Operation of the SBP-1100e with P3-55 Watt Solar Panels

The SBP-1100e Smart Battery Power System may be re-charged using various power conversion devices which are available as standard accessory items from Eleven Hundred Energy Corp. One re-charging option is the use of model P3-55 Watt Portable Solar Power Panels. A Solar Cable is required to connect the solar panels to the battery pack.

P3-55 Watt Portable Solar Power Panels

The model P3-55 Watt portable solar panels are rugged, foldable, weather-resistant and are moderately flexible to resist breakage, unlike conventional rigid solar panels which are difficult to transport and subject to breakage. The P3-55 Watt panels are compact when folded for storage or transport (11″ x 9″ x 1.3″) and lightweight (3.5 lbs). Unfolded, one panel is 55″ x 32″ in size, and 0.1″ thick, and it is equipped with four grommet holes, one in each corner. Available two colors: Desert Camo (tan) or Woodland Camo (olive drab). In full direct sun, striking perpendicular to the surface of the panel, and loaded for maximum power, the nominal DC power output is 55 watts at about 18 volts and 3 amps. New panels may exhibit up to 20% less output and will require several days of sun exposure to reach their full operating power. Maximum output power is reduced by 1% for each 3˚ F of temperature rise above a panel temperature of 77˚ F, and is similarly increased for temperatures below 77˚ F.

Weather and Seasonal Considerations

In most regions of the Earth, solar power is not 100% reliable from day to day, under changing weather conditions. By using the SBP-1100e Smart Battery Power System to store the energy produced by solar panels, power can be available continuously, for as long as sufficient energy remains stored in the battery pack. Intermittent or continuous power demands of up to 200 watts can be supplied by the battery pack.

Under ideal sunny conditions, a full set of eight P3-55 Watt solar panels, always perfectly aimed at the sun, could yield in excess of 2000 watt-hours per day. In practice, with eight panels angled to face the mid-day sun, and assuming 5 hours of sun per day, a daily energy supply of up to 1600 watt-hours may be supported in sunny weather, and up to 800 watt-hours in partly sunny weather. 800 watt-hours per day is equivalent to a 33 watt average load, powered 24 hours per day.

It is not practical to use solar panels during persistently cloudy seasons or in cloudy climates, nor generally in winter in the high latitudes where there is little sun. Winter itself is no barrier to using the P3-55 Watt solar panels, provided there are a few hours of mostly clear sunny skies most days, and provided the panels are held at the correct angle to fully face the mid-day sun.

Determining the Number of Solar Panels Needed

The absolute minimum number of P3-55 Watt solar panels required for charging the SBP-1100e Smart Battery Power System is two, but four panels are the minimum recommended for light-duty applications. More demanding applications will require up to eight panels. Generally, more sun implies that a smaller number of panels would be needed, and a larger daily energy demand or sustained power demand implies that a larger number of panels would be needed. Also, in order for charging to take place, the set of solar panels must supply in real time at least 55 watts more power than the power which is being used by the application load at that time. Using more than eight panels would usually provide little practical benefit because the SBP-1100e will not accept sustained input power from solar panels in excess of about 360 watts. To obtain maximum solar performance with one SBP-1100e Smart Battery Power System, a full set of eight solar panels is recommended.

To estimate the number of solar panels needed for a given application, first consider the expected weather conditions for the location and season. If there is full sun nearly every day, the weather conditions would be classified as "full sun", but if one or two days per week are overcast, or if two or more days per week are partly cloudy, then the weather should be classified as "partly sunny", for purposes of the calculation.

Determine the number of watt-hours needed by the application, per 24 hours. Then divide by 200 watt-hours for full sun conditions, or 100 watt-hours for partly sunny conditions. Add one, and then round up any fraction. Finally, if there will normally be more than 30 watts of steady load at the battery pack output during daytime charging, add one panel if the load is between 30 and 50 watts, add two panels if the load is between 50 and 90 watts, and add three panels if the load is between 90 and 130 watts. Brief, infrequent load power surges may be ignored. If the result of the calculation calls for using more than eight panels, then that indicates that one battery pack with one full set of eight solar panels may be insufficient to provide adequate performance in the application. In that case, consider combining two or more battery packs—see "Combining Battery Packs".

