



PowerSTAR

PS-2024-D

Maximum Power Point Tracking Solar Regulator

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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

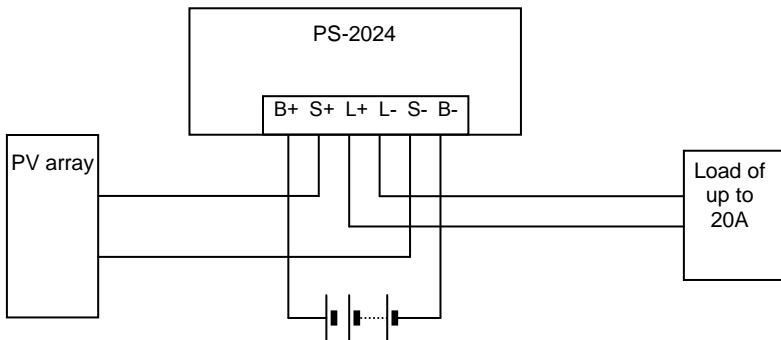


Figure 1

2 Specifications

2.1 General Operation

Battery Voltages.....	12V or 24V
PV Voltages	12V, 18V or 24V ¹

2.2 Absolute Maximum Ratings

These values must never be exceeded

Maximum voltage across battery terminals	60V
Minimum voltage across battery terminals ²	0V
Maximum voltage across photovoltaic terminals	65V
Minimum voltage across photovoltaic terminals	-65V
Maximum continuous input current from PV array	20A
Maximum continuous input power from PV array ("24Vin", "24Vout") ³	500W
Maximum continuous input power from PV array ("24Vin", "12Vout")	250W
Maximum continuous input power from PV array ("12Vin", "12Vout")	250W
Maximum continuous output current to battery ⁴	20A
Maximum continuous load output current	20A
Maximum continuous load output power	240W
Maximum ambient operating temperature.....	60°C
Minimum ambient operating temperature.....	-30°C
Maximum lightning induced current spike per terminal pair ⁵	400A
Maximum lightning induced spike energy across all terminals	5.4J

2.3 Metering Accuracy ⁶

Battery voltage	+/- 2%
Solar voltage	+/- 5%
Battery current	+/- 2% and +/- 0.1A
Amp hours ⁷	+/- 2% and +/- 1.5Ah
Time to float ⁴	+/- 5mins

2.4 Metering Range

Maximum battery voltage	34V
Minimum battery voltage	9V
Maximum solar voltage	50V
Minimum solar voltage	0V
Maximum battery current input.....	20A
Minimum battery current input.....	0A
Maximum battery current output	10A
Minimum battery current output	0A
Maximum battery temperature with sensing lug	60°C
Minimum battery temperature with sensing lug	-30°C

¹ 12V and 18V solar input will only work with a 12V battery. 24V solar input will work with 12V or 24V battery.

² The reverse polarity protection will blow the fuse if this condition is violated.

³ "24Vin" implies 72 silicon photovoltaic cells in series, commonly referred to as a 24V panel. "24Vout" implies 12 lead acid cells in series, commonly referred to as a 24V battery.

⁴ Current limiting will be implemented by the regulator if this condition is exceeded.

⁵ Maximum current for 0.4µs.

⁶ Voltage reading accuracy at regulator terminals, quoted tolerance is worst case over full operating temperature range.

⁷ 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-2024 solar regulator

- 1. LEDs
- 2. Communications port
- 3. Temperature compensation port
- 4. Screw terminal block
- 5. Fuse holder
- 6. Display
- 7. Enter Button
- 8. Cancel Button
- 9. Up Button
- 10. Down Button



Figure 2

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

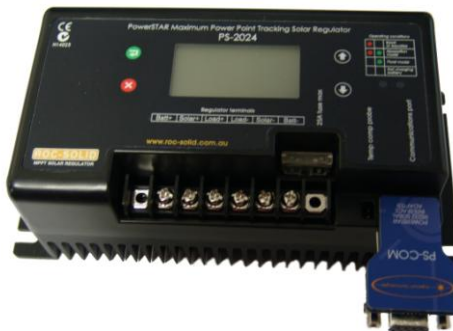


Figure 3

3.2 System Features

The PowerSTAR-2024 regulator has the following features:

- Maximum Power Point Tracking
- On board user interface
- 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 always on option
 - 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

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.

