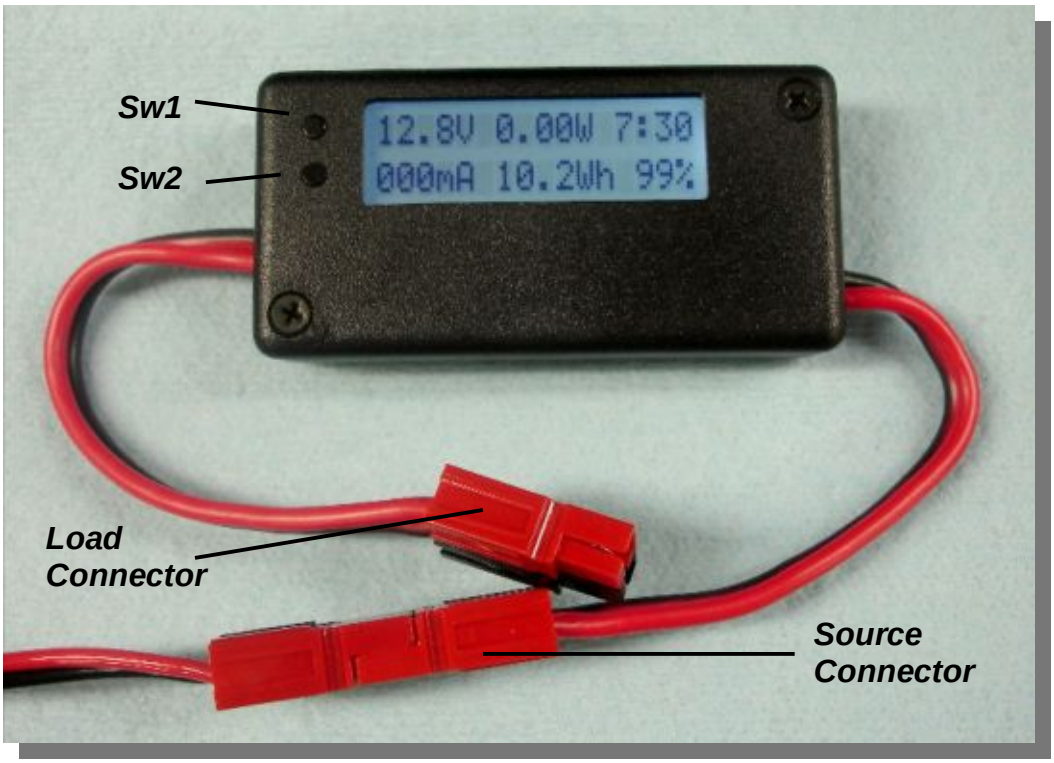
Battery Monitor Overview

Features:

- Powered from system source (battery or power supply)
- Low current consumption, typically 2mA with backlight off.
- Four menu selected backlight levels, off, low, consumes 0.5mA; medium, 1.5mA; and high 2mA.
- LCD Display simultaneously shows six values
    - Voltage measurement 4.5 to 16.3V displayed with 100mV resolution
    - Current measurement auto ranged provide three digit resolution in three ranges:
        - 000ma to 999ma with 1mA resolution
        - 1.00A to 3.99A with 10mA resolution
        - 4.0A to 40.0A with 100mA resolution
    - Elapsed time to 99h59min with 1minute resolution
    - Power auto ranging display with three digit resolution as either x.xxW, xx.xW or xxxW depending reading.
    - Amp hours or Watt hours user selectable with an auto ranging display. Amp hours show as xxxmAh, xx.xAh or xxxAh up to 999Ah. Watt hours show as xxxmWh, xx.xWh or xxxxWh up to 6,553 Wh.
    - Remaining Battery capacity displayed in % showing either 0,2,5,10,20,50,60,70,80,90, or 99%.
- Captures minimum battery voltage and peak current during any session
- Amp hour, Watt hour, and time accumulated readings can be reset to zero at any time
- Hibernate mode saves readings to EEPROM and can be restored on power-up. Battery Monitor consumes typically 2uA when hibernating so can be left attached to batteries.
- Battery Monitor automatically powers up when attached to a power source
- Power Pole connectors and 8cm 14ga pigtails connect the BM to source and load
- Updates readings frequently, 10,000 times per hour, or about 2.75 times per second.
- Utilities Menu and two function switches manage Battery Monitor features
- Low series resistance. 5.6mOhms typically with 5cm 12ga pigtails (Rsense=2.5mOhms)

Power Monitor Connection & Controls



Battery Monitor Specifications

Parameter	*Min*	*Typ*	*Max*	*Units*
Supply Voltage	4.5		35	Volts
Continuous Load Current			30	Amps
Maximum Peak Load Current (<1min)			40	Amps
Supply Current (display backlight off)		2.0	2.5	mA
Supply Current (display backlight hi)		4.0	5.0	mA
Supply Current in Hibernate or Off states		2	4	uA
Voltage Resolution		0.1		Volts
Current Resolution		0.001		Amps
Power Resolution		0.01		Watts
Time Resolution		1		minute
Amp hour resolution		0.001		Ah
Watt hour resolution		0.001		Wh
Maximum displayed Voltage		16.3		Volts
Maximum displayed Current		40.9		Amps
Maximum displayed Watts		999		Watts
Maximum displayed Amp hours		999		Ah
Maximum displayed Watt hours		6,553		Wh
Maximum displayed Time		99:59		Hrs:min
Voltage Accuracy		1	2	%
Current Accuracy		2	3	%
Time Accuracy			2	%
Power Amp hour Watt hour Accuracy		2	5	%

LCD Display Overview

The 16 character LCD display shows the following measurements simultaneously.

