SOLAR BOOST™ 50

50A 12/24V MAXIMUM POWER POINT TRACKING
PHOTOVOLTAIC CHARGE CONTROLLER

INSTALLATION AND OPERATION

MANUAL

THIS MANUAL INCLUDES IMPORTANT SAFETY INSTRUCTIONS
SAVE THESE INSTRUCTIONS

COVERED UNDER US PATENTS
6,111,391 • 6,204,645

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IMPORTANT SAFETY INSTRUCTIONS

1. Refer servicing to qualified service personnel. Incorrect installation may result in risk of electric shock or fire. No user serviceable parts in this unit.

2. Remove all sources of power, photovoltaic and battery before servicing or installing.

3. WARNING - RISK OF EXPLOSIVE GASES
   a) Working in the vicinity of lead-acid batteries is dangerous. Batteries produce explosive gasses during normal battery operation.
   b) To reduce risk of battery explosion, follow these instructions and those published by battery manufacturer and manufacturer of any equipment you intend to use in vicinity of battery.

4. PERSONAL PRECAUTIONS
   a) Someone should be within range of your voice or close enough to come to your aid when you work near a lead-acid battery.
   b) Have plenty of fresh water and soap nearby in case battery acid contacts skin, clothing or eyes.
   c) Wear complete eye protection and clothing protection. Avoid touching eyes while working near battery.
   d) If battery acid contacts skin or clothing, wash immediately with soap and water. If acid enters eye, immediately flood eye with running cold water for at least 10 minutes and get medical attention immediately.
   e) NEVER smoke or allow a spark or flame in vicinity of battery.
   f) Be extra cautious to reduce risk of dropping metal tool onto battery. It might spark or short circuit battery or other electrical part that may cause explosion.
   g) Remove personal metal items such as rings, bracelets, necklaces, and watches when working with a lead-acid battery. A lead-acid battery can produce a short circuit current high enough to weld a ring or the like to metal, causing a severe burn.

5. PREPARING TO CHARGE
   a) Never charge a frozen battery.
   b) Be sure battery is mounted in a well ventilated compartment.
   c) Add distilled water in each cell until battery acid reaches level specified by battery manufacturer. This helps purge excessive gas from the cells. Do not overfill. For a battery without cell caps, carefully follow manufacturers charging instructions.

6. CHARGER LOCATION & INSTALLATION
   a) Controller employs components that tend to produce arcs or sparks. NEVER install in battery compartment or in the presence of explosive gases.
   b) Protect all wiring from physical damage, vibration and excessive heat.
   c) Insure that the controller is properly setup for the battery being charged.
   d) Do not expose controller to rain or snow.
   e) Insure all terminating connections are clean and tight to prevent arcing and overheating.
   f) Charging system must be properly installed as described in these instructions prior to operation.
   g) Do not connect to a PV array capable of producing greater than 40 amps of short circuit current @ 25°C.

SAVE THESE INSTRUCTIONS

PRODUCT DESCRIPTION

Solar Boost™ 50 is a 50 amp 12/24 volt *Maximum Power Point Tracking* (MPPT) photovoltaic (PV) charge controller. Through the use of patented MPPT technology, Solar Boost 50 can increase charge current up to 30% or more. Solar Boost 50's sophisticated three stage charge control system can be configured to optimize charge parameters to precise battery requirements based on battery electrolyte type, battery size in amp-hours, and battery temperature. The system is fully protected against voltage transients, over temperature, over current, and reverse battery and reverse PV connections. A manual equalize function is also included to periodically condition flooded lead-acid batteries.

Solar Boost 50 employs series pass *Pulse Width Modulation* (PWM) charge voltage control. The advanced multistage charge control system combined with precise PWM voltage control leads to superior charging and enhanced battery performance. To provide optimum charge control on installations where battery load varies widely during charge, Solar Boost 50 can interface to an external current shunt to provide optimal charge control. Solar Boost 50 also includes an automatic current limit feature which allows use of the full 50 amp capability without worrying about overload or nuisance fuse blow from excessive current. The PWM control system uses highly efficient and reliable power MOSFET transistors. The MOSFET's are turned on and off at high frequency to precisely control charge voltage and MPPT. Environmentally sealed high current high reliability relays are used to disconnect the PV array at night to prevent unwanted current drain. Relays are used rather than blocking diodes for improved power conversion efficiency, current boost performance and true reverse battery polarity protection in an MPPT controller. The relays are not stressed by functioning as part of the voltage control system and continually turning on and off as with other PV controllers. They simply turn on in the morning and off in the evening, and in this application have a life expectancy in excess of 10^5 operations.

Since Solar Boost 50 is a high efficiency series pass "buck" type power converter with current limit, the battery can be charged from any power source with a voltage greater than the desired acceptance voltage setpoint, and less than the maximum PV open circuit voltage rating of 57 volts. Examples of this type of use include charge control from hydroelectric or wind generators, or charging a 12 volt battery from a 24 volt system.

Fully automatic temperature compensation of charge voltage is available as an option to further improve charge control and battery performance. The available SensorLug™ battery temperature sensor is built for long term reliability. The sensor element is environmentally sealed and encapsulated into a copper lug which mounts directly to the battery terminal. A user friendly digital display is also available to monitor PV charge performance. The display may be provided in the Solar Boost 50 controller, as a remote panel, or both. The remote panel cable may be up to 300ft/91.4m in length.

PART NUMBERS AND OPTIONS

- SB50............................... Solar Boost 50 controller without digital display
- SB50D .... Solar Boost 50 controller with digital display
- SB50RD25 .... SB50 remote digital display with 25' cable (standard duplex box mount)
- SB50PD.......................... SB50D front panel with digital display (add to SB50 to make SB50D)
- 930-0022-20................... SensorLug™ battery temperature sensor with 20' cable
- CS-100 .... 100A/100mV current shunt
- CS-200 .... 200A/200mV current shunt
- CS-500 .... 500A/50mV current shunt

OPERATION

During installation the Solar Boost 50 will have been configured to operate in a 12 or 24 volt system, and for three stage or two stage charge. Additional items which may be configured during installation include; acceptance and float voltage setpoints, battery amp-hour capacity, temperature compensation and whether full charge is determined using the internal current shunt or an optional external current shunt.

Once installed and configured, Solar Boost 50 charge control and MPPT operations are fully automatic. Charge turns on whenever the PV array is capable of producing sufficient power. When PV charge is on the Charge Status LED will indicate the present charge mode, and when PV power production is relatively high, it will show approximate battery state of charge. At night when PV power production stops, the PV array is disconnected from the battery to prevent unwanted current drain.