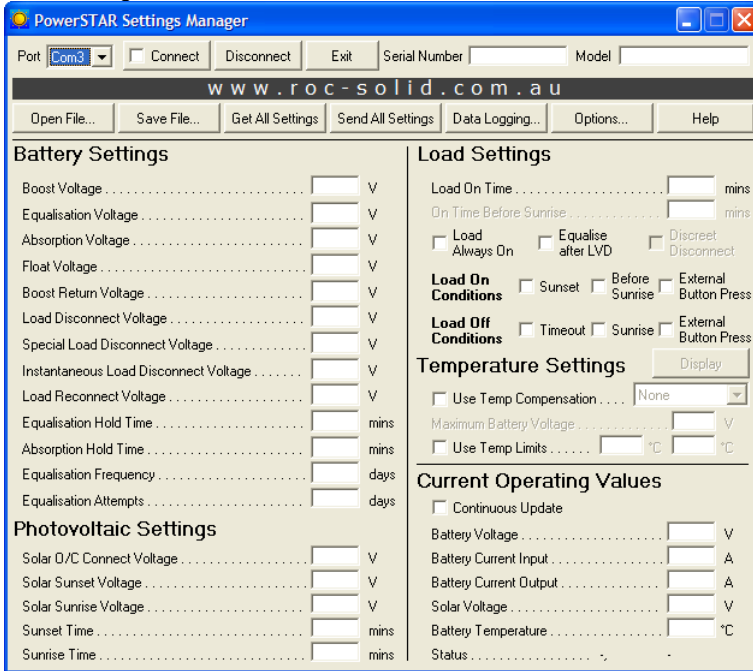


Figure 4

- 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-2024, 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.

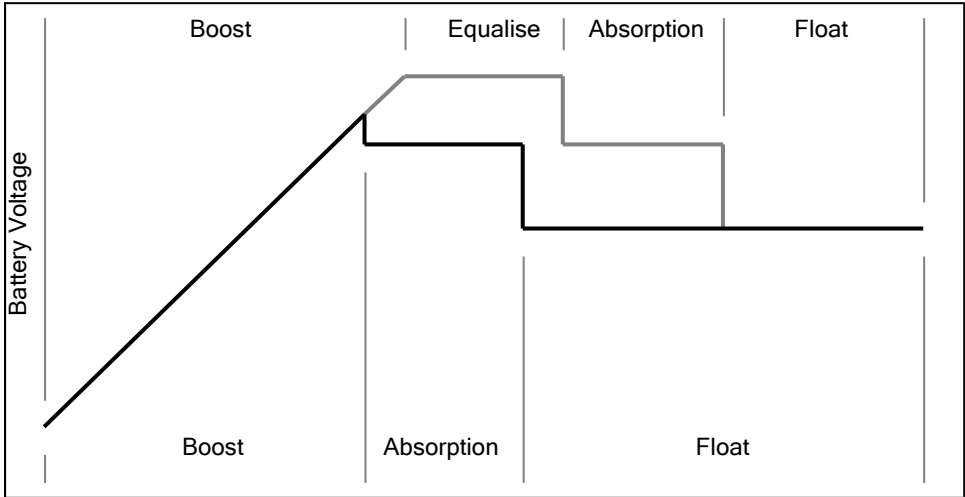


Figure 5

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

Normal load control

For this operation, the only *Load On Condition* is *Always on*. The load will be connected to the battery whenever the battery voltage is greater than the load reconnect voltage. The load will be disconnected if the battery voltage drops below the load disconnect voltage as described above.

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.¹⁰
 - Load on time = 420 minutes
 - Load on before sunrise = 120 minutes
 - Load on conditions enabled
 - Sunset
 - Before Sunrise
 - Load off conditions enabled
 - Timeout
 - Sunrise

¹⁰ 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 than 5 minutes. This prevents rapid power cycling of the light which can damage certain lights.