Here is an example of a calculation to estimate the number of solar panels needed for a particular application. If a radio transceiver is in use 24 hours per day, 99% of the time in receive mode drawing 20 watts, and 1% of the time in transmit mode drawing 100 watts, 500 watt-hours is the 24 hour energy demand. The SBP-1100e can deliver about 1000 watt-hours from a full charge, so a single fully-charged SBP-1100e will power the transceiver for 48 hours without sun. To keep the transceiver powered without interruption, at least 500 watt-hours of charging energy must be available per day, on average over each period of two or three successive days. After making allowances for less than optimal aiming of the panels and for power losses in charging and discharging, assume for estimation purposes that one panel yields an average of 40 watts in full sun during mid-day hours. Assume that "full sun" is 5 hours of full sun per day, and that "partly sunny" weather is the equivalent of half as much full sun time per day. So, each panel yields 200 watt-hours per day in full sun, and 100 watt-hours per day in partly sunny weather. Therefore in this example we would calculate a need for 2.5 panels for "full sun" operation, and five panels for partly sunny conditions, purely for watt-hours. The SBP-1100e charging algorithm increments charging power in steps of about 55 watts, therefore one additional panel should be added to assure there will be adequate charging power. Then, round up any fraction. Finally, add one or more additional panels as described in the previous paragraph to account for steady user loads exceeding 30 watts during charging, if any. In this example, the steady load is only 20 watts, so no additional panels are needed. The final result, in this example, is that four panels are needed for full sun, and six panels are needed in partly sunny conditions. If there is full sun nearly every day, four panels should be sufficient, but if one or two days per week are overcast, or if two or more days per week are partly cloudy, then six panels would be recommended.

The following table summarizes the potential daily watt-hours versus the number of panels for "full sun" and "partly sunny" weather, and provides the estimated charging time for charging a completely discharged SBP-1100e battery pack to a 90% state of charge, using P3-55 Watt solar panels, with no load on the battery pack during charging. (In the table, the charging time is not exactly proportioned to the number of panels, due to the incremental power steps used in charging.) If, during charging, power is also being supplied by the battery pack, estimate the time required for charging by considering a 40 watt load to be equivalent to taking away one panel in full sun, or taking away two panels in partly sunny conditions. Other loads would have a proportionate effect.

Number of P3-55 Watt Panels	Full Sun Daily Watt-Hours	Full Sun Charging Time	Partial Sun Daily Watt-Hours	Partial Sun Charging Time
2	400 watt-hours	18 hours	200 watt-hours	36 hours
3	600 watt-hours	9 hours	300 watt-hours	18 hours
4	800 watt-hours	6 hours	400 watt-hours	12 hours
5	1000 watt-hours	5 hours	500 watt-hours	10 hours
6	1200 watt-hours	4 hours	600 watt-hours	8 hours
7	1400 watt-hours	3.5 hours	700 watt-hours	7 hours
8	1600 watt-hours	3 hours	800 watt-hours	6 hours

Combining Battery Packs

Two or three battery packs, each with its own set of solar panels, may be combined to meet a greater daily energy requirement than can be provided by one battery pack, or to meet greater sustained output power levels than can be provided by one battery pack. When using multiple combined battery packs, each pack should have the same number of solar panels, as nearly as possible. For example, 13 solar panels would be divided between two battery packs with seven for one, and six for the other.

Battery packs may be combined by using a special output “combiner” cable which connects the outputs together to form one power source. One battery pack can supply about 200 watts continuous power at 13.8 volts, two packs can supply up to 400 watts, and three packs can supply up to 600 watts.

Similarly, the daily energy (daily watt-hours) available from two or three combined battery packs, each with its own full set of eight solar panels, is proportionately greater than the daily energy available from one pack and one full set of solar panels.

Multiple battery packs may also be combined purely to increase the system energy storage capacity. This might be done when a light load needs to be powered for a very long time between charges. For example, a 10 watt load connected to three fully charged battery packs with a combined capacity of 3000 watt-hours could run for about 300 hours between charges.

