Introduction:

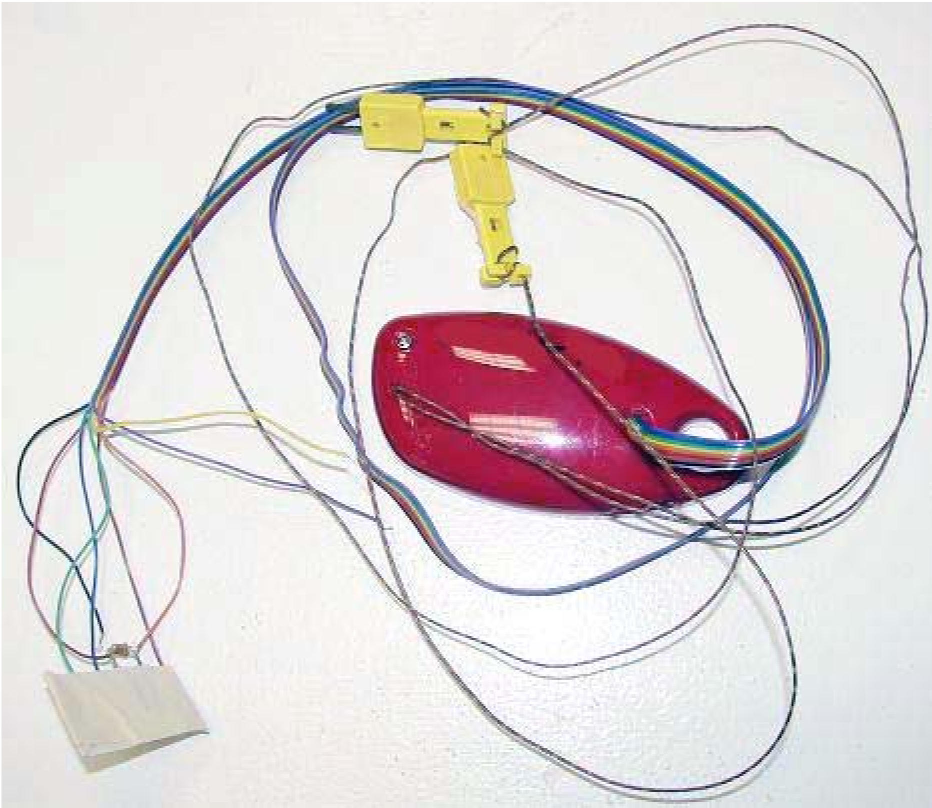
360° Test Labs has been retained to measure the performance and operating temperature of a solar device solar charger system over a temperature range of +20°C to +80°C, at relative humidity of 50% ± 5%.

Supplied to 360° Test Labs
As shown to the right:

1. DXX-XX-XX1 Client solar device Mono Sample (40% charge)
2. DXX-XX-XX2 Client solar device Mono Sample (60% charge)
3. Two AC/DC 5.5V 400mA mains adapters
4. One DC Output testing dongle with polarity markings
5. One DC Output adapter tip cable
6. One Mini USB tip
7. One Virgin Mobile branded UTStarcom PCS1450VMR mobile phone with one UTStarcom 3.7V 900mA BTR1450 Lithium Ion battery

Process

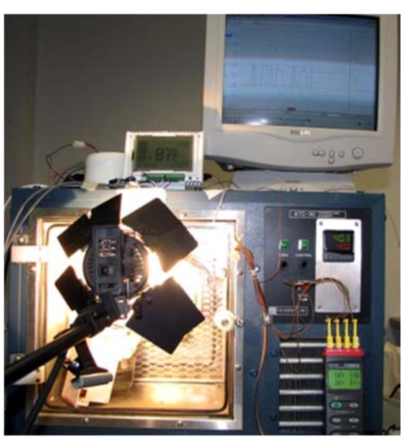
The two solar device products were slightly modified by placing thermocouples on the back side of the solar panel and on top of the battery. In addition, wires were added to allow monitoring of the battery and solar panel voltage and current; photos on the following page illustrate the modifications. A small hole was drilled in one end of the red cover to bring out the thermocouple wires but the battery-solar panel wires were fed through the existing hole in the case for the pushbutton on-off switch. To turn on the solar device, a thin tool was inserted through the hole and the pushbutton depressed.



