

# Experiment #4: Photovoltaic (Solar) Cells 196L

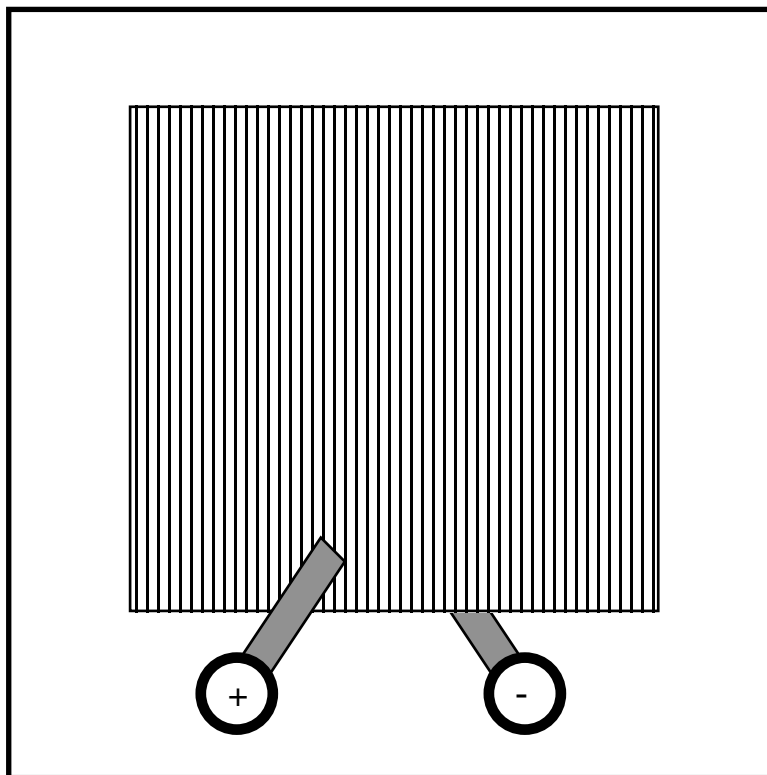
## Maximum Power Point

### I. Introduction

Insolation is the sun's rate of energy delivery, in Joules/Second or Watts, per unit area. On a bright sunny day noon-time insolation can reach 1000 Watts/m<sup>2</sup> or 100 Watts/ft<sup>2</sup>. Photovoltaic cells are about 10% efficient, therefore, electrical outputs of 100 Watts/m<sup>2</sup> or 10 Watts/ft<sup>2</sup> are possible, if the cells are efficiently power matched to an electrical load. This experiment involves a series of measurements to develop a graph of current produced by a photovoltaic cell as a function of its output voltage. The information from this graph is used to determine the operating point (meaning voltage and current) at which the cell will produce the maximum amount of power. For more information on Photovoltaics try: [www.energy.ca.gov/development/solar/index.html](http://www.energy.ca.gov/development/solar/index.html)

### II. Photovoltaic or Solar Cells

Under full sunlight, silicon solar cells produce, produce maximum power at an output voltage of about 0.5 volts per cell. Output current is proportional to insolation. A physically larger cell will produce proportionally more current, but the same voltage as a smaller one. Greater voltages can be obtained by connecting cells in series strings connected + to -. As an example, 24 cells can be connected in series to produce 12 volts. Solar cells can be connected in parallel to increase current. As an example, 8 cells that are capable of producing 500 mA each, connected in parallel, will produce 4 amperes.



Our Solar Cell Module

**III. Procedure: GROUP WRITE-UP BOTH PARTNERS MUST SIGN WRITE-UP**

- A. Record the number on your solar cell module \_\_\_\_\_.
- B. Set the DMM to its 200 mA. DC current range and connect the meter across your solar cell.
- C. Adjust the light source produce a current measurement of **30 mA**. *Be careful not to move the cell or the lamp during the rest of your measurements. If I is too large, a maximum power point will not occur within range of test resistance values listed below.*
- D. Set the DMM to its 2 Volt DC voltage range. This is a measurement of “Open Circuit Voltage” since the current flow from the solar cell through the voltmeter is very small. Record your measurement, it may be as low as 0.2 volts.

Open Circuit Voltage: \_\_\_\_\_

- E. Connect a decade resistance box in *parallel* with the cell and the DMM. Complete the data table below. (You can ignore the DMM’s 10M ohms that is connected in parallel with the Decade Box.)

<u>Decade Box Setting:</u>	<u>Measured Voltage:</u>	<u>Calculated Current:</u>	<u>Calc. Power:</u>
300 ohms	_____	_____	_____
100 ohms	_____	_____	_____
80 ohms	_____	_____	_____
50 ohms	_____	_____	_____
40 ohms	_____	_____	_____
30 ohms	_____	_____	_____
20 ohms	_____	_____	_____
10 ohms	_____	_____	_____
8 ohms	_____	_____	_____
6 ohms	_____	_____	_____
4 ohms	_____	_____	_____

- F. Make a graph of current as a function of voltage.
- G. Locate the point on the graph in Step F where the cell produces its Maximum Power Point. Power is voltage times current, so look for the point on the graph where the rectangle drawn from the point to the axes is the largest.

Maximum Power Point

Volts \_\_\_\_\_ Amperes \_\_\_\_\_ Watts \_\_\_\_\_

#### IV. Questions

1. A high efficiency refrigerator requires 1.2 kWh. per day. A photovoltaic array produces 10 Watts/ft<sup>2</sup> for the equivalent of 5 hours per day. Assuming that energy can be stored and retrieved from batteries and converted to 110 volts AC with 70% efficiency; how many square feet of solar cells are needed to operate the refrigerator?
3. If a solar cell produces 250 mA. at an output voltage of 0.4 volts, how many of these cells would be required to produce 8 volts at 0.75 Amps?
4. Make a drawing (schematic) showing how the cells must be connected to produce 8 volts at 0.75 Amperes in Problem #3.
5. Make a drawing (schematic) showing how the cells used Problems 3 & 4 can be connected to produce 12 volts at 0.5 Amperes.