PowerSTAR

PS-2012-SL

Maximum Power Point Tracking Solar Regulator

For solar lighting applications

Contents

1   Quick Start Guide

Ensure that the correct polarity is observed when making the connection to the battery or solar panel, or the fuse will blow.

Connect your PowerSTAR to a 12V battery, it is normal for the connection to the 12V battery to spark as the large capacitors charge up. Ensure that the regulator is not in an explosive environment when installing.

Plug in the RS-232 connection to your PowerSTAR with the other end into a PC serial port. If a serial port is not available then a RS-232 to USB converter can be used.

Start the program *PowerSTAR.exe* and connect to the regulator, if you have any problems see section 4.

Click the *Get All Settings* button in the PowerSTAR settings manager window to see all of the settings on the PowerSTAR.

Change all of the settings you require by entering in the respective values.

Once you have entered in all of your desired settings, click on the *Send All Settings* button, once all of your settings have been successfully saved on the regulator you will be informed with a message box.

Your regulator is now set up and ready for use. You can save these settings for use again in the future by pressing the *Save File…* button in the PowerSTAR settings manager. These saved settings can be used again in the future to program many regulators with the same settings by pressing the *Open File…* button and then pressing the *Send All Settings* button.

Connect the battery, photovoltaic array and load as shown in Figure 1.

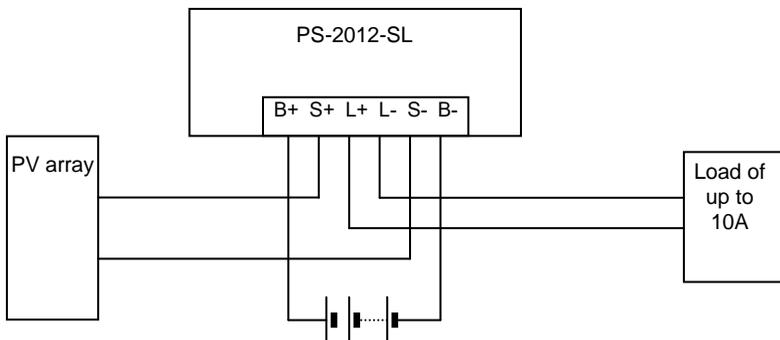Pressing the button labelled test on the regulator will connect the load for 30 seconds.

Figure 1

2   Specifications
2.1   Absolute Maximum Ratings
These values must never be exceeded

Maximum voltage across battery terminals..20V
Minimum voltage across battery terminals [1] 0V
Maximum voltage across photovoltaic terminals 26V
Minimum voltage across photovoltaic terminals ....-26V
Maximum continuous input current from photovoltaic array.................20A
Maximum continuous input power from photovoltaic array 250W
Maximum continuous output current to battery....................................20A
Maximum continuous output power to battery 250W
Maximum continuous load output current...10A
Maximum continuous load output power 120W
Maximum ambient operating temperature .... 60°C
Minimum ambient operating temperature ....-30°C
Maximum lightning induced current spike per terminal pair [2]............100A
Maximum lightning induced spike energy across all terminals 1.8J

2.2   Metering Accuracy [3]

Battery voltage.. +/- 2%
Solar voltage .... +/- 2%
Battery current .... +/- 2% and +/- 0.1A
Amp hours [4].. +/- 2% and +/- 1.5Ah
Time to float [4] .... +/- 5mins

2.3   Metering Range

Maximum battery voltage 17V
Minimum battery voltage 7V
Maximum solar voltage..22V
Minimum solar voltage...0V
Maximum battery current...20A
Minimum battery current...-10A

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[1] The reverse polarity protection will blow the fuse if this condition is violated.
[2] Maximum current for 0.4μs. 300A in total when combining current through each terminal pair.
[3] Voltage reading accuracy at regulator terminals, quoted tolerance is worst case over full operating temperature range.
[4] This value will be less accurate if the unit is disconnected or the value is read before that particular day has completed.

3   The Regulator
3.1   Regulator Parts

Figure 2 shows the various parts of the PS-2012-SL solar regulator

1.   LED
2.   Momentary switch
3.   Communications port
4.   Temperature compensation header
5.   Screw terminal block
6.   Fuse holder

Figure 2

The RS-232 translation unit connects to the auxiliary port as shown in Figure 3.

