FRESHMAN ENGINEERING CLINIC 1 – FALL 2002
ELECTRICAL AND COMPUTER ENGINEERING
MODULE ONE – SENSORS AND CIRCUITS

OBJECTIVES:

1. Understand the principles behind voltage, current and resistance.
2. Learn to use a ProtoBoard to construct a simple circuit.
3. Understand the concept of a transducer.
4. Learn to compute using Excel.
5. Research the structure and function of a solar cell.

SENSORS AND TRANSDUCERS

A sensor is a device that transforms energy from one form that might be difficult to measure into another form that can more easily be measured. In our experiment, we will transform light energy (electromagnetic energy) into electrical energy (electrons flowing or electrical current) and measure the voltage developed across a resistor due to that current. Then we will develop a relationship between the amount of light transmitted and the amount of voltage across the resistor. We will have created a gauge. In order to do this we will use a solar cell as our sensor (or transducer) and it will transform the light into current. For the moment we will not worry about HOW the solar cell changes light into current.

BACKGROUND

The manufacturer of car window film claims that the film will transmit 35% of the incident light or it will block 65% of the light from coming through the windows. We are going to test this claim.

SET UP

For this experiment you will mount a light source (flashlight) above a solar cell and progressively reduce the amount of light that is incident upon the solar cell by adding sheets of window film between the light source and the solar cell. For each light level you will obtain a voltage reading across a resistor in a circuit that is attached to the solar cell.

EXPERIMENT

1) On your protoboard build the circuit shown in Figure 1.
2) Insert your solar cell as shown in Figure 2.
3) Attach the leads from the Keithley Multimeter Unit across the 10 Ω resistor as shown in Figure 3.
4) Mount the flashlight on the stand 18” above the surface of the lab bench as shown in Figure 4.
5) Adjust the flashlight to shine directly over the solar cell.
6) Be sure that the clamp for holding the filters is in place (see Figure 5) but with no filter.
7) Take the first voltage measurement with no filter and record the voltage reading in your lab notebook.
8) Position one filter under the flashlight.
9) Add filters between measurements for a total of four filters (you should have a total of five measurements).

10) For your final measurement (#6) turn the flashlight off.
11) Move the leads to the 100 Ω resistor and repeat the experiment.
12) Construct the circuit shown in Figure 6.
13) Repeat the experiment with the leads attached to one of the 10 Ω resistors (see Figure 7).
14) Repeat the experiment with the leads attached to one of the middle 100 Ω resistors.
15) Repeat the experiment with the leads attached to the 100 Ω resistor that is next to the 1K Ω resistor.
16) You should now have 5 sets of data.

DATA ANALYSIS

We will assume that the case where there is no filter is full light and the case with the flashlight is off to be our zero setting. Each application of the filter should reduce the light transmitted by 0.65. When there is no filter the amount of light = 1. With one filter the amount of light should be 0.35. With two filters the amount of light should be (0.35) x (0.35) or $(0.35)^2$. With three filters $(0.35)^3$ and so on.

For each of your experiments you should first determine the amount of current flowing through the resistor (remember V=I x R). You will use Excel to do this calculation. Next you will find out if the current decreases in the same proportion as the film manufacturer claims that light through the film should decrease. Perhaps it is actually the power that decreases in proportion to the decreasing light. Power can be calculated using the formula, V x I (or since V=I x R, power = I^2 x R).

1) Log on to the computer at your work station.
2) Open Excel (Start>Programs>Microsoft Excel)
3) Enter your voltage values from the first measurement in column A.
4) To calculate the current you must divide the number in column A by the value of the resistor that the voltage was measured across.
5) To calculate this value for current you must enter the proper equation for each voltage value in an Excel cell.
6) To obtain instructions for doing this use Help>Contents and Index, go to Index.
7) Enter the word “formulas” (without the quotes) in section one.
8) Choose the option “entering” under the heading “formulas”.
9) This will tell you how to write a formula in a cell.

