



Generating Off-Grid DC/AC Solar Power

Laboratory Experience



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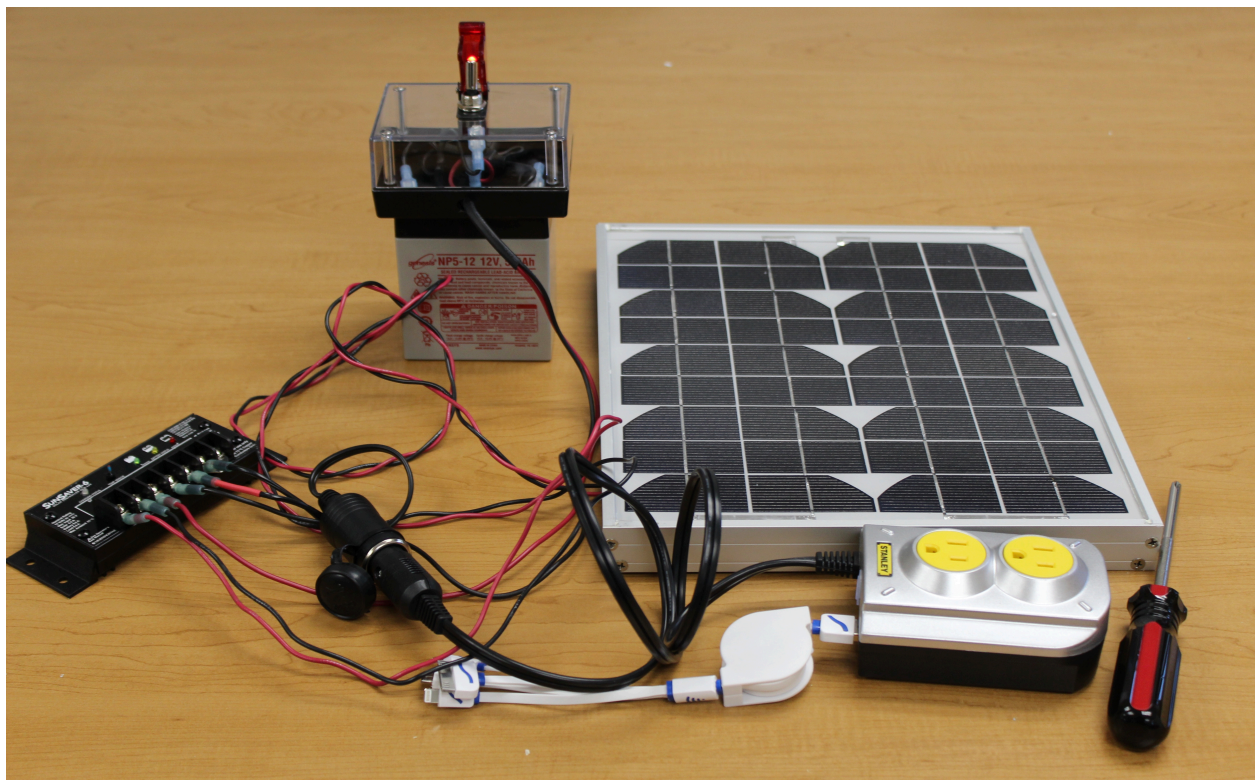
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Objectives

This kit is designed for middle school students to learn about solar energy and electricity. The set-up and tasks are moderately difficult, but should be attempted by the students directly. Adult supervision is necessary to avoid potential injuries (e.g. shock, burn) and damage to the equipment (e.g. stripped screw).