4.4 Temperature Compensation

Temperature compensation for battery charging can be performed by the PS-2024 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.

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.

5 On board display module

The display module is provided for setup and interrogation of the regulator. This module can change settings, show current operating parameters and display logged information.

Figure 6 shows the button configuration of the module. The menu structure of the module is navigated by pressing the buttons *Up*, *Down*, *Enter* and *Cancel*.

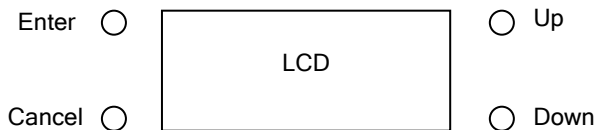


Figure 6, button configuration

5.1 Initialisation

The PS-DISP should be connected to the solar regulator after the battery terminals have been connected to the regulator. When the module first starts up, it shows the welcome screen of “PowerSTAR” for 2 seconds and then the current operation of the regulator it is connected to. Figure 7 shows the screen visible after the welcome screen. This *Current Operation* screen shows various operational parameters on the solar regulator.

Current Operation	
Batt Voltage	= 12.8V
Solar Voltage	= 17.1V
Batt Current	= 12.1A
Load Current	= 1.3A
Load state	= On
Charge mode	= Absorption

Figure 7, Displaying current operation

Pressing any button during the *Current Operation* screen changes to the top-level menu screen.

If a PC is connected to the display in this mode and the PC requests information then the display will temporarily show the text "BUSY" superimposed over the screen. The busy message will remain until all the requests from the PC have been met.

5.2 Menu System

The top-level menu is broken down into the sections of:

- Current Operation
- Settings
- Data Logging

From the top-level menu, the buttons *Up* and *Down* change the text that is highlighted, *Enter* selects the highlighted option and *Cancel* takes the screen back to *Current Operation*. Figure 8 shows the menu system under Settings, Battery Voltages, with the option *Boost Voltage* highlighted. Figure 9 shows the same menu after the *Down* button has been pressed once.

When there are more options than can fit in a screen, the screen will scroll one line from the bottom as shown in Figure 10.

Battery Voltages:
Boost Voltage
Equalisation Voltage
Absorption Voltage
Float Voltage
Boost Return Voltage
Load Disconnect Volt

Figure 8, menu system highlighting

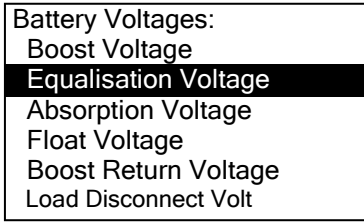


Figure 9, menu system highlighting

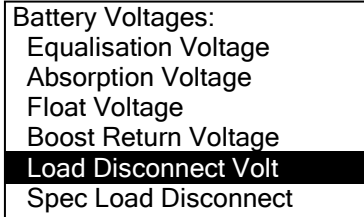


Figure 10, menu system scrolling

Pressing the *Enter* button will either take the screen to the next level of menu, or display the current setting and allow the user to change this setting. Pressing the *Cancel* button takes the display back to the previous menu level.

5.3 Settings

The settings menu hierarchy is defined below

Settings

- Battery Voltage
 - Boost Voltage
 - Equalisation Voltage
 - Absorption Voltage
 - Float Voltage
 - Boost Return Voltage
 - Load Disconnect Voltage
 - Special Load Disconnect Volt
 - Instant Load Disconnect Volt
 - Load Reconnect Voltage
- Battery Timing
 - Equalisation Hold Time
 - Absorption Hold Time
 - Equalisation Frequency
 - Equalisation Attempts
 - Equalise after Low Volt Disc
- Solar Settings
 - Open Circuit Connect Voltage
 - Solar Sunset Voltage
 - Solar Sunrise Voltage
 - Sunset Time
 - Sunrise Time

- Load Settings
 - Load Always On
 - On at Sunset
 - On Before Sunrise
 - On External Button
 - Off at Timeout
 - Off at Sunrise
 - Off External Button
 - Load On Time
 - On Before Sunrise Time
- Temperature Settings
 - Temperature Compensation
 - Maximum Battery Voltage
 - Use Temperature Limits
 - Low Temperature Limit
 - High Temperature Limit
- LCD Settings
 - Backlight Brightness
 - LCD Viewing Angle

5.3.1 Setting Voltages

When entering the voltage setting the display will be similar to Figure 11 (depending on the actual setting being modified). Upon entering this level of the menu, the PS-DISP displays the existing regulator setting. If the user presses *Enter* in this screen, the next display shown will be similar to Figure 12. The menu goes back to the previous page if the user presses *Cancel*.