Figure 3

3.2   System Features

The PowerSTAR-2012-SL regulator has the following features:

- Maximum Power Point Tracking
- User settings for:
    - Boost voltage
    - Equalisation voltage
    - Equalisation hold time
    - Equalisation frequency
    - Equalisation attempts before returning to normal operation
    - Absorption voltage
    - Absorption hold time
    - Float voltage
    - Boost return voltage
    - Load disconnect voltage
    - Special load disconnect voltage [5]
    - Instantaneous load disconnect
    - Load reconnect voltage
    - Solar open-circuit connect voltage
    - Solar sunset voltage
    - Solar sunset time
    - Solar sunrise voltage
    - Solar sunrise time
    - Load on time
    - Load on conditions
        - Sunset
        - Before sunrise
        - External button press
    - Load off conditions
        - Timeout
        - Sunrise
        - External button press
- Moisture resistant PCB conformal coating

- Connection via a PC RS-232 serial port
- Easy to use Graphical User Interface for the PC
- Ability to save configuration settings on PC
- Rapid and simple regulator upload of saved configuration settings
- Storage for 400 days datalogging
- Datalogging for:
    - Amp hours input
    - Amp hours output
    - Maximum battery voltage
    - Minimum battery voltage
    - Time to float
    - Days to next equalisation
- Export of datalogging information to universal spreadsheet format for further analysis
- Battery regulation modes:
    - Boost
    - Equalisation
    - Absorption
    - Float
- Lightning induced transient protection [6]
- Solar reverse polarity protection
- Battery reverse polarity protection
- Advanced MPPT control algorithm
- Temperature compensation

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[5] Optional, used if equalisation will be performed the next day to ensure that the battery can receive a good charge state at least once in the period of equalisation.
[6] This regulator has been designed and tested to survive induced voltage spikes due to nearby lightning striking. It would not survive a direct lightning strike.

4   PowerSTAR Settings Manager

The PowerSTAR settings manager is used to configure and download information from your PowerSTAR maximum power point tracking regulator.

- The PowerSTAR settings manager setup file is labelled *PowerSTARsetup.exe*. Run this file to install the program. Once installed, run the PowerSTAR settings manager, the window in Figure 4 should be seen.
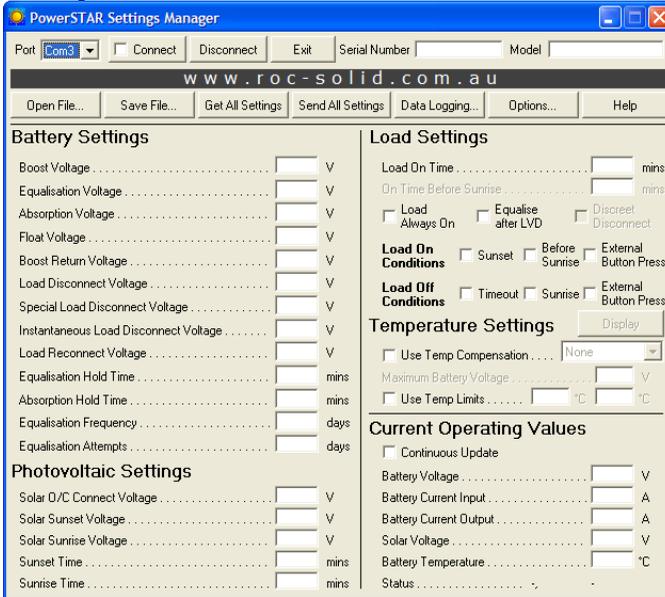

Figure 4

- Choose which COM port on your PC you wish to connect via by altering the value in the pulldown box in the top left of the window.
- Connect the RS-232 cable between the PC and the PowerSTAR.
- Apply 12V to the battery terminals of the regulator if power is not already applied.
- Click the *Connect* button. The tick box in the connect button will be enabled if a successful connection has been established. If the tick is not seen, check that the COM port is not being used by another application, also check that the correct port has been selected and that power is applied to the unit.
- Click the *Get All Settings* button to display all of the current settings.
- Enter in all of the settings you wish to modify. Placing the mouse cursor over a label will bring up a tip explaining the setting.
- Click the *Send All Settings* button. A message box will appear verifying the settings were correctly recorded on the regulator.
- Once all settings have been determined, you can save your settings for later use by pressing the *Save file…* button.
- If you wish to use these settings again at a later date, just click the *Open file…* button and then the *Send All Settings* button. By doing this, setting up multiple units is a quick and simple process.