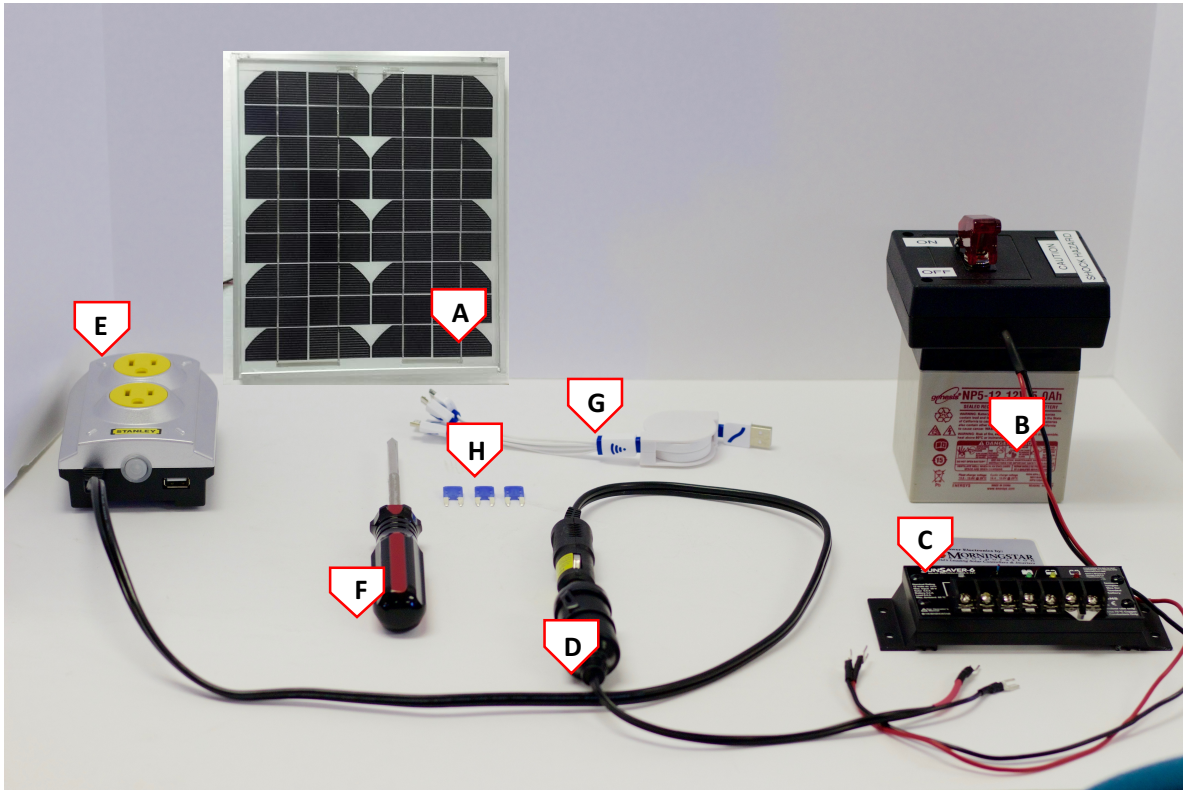
Key concepts covered in the activities include:

- conversion of energy forms
- electricity flow



Off-Grid DC/AC Solar Power System

Materials and Diagram



A – Photovoltaic Unit (PV Panel)
B – Battery
C – Solar Charge Controller
D – Auxiliary Power Port Adapter

E – Inverter
F – Screwdriver
G – Cellular Device Charger
H – Extra Fuses

Safety Precautions and Charge Controller

**WARNING!! SHOCK, ARC,
AND BURN HAZARD!!**

Note: the battery may be holding a charge without being connected to the circuit. Therefore, the **BATTERY SHOULD ALWAYS BE CONSIDERED HOT!**