The instructions above should get you started on your investigation. Your lab report, which is due next week, should answer the following questions:

1) In the first circuit you used what is the relationship between the currents in the 10 Ω resistor and the currents in the 100 Ω resistor?
2) In the second circuit you used what is the relationship between the currents in the 10 Ω resistor and the currents in the 100 Ω resistor that was closest to the 1K Ω resistor?
3) Answer questions 1 and 2 for power dissipated in the resistors.
4) What values of current would you expect if current and light level were directly proportional? (Remember that we are using the values at “no-filter” and at “flashlight-off” as our references)

5) What values of power would you expect if power dissipated in the resistor were directly proportional?
6) Does this solar cell sensor “work”? Explain what you think that it tells you about the light transmitted through the window film.
7) How does a Solar Cell work?

LABORATORY REPORT FORMAT

- Lab report must be TYPED
- Only ONE report is required from each group
- Each individual must maintain a Laboratory Notebook
- Cover Page
  - Course Title
  - Module Title
  - Names of Group Members
  - Date handed in
- Body
  - Objective
  - Equipment and Software Used
  - Procedures
  - Results (Tables and Graphs)
  - Discussion of results

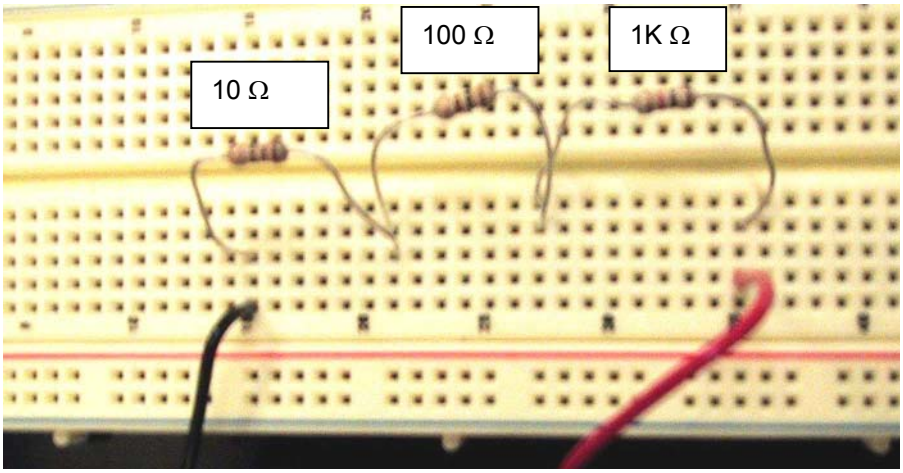
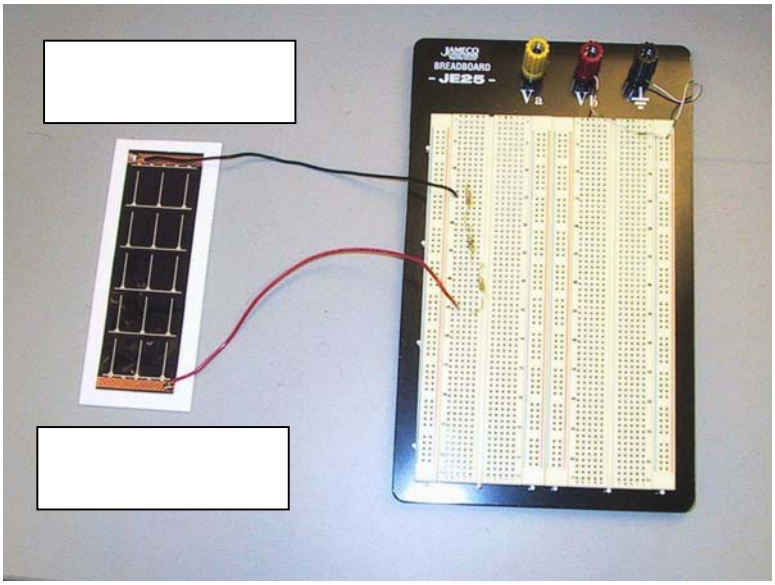