Modified solar device. The ribbon cable is connected to the battery and solar panel inside the case; note that this cable was brought outside the case by omitting the plastic part that pressed on the original pushbutton switch. To turn on the solar device, a thin tool is inserted between the ribbon cable wires into the solar device and onto the pushbutton switch. The two internal thermocouple wires were brought out through a new hole drilled into the case.

All of the electrical parameters were measured and recorded as the temperature of the solar device product was maintained constant with the solar device inside a controlled temperature chamber. The temperature chamber was controlled by a thermocouple attached to the backside of the solar device. Two additional thermocouples were attached to the solar device as well; one on the back side next to the T° chamber's thermocouple, and the other on the front of the solar panel at the edge.

The temperature was then adjusted in 10 degree steps from +20°C to +80°C. Electrical data was recorded continuously by a Dataq DI-158U 4-channel differential data logger. Humidity was controlled by a humidity sensor inside the chamber next to the solar device itself, and was recorded by an Extech 42270 temperature-humidity Datalogger.



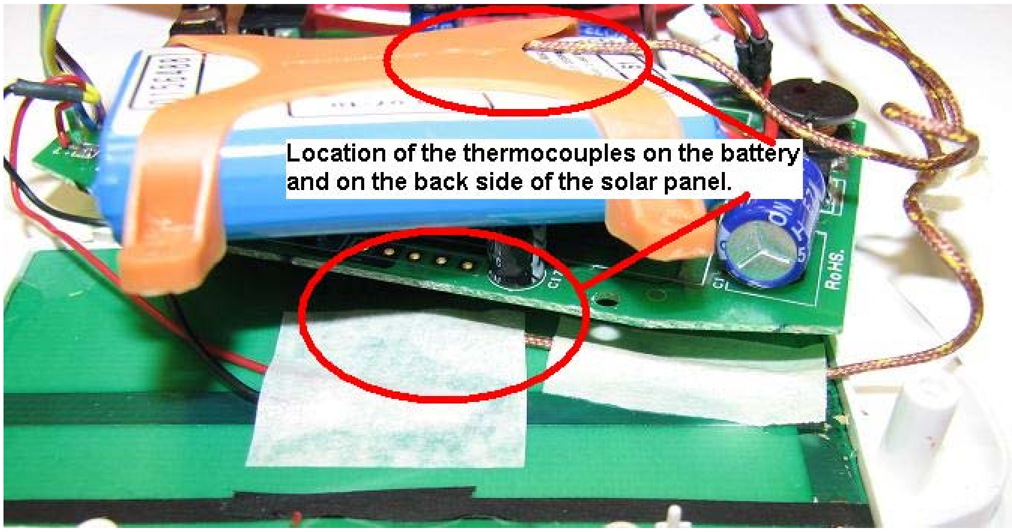
Light Application [1]