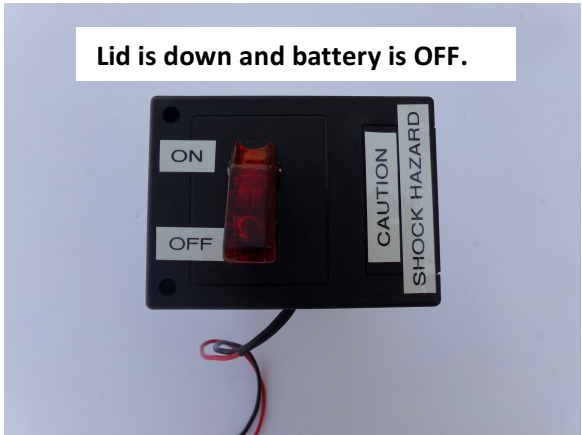
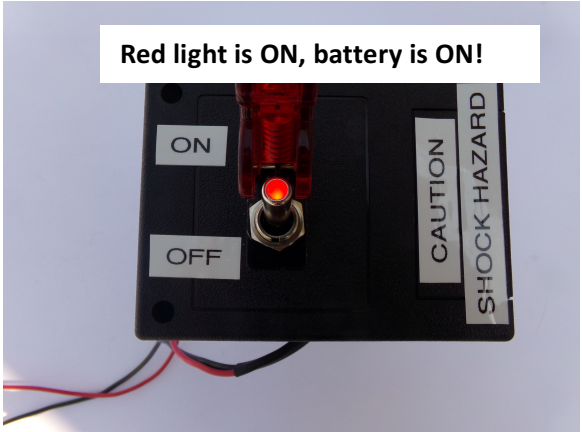
DO NOT touch the **BLACK and RED** wires together! Keep the sleeves on the wires until you are ready to attach the battery to the controller.

The battery is labeled ON and OFF. Be sure to keep the **SWITCH OFF** until instructed otherwise in the procedure.

When the battery is powered on, the tip of the switch will illuminate a red light.

Note: the light may not always turn on, so always assume the battery is on when the switch is in the “ON” position.

Failure to follow these precautions can result in injury or damage to the equipment ☹.



Off-Grid DC/AC Solar Power System Assembly

- 1) Ensure that the battery (part B) is in the OFF (down) position. When the battery is OFF, the switch will NOT be illuminated. (Refer to photos on page 3!)

- 2) Locate the Charge Controller (*Figure 1*). Notice that there are screw slots designated for each of the components. Each component is given a screw slot for its positive (+) and negative (-) connections. There are also indicator lights for charging status. The charging light will illuminate and remain lit when the battery is charging. This light may flash when the battery is connected, but is not charging. The Battery Charge Indicator Lights indicate the amount of charge the battery is currently holding. The green light indicates a fully charged battery; the yellow light indicates a partially charged battery; and, a red light indicates little to no charge in the battery.

- 3) Locate the PV Panel (part A). Notice that there are two wires connected to the back of the panel: one black and one red.

RED wires are POSITIVE (+)

BLACK wires are NEGATIVE (-)

At the end of every wire is a fork-like prong.

- 4) **KEEPING THE SOLAR PANEL FACE DOWN**, connect the **RED** wire from the PV Panel to the **POSITIVE** terminal on the Charge Controller designated for the PV Panel (i.e. Solar). Do this by loosening the corresponding screw, slipping the fork underneath the screw, into a socket where the prong should fit (Refer to *Figure 2*) and then tightening the screw onto the fork (*Figure 3*).



Figure 3– Solar Charge Controller

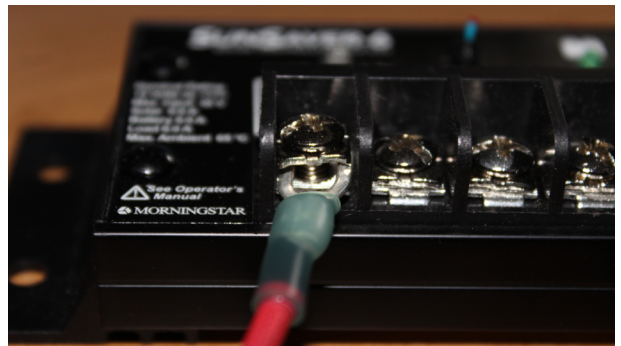


Figure 1 – be sure to place forks into the sockets below screws.