FIGURE 1 – SERIES CIRCUIT



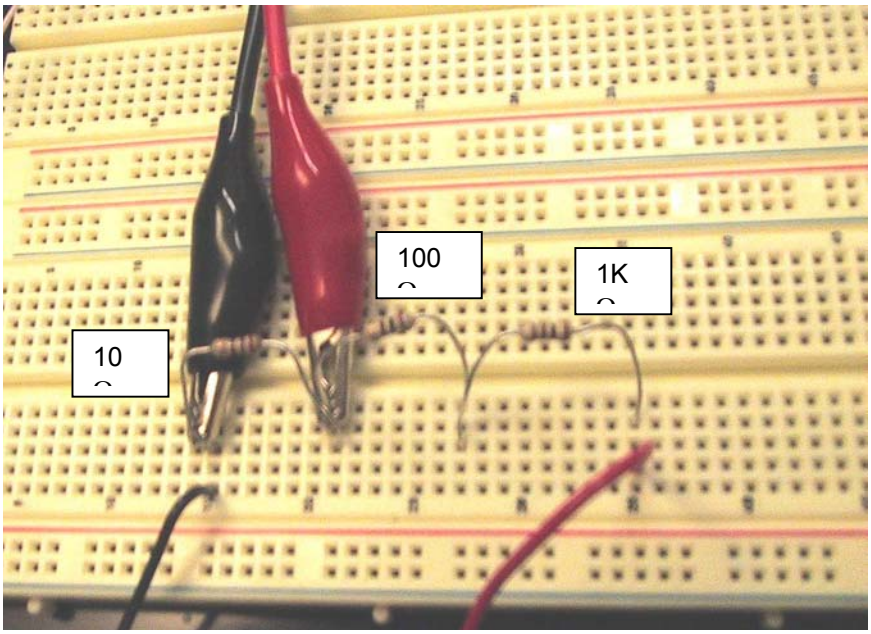


FIGURE 3 – CLIP LEADS FROM DAC ATTACHED TO 10Ω RESISTOR

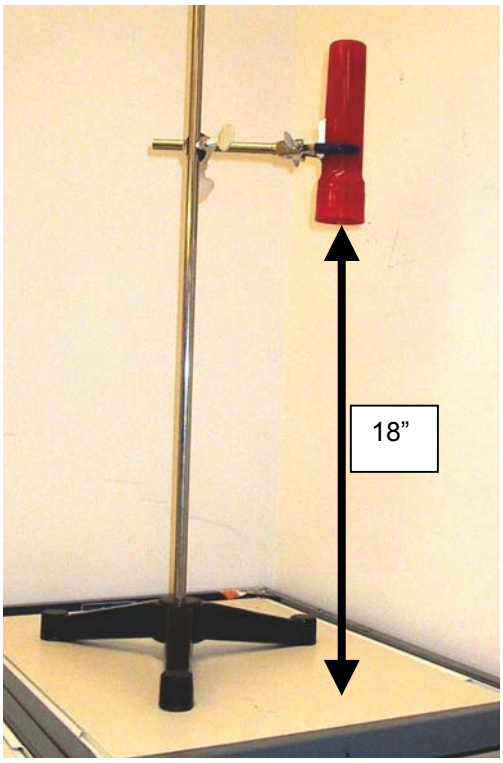


FIGURE 4 – POLE STAND WITH FLASHLIGHT MOUNTED

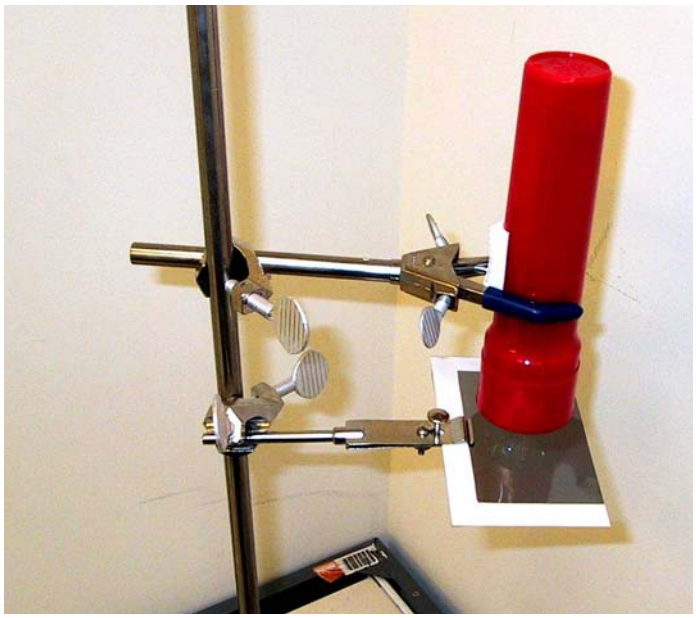