FRONT PANEL AND REMOTE DISPLAY INDICATORS

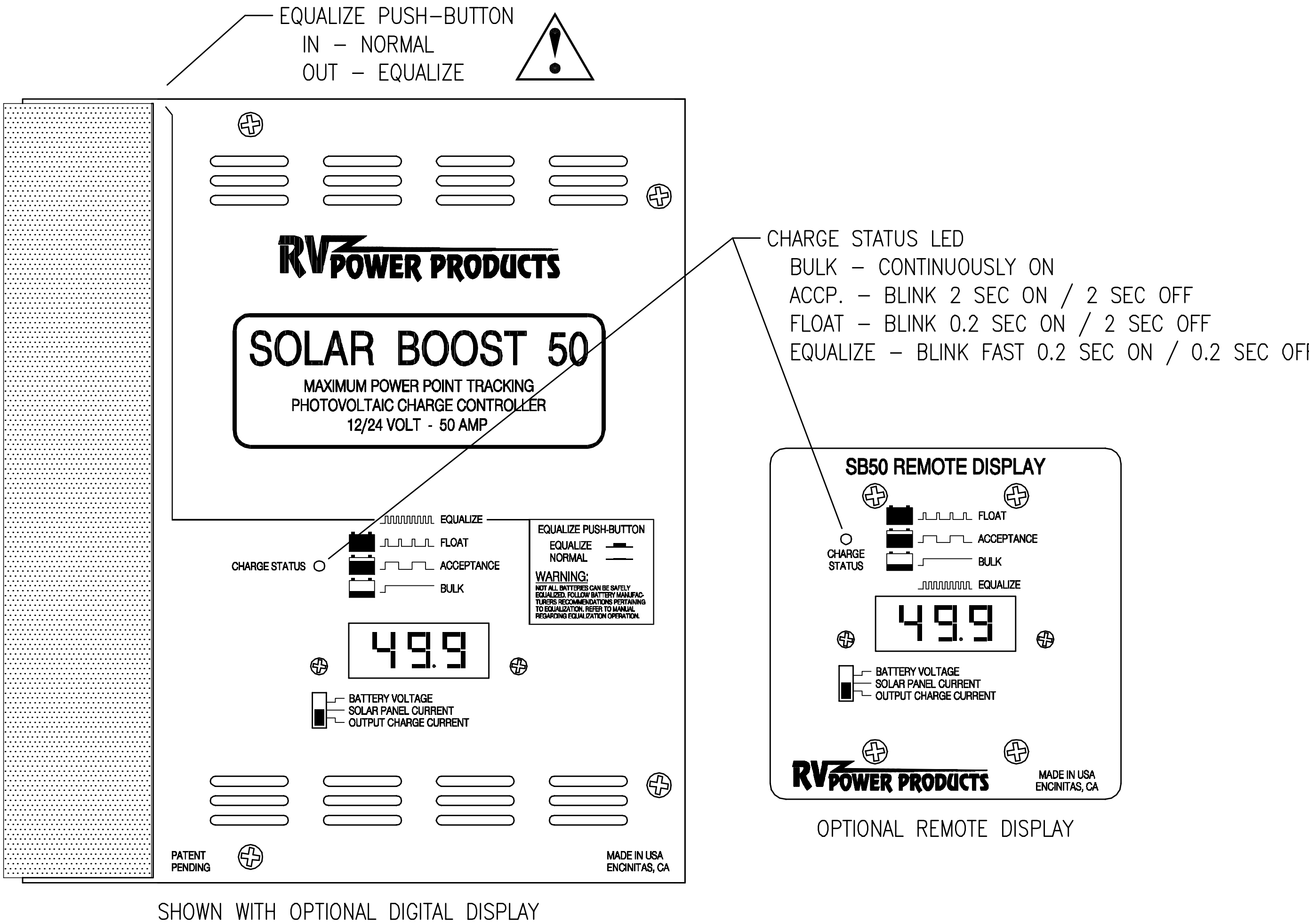

Figure 1

Note that a minimum battery voltage of 9 volts in 12 volt systems, or 18 volts in 24 volt systems, is required for Solar Boost 50 to operate.

OPTIONAL DIGITAL DISPLAY

An optional digital display is available to monitor PV charge performance. The display is available in the Solar Boost 50 controller chassis, and as a remotely mounted panel. Both the chassis display and the remote display may be installed and used simultaneously. The digital display can be selected to show Battery Voltage, Solar Panel Current, or Output Charge Current. When the MPPT system is functioning, charge current boost can be seen by noting the difference between Solar Panel Current and Output Charge Current. If MPPT is not operating, it is normal for Output Charge Current to show 0.1 or 0.2 amps less than Solar Panel Current since the system consumes 150/90mA at 12/24 volts respectively to operate during charge.

CHARGE STATUS INDICATOR

An LED charge status indicator is provided both with and without the optional digital display. Indicator function is identical for the SB50, SB50D, and SB50RD.

CHARGE STATUS INDICATOR

INDICATOR ACTION	CHARGE MODE	TYPICAL BATTERY STATE OF CHARGE
OFF	CHARGE OFF (NO PV OR OVER TEMP.)	NOT DISPLAYED
CONTINUOUSLY ON	BULK	LESS THAN 70% FULL
BLINKING 2 SEC ON / 2 SEC OFF	ACCEPTANCE	BETWEEN 70% - 95% FULL
BLINKING 0.2 SEC ON / 2 SEC OFF	FLOAT	FULLY CHARGED
BLINKING RAPIDLY 0.2 SEC ON / 0.2 SEC OFF	EQUALIZE	N/A

TABLE 1

THREE STAGE CHARGE CONTROL

Solar Boost 50 is typically configured for a three stage charging process. Acceptance and float voltages are factory set to approximately 14.3/28.6 volts and 13.3/26.6 volts respectively, which are appropriate for a liquid electrolyte lead-acid battery at 80°F. As described in the installation section, the most highly optimized charge process is obtained by using the optional SensorLug battery temperature sensor, and if battery load varies during charge, an optional external current shunt to determine full charge based on net battery charge current.

Bulk Charge

During the bulk charge stage, the charge status LED will be on continuously. Solar Boost 50 delivers as much charge current as possible during bulk to rapidly recharge the battery. In the bulk stage, the battery is typically at a low state of charge of less than 70% full. Bulk charge is initiated when; 1) Charge current during acceptance or float increases above the Float Transition Current, or 2) Insufficient power is available from the PV array to hold the battery at the desired acceptance or float voltage. Maximum available charge current during bulk varies with the number and size of PV modules installed, available solar energy, and operation of the proprietary MPPT current boosting system. Electronic current limit prevents the possibility of overload by limiting output current to 50 amps regardless of available PV input current or input power.

Acceptance Charge

Following bulk charge, the system changes to a constant voltage mode where the acceptance voltage is applied to the battery. In the acceptance stage, the battery is typically at a high state of charge of between 70% to 95% full. With installation of the optional SensorLug battery temperature sensor, the acceptance voltage continuously adjusts to the optimum value based on battery temperature. The graph of Figure 2 shows acceptance voltage as a function of battery temperature for the factory setpoint of 14.3/28.6 volts @ 80°F. Charge current slowly decreases as the battery continues to charge at the acceptance voltage. When charge current during acceptance decreases to the Float Transition Current, typically set to 1.0 amps per 100 amp-hours of battery capacity, the battery is fully charged without being over charged.

Float Charge

Once the battery is fully charged the charge control system switches to the float charge stage. During float charge, a constant float voltage of 13.3/26.6 volts is applied to the battery to maintain it in a fully charged state without excessive water loss. The purpose of float charge is to provide a very small charging current to offset self discharge of the battery. During float charge a healthy lead-acid battery that is fully charged and stabilized will draw approximately 0.1 - 0.2 amps per 100 amp-hours of battery capacity. For example, a typical 350 amp-hour battery will draw approximately 0.4 - 0.7 amps. If the battery attempts to draw more current than the Float Transition Current, the system will switch back to acceptance or bulk. Continuous application of a proper float voltage to a fully charged battery will not harm the battery or lead to excessive water loss.

TWO STAGE CHARGE CONTROL

Certain battery types or system configurations may require two stage charge control. Solar Boost 50 can be configured for a two stage bulk-acceptance or bulk-float charging process to accommodate these batteries or systems. Refer to the Solar Boost 50 Setup section to configure two stage charge.

EQUALIZATION

WARNING: Not all batteries can be safely equalized. Equalization should only be performed on vented liquid electrolyte lead-acid batteries. Follow battery manufacturers recommendations pertaining to equalization.

Equalization is essentially a controlled over charge and should only be performed on vented liquid electrolyte lead-acid batteries. Since each cell of a battery is not identical, repeated charge/discharge cycles can lead to an imbalance in the specific gravity of individual battery cells. Stratification of the electrolyte can also occur. Equalization brings all battery cells up to the same specific gravity, and eliminates stratification by heavily gassing the battery. Note that the three stage charge technique matched to battery size, type and temperature provided by Solar Boost 50 minimizes the need for equalization, as the battery is properly and fully charged on each cycle.