Source Voltage Load Power Elapsed Time

Load Current ***Amp Hours or Watt Hours*** ***Remaining Battery Capacity***

Connecting & Controlling Battery Monitor

Connections

Connect the Power Pole connector closest to the switches to the load, and the other connector to the source. BM does not require a load to operate but must be connected to a source for power. When connected to a power source between 4.5V and 16.3V BM will automatically power up and display a splash screen that shows the software version on line one of the display. Line two of the display shows the location of the source and load connections at each end of the display and arrows point in the direction that the current must flow. For proper measurements current must always flow from source to load. BM is unidirectional. If source and load connectors are swapped BM won't be damaged and will show the load rather than the source voltage, but current, power, amp hour, and watt hour readings will remain at zero.

Switch Operation While Measuring

Pressing Sw1 for less than three seconds will invoke the Utilities menu. If Sw1 is held down for more than three seconds the unit will go into 'Hibernate' mode.
Pressing Sw2 will turn the unit on if it is off and connected to a source. When BM is on, pressing Sw2 for more than three seconds turns the unit off.
If BM had returned from hibernate mode at the beginning of the session and if the 'Clear Readings' menu was never invoked then when Sw2 is pushed the unit will update stored parameters to EEPROM and enter hibernate mode rather than turn off.
If Battery Monitor resumed from hibernation and is unplugged from the source without first going back into hibernation or being turned off, the current session data will be lost, but the hibernation data from the last session will still be available and can be resorted on next power-up.

Utilities Menu

Battery Monitor contains the following utility menu items

- *Restart Readings* – clears Amp hour, Watt hour, time, minimum voltage and peak current readings
- *Show Vmin & ILp* – shows minimum voltage and maximum peak current. These two readings can also be cleared using this menu item
- *Choose Ah or Wh* – selects units displayed mode either Amp hours or Watt hours
- *Set Backlight* – selects High, Medium, Low, or off backlight levels
- *Select Battery Type* – choose one of up to 8 batteries governing percent capacity readings
- *Time Tick Cal* – tweak elapsed time accuracy
- *Hibernate* – places Battery Monitor into its hibernation state
- *Power Off* – turns Battery Monitor off

Enter the utilities menu items by pushing Sw1 for less than three seconds. Scroll through the utilities menus by momentarily pressing Sw1. When at the end of the utilities menu items pressing Sw1 again returns the user to the top of the menu list.
When a down arrow appears next to Sw1 the user can scroll through sub-menu items, or change values but they will not be selected or saved. If a left arrow appears next to Sw1, the user can select that option and it will be executed or saved. Sw2 is used only to select, save, or execute menu options. When an option is selected it's saved or executed and the program returns to measuring.
Note that in some menu items there is no ability to 'escape' back to the measuring subsystem. Often you will need to choose an option to end the utilities menu. If you enter a menu item by mistake, it's typically best to select the 'No' option or the current value.
While in the utilities menu, the Amp hour, Watt hour, elapsed time, Vmin, and ILp, are not updated.

Battery Monitor Accuracy & Measurement Notes

Battery monitor measures time, source voltage and load current to typically better than 2% accuracy, and should always be less than 3% total error. Power, Amp hour or Watt hour measurements are derived from time, source voltage and load current and are typically better than 4% accurate. Hibernate and Off state current is typically 2uA and less than 5uA maximum. Battery monitor auto ranges load current measurements and resulting Amp hour or Watt hour readings showing so is capable of showing 1mA, 1mAh or 1mWh resolution.

Minimum Current Measurements

Battery monitor uses a chopper stabilized op-amp in a high gain configuration to achieve 1mA resolution. On the most sensitive current range, the amplifier gain is 1600 resulting in 4uA of voltage as the input per milliamp of load current. The sense amplifier's maximum input offset is 3uV with a temperature coefficient of 30nV per deg. C. As a result Battery Monitor may display a reading error of up to +/-1mA resulting from worst case amplifier offsets. Also large currents through the sense resistor will cause its temperature to rise, and when the load is suddenly removed, Battery monitor may show a residual current reading until the temperature in the sense resistor returns to ambient.

Amps Peak and Volts Minimum

Battery Monitor uses an auto ranging measurement system to achieve its resolution while maintaining a wide measurement range. During transitions from one measuring range to another the current sense amplifier may be subject to transients and needs time to settle. In order to avoid capturing false peak readings, the unit ignores current peaks and for consistency, voltage minimums on the first reading after a range change, so it may take two readings, or about 600mS for the system to acquire a new valid peak current or minimum voltage.

In Circuit Resistance and Voltage Drop

Battery Monitor uses a 2.5miliohm sense resistor to measure current, so at 40 amps this element will create a 100 millivolt drop between the source and load. However the series resistance of the units wiring and connectors can result in a significant additional voltage drop. For example 8 cm 14gague copper wire pigtails on each end of Battery monitor along with the mating resistance of two Power Pole connectors will add 5.4 milliohms for a total for about 7.9 milliohms. While this may not sound like much, the total voltage drop from source to load at 40 Amps will be 315 mV, 100 mV in the sense resistor and 215 mV in the interconnect wiring and connectors. This will result in 12.6 watts power dissipation, 4 Watts in the sense resistor and 8.6 Watts in the connector and interconnect wiring.

Utilities Menu and In Circuit Testing

While in the utilities menu, session elapsed time, Amp hours, Watt hours, peak load current and minimum battery voltage measurements are not updated. So while in the utilities menu these parameters will not change. However their values are retained unless cleared by the user, and while in the utilities menu Battery Monitor continues to behave in-circuit the same way it does when measuring, that is it acts like a very small resistance in series with the battery.