APOLLO SOLAR

WHITE PAPER
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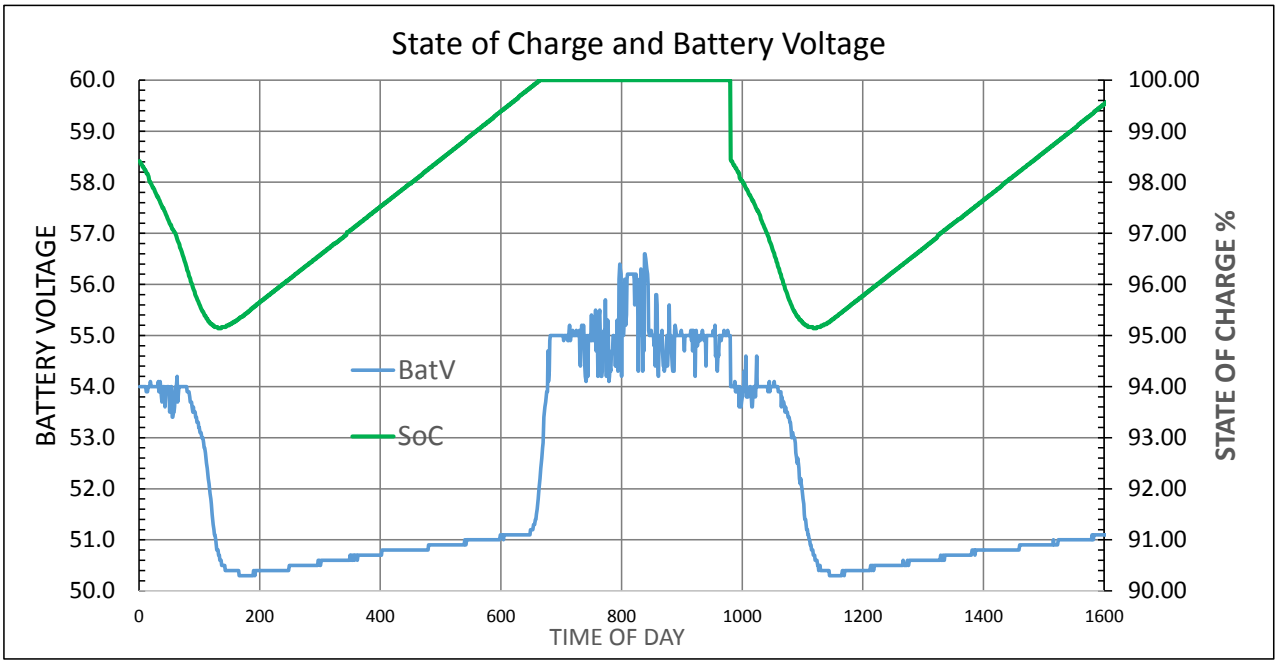
BATTERY VOLTAGE and STATE of CHARGE
Using the T80HV Charge Controller

The Apollo Solar T80HV Battery Charge Controller has a feature which is unique in the industry. It displays the actual amount of energy in the Battery called State of Charge (SoC). This White Paper describes the Benefits of the State of Charge reading, How it works, and How to use it.

BENEFITS OF THE STATE OF CHARGE READOUT:

It is essential for all devices which use batteries as their source of energy, for the user to know how much energy is he has in his battery. This may seem totally obvious, but the reason it is not available on every battery is because it is rather difficult to do with any degree of accuracy. Apollo Solar developed the hardware and software to display the State of Charge and integrated it into our PV Battery Charge Controller product line including the T80 and T80HV.

The graph below shows the actual data from a remote Battery Based Telecom BTS. We show the SoC in green using the right side axis and the Battery Voltage in Blue using the left side axis. The point is to determine how much energy remains in the battery. It is easy to see the difference. Finding the battery energy by reading the instantaneous voltage is inaccurate and often misleading. The SoC provides a clear, noise free reading of the Percentage of the Battery Capacity. Most importantly, the SoC reading is free of the effects of the load or the charger which are connected to the battery and give a false low or high voltage reading unrelated actual SoC.



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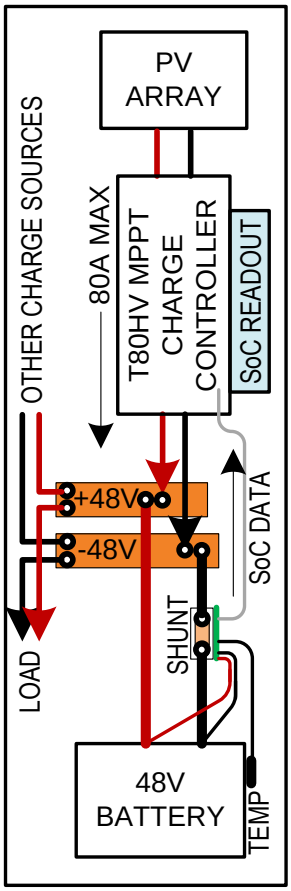
HOW THE SoC READOUT WORKS:

The concept is simple: We know the size or capacity of the battery, which is how much energy it will hold when Full. Starting with a Full battery, we subtract the coulombs that are discharged from the battery into the load. (A coulomb is the amount of charge transferred by 1 Amp for 1 second.) And we add the coulombs that are charging the battery. The result is displayed continuously as a Percentage of Full Capacity. The flow in and out of the battery will continue all day. When the battery is charged up to Full again, the counter is reset to 100% in case the counter was not perfectly accurate.

HOW TO USE THE SoC FEATURE IN THE T80HV:

The diagram at the right shows how the energy flows from the PV Array, through the T80HV, through the SHUNT and into the battery. The Battery Current as well as the Voltage and Temperature are sent back to the SoC circuit in the T80HV



In actual practice there are specific steps. The energy storage Capacity of the battery must be programmed in the T80HV during setup. This tells us the size of the energy "tank" when it is full. The Battery Shunt is used to read the energy going into and out of the battery. So all loads and all charging devices must be connected to this shunt.

When first turned on, the T80 must set the coulomb counter to 100% when the battery reaches the first Full charge. The battery is defined as Full when it goes from the Absorb Stage into the Float Stage. Note that the T80 LCD display will read **???** before it reaches Float the first time.

It is critical to understand that the T80 must go through the Absorb Stage in order to go into the Float Stage which sets the 100% Full point. If the Battery is charged by an external generator, for example, such that the T80 does not see that Absorb voltage set point (typically set at 2.350 volts per cell or 56.4 volts in a 48 volt system), the T80 cannot set the 100% point.

A NOTE ON RESOLUTION AND ACCURACY:

The T80 can deliver 80 Amps from the PV array into the battery. 80 Amps for 1 hour is 288,000 coulombs, so we have plenty of resolution with our coulomb counting method.

No batteries are perfectly efficient in converting between electrical energy and chemical energy. A typical lead-acid battery will lose about 7 % to 10% during charging and another 7% to 10% during discharge. The T80 has a place to program in these parameters if they are known. The losses vary greatly depending on the rate of charging or discharging (Peukert's factor), the temperature of the battery and the age of the battery. The accuracy of the T80 Coulomb counter will deteriorate over time because of these factors. However, as soon as the T80 brings the battery up to the Float stage again the counter is reset to an accurate 100%. The PV Array must be large enough to reach Float often.