Solar Charging of OceanServer Li-Ion Battery Arrays

Technical Summary

January 2006

The OceanServer Intelligent Battery and Power Systems (IBPS) allows the designer to add to the system design, any number of lithium ion smart battery packs as a power source for battery power or battery backup. The standard charging method is for the user to connect an 18V DC power source to the MP-04 or MP-08 Controller. The Controller will automatically start charging all of the battery packs if they require a charge. The BB-xx, MP-xx and XP-xx Series Controllers are designed for direct connection to solar panels for charging and load sharing as long at the solar panels have the correct output voltage.

This example shows some test results using two off the shelf low cost solar panels. The voltage range required by the OceanServer system is in the 17.2 – 24V range. This range is commonly used in the high volume building and boating industries for charging lead acid batteries.

A typical system may be a small-embedded computer or remote device that uses regulated or raw DC power. The MP-04/08 controller operation will take the charge power that is developed from weak sources and uses it to provide the load with power ahead of the battery system. If there is more power than the load requires the excess is used to charge the batteries, if there is less the remainder will come from the battery system.

Example: (1) Charging
Charge Power: 60 Watts of charge power from Solar available
System power load: 40 W
Batteries: Output: 0 W; Charge: 20W

(2) Battery load reduction
Charge Power: 30 Watts of charge power from Solar available
System power load: 40 W
Batteries: Output 10 W; Charge: 0W

The MP-04/08 Controllers dynamically balance out the DCIN voltage and use it first for sourcing the load and direct any excess toward charging the batteries. This happens in microseconds so that power to the load computer or electronics is not disrupted.

The switching regulators used to produce the accurate charge voltage are above 95% efficient, a key system attribute. The voltage of the solar cells (and other weak sources such as fuel cells) will decrease as you attempt to draw more power than the cell can

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provide. This lower voltage tends to be the point of maximum efficiency of the converter, in the high 95% range. The Li-Ion packs are also close to 100% efficient at absorbing recharge energy (i.e. at low currents, very little waste heat is generated).

If several solar panels are used they could each be connected to an individual DCIN path or a separate group of DCIN paths and used to charge only those batteries connected to that path. The DCIN paths are isolated from each other. To connect two solar panels a diode can be connected in series with the (+) terminals from each panel that then connects to a single DCIN pin. This way both solar panels source power for system operation and charging and stay isolated from each other.

This example shows 4 batteries in the system but the technology will allow from 1 to over 100 battery packs in the power system.

OceanServer IBPS building blocks

- MP-04 Intelligent Battery and Power System supports 1 to 4 OceanServer 95 Whr Smart Li-ion battery packs.
- MP-08 has the same features but supports up to 8 battery packs.
- BA95FL Smart Battery Pack, flying leads, 95 Whr, 14.4V, 6.6Ah. (Not subject to DOT class 9 hazardous goods shipping regulations.)
- DC-023 module allows the user to generate regulated power for operation of an embedded computer or electronics.
- DC1-HV, DC2-HV – High voltage, high power output converters

Example Configuration:

- The MP-04 Intelligent Battery and Power System
- 4 x BA95FL, 95 Watt-hour Smart Li-ion packs
- Cable to directly parallel connect solar panel to both Charge DCIN connectors on the MP-04 Controller
- PC running "Fullbats" monitoring software to show results
- Two examples of off the shelf solar panels with appropriate specifications follow.

Figure 1: Large and small solar panels and the MP-04 controller and BA95FL Li-ion packs in the foreground.

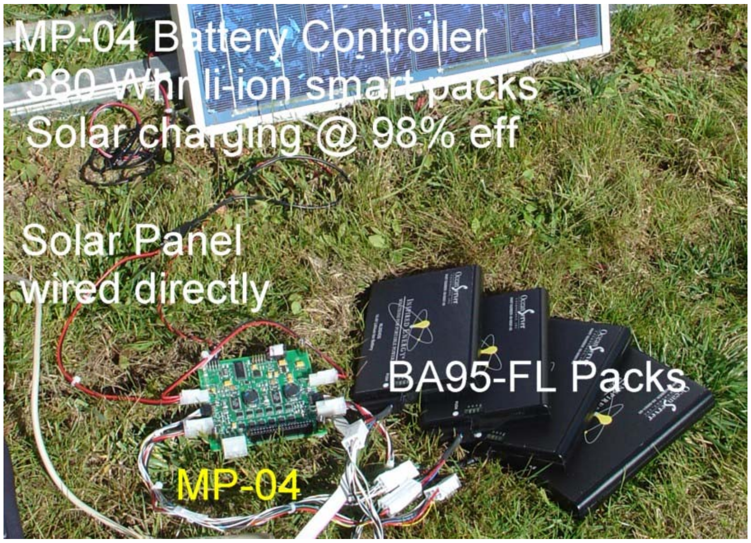

Figure 2: The large solar panel connected in parallel to both inputs for the DCIN charge voltage on the MP-04 controller. No diodes were required.