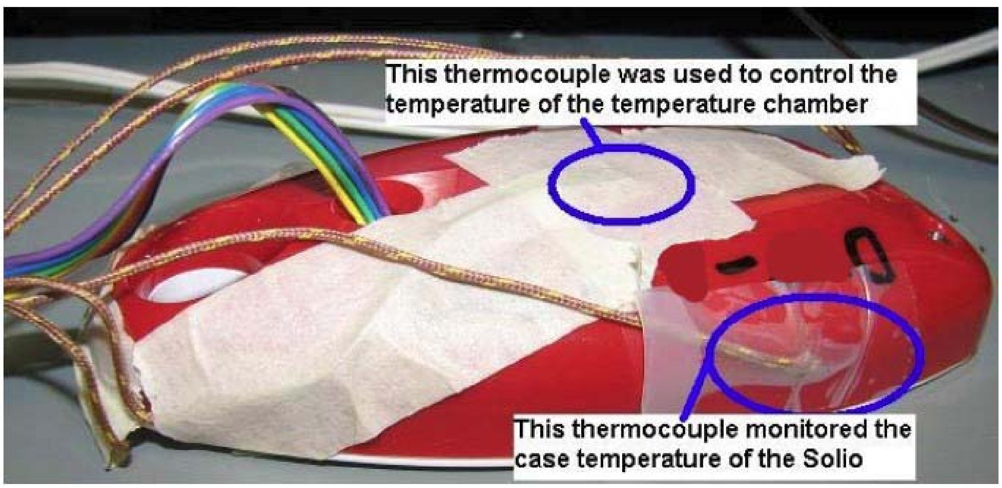
T° Monitoring

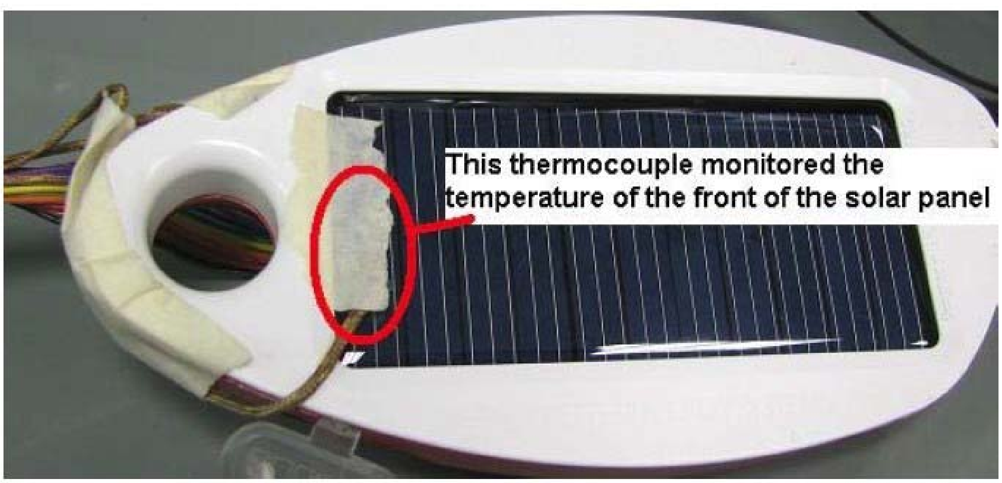
Load Application

[1] Lowel P2-10 Pro-light 250W, 3200K, Quartz Halogen lamp with barn door attachment

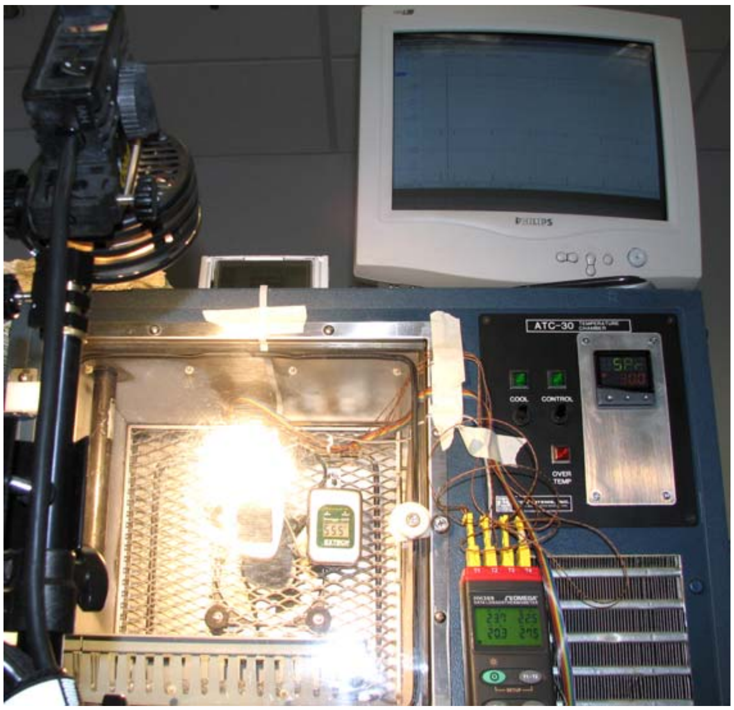
Omega HH309 Datalogger Thermometers were used to record the temperatures in and outside of the solar device under test. The three photos below show where these five thermocouples were positioned.







The photos below show the temperature chamber with the solar device under test, the Extech temp-humidity recorder to the right, and the voltage charting on the CRT monitor. The gray ribbon cable from the humidity sensor to the external controller can barely be seen in the top center of the picture at right. The tip jack connector is plugged into the solar device then spliced to a longer cable to bring the output of the solar device outside the chamber where it was connected to a resistive load and voltmeter for monitoring of the output of the solar device; this cable is the gray-white ribbon cable seen running along the side wall of the chamber. The electrical data from the solar device's battery and solar panel is carried out of the solar device and chamber by the multi-color ribbon cable on the right side of the chamber.