A proper equalization cycle is a substantial over charging of the battery at relatively high voltages with significant battery gassing. Solar Boost 50 features a manually operated equalization function since an operator should always plan and monitor the process. The operator should ensure that equipment connected to the battery can tolerate the high equalization voltage which will be applied to the battery, and that the battery attains the proper voltage for the desired time period. Battery voltage setpoint during equalization will be the bulk voltage plus 1.0 or 2.0 volts for 12 or 24 volt systems respectively. Note that with temperature compensation, the equalization voltage can be quite high at cool temperatures.

As shown in Figure 1, the equalization push-button is located on top of the enclosure. Equalization is enabled when the push-button is out, and the Charge Status LED blinks rapidly. Equalization is normally conducted approximately once per month, with the battery held at the equalization voltage for a period of approximately two hours. It is best to equalize a battery that is already fully charged so that the desired equalization voltage is reached quickly. Following the desired equalization period, the equalization cycle is terminated and normal charge operation is resumed by again pressing the equalization push-button. The battery should then be topped off with distilled water per the battery manufacturers recommendations.

Disabling Equalization

For certain battery types or electrical systems, it may be desirable to eliminate the possibility of initiating the equalization cycle. This can be accomplished by gently pulling the red equalization push-button cap off of the equalize switch and ensuring that the remaining switch plunger is in the normal position. Use needle nose pliers and gently rock the cap side to side while pulling to avoid damaging the switch mechanism.

OPTIONAL TEMPERATURE COMPENSATION

The ideal charge voltage required by batteries changes with battery temperature. Temperature compensation of charge voltage leads to enhanced battery performance and life, and decreased battery maintenance. Fully automatic temperature compensation can be provided through use of the optional SensorLug battery temperature sensor. If your system includes this option, the charge voltage setpoints will continuously adjust to the proper value based on measured battery temperature. Appropriate temperature compensation curves for either lead-acid and NiCd battery chemistry can be selected. The lead-acid curve for a 12 volt system (6 cells) is –30.0 millivolts/°C or –16.7 millivolts/°F, whereas the 12 volt NiCd curve (10 cells) is –20.0 millivolts/°C or –11.2 millivolts/°F. These values double for a 24 volt system. The graph of Figure 2 shows lead-acid charge voltage setpoint vs. battery temperature for the factory acceptance voltage setting of 14.3/28.6 volts @ 80°F, and float voltage setting of 13.3/26.6 volts @ 80°F.

LEAD-ACID CHARGE VOLTAGE SETPOINT -VS.- BATTERY TEMPERATURE

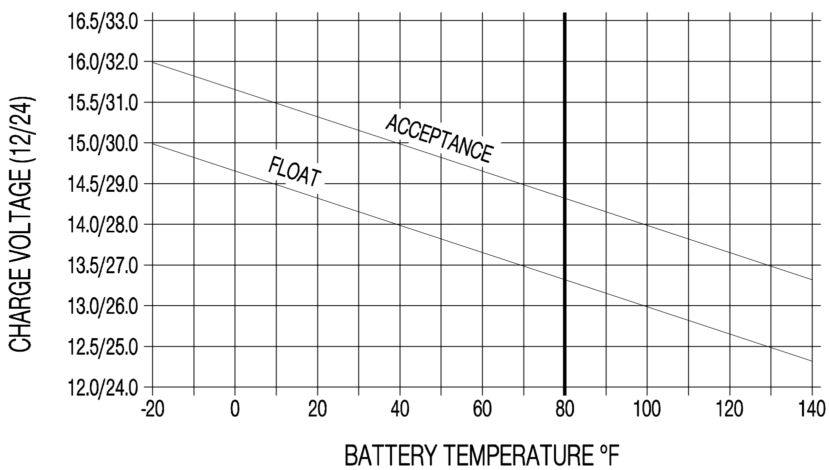

Figure 2

MAXIMUM POWER POINT TRACKING (MPPT)

MPPT and associated current boost operation is fully automatic and will function whenever sufficient PV voltage and current are available. The percent increase you will receive in output charge current relative to PV array current is variable, and will change with operating conditions. When conditions are such that sufficient PV voltage and current are not available to produce an increase in output current, Solar Boost 50 will operate as a high performance series pass PWM controller. Current boost performance can be easily monitored using the digital display. Whenever output charge current is greater than PV array current, current boost is functioning. A minimum PV current of just under two amps is required before current boost can begin to operate.

The principal operating conditions which affect current boost performance are battery voltage and PV array temperature. At constant solar intensity the power available from a PV array changes with array temperature. A PV array's power vs. temperature characteristic is such that a cool PV array can produce a higher voltage, and therefore more power, than a hot PV array. When PV voltage is sufficiently high for MPPT to operate, a constant power output is delivered to the battery. Since output power is essentially constant while MPPT is operating, a *decrease* in battery voltage produces a corresponding *increase* in charge current. This means that the greatest current increase occurs with a combination of cool ambient temperature and low battery voltage. Solar Boost 50 delivers the greatest charge current increase when you need it most, in cold weather with a discharged battery.

Because output power is constant while boost is operating, anything that leads to lower battery voltage will produce an increase in output charge current. While a discharged battery is one way to produce lower output voltage, and therefore higher output current, other normal conditions may produce lower voltage as well. Any 12/24 volt power consumption during the day will decrease net battery charge current, which decreases battery voltage. Operating a large inverter or application of other heavy loads can produce substantial drops in output voltage leading to significant increases in output current. Additionally, anything that can be done to lower PV array temperature will also lead to increased charge current by increasing PV power production. Installing modules in a breezy location for example will cool the PV array due to increased air circulation.

HOW MPPT WORKS

A PV module is a *constant current* type device. As shown on a typical PV module voltage vs. current curve, current remains relatively constant over a wide range of voltage. A typical 75 watt module is specified to deliver 4.45 amps @ 17 volts @ 25°C. Conventional PV controllers essentially connect the PV array directly to the battery when battery voltage is low. When this 75 watt module is connected directly to a battery charging at 12 volts, the PV module still provides approximately the same current. But, because output voltage is now at 12 volts rather than 17 volts, it only delivers 53 watts to the battery. This wastes 22 watts of available power.

Solar Boost 50's patented MPPT technology operates in a very different fashion. Under these conditions Solar Boost 50 calculates the maximum power voltage (V_{MP}) at which the PV module delivers maximum power, in this case 17 volts. It then operates the PV module at 17 volts which extracts maximum power from the PV module. Solar Boost 50 continually recalculates the maximum power voltage as operating conditions change. Input power from the peak power tracking controller, in this case 75 watts, feeds a switching type power converter which reduces the 17 volt input to battery voltage at the output. The full 75 watts which is now being delivered at 12 volts would produce a current of 6.25 amps. A charge current increase of 1.8 amps or 40% is achieved by converting the 22 watts that would have been wasted into useable charge current. Note that this example assumes 100% efficiency to illustrate the principal of operation. In actual operation, boost will be somewhat less as some available power is lost in wiring, connections, fuse and in Solar Boost 50.

TYPICAL CURRENT BOOST PERFORMANCE

As described above current boost performance for a particular installation varies with PV array temperature and battery voltage. Two of the other primary factors which affect boost performance include system wiring and PV module design. The effect wiring has on performance is that power wasted heating undersized wiring is unavailable for charging. This is discussed further in the Battery And PV Wiring section. The effect PV module design has on performance is that modules with a maximum power voltage (V_{MP}) of 17 volts or higher will tend to produce more boost, whereas PV modules with V_{MP} less than 17 volts will tend to produce less boost. Additionally, more PV modules will tend to produce more boost, whereas fewer PV modules will tend to produce less boost.