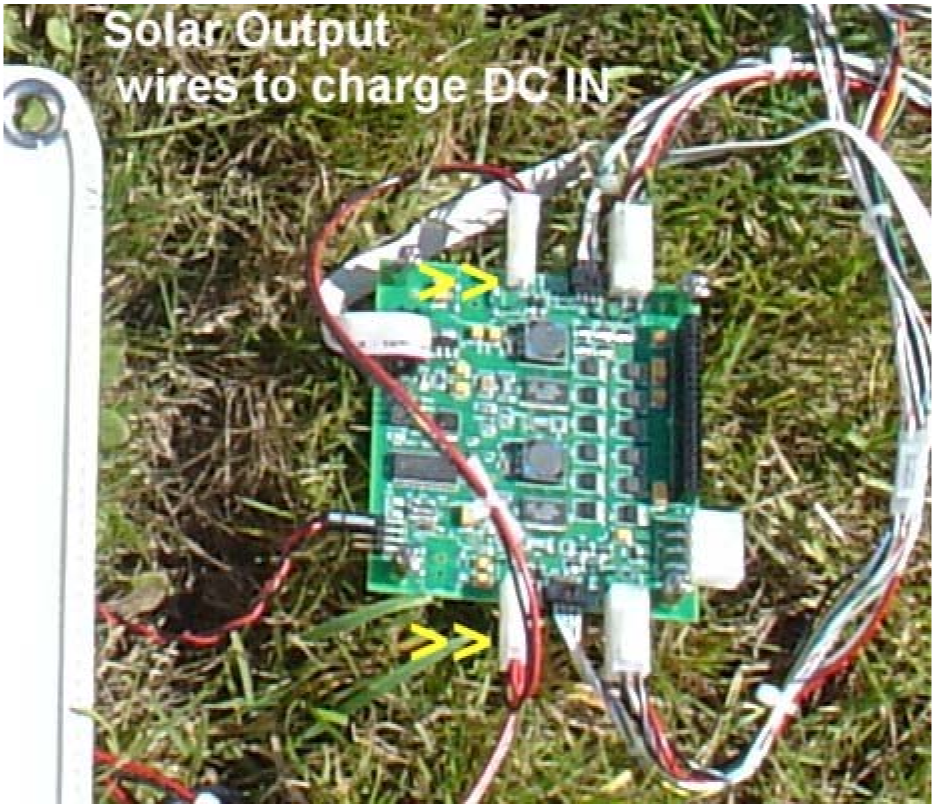

Figure 3: This is a close up of the MP-04 controller showing the solar panel output wires directly connected to the DCIN 2 pin connectors. The MP-04/08 Controllers accommodate two batteries per channel and have one DCIN input per pair of batteries.

The IBPS provides detailed system status, fuel gauge, charge current, discharge current, voltage, power, runtime to empty, charge time to full, percent of remaining capacity, Amp hours, etc. User devices can integrate this information to improve system operation and to enhance monitoring status. The hardware is provided with two Windows™ GUI applications, **MiniBats™** and **FullBats™**, that let the user monitor and graphically present the status of the battery system. This GUI-based aid is viewable from a host system, or can be displayed in configurable, abbreviated form on an optional LCD display. Below you can see the information displayed by OceanServer's **FullBats™** application.