Synopsis of Test Results

We found that solar device DXX-XX-XX1 would not provide more output current than about 220 milliamperes; when the load resistance was reduced further, the solar device would shut off its output. solar device DXX-XX-XX2, on the other hand, was able to provide as much output current as 1 ampere although the voltage was down to just 2 volts at that load current. The table on the following table shows the output voltage, current, and load resistance for each solar device. These tests were performed at room temperature and humidity (25°C, 40% RH) outside of the T° chamber.

DXX-XX-XX1	
Iout, amps	**Eout, VDC**
0.00	5.14
0.25	4.97
0.05	4.94
0.75	4.86
0.10	4.80
0.15	4.65
0.20	4.47
0.21	4.44
0.22	4.41

DXX-XX-XX2	
Iout, amps	**Eout, VDC**
0.00	5.17
0.05	4.90
0.10	4.68
0.20	4.50
0.30	4.42
0.40	4.20
0.50	3.44
0.76	2.36
1.00	2.00

Temperature Performance Analysis

Although we continuously recorded both electrical and environmental data, we waited for the temperature data of the thermocouples on the solar device to stabilize before recording final data. The following table shows the results.

Date [2]	102808	102808	102708	102808	102808	102808	102808
Time	1606	1734	2345	1116	1309	1410	1443
Set Temp, C°	20	30	40	50	60	70	80
Front of Solar Panel, C°	30.4	41.2	55.1	62.1	74.9	81.7	92.3
Back Case of solar device, C°	14.2	27.6	38.9	48.9	61.2	67.9	80.3
Top of Battery, C°	23.8	35.2	46.8	57.6	63.5	73.9	85.8
Back of Solar Panel, C°	35.4	46.2	61.5	71.2	75.1	86.3	97.9
RH, %	26.2[3]	44.6	45.4	48.7	52.6	58.8	51.6
Eout, VDC	4.43	4.44	4.56	4.8	5.77	-----	-----
Rl, ohms	15	15	15	25	100	-----	-----
Iout, amps	0.295	0.296	0.304	0.192	0.058	-----	-----
Ebatt, VDC	3.586	3.43	3.563	3.672	3.797	3.789	3.789
Ibatt, amps	0.289	0.305	0.477	0.328	0.148	0	0
Esc, VDC	4.648	4.44	4.266	4.547	5.226	5.195	4.938
Isc, amps	0.0578	0.0563	0.05	0.05	< 0.016	< 0.008	< 0.008

As the temperature was raised, we found it necessary to increase the resistance of the load resistor connected to the output of the solar device as the solar device shut off its output at lower and lower current levels; i.e., as the temperature climbed, the solar device became less able to provide high output current.

During the run-up to +70°C, while passing through about +65°C, the solar device shut off its output which could not be turned on again at higher temperatures; thus, there is no output data in the table above for +70°C and +80°C.

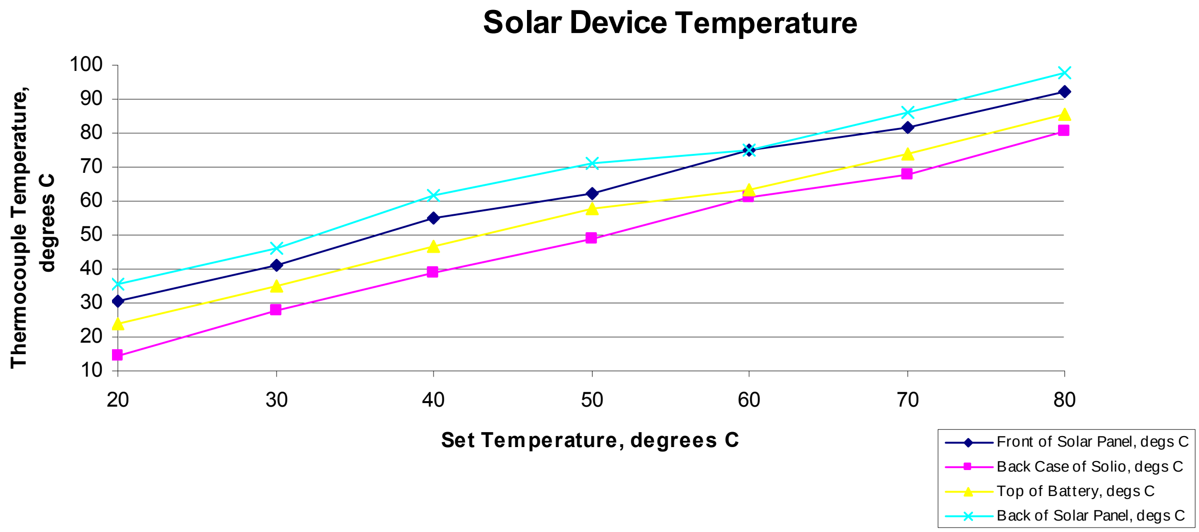
The solar panel charged the battery at about 55 milliamperes while also driving the external load resistance. However, as the temperature passed through about +65°C and the solar device shut off its output, then the solar panel current also decreased.