For a 24 volt system using eight 75 watt PV modules with peak power specifications of 4.45 amps @ 17 volts @ 25°C, representative boost performance under a variety of operating conditions is shown in Table 2. Your current boost performance will vary due to a variety of factors. What you can be sure of is that Solar Boost 50 will automatically deliver the highest charge current possible for a given installation and set of operating conditions.

TYPICAL 24V CURRENT BOOST PERFORMANCE
EIGHT 75 WATT PV MODULES

BATTERY CONDITION AND VOLTAGE	AMBIENT CONDITIONS	PV INPUT CURRENT	OUTPUT CHARGE CURRENT	PERCENT INCREASE
FULLY DISCHARGED 21.8V	35°F EARLY MORNING	8.8 AMPS	12.1 AMPS	38%
HIGHLY CHARGED 27.6V	45°F CLOUDY, BREEZY	7.9 AMPS	9.3 AMPS	18%
HIGHLY DISCHARGED 23.6V	65°F CLEAR, STILL AIR	16.7 AMPS	18.4 AMPS	10%
HIGHLY CHARGED 27.6V	75°F CLEAR, STILL AIR	18.5 AMPS	18.5 AMPS	0%

TABLE 2

TEMPERATURE AND OUTPUT POWER

Over temperature protection is provided to protect the unit from damage due to high output power at high ambient temperatures. When mounted vertically as described in the installation section, Solar Boost 50 can deliver full output in an ambient temperature of up to 40°C (104°F). If cooling is restricted at high power levels or ambient temperature is higher than 40°C, the charge control system will cycle on and off, reducing average power delivery to within safe limits. During periods of thermal shutdown the Charge Status Indicator will display an “off” condition.

INSTALLATION

WARNING: Read, understand and follow the Important Safety Instructions in the beginning of this manual before proceeding. The system must be installed in accordance with local codes and standards. Adjustments or connections other than those shown in Figure 3 void the limited warranty.

OVER VOLTAGE / REVERSE POLARITY PROTECTION

Solar Boost 50 is fully protected against reverse polarity and high voltage transients for both the PV array and the battery. If the battery is connected reverse polarity, Solar Boost 50 will not operate. If the PV array is connected reverse polarity, Solar Boost 50 will not provide output current and the Solar Panel Current display will show *negative* current. Should high PV current be available during reverse PV connection the heatsink will become quite warm but no damage to the unit will result. Note that the unit is not protected against reverse battery connection to the PV terminals. Damage of this type is not covered under the limited warranty.

ELECTROSTATIC HANDLING PRECAUTIONS

While transient voltage protection is provided for terminal block connections, exposed circuits may be damaged by electrostatic discharge during installation and handling. Discharge yourself by touching a water faucet or other electrical ground prior to handling the unit and avoid touching components on the circuit boards. Keep the Digital Display in it’s electrostatic protective bag until it is installed. All electronic circuits may be damaged by static electricity and these instructions combined with special packaging are provided to minimize the possibility of damage. The risk of electrostatic damage is highest when relative humidity drops below 40%.

MAXIMUM PV SHORT CIRCUIT CURRENT AND NEC

To be compliant with National Electrical Code (NEC), solar module controllers should be sized to provide 125% more rated capacity than the 25°C short circuit current rating of the PV modules, and then all components be sized another 125% greater. However, Solar Boost 50 can regularly produce more than 40 amps of output current from 40 amps of input current. The NEC does not cover MPPT type controllers with electronic current limit, but bases the rules on older less sophisticated controllers which are unable to manage conditions of higher than expected current. Our interpretation of the spirit of the NEC is that Solar Boost 50 connected to 40 amps of short circuit PV current, and branch circuit protection of 60 amps is compliant with the spirit of NEC requirements. This is because the system is rated for and electronically limited to 50 amps of output current. With wiring and branch circuit protection then rated at 60 amps, the 125% margin is always maintained. The final judgement of acceptability is to be made by the local authority with jurisdiction.

SOLAR BOOST 50 SETUP

Solar Boost 50 has several setup options that need to be configured prior to connection and use. These selections are configured by setting a single 12 position dip switch on the main circuit board. Refer to Figure 3 for setup adjustment locations.

Default Factory Setup

- System voltage.. 24V
- Temperature compensation... Disabled
- Float transition current measurement.................................. Internal shunt measuring output charge current
- Float transition current 5.0A
- Charge mode .... Three stage
- Acceptance voltage 28.6V
- Float voltage 26.6V
- MPPT operating point ($V_{OC} – V_{MP}$).. 4.4V (36 cell module)

SETUP AND WIRING DIAGRAM

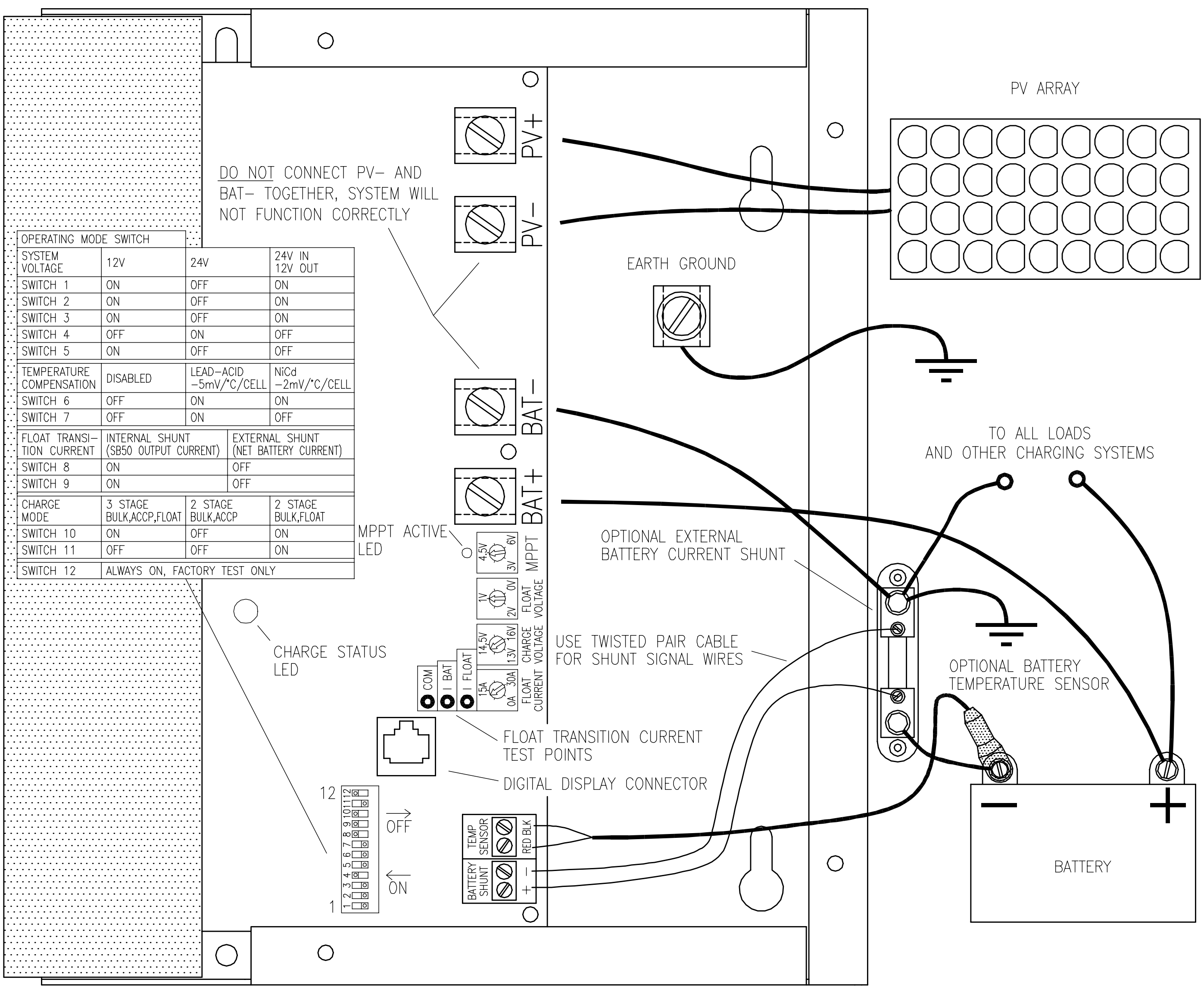

Figure 3

Nominal System Voltage

Select nominal system voltage for 12 or 24 volt.

