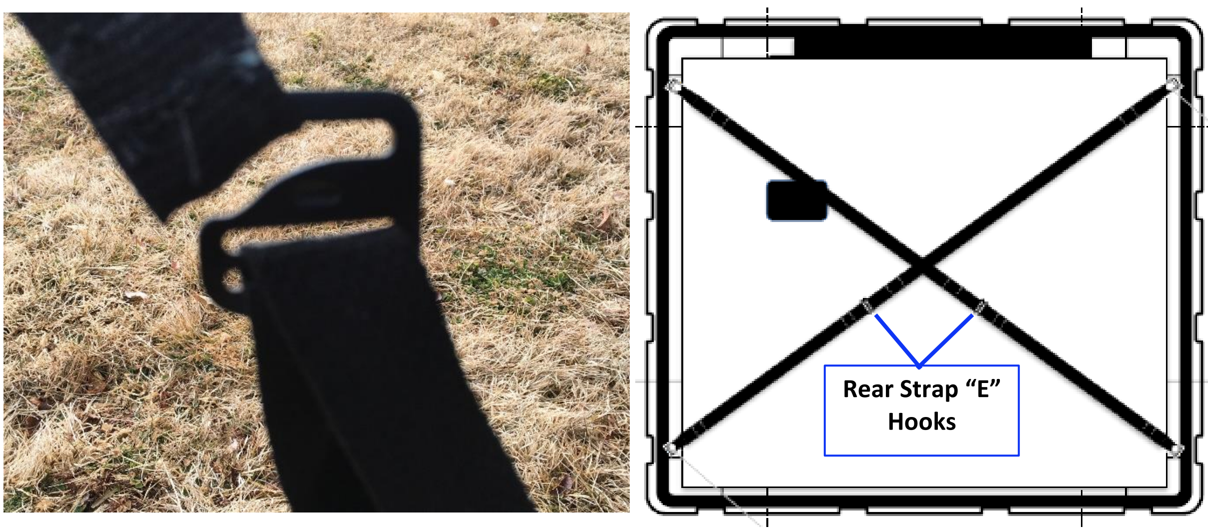


Figure 22. Secure Solar Panel Assemblies

CAUTION

Failure to properly secure the solar panels within the case may cause damage during transit and, if done repeatedly, is likely to degrade panel performance over the life of the panel.

5. Re-combine and Secure the Case

6a. Lift and rotate the Case Top to place the open side onto the Case Bottom's open side, aligning the case tongue and groove lip and taking care to avoid pinching fingers (Figure 23).

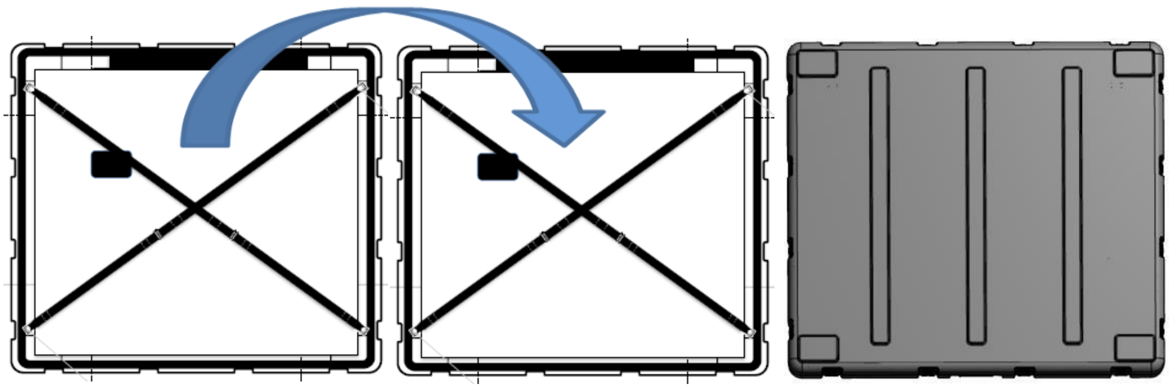


Figure 23. Re-combine the Case Top and Bottom

CAUTION

When placing Case Assembly Top and Bottom together take care to avoid pinching fingers.