We also noticed, as the temperature approached +65°C, that the unloaded output voltage of the solar device had increased to more than 6.1 volts. We noted that according to supplied technical details, a battery fault will occur at +65°C.

[2] Significant testing was conducted on the solar device DXX-XX-XX1 unit. However, due to the output issue noted above, 360° chose to disregard all related test data, and retest with the DXX-XX-XX2 unit.

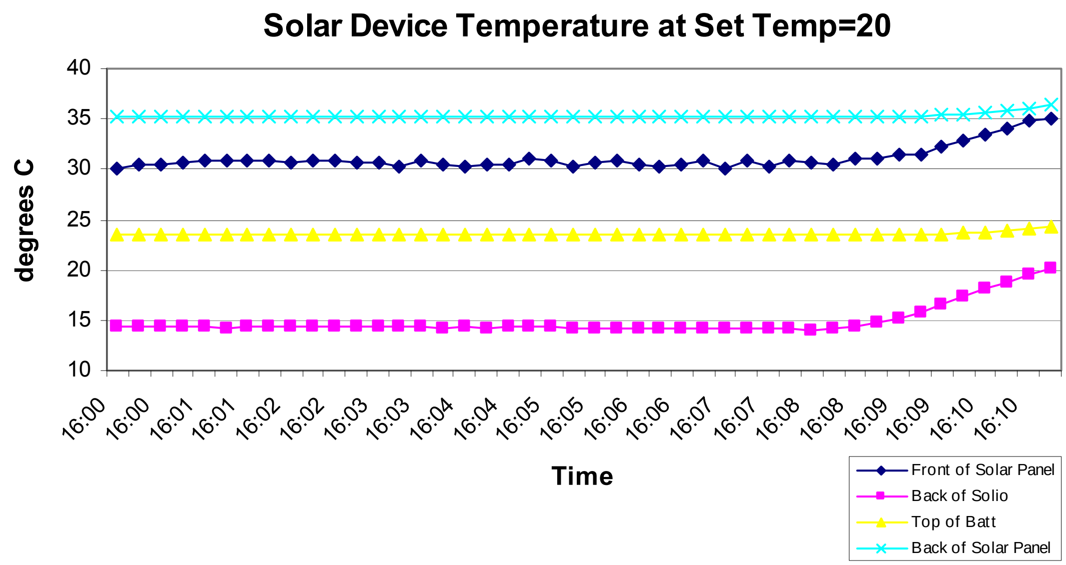
[3] A previous test trial without an applied load at 51.2% RH, yielded consistent results.

The following chart shows the temperature at each of the four locations on the solar device. As can be expected, the back side of the solar panel was the hottest location, averaging about 15°C hotter than the back of the red case which was not exposed to the lamp. The battery temperature was generally just under 10° warmer than the back case when powering the solar device; but above about +65°C where the solar device turned off its output and stopped drawing current from the battery, then the battery temperature was only a few degrees warmer than the back case.