SWITCH 1	SWITCH 2	SWITCH 3	SWITCH 4	SWITCH 5	SYSTEM VOLTAGE
ON	**ON**	**ON**	OFF	**ON**	12 VOLT
OFF	OFF	OFF	**ON**	OFF	24 VOLT
ON	**ON**	**ON**	OFF	OFF	24 VOLT INPUT / 12 VOLT OUTPUT

It is also possible to wire the PV array for 24 volts and charge a 12 volt battery by selecting the 24 volt input / 12 volt output mode. In this 24/12V operating mode a minimum PV input current of approximately 1.5 amps is required for MPPT to operate and PV voltage to rise the desired operating point. When MPPT operates, output charge current will be approximately 2X or more PV input current. This special operating mode can be quite useful for 12 volt systems with very long PV wiring lengths, as wire length can be four times as long for a given wire size by doubling input voltage and halving input current as shown in Table 3. This operating mode can also solve problems associated with very high temperature operation where conventional controllers cease to deliver current due to temperature induced PV voltage reduction. In this mode input current should be limited to 20 amps.

Charge Mode

Solar boost 50 can be configured for two stage or three stage charging. Typically three stage charge is used, but certain battery types or system configurations may benefit from two stage charge. When configured for two stage charge, equalization still operates as described.

SWITCH 10	SWITCH 11	CHARGE MODE
ON	OFF	THREE STAGE (BULK, ACCEPTANCE, FLOAT)
OFF	OFF	TWO STAGE (BULK, ACCEPTANCE)
ON	**ON**	TWO STAGE (BULK, FLOAT)

Float Transition Current Measurement Shunt

Solar Boost 50 measures charge current during acceptance to determine when the battery is fully charged. A lead-acid battery is considered fully charged when charge current during acceptance decreases to 1.0 amps per 100 amp-hours of battery capacity. Solar Boost 50 can use the internal current shunt measuring Output Charge Current, or an external current shunt measuring net battery current to determine full charge. When the battery is unloaded during charge, or the load during charge is relatively constant, using the internal shunt is a good choice.

SWITCH 8	SWITCH 9	BATTERY CURRENT MEAUREMENT USED BY CHARGE CONTROL SYSTEM
ON	**ON**	INTERNAL CURRENT SHUNT (MEASURING OUTPUT CHARGE CURRENT)
OFF	OFF	EXTERNAL CURRENT SHUNT (MEASURING NET BATTERY CHARGE CURRENT)

However, if battery load is highly variable during charge more effective charge control can be obtained through the use of an external current shunt measuring net battery charge current. The wiring diagram of Figure 3 shows how this optional external current shunt would be used. Note that this shunt can be an already existing shunt which is part of a separate standalone battery monitor system, as long as it is in the negative leg of the battery and is wired to measure net battery current. A variety of optional current shunts are available through your local RV Power Products dealer.

The advantage the external shunt provides could be illustrated in the following manner. Suppose a battery is at a fairly high state of charge in the acceptance mode, and is drawing 5 amps of charge current which is being provided by Solar Boost 50. If a 10 amp load is then placed on the battery, Solar Boost 50 increases output current to hold the battery at the desired acceptance voltage. Solar Boost 50 is now delivering 15 amps, 5 amps to the battery as before, plus 10 amps to the load. Using the internal shunt, it appears that the battery is now consuming 15 amps of charge current. But, the external shunt still senses 5 amps of charge current since it is measuring net battery charge current. With the external shunt connected to the Solar Boost 50 charge control system, the charge control system properly measures charge current at 5 amps, producing optimal control of the charge process despite changes in battery load during charge.

Float Transition Current Setpoint

The Float Transition Current setting controls when the system switches between acceptance and float. If charge current is less than the Float Transition Current setpoint, the system will switch to float. If charge current greater, the system will switch to acceptance. Set the Float Current potentiometer for a voltage on the “I Float” relative to “Com” test point for 0.1 or 0.01V per amp of desired Float Transition Current as shown below. For example, if battery capacity is 500 amp-hours requiring a Float Transition Current of 5.0 amps, and a 100mV/100A shunt is used, set the “I Float” test point voltage to 0.50V. When using an external shunt, actual net battery current can be measured on the “I Bat” test point relative to “Com” at the same scaling.

RVPP CURRENT SHUNT PART NUMBER	CURRENT SHUNT RATING	“I FLOAT” & “I BAT” TEST POINT SCALING	MAX CURRENT MEASUREMENT AT “I BAT” TEST POINT
INTERNAL SHUNT	50A / 50mV	0.10V PER AMP	±40 AMP
CS-100	100A / 100mV	0.10V PER AMP	±40 AMP
CS-200	200A / 200mV	0.10V PER AMP	±40 AMP
CS-500	500A / 50mV	0.01V PER AMP	±400 AMP

When using the internal shunt measuring Output Charge Current, the Float Current potentiometer is also set for a voltage on the “I Float” relative to “Com” test point of 0.1V per amp of desired Float Transition Current. However, if battery load is a constant 10 amps, add 10 amps to the setting. For example, if the battery capacity is 500 amp-hours requiring a Float Transition Current of 5.0 amps (plus 10 amps of load), set the “I Float” test point voltage to 1.50V for a setting of 15 amps. If load current is highly variable and the internal shunt is used, select a Float Transition Current that allows the system to switch to float during light load and full charge conditions.

Maximum Power Voltage

The nominal setting for this adjustment is the difference between the PV module’s *open circuit voltage* (V_{OC}) and *maximum power voltage* (V_{MP}). These voltage values are typically listed on both the PV module datasheet and on the rating label affixed to each PV module. This value needs to be set correctly for the MPPT system to deliver maximum current boost. The factory setting is 4.4 volts which is the appropriate value for popular modules. These modules typically list V_{OC} at ≈21.4 volts and V_{MP} at ≈17.0 volts, which yields; 21.4V - 17.0V = 4.4V.

Solar Boost 50 updates the maximum power operating point approximately every 10 seconds by briefly turning off the output to sample PV open circuit voltage. It then operates the PV array at a voltage approximately equal to the sampled open circuit voltage minus the MPPT voltage setting. Factors other PV open circuit voltage fine tune the actual operating point, but PV open circuit voltage is the primary factor. Note that the values above and the scaling shown on the MPPT adjust potentiometer in Figure 3 relate to a single 36 cell module. When two modules are connected in series for a 24 volt input system, Solar Boost 50 automatically doubles voltage the difference setting between V_{OC} and V_{MP} based on the position of dip switch 5.

SWITCH 5	ACTUAL MPPT V_{OC} - V_{MP} OPERATING RANGE	DEFAULT MPPT V_{OC} - V_{MP} SETTING	NUMBER OF PV MODULES IN SERIES	NOMINAL PV INPUT VOLTAGE
ON	3V – 6V	4.4V	1	12V
OFF	6V – 12V	8.8V	2	24V

Optimizing MPPT

As indicated above, the peak power voltage setting (V_{OC} - V_{MP}) is a nominal value. The combined effects of manufacturing tolerances in the PV module and wiring resistance in a particular installation can sometimes shift the optimum setting. While not required, it is recommended that for maximum boost performance this adjustment be fine tuned following installation. This is a one time setup and does not require seasonal adjustment. Fine tuning is also desirable following installation of additional PV modules or other substantial system change.

