# ECE 162 Lab Report Week 3 – Solar Cell

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## Purpose

The purpose of this lab is to study the electrical properties of a solar cell. For the sake of consistency, the photocell will be held under a lamp at a constant distance to maintain constant light seen by the solar cell.

## Theory

In this lab we were asked to compare current and voltage readings with different values of resistors to be placed in parallel with the solar cell. This will create an I-V curve, which should be bowed out. An example of an I-V curve is shown below in Figure 1:

Figure 1

From the I-V curve, there are many interesting values that can be found. The first is series resistance (Rs). This is essentially a sum of losses through the different contacts included in the solar cell, and current through the base of the cell. A simple method for approximating the series resistance is to find the slope of the I-V curve near the open-circuit voltage point. Figure 2 below shows the presence of series resistance in a circuit depicting the solar cell.

Figure 2

Similar to the series resistance is the shunt resistance (Rsh). This is causes by small manufacturing imperfections. Low shunt resistance in a solar cell can cause power losses by providing alternate paths for light-generated current to flow. This alternate flow reduces the amount of current flowing through the solar cell junction, therefore reduces total voltage generated by the solar cell. Figure 3 below shows the presence of shunt resistance in a circuit depicting the solar cell.

Figure 3

Another thing that can be found from the I-V curve is the maximum power that can be output by the solar cell. This is the power recorded at the “elbow” of the I-V curve. Graphically, power can be interpreted as the area of any rectangle bound above by the I-V curve. The maximum power output, then, can be interpreted as the rectangle bound above by the I-V curve which has the greatest area. Knowing the size dimensions of the solar cell and the power of the lamp used to shine light, one can now calculate the efficiency of the solar cell. This is a useful metric for comparing different solar cell design. Most solar cells used in industry are capped around 10% efficiency, but for this lab we can expect significantly less than that.

## Experimental Method

* Measure the short circuit current of the solar cell by applying a solar load and connecting each lead to the AVO. Record the current measured.
* Measure the open circuit voltage by applying a solar load to the cell and attaching either end to a voltmeter.
* Measure current and resistance across a resistor placed in series with the solar cell. Iterate this step several times using resistors between the values of 10 Ω and 100 kΩ to find the elbow of the I-V curve. For this experiment I used 10 Ω, 100 Ω, 1 kΩ, 10 kΩ and 100 kΩ.

## Diagram

For measuring the voltage across the resistor we want to take readings on either side of the resistor. The solar cell should be placed in parallel with the resistor in order to force current through it. A diagram of how to take this measurement is shown below in figure 4.

Figure 4

The other physical quantity we want to measure in this experiment is the current going through the resistor. This is done by putting the current reader in series with the resistor, and attaching the solar cell to force current through both the resistor and the current reader. The current through the resistor will be the same as the current through the resistor because they are in series. This is shown below in figure 5.

Figure 5

## Results

Several physical quantities were measured in this experiment. First and most simply measured were the size dimensions of the solar cell. The cell was measured to be a perfect square, with side length on 5.6 cm. This is significant because the light source used in this experiment is defined in units of (W/m^2), so the maximum light absorbed by the solar cell is limited by its size. Multiplying the area of the cell and the power of the light source we get . This quantity will be used later.

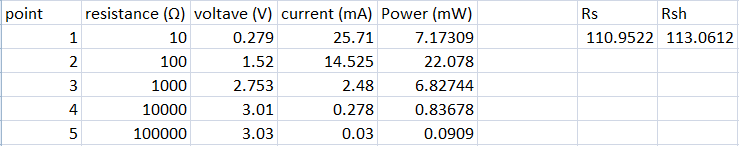


Figure 6

Shown above in figure 6 is a picture of the experimental data recorded in this lab. As you can see, there are 5 resistance values between 10 Ω and 100 kΩ, each being a different order of 10. Voltage and current was measured for each case, and power was calculated by multiplying current and voltage together. Maximum power is recorded at a resistance of 100 Ω; therefore we know that this is the “elbow” of the I-V curve. Rs and Rsh are calculated graphically by finding the slope between two points at either side of the I-V curve. These values are measured in (Ω). Shown below in figure 7 is the I-V curve

Figure 7

As you can see, the curve is not nearly as exaggerated as it is in the textbook. The real-world curve is much more subtle, but the “elbow” is there nonetheless. At a resistance of 100 Ω, the power produced is 22.078 mW, or .022 W.

Earlier we calculated that the maximum power that the solar cell could see was 3.13 W. The maximum power output by the solar cell in this experiment, measured using a resistor of 100 Ω, was 22.07 mW. Dividing the measured power by the maximum power gives the efficiency of the solar cell.

## Discussion

The low efficiency number for the power of the solar cell is surprising at first. But there are several things to note. First is that the efficiency for solar cell technology is capped around 10% for even the best solar cells. Another issue with this solar cell is that not all of the light from the lamp is absorbed by the solar cell. Some of it misses off the sides, and some is reflected back to the source. Additionally, the smaller a solar cell is, the less efficient it will be. The cell used in lab was very small, therefore will not reach the efficiencies seen by large cells used in industry. All of this will contribute to the seemingly small calculated efficiency value.

## Conclusion

This lab is likely the most interesting one yet. This has real-world application in analysis of solar cells. Included in this lab is calculation of Rs  and Rsh, which are both important contributors to the efficiency of the solar cells. The higher these values, the higher the efficiency of the solar cell. This lab also included calculating the efficiency of the solar cell, which is a key metric in comparing different designs of solar cell. While our cell was not particularly competitive with cells that are used in industry, it had many things going against it, and its low efficiency was not particularly.

One thing that was not discussed in this lab was the % error in the measurements. The light source is unlikely to have been constant in this lab, as it involved holding the solar cell near a light source. This would provide some error in the measurements, but this is difficult to measure, therefore this was neglected in this lab, and assumed to be a constant.