FIGURE 5 – FLASHLIGHT WITH FILTER ASSEMBLY

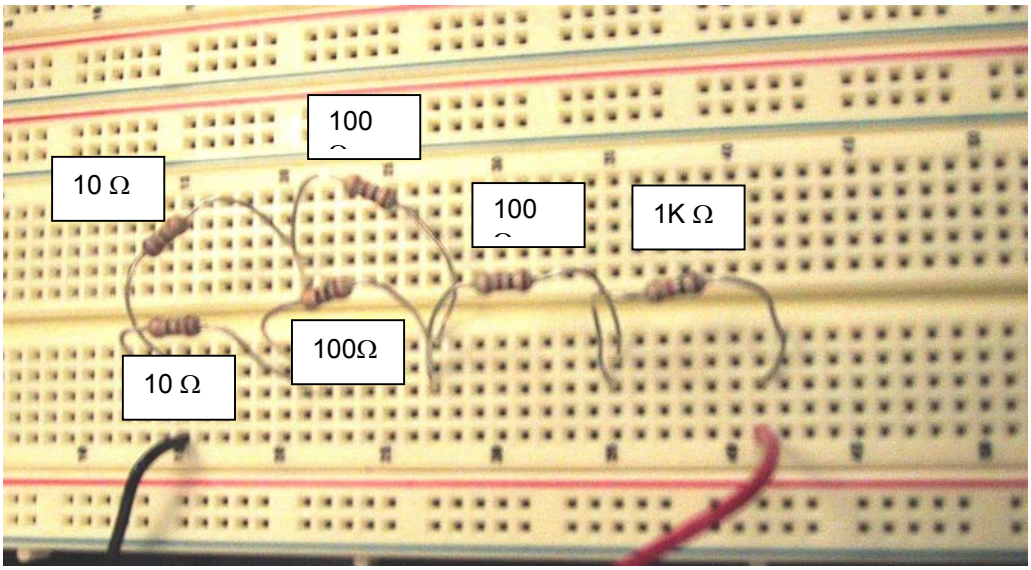


FIGURE 6 – SECOND CIRCUIT CONFIGURATION

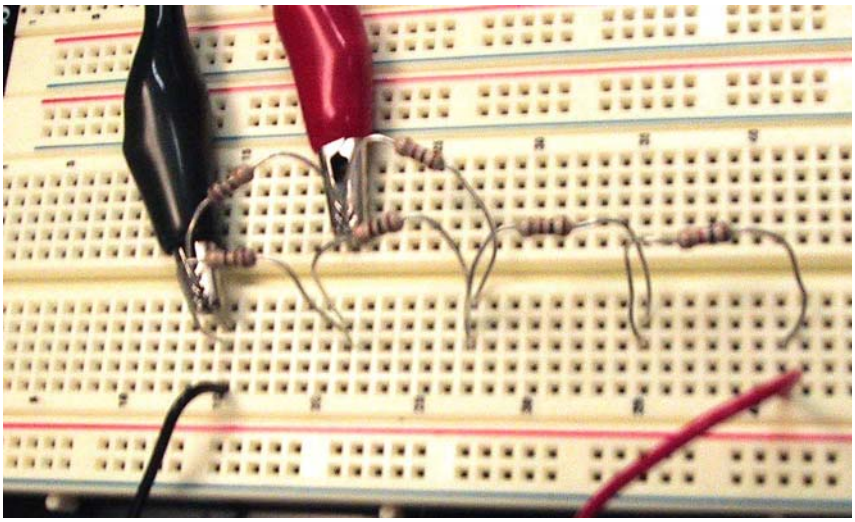


FIGURE 7 – SECOND CIRCUIT WITH CLIP LEADS ATTACHED TO 10 Ω RESISTOR