Fine tuning is easily accomplished by slowly adjusting the MPPT adjust potentiometer to obtain maximum Output Charge Current. Adjustment is best done in full sun with a discharged battery and cool ambient temperatures. The red MPPT Active LED above the potentiometer turns on when MPPT is functioning and adjustment can be made. Verify that the LED remains on at the maximum current adjustment point, <u>and</u> as you check for a slight drop in current on either side of the maximum point. If LED does not remain on, MPPT is not operating due to a combination of high PV temperature and/or high battery voltage. MPPT can usually be made to operate by lowering battery voltage through application of a heavy DC load. If in doubt, leave the adjustment at the factory default position of midway between 11:00 and 12:00 o'clock as shown in Figure 3.

Temperature Compensation

For temperature compensation to operate, the SensorLug battery temperature sensor must be installed and the desired temperature compensation curve must be enabled. Solar Boost 50 will not provide output current if temperature compensation is enabled with the SensorLug connection open (not installed), or if the SensorLug is shorted or installed reverse polarity.

SWITCH 6	SWITCH 7	12V CURVE	24V CURVE	TEMPERATURE COMPENSATION
OFF	OFF	N/A	N/A	DISABLED
ON	**ON**	-30mV/ºC (6 cells)	-60mV/ºC (12 cells)	ENABLED LEAD-ACID
ON	OFF	-20mV/ºC (10 cells)	-40mV/ºC (20 cells)	ENABLED NiCd

Acceptance Charge Voltage

The factory setting of approximately 14.3/28.6 volts is suitable for most liquid electrolyte batteries and does not require adjustment. If you need to change the setting, the Charge Voltage potentiometer location is shown in Figure 3. With the battery at or near full charge, set mode switches #10 and #11 to "off" to place the system in the acceptance charge mode. Verify that the Charge Status LED continues to show acceptance. If temperature compensation is installed, first turn mode switch #6 to "off" to disable temperature compensation. The SensorLug does not need to be disconnected. Adjust the charge voltage to the desired 80°F value. Return the mode switches to their previous settings.

Float Charge Voltage

The factory setting of approximately 13.3/26.6 volts is also suitable for most liquid electrolyte batteries and does not require adjustment. If you need to change the setting, the Float Voltage potentiometer location is shown in Figure 3. Note that the float voltage is set relative to the acceptance voltage, so set acceptance first. With the battery at or near full charge, set mode switches #10 and #11 to "on" to place the system in the float charge mode. Verify that the Charge Status LED continues to show float. If temperature compensation is installed, first turn mode switch #6 to "off" to disable temperature compensation. The SensorLug does not need to be disconnected. Adjust the float voltage to the desired 80°F value. Return the mode switches to their previous settings.

SOLAR BOOST 50 INSTALLATION

The Solar Boost 50 controller should be mounted to a vertical surface with the heatsink fins oriented vertically to promote convection cooling. If not mounted vertically, Solar Boost 50 may reduce average output power to prevent damage due to over temperature. A variety of conduit knockouts are provided for wiring. Figure 3 identifies field connections and connection locations. Figure 4 provides a detailed dimensional drawing.

For best thermal performance and reliability, mount the controller to a vertical surface free of air flow restrictions. Orient the heatsink fins vertically to promote convection cooling.

DETAILED DIMENSIONAL DRAWING

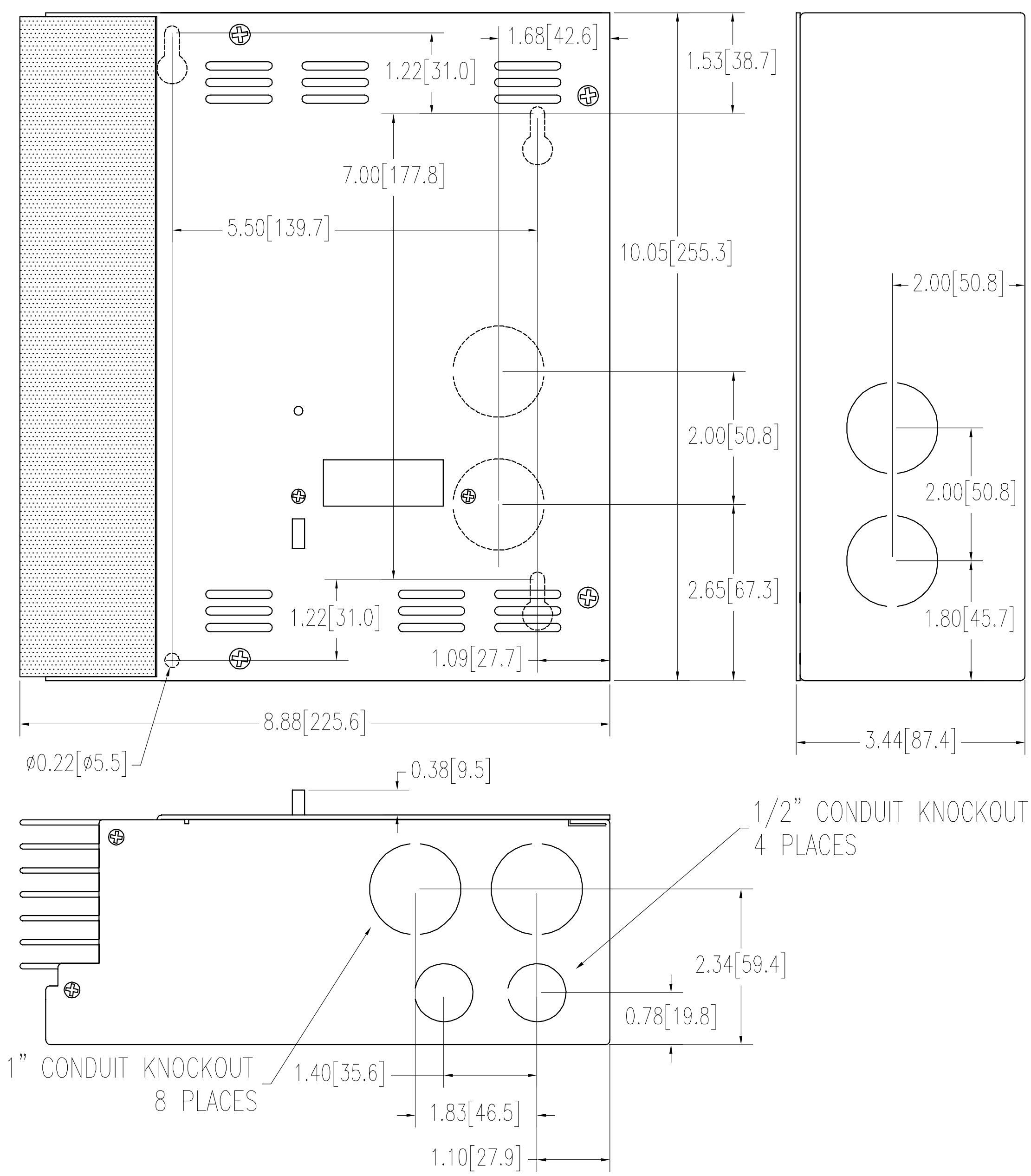

FIGURE 4

BATTERY AND PV WIRING

Wiring requirements for Solar Boost 50 are different than conventional PV controllers. While the performance of other controllers may be affected somewhat by wiring, wiring and connections used with Solar Boost 50 can have a significant effect on current boost performance. Solar Boost 50 increases charge current by transforming previously wasted power into useable charge current. The effect wiring has on current boost performance is that power wasted heating wires or connections is power that is unavailable to charge the battery. Solar Boost 50's PV and battery compression terminals will directly accept wire size up to 1/0 AWG.