- Click on the *Continuous Update* tick box to see the current operation of the regulator. The computer will poll the regulator frequently and display that information.

4.1 Battery Settings

Boost

Maximum power is transferred to the battery until this voltage is reached

Equalisation

A 12V lead acid battery consists of 6 cells in series. As the battery is charged and discharged, the state of charge between individual cells may vary. An equalisation process is routinely performed to ensure that one cell does not become significantly more discharged than the other cells, usually once every 20-40 days (Equalisation Frequency). Batteries are equalised by routinely increasing the voltage of the battery beyond normal levels. Any cell that is already fully charged will turn this excess energy into heat, but any cell undercharged will get a chance to reach a fully charged state. The equalisation attempts setting is there to prevent damage to the battery if there is not enough solar input to successfully complete equalisation. A normal setting would result in the regulator returning to normal operation after attempting to reach equalisation for 3 days.

Absorption

The battery is held at the absorption voltage for the absorption hold time (usually 90-180mins) to put the last 10%-30% of charge in to the battery.

Float

Also known as trickle charge. This keeps the battery topped up and only a small amount of current is transferred unless a load is placed on the battery.

Boost Return

Once the battery voltage drops below the boost return value, the battery charging cycle starts again.

Load Disconnect

Once the battery is completely discharged, the load is disconnected. The battery voltage must be below the load disconnect voltage for 5 minutes. This prevents any short term loads or high inrush startup currents from disconnecting the load

Special Load Disconnect

Set this value to the same voltage as load disconnect if this setting is not required. This is an option to increase the chance of reaching equalisation during low light periods. The load disconnect voltage is internally changed to the special load disconnect voltage the day before attempting equalisation. By setting this value to a higher voltage, the battery will not be as deeply discharged, increasing the chance of equalisation.

Instantaneous Load Disconnect

The load is instantly disconnected if the battery voltage drops below this value. For the PS-2012-SL, we recommend this value is greater than 9V.

Load Reconnect

The load will be reconnected if the voltage increases above the set level unless in night light mode. As a night light controller if the load is disconnected due to low voltage, the load will not come on again until the next day.

Figure 5 shows the battery charge voltage over time. The black line shows the charge regime over a normal cycle and the grey shows the change when going into equalisation mode.
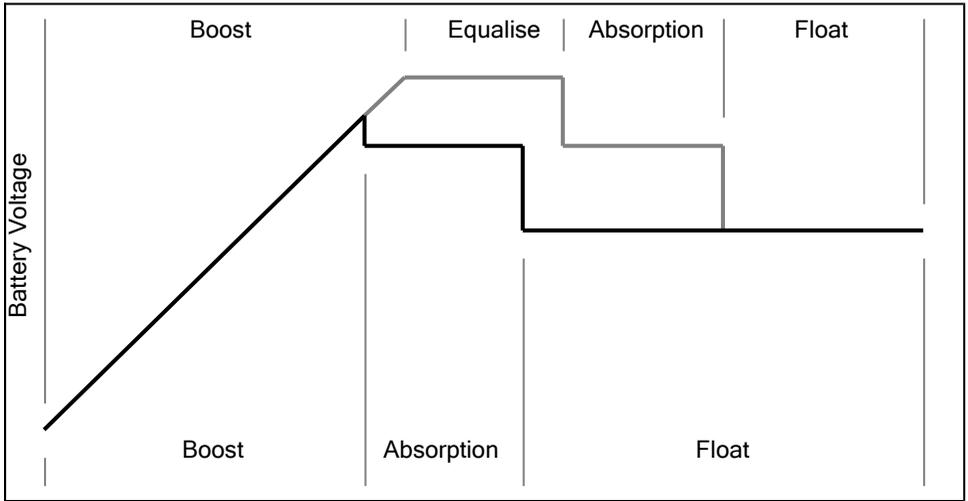
Figure 5

4.2   Photovoltaic Settings

Solar O/C Connect
> The regulator connects the panel to extract power when the solar voltage increases above the set level, and disconnects when below.

Solar Sunset
> When the solar voltage stays below the set voltage for the set time (eg 6V for 5 minutes) the regulator goes into night mode. If the load option is set to turn on at sunset, the regulator will connect the load to the battery. The sunset voltage must be at least 1V less than sunrise and should be timed for at least 5 minutes.