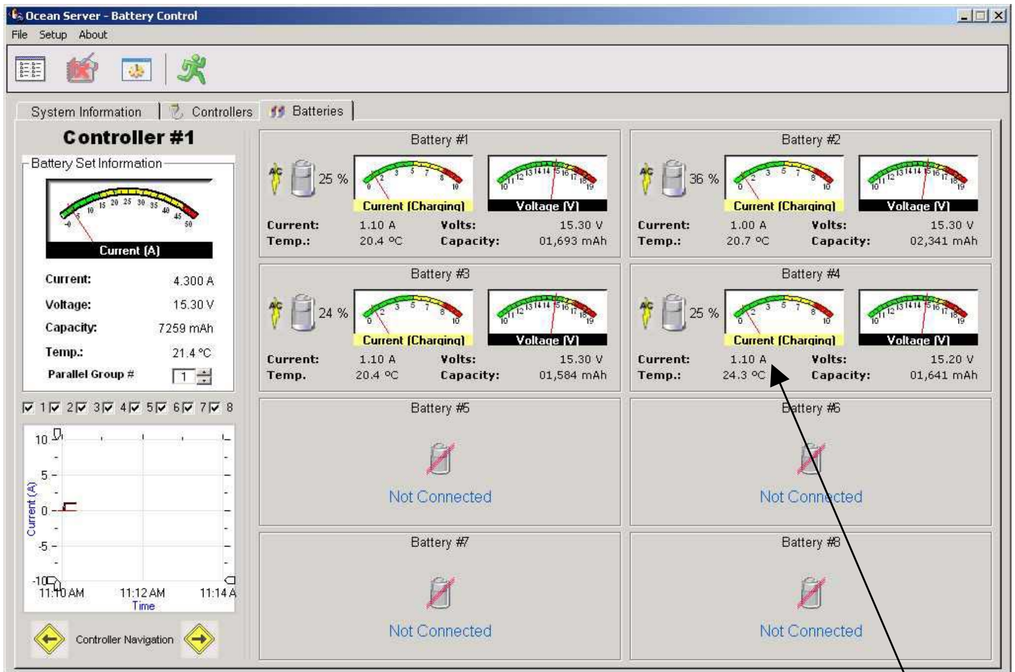

Figure 4: Screen capture showing the four battery packs charging at a rate of ~1.1Amps per battery pack. The solar panel output was 64 Watts, 4Amps @ 16.2V

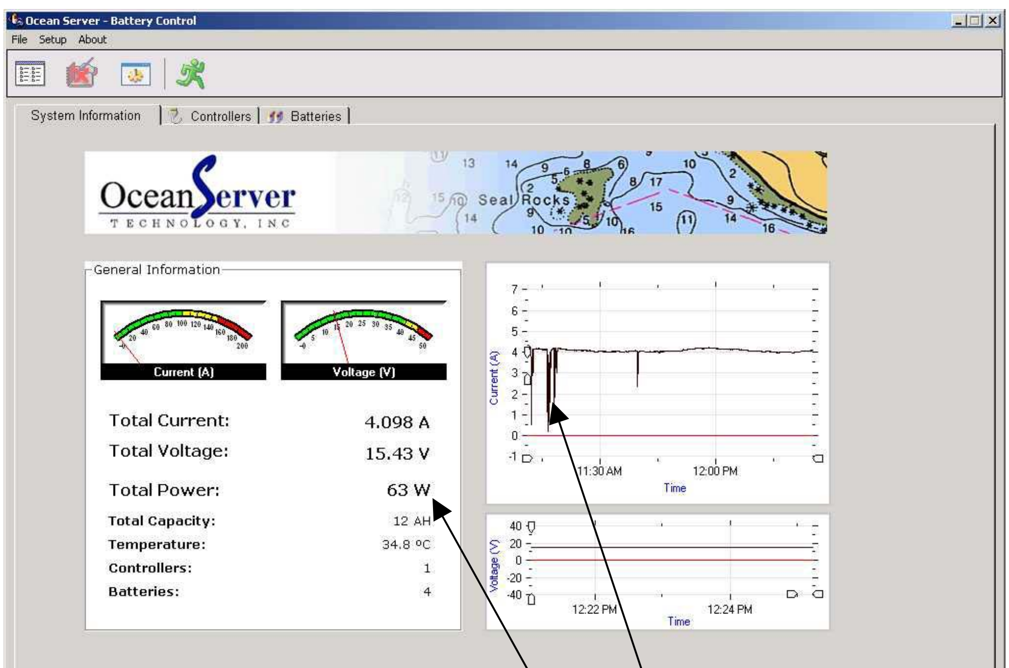

Figure 5: This is the main screen showing total power flowing into the battery packs and a plot of the current over time. You can see the small dips toward 0 amps when a cloud passed in front of the sun. At this rate of charge, the four packs would be fully charged (if fully discharged) in about 6 hours. If the solar panel were connected to one channel the two packs would be fully charged in about 3.5 Hours.

