Ice Ice PV!

Student Investigation Guide

In this experiment, you examine how the power output of a PV solar panel is affected by temperature changes. Using a 100-watt lamp and a small PV panel connected to a digital multimeter, vary the temperature of the panel and record the resulting voltage output. Next, plot the panel's power output and calculate the panel's temperature coefficient.

Real-World Applications

Photovoltaic power generation is becoming a cost-efficient method of electricity generation throughout the world. Many parameters affect the power output of a PV panel. To predict the power output of a PV system in different geographical locations and climates, engineers must understand how a PV panel responds to exposure in a range of different temperatures. Engineers have designed a variety of methods to effectively control the temperature of a solar panel to increase its efficiency, yet it often requires unique solutions for the many different environments and applications in which solar power is used.

Introduction

When designing a solar PV power plant, engineers determine the expected power output of the entire plant. To do this, they must take into account all the factors that affect the efficiency of the PV panels and electrical equipment over the life of the power plant. Let's explore some of those factors.

If engineers installed the exact same power plant in Las Vegas, NV, and Fargo, ND, do you think it would produce the exact same amount of power over the course of a year? (Answer: No) Would it produce more or less power and what are some of the factors that would influence the power generation of the PV plants?

Well, for starters the collector slopes would be different for each latitude. If not set correctly, the panels lose efficiency because they would not be facing the optimal direction. Another factor is the weather. The

weather in Fargo is extremely different than the weather in Las Vegas. Las Vegas is in a hot and sunny, desert climate while Fargo is covered in snow many months of the year. It is obvious that snowy and cloudy days result in the PV panels producing less power, but what about a sunny day in Fargo vs. a sunny day in Las Vegas? How do you think the ambient temperature (surrounding environmental temperature) of the air would affect the efficiency of the solar panels?

The temperature of a PV cell is directly influenced by both the ambient temperature and amount of solar radiation hitting the panel. The same PV panels installed in Fargo will be colder then the panels in Las Vegas, but is this a good or bad thing? Let's do an experiment to find out!

Materials List

Each group needs:

- mini PV panel
- 2 wires with alligator clips
- lamp with 100-watt incandescent lamp
- multimeter
- stop watch
- calculator
- Student Investigation Guide, one per group
- Investigation Worksheet, one per person

To share with the entire class:

- a bucket of ice water (large enough to submerge three-quarters of the PV panel)
- masking tape
- towel or paper towels
- (optional) thermometer, to measure the room temperature

Troubleshooting Tips

The wire connections are very important. Make sure the connections are tight throughout. If you do not get a reading on the multimeter, look for a bad connection or alligator clamp somewhere in the circuit.

Be sure that the conductive pieces, especially the ends of the leads of both the PV panel and the multimeter, are not touching any other conductive materials, such as a metal table.

Be sure you understand how to use the multimeters, take measurements in the correct setting, and convert the units as necessary (for example, 78.9 mA read from the multimeter equals .0789 A).

Experimental Set-Up

1. Gather each of the items on the materials list.
2. Set up the 100-watt lamp in a stable position at your desk or lab station. Position the lamp about 1 foot (31 cm) from the flat surface where the PV panel will be placed. It is critical that the lamp does not move during the experiment.
3. Center the PV panel under the lamp (with the lamp turned OFF). Mark one corner of the PV panel with two pieces of tape placed at a 90° angle to mark where the corner of the panel must be placed throughout the experiment.

4. Assemble the circuit shown below.

5. Turn the multimeter to measure current in the 20mA DCA setting. Note: Some multimeters use a squiggly line to symbolize AC (~) and a straight line to symbolize DC (—).

Experimental Procedure

6. Place the panel under the lamp (still OFF), its corner lining up with the tape marks.
7. Follow these steps to record the room temperature, current and voltage at ambient conditions and fill in the table on page 1 of the worksheet. The panel is at ambient conditions when it is at the typical room air temperature, so take these measurements quickly before the lamp starts to heat the panel.
   - Measure room temperature with a thermometer. (If you do not have a thermometer, assume a room temperature of 25 ºC.) If your thermometer is in ºF, use Equation 3 (on the worksheet) to convert it to ºC.
   - Turn the lamp on and measure the current, I, in the 20mA DCA setting. Convert the current from mA to A by dividing by 1,000.
   - Switch the multimeter to measure voltage, V, in the 200 V DCV setting on the multimeter. Record this value on the worksheet.
   - Calculate the power using Equation 1(on the worksheet); watch your units.
8. Detach the leads from the panel and bring it to the bucket filled with ice-water. Leave the multimeter at your desk to avoid contact between electrical parts and water.
9. Submerge the PV panel approximately three-quarters of the way into the bucket of ice water for one minute. Tips: **Do not hold the panel by the wires! Do not let the wires get wet! Hold the panel by its edges and not by its leads, because the leads will pull out!**
10. Return the multimeter to the 20V DCV setting.
11. After 1 minute, remove the panel from the ice water and quickly dry it with a towel. Return to the desk and quickly attach the leads of the panel to the multimeter.
12. When the circuit is connected, place the panel back under the lamp in the position marked by the tape. Immediately record the voltage. (Since a direct temperature measurement cannot be made of the panel, assume the first voltage value to be taken at 0 ºC [32 ºF]).
13. At 30-second intervals, record the voltage from the multimeter. Continue to do this for 15 minutes or until the voltage stops significantly changing.
14. Calculate the power output of the panel at each of the time intervals. Graph power output vs. time.
15. Complete the worksheet questions.