Solar Sunrise
> When the solar voltage stays above the set voltage for the set time (eg 7V for 5 minutes) the regulator finishes the datalogging for the day and initiates the next days datalogging. If the solar voltage increases above the Solar O/C Connect voltage, the regulator instantly connects the solar panel and increments the datalogging day. This is done so that when the regulator is first connected it does not take 5 minutes before generating power.

4.3   Load Settings

Night light control, on at sunset, off after timeout
> For this operation, the only *Load On Condition* is *Sunset*, and the only *Load Off Condition* is *Timeout*. The *Load On Time* is set to the number of minutes that the load should be connected. The load will be disconnected early if the battery voltage drops below the Load Disconnect voltage as described earlier.

Night light control, on at sunset, off at sunrise
> For this operation, the only *Load On Condition* is *Sunset*, and the only *Load Off Condition* is *Sunrise*. The load will be disconnected early if the battery voltage drops below the Load Disconnect voltage.

Night light control, on at sunset, off after timeout, on before sunrise, off at sunrise

This operation is used if the light is not needed all night long, only for a set time after sunset and before sunrise. The *Load On Conditions* are *Sunset* and *Before Sunrise*, and the *Load Off Conditions* are *Timeout* and *Sunrise*. The *Load On Time* is set to the number of minutes that the load should be connected for the first period of the night. The load will be disconnected early if the battery voltage drops below the Load Disconnect voltage as described earlier, if this occurs the load will not be connected again until more power is transferred to the battery (i.e. not until the next night). The *On Time Before Sunrise* is set to the number of minutes before sunrise that the load should be connected. This regulator calculates the time to turn the load on based on the last sunrise. The first time the regulator is connected, it will not know when sunrise actually occurs. Therefore the first time it is connected, the load on before sunrise will either be late, or will not come on at all. But subsequent times it will turn on unless the battery voltage has dropped below the load disconnect voltage during the night.

Settings examples
- The solar sunset voltage should always be at least 1V less than the solar sunrise voltage.
- The solar sunset and sunrise times should always be more than 5 minutes, this decreases the change of the light turning on and off multiple times when intermittent cloud is present at sunrise or sunset.
- To run a light from sunset to sunrise.
  - ○ Load on time = 960 minutes
  - ○ Load on before sunrise = 0 minutes
  - ○ Load on conditions enabled
    - ▪ Sunset
  - ○ Load off conditions enabled
    - ▪ Timeout
    - ▪ Sunrise
- To run a light for 7 hours after sunset and 2 hours before sunrise. [7]
  - ○ Load on time = 420 minutes
  - ○ Load on before sunrise = 120 minutes
  - ○ Load on conditions enabled
    - ▪ Sunset
    - ▪ Before Sunrise
  - ○ Load off conditions enabled
    - ▪ Timeout
    - ▪ Sunrise

4.4   Temperature Compensation

Temperature compensation for battery charging can be performed by the PS-2012-SL by connecting a PS-TS, temperature sensing lug to the two pin header near the communications port. The solar regulator needs to be set up for temperature compensation in the PowerSTAR Settings Manager software.

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[7] As the seasons change, the time between the light turning off and on again will vary. The light will run continuously all night if the time between turn off after sunrise and turn on before sunset is less then 5 minutes. This prevents rapid power cycling of the light which can damage certain lights.

4.5   Data Logging

- Press the *Data Logging* button to see the datalogging window.
- Enter the number of days of data to download.
- Click on *Download*, a dialog box will appear to save the file.
- The data is saved as .csv format and can be opened in any spreadsheet program for graphing or analysis.
- The data record period is from sunrise to sunrise. This way useful information can be obtained about when during the night a light was turned off due to low battery voltage by analysing the ampere hours out for the night. Datalogging from other regulators is frequently recorded from midnight to midnight, which can make data analysis extremely difficult.
- By logging sunrise to sunrise, the AH in figure shows the energy transferred to the battery during the day. The AH out shows the energy transferred to the lamp during the night.
- Maximum and minimum battery voltages for the day are recorded.
- The time to float is the amount of time in hours between the regulator first connecting the PV array and the battery reaching float mode.
- Days to next equalisation shows the number of days until next attempting equalisation.
- Run time shows the number of hours between sunrises, or the number of hours that the regulator had been connected.