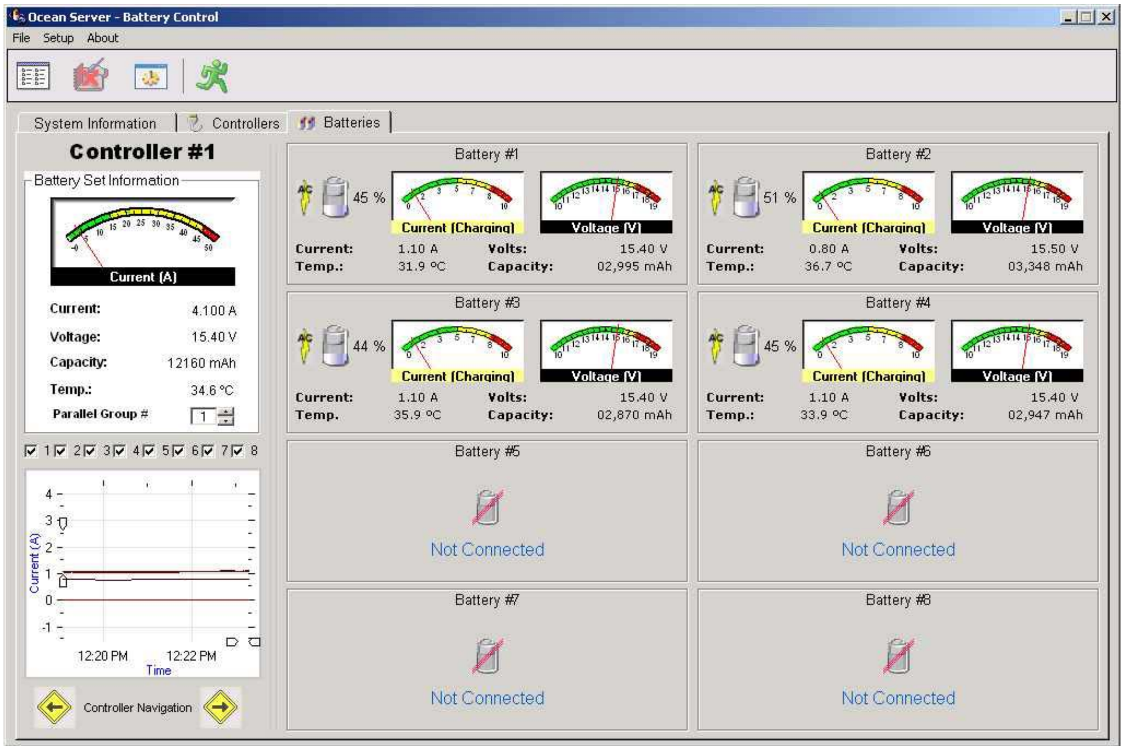

Figure 6: This screen capture shows the same four batteries and the state of charge after 70 minutes.