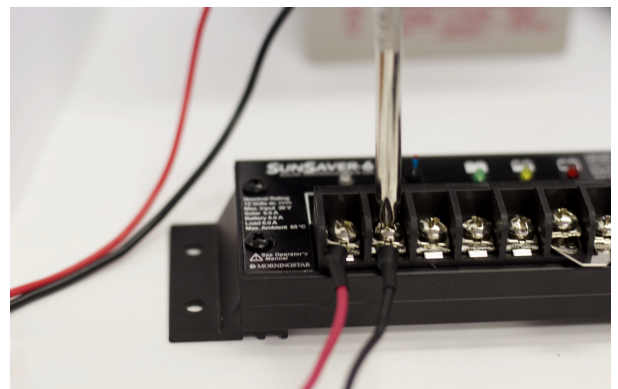


Figure 2 – Tighten Screws to hold forks in place

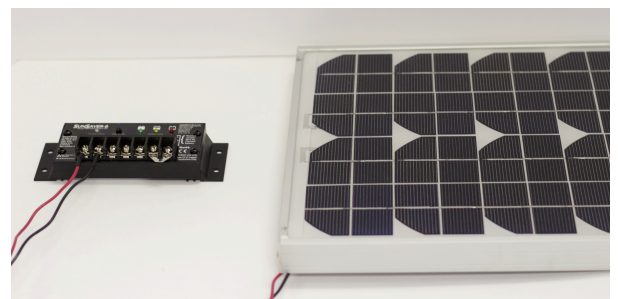


Figure 4 – Panel Connected to Charge Controller

5) Connect the **BLACK** wire from the PV Panel to the **NEGATIVE** terminal on the Charge Controller designated for the PV Panel.

6) Locate the battery. Again, ensure that the switch is in the **OFF** position and the ends of the wire are covered with sleeves. Remove the sleeve for the **RED** wire. Using a screwdriver, connect the **RED** wire from the battery to the **POSITIVE** terminal on the Charge Controller designated for the battery. Again, do this in the same manner as you did for the PV panel. Then remove the sleeve for the **BLACK** wire and connect the **BLACK** wire from the battery to the **NEGATIVE** terminal on the Charge Controller designated for the battery (Figure 5).

7) Locate the Auxiliary Power Port Adapter (part D). Connect the RED wire from the Aux Adapter to the POSITIVE terminal on the Charge Controller designated for the LOAD. Connect the BLACK wire from the Aux Adapter to the NEGATIVE terminal on the Charge Controller designated for the LOAD.

8) Locate the Inverter (part E). Connect the Inverter (male) to the Auxiliary Adapter (female) as noted in figure 7.