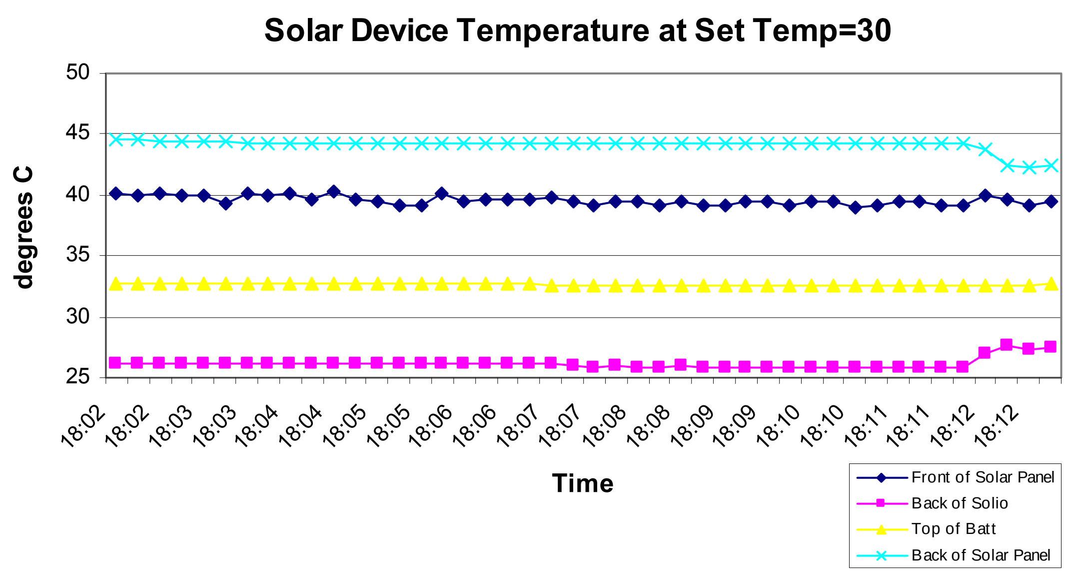
Note that the temperature of each location on the solar device increases by about the amount of the ambient temperature rise.

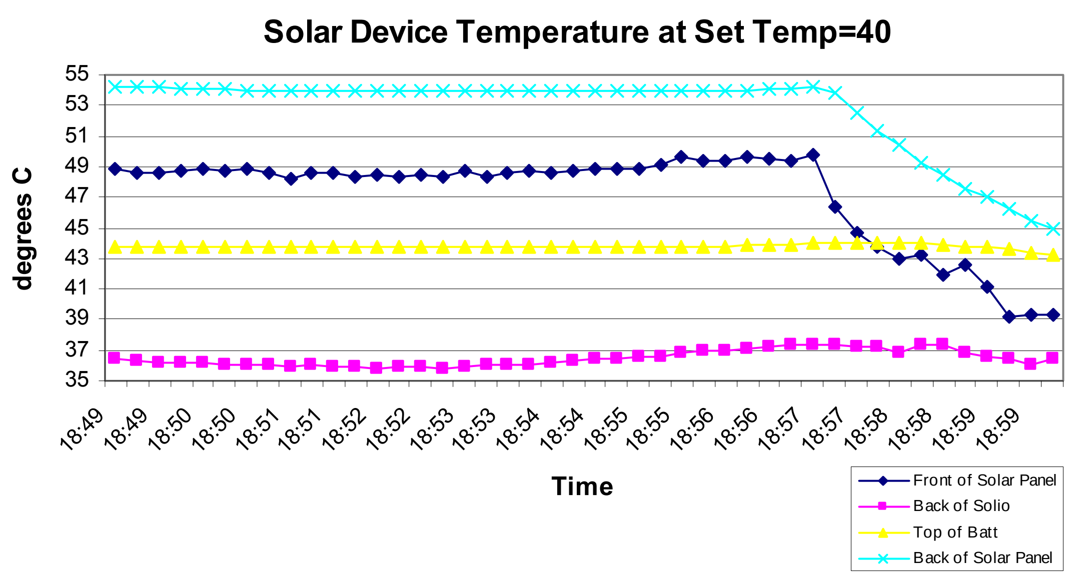
The following plots show the temperature differential between the four thermocouples mounted on and within the solar device in greater detail. We retested certain temperatures to obtain the best data and so not all temperature plots shown henceforth will be consecutive in time.