The following standard 10′ combiner cables, terminated with #10 stud size ring terminals, are available:

SBP 2-Way Output Combiner Cable

Model № SBP-COMBO-2-RT-10FT

Application: Use this cable to combine two SBP-1100 Smart Battery Packs to form one power output

SBP 3-Way Output Combiner Cable

Model № SBP-COMBO-3-RT-10FT

Application: Use this cable to combine three SBP-1100 Smart Battery Packs to form one power output

Custom-made Combiner Cables can be supplied to meet specific requirements. Contact Eleven Hunred Energy for details.

A screw terminal block is available to be used with any standard SBP Combiner Cable as a power collection and distribution point. The following double-row 2-position Terminal Block (barrier terminal strip) has two double connections for #10 ring terminals:

2-position #10 Terminal Block

Model № T-BLOCK-10-2

Application: Use with any SBP Output Combiner Cable with #10 ring terminals

Choosing a Solar Cable

After determining the number of solar panels required for the application, select a Solar Cable which will accommodate at least the required number of panels, and which will be long enough to accommodate panel placement. A Solar Cable consists of a MIL circular connector which plugs into the power input receptacle on the SBP-1100e Smart Battery Pack, a “trunk” portion, several feet long, which joins the MIL connector to the main splice, and two or more cable arms splitting off from the main splice. Depending on the specific cable, each cable arm is terminated either with one 2-position SAE trailer connector, which can connect to one solar panel, or, each arm is terminated with a short (3 ft.) “Y” extension which has two 2-position SAE trailer connectors, for connection to two solar panels. The cable name specifies the number of arms, the number of panels which can be accommodated, and the overall length of the cable. The 3-foot length of the short “Y” extensions is not included in the stated length of the cable.

There are trade-offs involving the overall length, number of arms, weight, and cost of solar cables, so the anticipated placement of the panels relative to the battery pack should be considered, as well as the means of propping up or aiming the panels to most accurately face the mid-day sun. See “Deployment”.

All of the Solar Cables listed below as standard accessories are constructed of rugged UL type SOOW or type SJOOW black rubber-jacketed 16 AWG 4-conductor and 2-conductor water, oil, and sunlight-resistant cable, excepting the short "Y" extensions, which are made of UL type SPT-1 black 18 AWG 2-conductor cord, and which have molded splices and molded trailer connectors. All cables are equipped with tethered protective/safety caps at each trailer connector, for covering up the exposed contacts of any trailer connector which is not otherwise connected. The MIL connector back shell is splash-proof by being covered with adhesive-lined shrink tubing, and the splices are similarly splash-proof, or, in some cable models, where noted, the main splice is epoxy-potted.

The following Solar Cables are available, and are listed here in order of lower to higher cost:

Name:	SBP Solar Cable, 2 arm, 4 panel, 12 ft.
Model №	SBP-CBL-SOLAR-2A-4P-12FT
Construction:	Trunk 6 ft., two arms, 6 ft. each; two "Y" extensions, 3 ft. each
Transport:	Weight, 2.3 lbs. May be coiled in a space 15 x 15 x 1.5 inches.

Name:	SBP Solar Cable, 2 arm, 4 panel, 20 ft.
Model №	SBP-CBL-SOLAR-2A-4P-20FT
Construction:	Trunk 10 ft., two arms, 10 ft. each; two "Y" extensions, 3 ft. each
Transport:	Weight, approx. 4 lbs. May be coiled in a space 15 x 15 x 2 inches.

Name:	SBP Solar Cable, 3 arm, 6 panel, 20 ft.
Model №	SBP-CBL-SOLAR-3A-6P-20FT
Construction:	Trunk 10 ft., three arms, 10 ft. each; three "Y" extensions, 3 ft. each
Transport:	Weight, approx. 5 lbs. May be coiled in a space 15 x 15 x 2 inches.