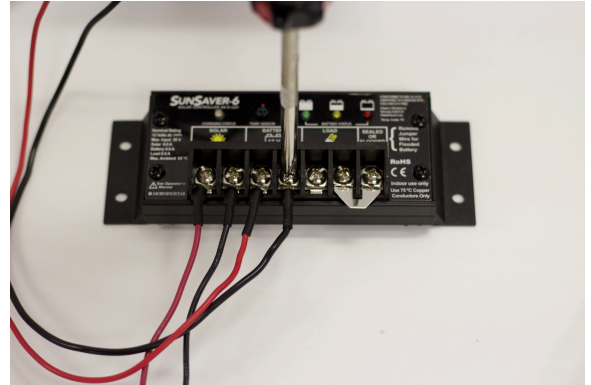


Figure 5

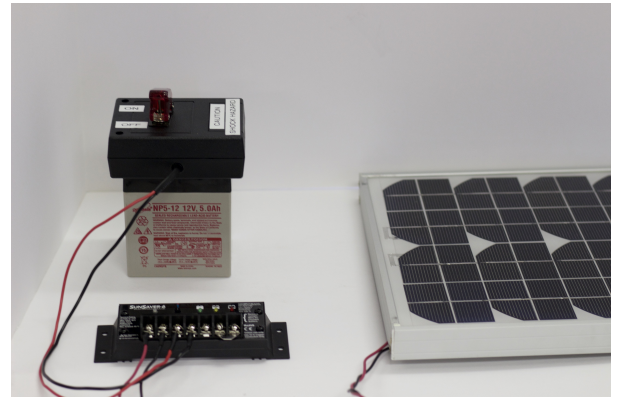


Figure 6

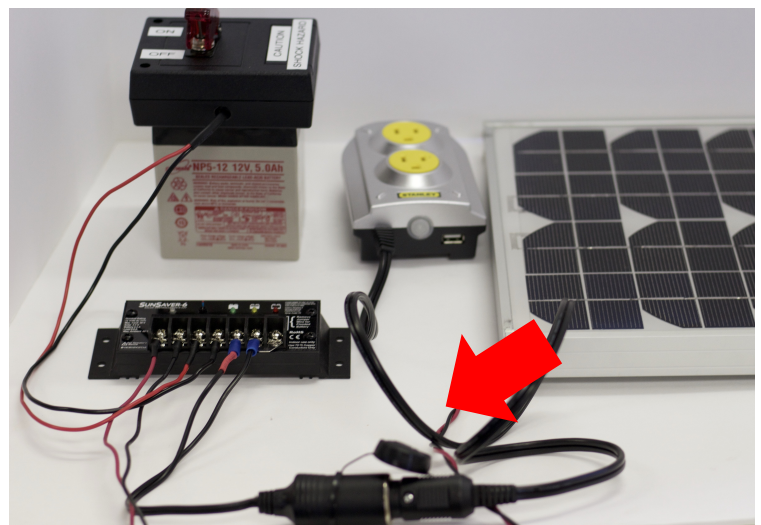


Figure 7

- 9) Flip the switch on the battery to the ON position. The lights on the Charge Controller will light up.
- 10) Push the button on the bottom of the Inverter. When the Inverter is ON, the button will illuminate **blue** (Figure 8).
- 11) You have now connected the Off-Grid System! There are two outlets on the front of the Inverter that can be used to power a small AC device. Additionally, there is a USB port next to the illuminated light that can also be used to power a small device via USB.



Figure 8 – Invertor button illuminated

Experimental Procedure

- 1) Check to make sure all wires are connected properly into the Solar Charge Controller.
 - a) Ensure that everything is wired correctly.
 - b) Ensure that the inverter is on and illuminated.
- 2) Turn over the photovoltaic unit facing the sun. Ensure it is receiving DIRECT sunlight. No shade should be covering the panel.

Note: If it is a cloudy day, this may affect the outcome of the experiment, as it may not have enough power to sustain the system.
- 3) Using the inverter, plug in the cellular device charging cables into the USB port of the inverter.
- 4) Plug in a cellular device to ensure the system is working properly.

If the cellular device does not show a charge, here are a few troubleshooting tips:
- 5) Turn the battery **OFF**. Make sure you close the lid of the switch to keep it secured.

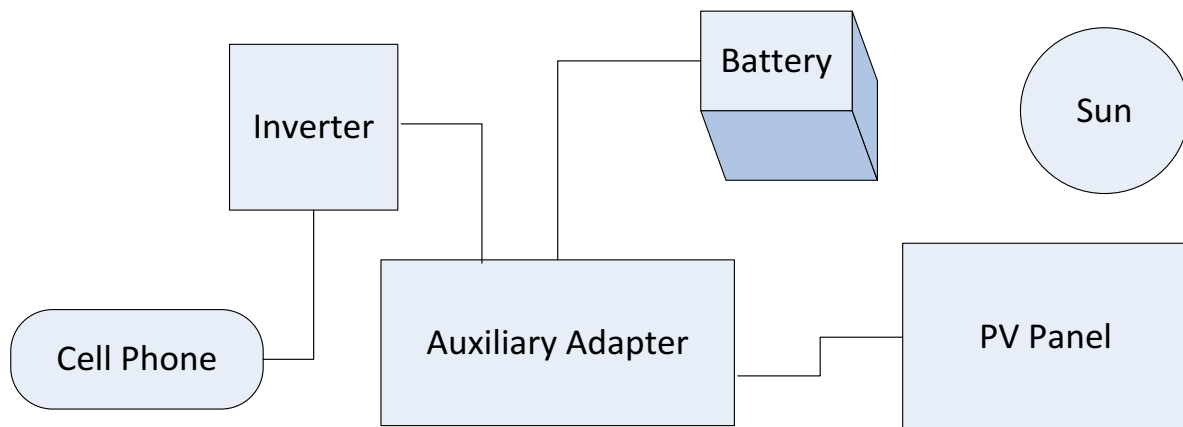
Is the cellular device still charging?
- 6) Turn the battery **ON** and remove the panel from the sun. (Place it face down, with the cells facing the table or surface).