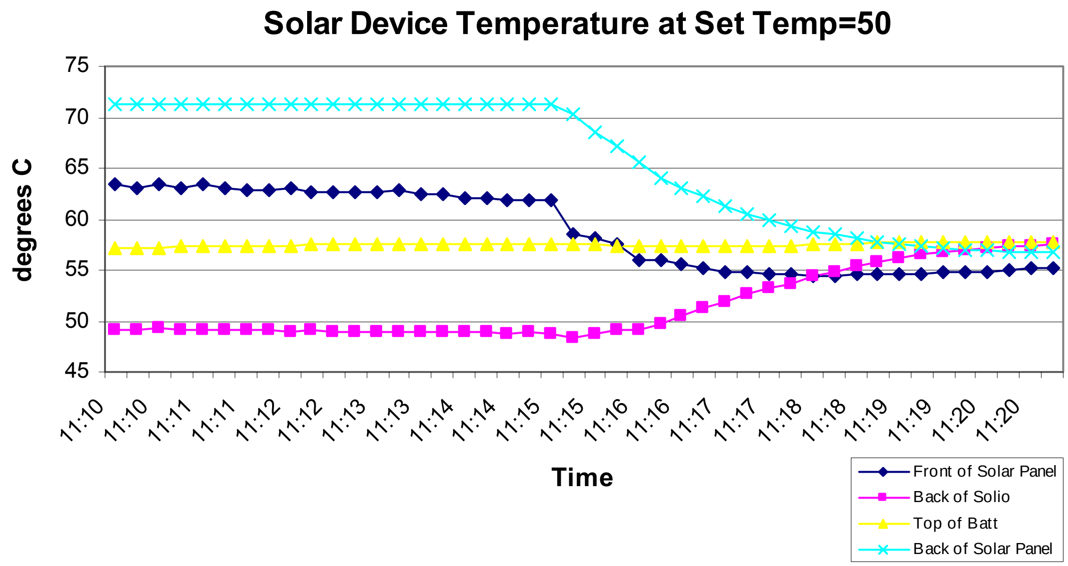


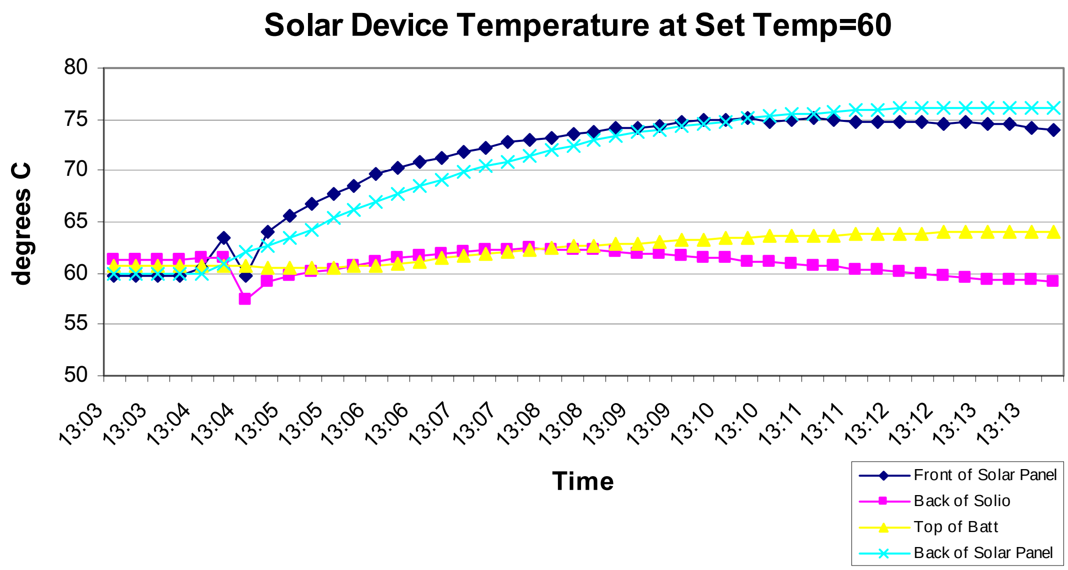
In the plot above, it is clear that the temperatures have stabilized for some minutes before data was taken. The Set Temperature of the chamber was then increased to 30°C at about 1608, as can be seen from the climbing traces above.

NOTE: Unless otherwise noted, strong trend changes seen on a plots right portion represent opening of the chamber, removal of a light source, ramping to next temperature increment, or other setup related activities.