Name:	SBP Solar Cable, 4 arm, 8 panel, 20 ft.
Model №	SBP-CBL-SOLAR-4A-8P-20FT
Construction:	Trunk 10 ft., four arms, 10 ft. each; four "Y" extensions, 3 ft. each
Transport:	Weight, approx. 6 lbs. May be coiled in a space 15 x 15 x 2.5 inches.

Name:	SBP Solar Cable, 8 arm, 8 panel, 24 ft. (former name: Solar Panel Adapter Cable)
Model №	SBP-CBL-SOLAR-8A-8P-24FT (former model no.: SBP-IC-SOLAR-8P-20FT)
Construction:	Trunk 4 ft., eight arms, 20 ft. each; epoxy-potted main splice
Transport:	Weight, 14 lbs. May be coiled in a space of 0.6 cubic foot. May be coiled to fit in a 12 x 12 x 12 inch box with padding.

Custom-made Solar Cables can be supplied to meet specific requirements. Contact Eleven Hundred Energy for details.

Deployment

To deploy a P3-55 Watt solar panel, unfold the panel and place it in a sunny location. The dark-colored side of the panel should directly face the sun, with the sun's rays striking the panel perpendicular to its surface. Secure the panel against wind using cordage and the grommet holes in the corners of the panel. The grommet holes will accommodate cord or rope up to 1/4 inch diameter, as well as most bungee cord hooks. As the sun moves through the sky during the day, the panels may be re-aimed from time to time to maintain optimum power performance, or, as a compromise, the panel may be set up to catch the mid-day sun, and left in that position all day. For example, the battery pack might be placed inside a tent, and the solar panels might be draped over a south-facing sloping roof of the same tent. Panels might be draped over a parked vehicle to face in the general direction of the sun, or the panels may be laid out or propped up on sloped terrain facing the sun.

Note: Avoid blocking the sun's rays from hitting any part of the active solar cell areas of the panel, and avoid having any part of the panel in shade or in a shadow. If even a small part of a panel is shaded, that will result in a significantly decreased power output.

Connect each deployed panel to one trailer connector on the SBP Solar Cable, and connect the trunk of the Solar Cable to the SBP-1100e Smart Battery Pack. To mate the trailer connectors, grasp each connector firmly between thumb and forefinger, and twist and wiggle the connection while firmly pushing the connectors together. Make sure that the connections are tight, to help keep out water, and if any amount of rain is expected, wrap each mated pair of connectors with two layers of 2-inch wide weather-resistant adhesive tape, such as duct tape or military green tape.

Check that any un-terminated trailer connectors on the Solar Cable are firmly covered with the provided tethered protective cap. If the cap is missing, wrap some 2-inch wide tape around the connector to cover up the exposed contacts, or push the unused connector into an unused protective cap elsewhere on the cable. Do not connect two trailer connectors on the Solar Cable to each other—that would short-circuit the cable. If the cable is short-circuited, it is unlikely to harm the solar panels or the solar cable, but charging would not work.

Safety Precautions and Lightning Protection

The highest voltage which would normally be present in the Solar Cable is about 30 volts, which is not a significant shock hazard. Power levels of several hundred watts may potentially be present in the solar cable, thus protective caps are provided to cover any unused trailer connectors. In normal operation, positive voltages between 15 volts and 30 volts will be present on the male contacts of the un-terminated Solar Cable trailer connectors, relative to the system ground which is carried on the female contacts. Use the protective caps to prevent accidental short circuits which might cause sparking and which would interfere with charging.

Avoid laying the Solar Cable or the solar panels so as to cause trip hazards or be an impediment to passage.

When solar panels and the Solar Cable are deployed outdoors, there is a possibility that the panels or the cable may be struck by lightning, resulting in voltage surges which may affect user equipment and/or pose a hazard to personnel. As a precaution, user equipment which is connected to a solar-charged SBP-1100e should be properly earth-grounded via a wire clamped to a copper-clad grounding rod driven into the ground. As a further precaution, the Solar Cable should be disconnected from the SBP-1100e Smart Battery Pack whenever a storm approaches, if possible, as this will protect the battery pack and the downstream equipment. Finally, the Solar Cable itself may be safety-grounded by earth-grounding the “ground” (female) terminal of an unused trailer connector on the Solar Cable. To do this, obtain a 2, 3, or 4-position trailer connector with pigtail wires and one male contact with one or more female contacts, and connect the wire from the male contact to a grounding rod. Do not connect the other wires and tape them up. Then mate that trailer connector to an unused connector on the Solar Cable.