Is the cellular device still charging?
- 7) Document your observations.

Electricity Flow

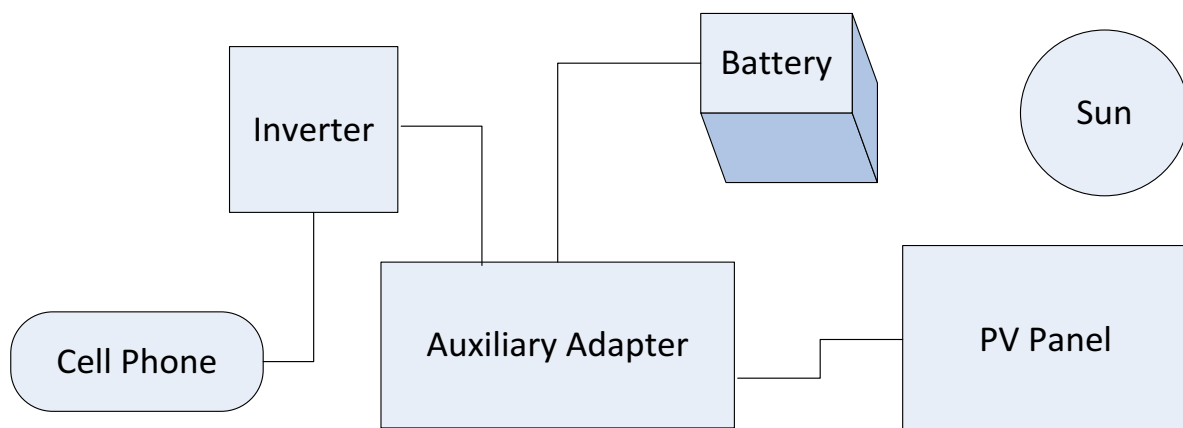
Consider the first situation. The battery is **on** and the PV panel is **face down**.

- What item is the power source?
- What type of energy is the power source?: radiant, thermal, sound, electrical (light) and mechanical (motion), chemical potential, gravitational potential, nuclear potential, elastic potential
- Identify the energy form changes.
- Diagram the flow of electricity with arrows. (This is the direction that the electrons flow)



Consider the second situation. The battery is **off** and the PV panel is **facing the sunlight**.

- What item is the power source?
- What type of energy is the power source?: radiant, thermal, sound, electrical (light) and mechanical (motion), chemical potential, gravitational potential, nuclear potential, elastic potential
- Identify the energy form changes.
- Diagram the flow of electricity with arrows. (This is the direction that the electrons flow)



Disassembling the System

- 1) Disconnect the powered device.
- 2) Push the button on the bottom of the inverter to power the inverter OFF
- 3) Flip the switch on the battery to the OFF position.
- 4) Disconnect the inverter from the Aux Adapter.
- 5) Disconnect the wires connecting the Aux Adapter to the Charge Controller, first **Black** then **Red**.
- 6) Again, assuring that the battery is in the OFF position, disconnect the battery wires from the Aux Adapter. Place the sleeves over the ends of the wire for the battery.
- 7) Finally, disconnect the wires for the PV panel.
- 8) Make sure the screws on the Charge Controller are not loose. That's it!