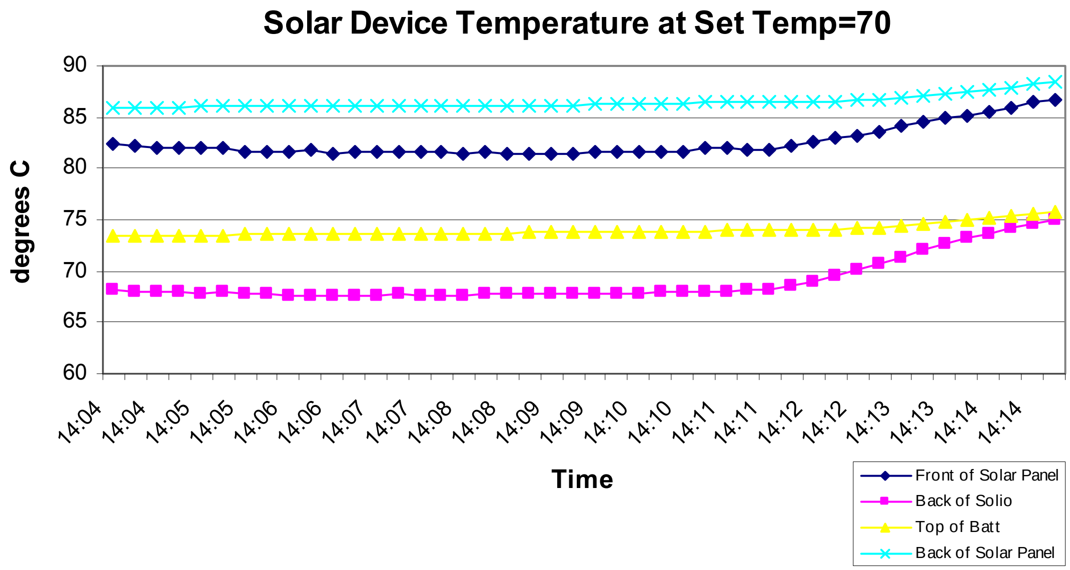


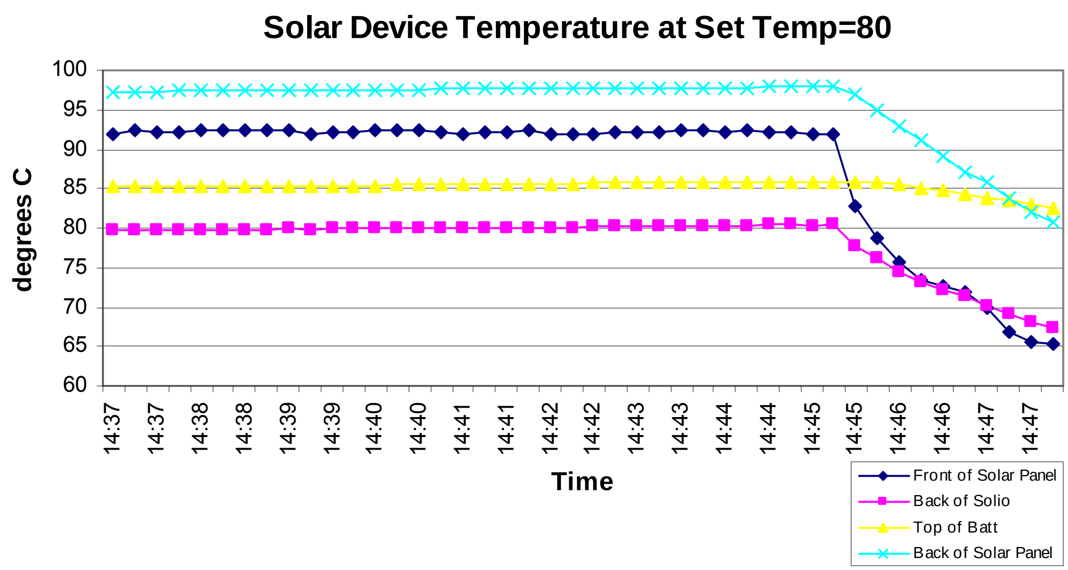






The constantly changing temperatures seen above in the 60°C plot resulted from the solar device shutting down its output load before all temperatures had stabilized. The shutdown occurred at about 1304 as seen above; the sharp jumps in temperature are from opening the temperature chamber door to attempt to turn the solar device's output back on. However, it continued to shut off almost immediately, even with no output load. The solar device continued to charge the battery, however, as shown in the earlier table.





Other Notes and Comments

solar device DXX-XX-XX1 would not provide more than about 220 milliamperes before shutting down. It otherwise appears to be operating properly, including giving the proper LED indications for all of the various “conditions”. We initially began our testing with that device but ultimately concluded that the unit would not provide the desired output current; therefore, we discontinued temperature tests with it. Its circuitry indicates that the battery has a 60% charge.

However, we noticed on the Client web page that the solar device is normally provided with three solar panels instead of the single panel we received. While this would not be expected to affect the output current capability, we wonder if perhaps this particular unit has been modified with firmware such as to limit the output current as we noticed. If this is, indeed, the case, then the current capability that we found is likely to be normal.

We also checked the charging performance of the good solar device by using the wall charger, and found that it charged properly up to where it shut off at about +65°C.