PV– and BAT– connections must not be connected together as shown in Figure 3 or the system will not function properly. Resistance between these terminals is less than 3mΩ and therefore provides earth ground connection to the PV array.

A desirable installation would produce a total system wiring voltage drop of 3% or less, which can be achieved using the wire sizes shown in Table 3. Table 3 is meant to serve as a wire size guide which will lead to good boost performance with reasonable wire sizes. The lengths shown are one way for the wire pair between the PV array and battery, with Solar Boost 50 placed somewhere in the middle. A wire size less than 6 AWG should not be used for battery or PV connections.

Larger wire sizes will improve boost performance whereas smaller wire sizes will reduce boost performance. When considering wiring, fuse, and connection options *think big and short* as larger heavier components and shorter wire lengths offer less resistance and voltage drop. Note that the lengths shown in Table 3 are for a total PV short circuit current of 40 amps. If current is halved, length can be doubled. If the preferred wiring described here is not practical or possible, Solar Boost 50 will still function properly but current boost performance may be diminished.

All wiring must be completed in accordance with applicable codes and standards. At a minimum there must be a fuse or circuit breaker located close to the battery rated at 60 amps maximum.

MAXIMUM CONDUCTOR PAIR LENGTH
FOR A 3% VOLTAGE DROP AT 40 AMPS

WIRE GAUGE AWG	12 VOLT SYSTEM FEET / METERS	24 VOLT SYSTEM FEET / METERS
6 AWG	12.8 / 3.9	25.7 / 7.8
4 AWG	20.4 / 6.2	40.8 / 12.4
2 AWG	32.5 / 9.9	64.9 / 19.8
1/0 AWG	51.7 / 15.8	103.3 / 31.5
2/0 AWG	65.8 / 20.1	131.6 / 40.1
3/0 AWG	82.9 / 25.3	165.9 / 50.6
4/0 AWG	104.6 / 31.9	209.2 / 63.8

TABLE 3

OPTIONAL BATTERY TEMPERATURE SENSOR

The optional SensorLug battery temperature sensor is used to control charge voltage based on measured battery temperature. The SensorLug is electrically isolated and mounts directly to any battery terminal. Note that connections are polarized (red/black), and must be connected as shown in Figure 3. For temperature compensation to operate, it must be enabled as described in the Setup section. Solar Boost 50 will not provide output current if temperature compensation is enabled with the SensorLug connection open (not installed), or if the SensorLug is shorted or installed reverse polarity.

OPTIONAL EXTERNAL CURRENT SHUNT

As described in the Float Transition Current Measurement Shunt and Float Transition Current Setpoint sections, charge control is enhanced through the use of an external current shunt. If used, the external shunt should be installed in the battery negative cable and connected to Solar Boost 50 as shown in Figure 3 so that it measures net battery current only. With net positive charge current going to the battery, the signal polarity on the battery shunt terminal block must be +/– as shown in Figure 3. This can be verified by measuring the voltage on test points “I Bat” with respect to “Com”. The voltage should be positive with net positive charge current flowing, scaled appropriately for the shunt installed. Use twisted pair cable 18-22 AWG for shunt signal wires.

Shunt polarity must be correct for the charge control system to operate properly.

Make no connection to the Battery Shunt terminal block if the external shunt is not used.

OPTIONAL DIGITAL DISPLAY

The digital display connects to the main circuit board connector as shown in Figure 3. Cabling uses standard RJ-45 8-pin connectors, wired as shown in Figure 5. Non twisted pair cable is typically suitable for lengths up to 40ft/12.2m. Longer lengths should use standard Category 5 computer network cable, wired pin to pin with no swap. Typical Category 5 unshielded twisted pair (UTP) cable wiring used for the SB50 Remote Display (SB50RD25) is shown in Figure 5. With a Category 5 UTP cable, up to 300ft/91.4m of cable may be used to connect to the SB50RD. Longer lengths are possible and can be evaluated on an individual basis. The SB50RD mounts into a standard duplex wall mount box.

A digital display may also be mounted in the controller unit (SB50PD). If this is the case, the panel display plugs into the Digital Display connector shown in Figure 3, and the SB50RD cable plugs into the spare receptacle on the front panel digital display. The two receptacles on the digital display are internally wired in parallel.

SB50 REMOTE DISPLAY CABLE SCHEMATIC

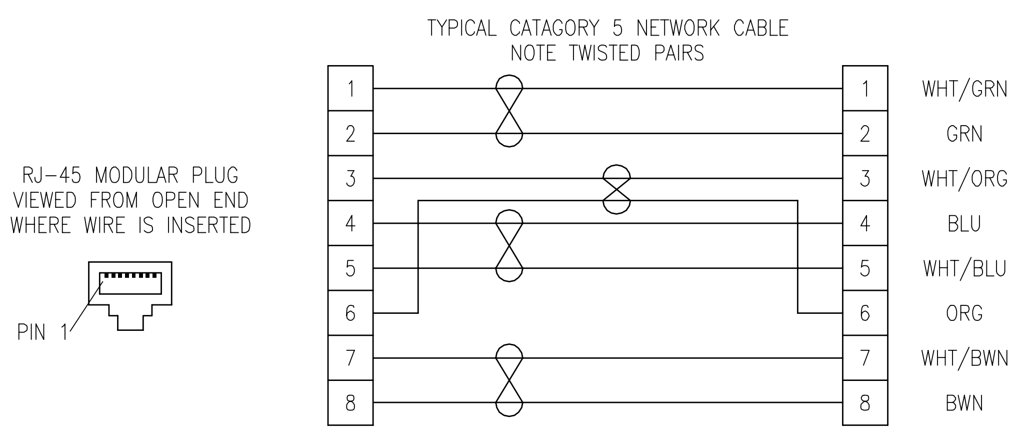

FIGURE 5

INPUT POWER SOURCES OTHER THAN PV MODULES

Since Solar Boost 50 is a high efficiency series pass “buck” type power converter with current limit, the battery can be charged from virtually any power source with a voltage greater than the acceptance voltage setpoint, and less than the maximum PV open circuit voltage rating of 57 volts. Examples of this type of charge control include hydroelectric or wind generators, or charging a 12 volt battery from a 24 volt electrical system. Whether a particular input power source will operate properly with a Solar Boost 50 depends on two criteria. These are;

1. The power source must be able to operate open circuit. This is because Solar Boost 50 uses series pass type control to lower output power when necessary. The input may go fully open circuit when the battery is fully charged. Periodic open circuit operation is also used by the MPPT system. Open circuit voltage must not exceed 57V. Input power sources which require “shunt” type power control cannot be used with a Solar Boost 50.

2. If the input power source cannot supply all the input current necessary, the Solar Boost 50 will select an input operating point based on it’s MPPT control algorithm so as to not overload the input source. Input current can be estimated by; *input_current = output_current x output_voltage ÷ input_voltage*. How well the MPPT system will work with a given input source depends on the output impedance and output characteristics of the input power source. See the Maximum Power Voltage and Optimizing MPPT sections for further discussion of the input operating point. Generally, the input will be operated at some voltage level less that the input open circuit voltage based on how MPPT is setup.