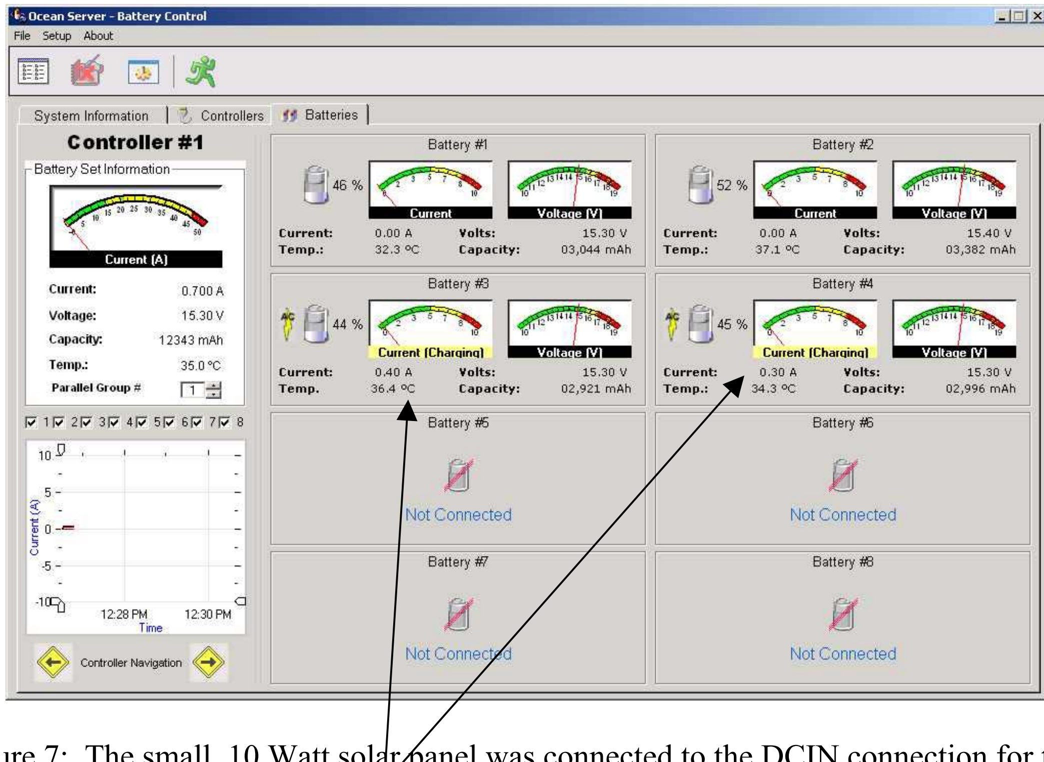

Figure 7: The small, 10 Watt solar panel was connected to the DCIN connection for the pair of batteries (3,4) and allowed to charge. This shows the ability of the MP-04/08 Controllers to capture most of the energy from very weak sources.

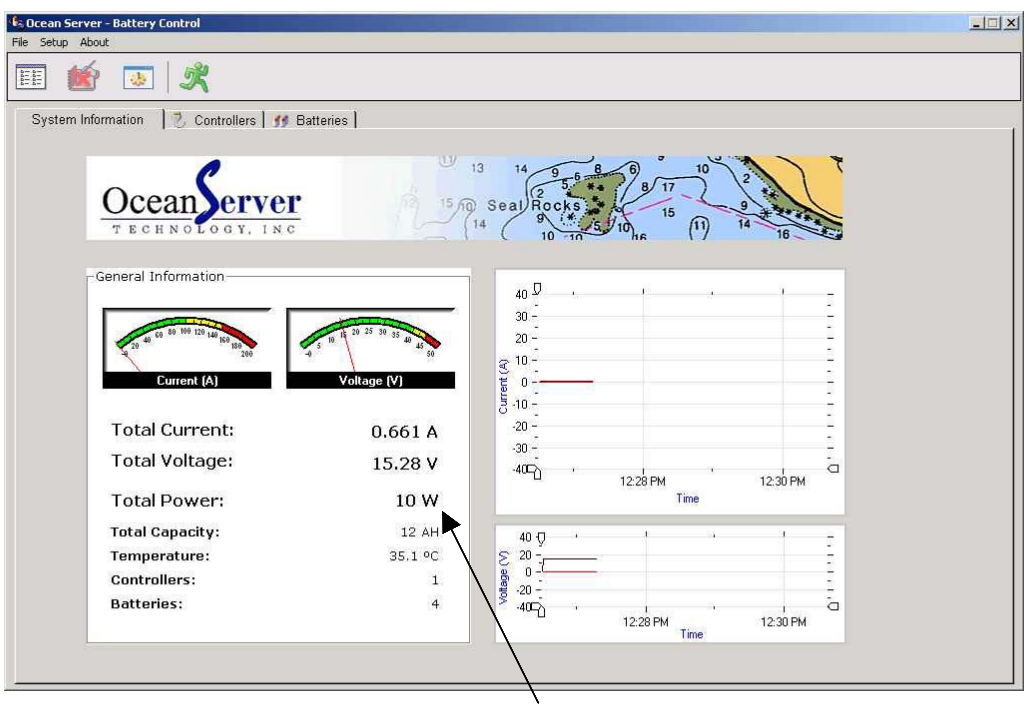

Figure 8: This is the system screen with the 10 Watt panel connected to the pair of batteries. This panel has delivered 13 watts when tested in the same location in August.