6b. Secure all 16 case latches by first turning the butterfly latch handle counterclockwise to ensure that it is fully open/extended, and then while holding in the vertical position rotate the latch handle clockwise to secure to the catch on the Case Top and fold down the butterfly handle flush with the outer case wall. (Figure 24)

Figure 24. Secure the Case Latches

CAUTION

When placing Case Top and Bottom together take care to not allow straps and debris to interfere with the case fit. Not doing so will cause undue strain to the latches that could result in latch damage when they are being secured and will also interrupt the weather-seal integrity.

Preventive Maintenance Servicing and Checks

To ensure continuing efficient and safe operation, several checks are recommended prior to each use. There are no specialty tools required for the preventive maintenance or service of Expedition™ 570.

1. Inspect Solar Panel and Wiring Material Condition

Inspect panels, wires, and cables for physical damage. Look for cuts that expose wire in the panel interconnect wires and Wire Harness Collector Cable, cuts in the panel that expose the metal electrical grid or bus bars, separation of the solar panel junction box from the panel back surface or cracks in the solar panel junction box that violate the box's water tight integrity. If any of these conditions exist, remove the affected Solar Panel Assembly from Service and contact Nishati for replacement components.

2. Clean Solar Panel Surface to Maximize Performance

Though the Expedition™ 570 solar panel front surfaces are inherently soiling resistant, panels may require occasional cleaning to ensure maximum performance, particularly after being exposed to blowing dirt or dust following precipitation. To remove any dust/water spots, each solar panel should be wiped down with a clean damp cloth.

3. Bypass Diode Performance Check

Solar panel bypass diode operation can be periodically verified using the test method described below, if the Expedition™ 570 is connected to a solar controller with a graphical user display that shows real-time solar array power output / controller input data.

1. 3.a. Ensure that all four solar panels are interconnected in series and that the array is oriented toward the sun and unshaded.
2. 3.b. Ensure the array Wire Harness Collector Cable is connected to a solar controller that monitors and displays real-time solar array output power.
3. 3.c. If the controller includes solar input circuit breakers, ensure the circuit breakers are in the "On" position.
4. 3.d. Fold each upper solar panel down one at a time (Figure 25) and note the change in output power on the controller display.

- With working bypass diodes, the output power should drop by about 40 to 60%. For example, if all four panels are producing 500 watts prior to shading two panels, then two unshaded panels should produce around 250 watts.
- If power drops to, or near to, zero when two panels are shaded, then one or more bypass diodes in either or both shaded panels is not functioning properly.

Figure 25. Shade Solar Panel Sub-Assemblies One Pair at a Time

NOTE

If a Solar Panel Assembly fails the bypass diode check, remove the assembly (two solar panels) from the array, replace with a properly functioning assembly, and contact Nishati for a replacement Solar Panel Assembly.

Provisioning Information

Table 1. Expedition™ 570 Provisioning Information

Nomenclature	Nishati Part Number	OEM CAGE Code	NSN	U/I	Description
Expedition 570	225651	75CR6	TBA	ea.	Portable Solar Array, Self-contained with Nishati Endurance 140 Solar Panels
Expedition 570 SL-3					
Wire Harness Collector Cable	217179	75CR6	6150-01-646-8450	ea.	Wire Harness, Expedition
Sand Bags	217100 Item 6	81349	8105-00-142-9345	ea.	Polypropylene Desert Tan Sand Bag
Expedition 570 Maintenance					
Solar Panel Assembly	225200	75CR6	TBA	ea.	(2) Glass-free Solar Panel Sub-Assemblies joined on edge by Solar Panel Hinge Assembly (PN 225203), and equipped
Support Tube Assembly, Solar Panel	225250	75CR6	TBA	ea	Panel Support Tube only
Case Assembly, Lower	225105-1	75CR6	TBA	ea	Rugged molded case lower half with lift and carrying handles and latch hardware
Case Assembly, Upper	225105-2	75CR6	TBA	ea	Rugged molded case upper half with latch hardware
Strap Assembly, Solar Panel Support and Stowage	225235	75CR6	TBA	ea	Includes Lower Tension Straps, Stowage Retention Straps and attachment hardware