TROUBLESHOOTING GUIDE

SYMPTOM	PROBABLE CAUSE	ITEMS TO EXAMINE OR CORRECT
Completely dead, no display	No battery power	Battery disconnected, overly discharged, or connected reverse polarity. Battery powers the system, not PV.
Display OK, but system will not turn on (charge status LED off)	PV disconnected PV reverse polarity PV- connected to BAT-	Verify PV connection. Requires PV to supply at least 0.15A at 2.5V more than battery voltage to begin charge. Reverse polarity PV will cause heat sink to heat, and display to show “negative” PV current if battery is connected. PV- & BAT- must be separate for proper operation. PV- must receive earth ground via shunts inside the SB50 which internally connect PV- to BAT-. External connection prevents proper operation of internal shunts and measurement system.
Charge status LED on in Bulk, but no output charge current	Dip switches set for incorrect system voltage Temp sensor installed reverse polarity or sensor failed short	Double check dip switches #1-5 Correct sensor polarity or replace sensor. Proper temp sensor terminal voltage when connected is 2.98V at 25°C, changing at +10mV/°C.
Charge status LED on in Float or Accept., but no output charge current	Battery voltage greater than charge voltage setpoint Dip switches set for incorrect system voltage Temp compensation enabled without sensor installed or sensor failed open	This is normal operation. Output is off due to high battery voltage which may be caused by other charging systems. Double check dip switches #1-5 Disable temp compensation, or replace sensor. Proper temp sensor terminal voltage when connected is 2.98V at 25°C, changing at +10mV/°C.
Charge status LED on in Bulk, but no output charge current & relays click on/off	Fuses blown (fuses not present in later units) Dip switches set for incorrect system voltage	Replace both 30A fuses with same mfg. and type. Fuse clips must grip tightly, squeeze clips lightly if necessary. Double check dip switches #1 & 2. Verify PV- and BAT- are not connected together via earth GND or other connection.
Charge status LED on in Float or Accept., relays click on/off	Charge current is very low and the system is on the edge of being able to stay on	If charge current is very low (≈0.1 – 0.2A) because battery voltage is at setpoint, relays may switch on/off. This normal and will cause no harm. The on/off symptom will go away with a slight increase or decrease in battery voltage, or increase in load.
Relays click on/off rapidly	Dip switch #12 off	Double check dip switch #12, must always be on. Used for factory test only.
Charge status LED blinks rapidly, charge voltage may be high	System in equalize mode	Disable equalize by pressing the equalize pushbutton.

SYMPTOM	PROBABLE CAUSE	ITEMS TO EXAMINE OR CORRECT
Charge current is lower than expected, PV current may be low as well	Battery is highly charged Worn out PV modules Low insolation PV- connected to BAT- MPPT improperly setup	Normal operation, system will be in Acceptance or Float and current is reduced to control battery voltage. Replace, or use as is. Atmospheric haze, PV's dirty, sun low on horizon, etc. PV- & BAT- must be separate for proper operation. PV- must receive earth ground via shunts inside the SB50 which internally connect PV- to BAT-. External connection prevents proper operation of internal shunts and measurement system. Verify dip switch #5, verify proper MPPT setup and MPPT trim. See Maximum Power Voltage and Optimizing MPPT sections.
MPPT Current boost is less than expected	PV maximum power voltage (V_{MP}) is not much higher than battery voltage, leaving little extra power to be extracted PV's hot MPPT improperly setup	May result from PV's with low V_{MP}, as PV's with higher V_{MP} produce greater power and current boost potential. PV's with $V_{MP} \geq 17V$ work best, PV's with <36 cells tend to work poorly. Excessive PV wiring voltage drop due to undersize wiring, poor connections, etc., consumes and wastes available power. This simulates having PV's with low V_{MP}. Battery is nearly charged and battery voltage is high. Output during MPPT operation is "constant power" so higher battery voltage produces less charge current. V_{MP} and available power decrease with increasing PV cell temperature. Cooler PV's will produce greater boost. MPPT LED off indicates that extra power is not available from PV array. It is normal for boost to decrease as temperature rises. Verify dip switch #5, verify proper MPPT setup and MPPT trim. See Maximum Power Voltage and Optimizing MPPT sections.
System appears OK, but will not correctly switch between Accept. & Float	Not set for 3 stage charge System will not switch out of Bulk and into Acceptance or Float System will not switch from Float to Acceptance System will not switch from Acceptance to Float	Double check dip switches #10 & 11 Battery is discharged to the point where net charge current cannot bring battery voltage up to the desired charge voltage setpoint. PV power may be too low or loads too high. Battery may be fully charged. System will stay in Float and not switch to Acceptance until charge current is greater than Float Transition Current setting. See Float Transition Current Setpoint section. PV array may be too small for battery amp-hours. If PV array is too small, consider using 2 stage charge. External shunt is used and sense wires are wired reverse polarity. Verify charge current polarity and magnitude using "I BAT" test point. See Float Transition Current Measurement Shunt and Setpoint sections. Battery may not be fully charged. System will not switch to Float until charge current drops to less than the Float Transition Current setpoint during Acceptance. See Float Transition Current Setpoint section. Loads during charge may be high while using internal current shunt. Consider using external shunt. See Float Transition Current Measurement Shunt section.
At high ambient temperature, charge turns off	System temporarily shuts down due to high heat sink temperature	Improve ventilation or reduce PV power. Providing sufficient ventilation or operating conditions which do not cause over temperature shut down will improve reliability.

SPECIFICATIONS

Output current rating	50A
System voltage	12/24V nominal
Max. PV Open circuit voltage	57V
Max. battery voltage	57V
Output current limit	50±2A
Volt meter full scale range	60.0V
Volt meter accuracy	±0.3% full-scale
Current meter full scale range	±60A
Current meter accuracy	±0.5% full-scale
Acceptance voltage	13-16/26-32V typical
Float voltage	0-2/0-4V <Accept.
Equalize voltage	1V/2V >Accept.
Power conversion efficiency	97% typical @ 40A

Temperature compensation	
Lead-Acid	-5.0mV/°C/cell
NiCd	-2.0mV/°C/cell
Current consumption	
Standby	30mA typical
Charge on	150/90mA typical
Cabinet dimensions	10”Hx8¾”Wx3½”D
Remote display module	14½”Hx4½”Wx1¾”D
Storage temperature range	-40 to +85°C
Specified temperature range	0 to +40°C
Extended range	-40 to +50°C (will operate but may not meet specifications)

THREE YEAR LIMITED WARRANTY

RV Power Products Inc. (hereinafter RVPP), hereby warrants to the original consumer purchaser, that the product or any part thereof will be free from defects due to defective workmanship or materials for a period of three (3) years subject to the conditions set fourth below. If within the coverage of this limited warranty, RVPP will repair or replace the product at RVPP’s discretion. During year one (1), parts and labor are provided at no cost. During years two (2) and three (3), parts are provided at no cost and labor is charged at RVPP’s prevailing labor rate. The original consumer purchaser is responsible for all transportation costs and insurance.

1. This limited warranty is extended to the original consumer purchaser of the product, and is not extended to any other party.

2. The limited warranty period commences on the date the product is sold to original consumer purchaser.

3. This limited warranty does not apply to any product or part thereof damaged by; a) alteration or disassembly, b) repair or service not rendered by an RVPP authorized repair facility, c) accident or abuse, d) corrosion, or e) operation or installation contrary to instructions pertaining to the product.

4. RVPP’s liability for any defective product or any part thereof shall be limited to the repair or replacement of the product, at RVPP’s discretion. RVPP will not be liable for any loss or damage to person or property, or any other damages, whether incidental, consequential or otherwise, caused by any defect in the product or any part thereof. Some states do not allow exclusions or limitations of incidental or consequential damages, so the above limitation may not apply to you.

5. Any implied warranty for merchantability or fitness for a particular purpose is limited in duration to the length of this warranty. Some states do not allow exclusions or limitations on how long an implied warranty lasts, so the above limitation may not apply to you.

6. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

7. To obtain warranty repairs, contact RVPP at 800-493-7877 or 760-944-8882 to obtain a Returned Goods Authorization (RGA) number. Mark the outside of the package with the RGA number and return the product, postage prepaid and insured to the address below. A copy of the purchase receipt identifying original consumer purchaser must accompany the product to obtain warranty repairs.

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