The user presses the *Up* and *Down* buttons to modify the value in each digit, pressing *Enter* to move to the next digit. The setting will not be saved if the user presses *Cancel* at any time during this process.

Figure 13 shows the display when the last digit is modified. If the user presses *Enter* then this setting will be checked for validity (ie within specified ranges of the relevant regulator model). If valid then the value is sent to the regulator, if not valid then an error message is displayed.

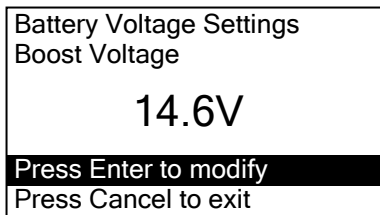


Figure 11, Setting Voltages

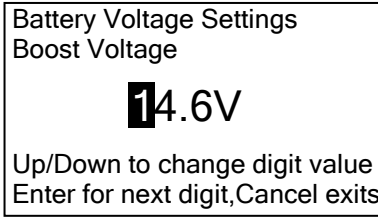


Figure 12, Setting Voltages

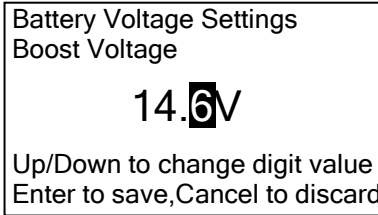


Figure 13, Setting Voltages

All communications with a PC is disabled while changing settings. For communications with a PC, the display needs to be within the menu structure and not modification of settings.

5.3.2 Setting Times and Days

The setting of times (for charge and load control) and days (for equalisation) is similar to section 5.3.1, but with either “minutes” or “days” after the number and no decimal place.

5.3.3 Enable/Disable Settings

The only options for Enable/Disable settings are for the option to be Enabled or Disabled. Figure 14 shows the setting before modification. Figure 15 shows the screen during modification of the setting. Pressing the *Up* or *Down* button on this screen will result in the highlighted value changing between *Enabled* and *Disabled* with each button press.

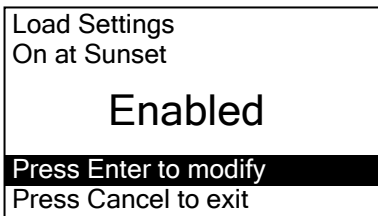


Figure 14, Setting Voltages

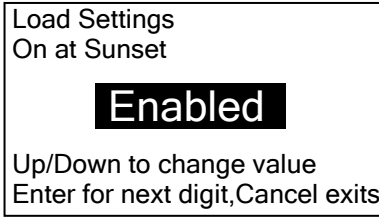


Figure 15, Setting Voltages

5.4 Data Logging

The user can look at information that has been logged by the solar regulator by selecting *Data Logging* at the lowest level menu.

Information displayed includes:

- Day (number of days before today)
- Ah in (energy in)
- Ah out (energy out)
- Maximum battery voltage over the day
- Minimum battery voltage over the day
- Time to float
- The length of the day logged
- The number of days until next equalisation attempt
- Flags (see the document 'PowerSTAR datalogging flags' for further explanation)

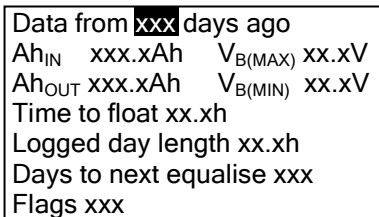


Figure 16, Viewing logged data

Figure 16 shows the generic information displayed for data logging. The user changes the day viewed by pressing *Up* or *Down* button which increments/decrements the day counter respectively.

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