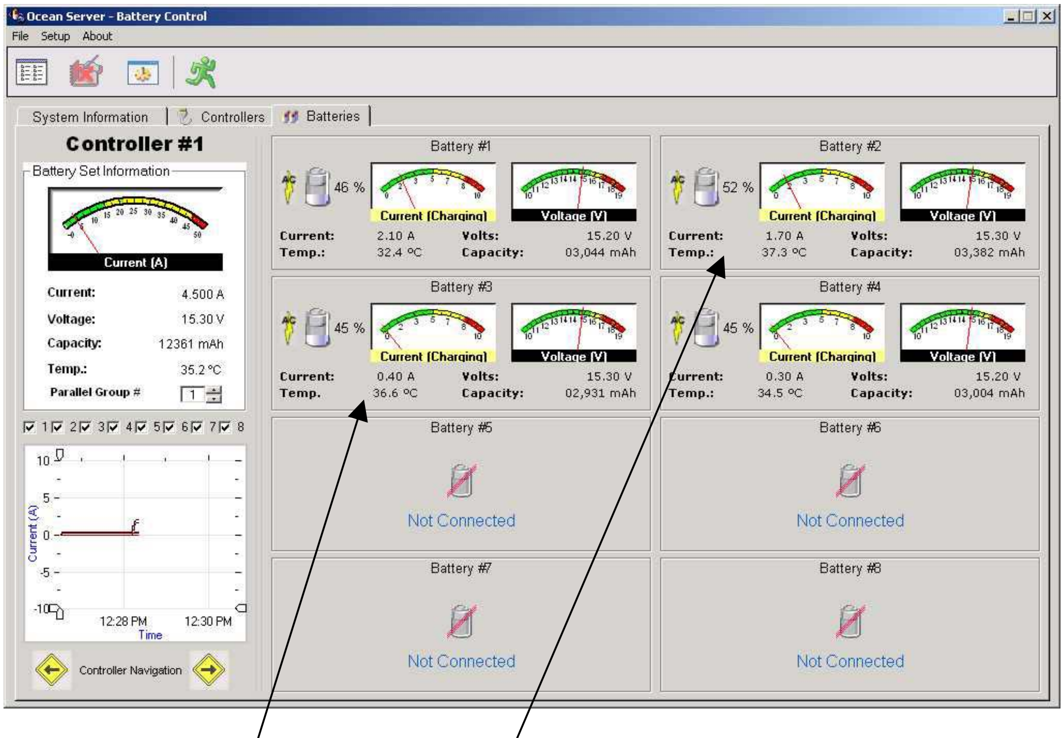

Figure 9: This example shows the 80 Watt solar panel connected to the DCIN pin for batteries 1,2 and the 10 Watt solar panel connected to the DCIN pin for batteries 3,4. Notice the much lower current provided for charging the second pair of batteries. If a diode were used on the feeds from each solar panel, they could be connected in parallel to any number of DCIN connectors for balanced charging of the batteries.

Model	Rated Power (Watts)	Rated Voltage (Vmp)	Rated Current (Imp)	Open Circuit Voltage (Voc)	Short Circuit Current (Isc)	Dimensions (inches)	Unit Weight (lbs)
USF-5	5	16.5	0.30	23.8	0.37	21.80" x 9.71"	1.18
USF-11	10.3	16.5	0.62	23.8	0.78	21.80"x 16.70"	2.00
USF-32	32	16.5	1.94	23.8	2.40	56.27" x16.70"	4.70

UNI-SOLAR

Specifications

	BP 380	BP 375[2]
Maximum power (P_{max})[1]	80W	75W
Voltage at P_{max} (V_{mp})	17.6V	17.3V
Current at P_{max} (I_{mp})	4.55A	4.35A
Warranted minimum P_{max}	76W	71.3W
Short-circuit current (I_{sc})	4.8A	4.75A
Open-circuit voltage (V_{oc})	22.1V	21.8V
Temperature coefficient of I_{sc}	(0.065±0.015)%/°C	
Temperature coefficient of voltage	-(80±10)mV/°C	
Temperature coefficient of power	-(0.5±0.05)%/°C	
NOCT[3]	47±2°C	
Maximum system voltage	600V (U.S. NEC rating) 1000V[4] (TÜV Rheinland rating)	
Maximum series fuse rating	20A (U, H versions) 15A (S, L versions)	

Figure 10: Specifications for the Uni-Solar and BP 380 panels used in this test.

Figure 11. Example cost data from: http://shop.altenergystore.com/ Solar panels used in this study.

For Additional Information

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