Operation and Maintenance

Once a set of solar panels has been properly set up, slanted to face the mid-day sun, securely tied in place, and proper charging action has been observed and verified, little operator attention or intervention is necessarily required, and the installation may be left unattended for weeks or months.

If an operator is available to monitor and maintain the system, recommended action items include:

1. Several times daily (early morning, mid-day, and late afternoon) check and log the time, the state of charge of the battery pack, the weather, and the load current or power. At any time, the state of charge, and other information such as input and output current and voltage may be checked by pressing the SCROLL button on the battery pack control panel. Over time, the logged information will provide a performance baseline which may help detect problems and in determining whether more solar panels are needed.

2. Daily, or as often as seems appropriate, check the panels for dust or debris on the active surfaces, and brush off any accumulation. If only a small part of the active surface of a panel is covered or in shadow, the output power of the panel will be substantially reduced. When needed, clean the active surfaces of the panels using a rag or a mild bristle brush wetted with plain water, or water with soap or detergent.

3. Monthly, check that the panels are securely tied in place, and check for deterioration of the tie-down cordage. Consider re-positioning or re-aiming the panels, if needed, due to seasonal changes in the position of the mid-day sun in the sky. Check the Solar Cable for damage, and un-mate the trailer connector at each panel to check the contacts for corrosion, including the female contacts. If corrosion is present, scrape it off. Re-mate the trailer connectors tightly, and if rain is expected, wrap two layers of 2-inch wide tape around each mated pair of trailer connectors to help keep water out of the connection. To un-mate trailer connectors, do not pull on the wires, instead grasp each connector firmly between thumb and forefinger, and twist and wiggle the connection back and forth while firmly pulling the connection apart. Check that any un-terminated trailer connectors on the Solar Cable are firmly covered with the provided tethered protective cap. If the cap is missing, wrap some 2-inch wide tape around the connector to cover up the exposed contacts, or push the unused connector into an unused protective cap elsewhere on the cable. Do not connect two trailer connectors on the Solar Cable to each other—that would short-circuit the cable.

Troubleshooting

If charging stops while the sun is shining on the solar panels, it might be because the battery pack is already fully charged. Press the SCROLL button to read the state of charge. Press the SCROLL button repeatedly to view other information such as input and output current and voltage, and estimated time to charge. As a battery pack nears full charge, the charging current will drop off, and the actual state-of-charge reading for a fully charged battery pack will be a few points less than a full 100%. If a battery pack shows a high state of charge, and it is not indicating “CHARGING” at the control panel display while there is also no load on the battery pack output, that battery pack is considered to be fully charged. Note that the power drawn by the load which is connected to the battery pack will be drawn from the solar panels, if the solar panels are able to provide that much power, so power indicated at the input of the battery pack is not necessarily charging power.

If it is suspected that a solar panel is bad, disconnect the suspect panel from the cable, and use a multi-meter to measure the open-circuit voltage, with the panel in the sun. It should be about 30 volts. If the multi-meter has a 10 amp (or greater) DC current measurement capability, use that to measure the short-circuit current with the panel in strong sun, with the panel aimed directly at the sun. The short-circuit current should be about 3.5 to 4 amps. If the test results seem inconclusive, the measurements for the suspect panel should be compared with similar measurements made with a known good panel under the same conditions.

If strong sun is shining on the panels, but there appears to be no power available from the solar cable, as indicated by low input voltage and current readings at the battery pack control panel, check the voltage at an unused trailer connector on the Solar Cable. If the voltage is zero or is very low, the cable may be short-circuited or overloaded. Disconnect the cable from the battery pack and measure the cable voltage again. Disconnect all the solar panels and use a multimeter to check for a short circuit at each trailer connector on the cable. Check each solar panel as described in the previous paragraph.

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