

University of Pennsylvania
Electrical & Systems Engineering Undergraduate Laboratories

ESE 112: Introduction to Electrical & Systems Engineering

Lab 2-Part III: Light Sensor Circuit with LabVIEW and Circuit Simulation with Multisim

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Objective

The objective for this lab is to introduce students to basic application of the LabVIEW software and the Data Acquisition board. The students will recreate a part the light-sensing circuit from the previous lab using a virtual instrument created in LabVIEW and a simple circuit involving only a resistor and photocell. The students will also quickly familiarize themselves with Multisim, a widely used circuit simulation tool.

Background

CdS (Cadmium Sulfide) Cell

CdS cell is in essence a resistor that changes its value with light intensity. More details regarding the CdS cell can be found in the previous lab.

LabVIEW

LabVIEW stands for **L**aboratory **V**irtual **I**strumentation **E**ngineering **W**orkbench. It is a piece of software which allows the user to write programs, of various complexities using a graphical language known as G.

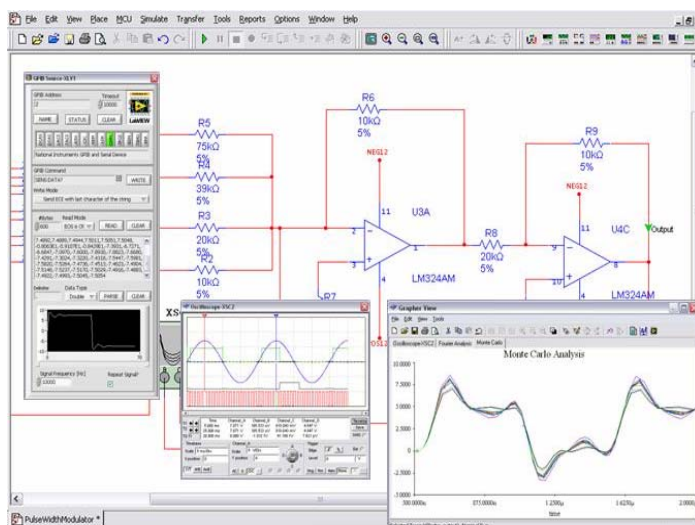
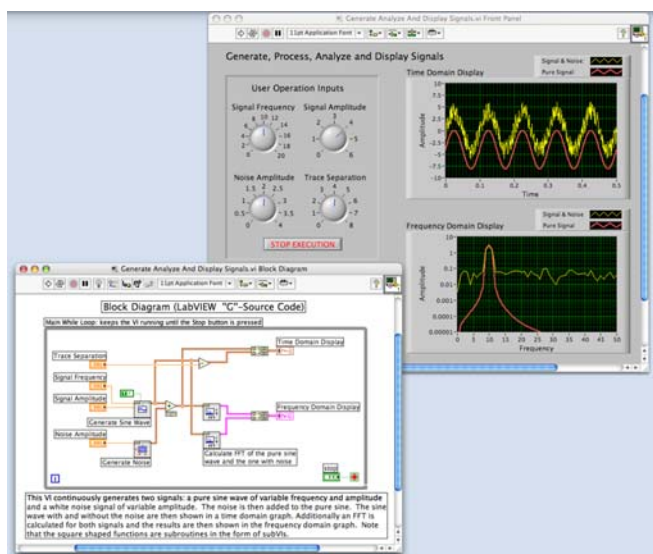


Figure 2- Sample LabVIEW and Multisim Programs

The most common uses for this software are data acquisition (which will be done in this lab), and control of instruments. One could, for example collect data from a physical circuit, perform some operations or conversions on it, and output in back into this circuit as a voltage signal through the data acquisition board (DAQ).

Mutisim

Multisim is a circuit simulation program created by National Instruments, in order to simplify the design and testing of analog circuits. It is based on software called SPICE (Simulation Program with Integrated Circuit Emphasis) developed in Berkley in the 1970s. This program was mainly used for educational use, and still remains the software of choice for many ESE classes. It is simple enough to be learned quickly, yet has enough depth to be useful for higher level classes.

DAQ Board

A data acquisition board is a computer hardware add-on that allows the computer to receive and send signals to physical circuits using a cable connected to the interface connected to the computer.



Figure 3- Data Panel on Lab PCs

Digital Multimeter

The digital multimeter used in this lab will be conceptually the same as the one used before but this will be a stationary model with more functionality. It is used in the same way as the portable DMM used before, the instructions for which are reposted here.

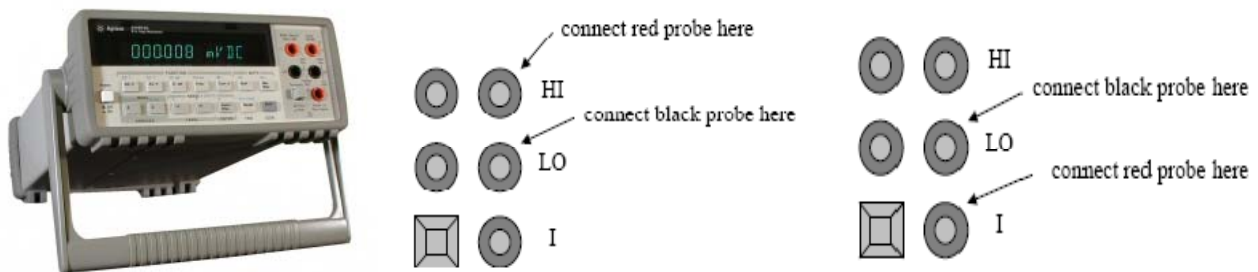


Figure 4(a)- Digital Multimeter (HP34401A), 4(b) - Measuring Voltage 4 (c) – Measuring Current

For all our intended purposes, we will be working with DC (direct current) voltage (V) and current (A). To measure the voltage, connect the leads as shown in Figure 4 (b). To measure current, connect the leads shown in Figure 4 (c) and then press the “Shift” key + “DC V” key. To measure resistance, use the same configuration for leads as measuring voltage; however press the 2W key on the DMM to change to measuring in resistance units.

Materials

Protoboard
Cds Cell
2 AA batteries
Resistors
DMM
Hookup Wires
Computer with LabVIEW software and DAQ Board
LED

PreLab

1. What are three advantages of simulation software as opposed to creating the circuit out of actual components?
2. What are three disadvantages of simulation software as opposed to creating the circuit out of actual components?

Lab Instructions

1. Calibrating CdS Cell

This part of the lab will allow you to measure the intensity of light using an external cadmium sulfide (CdS) photocell sensor. The change in resistance of the photocell can be converted to change in voltage of a circuit. Using appropriate hardware and software a PC can read this change in voltage and generate software triggered output.

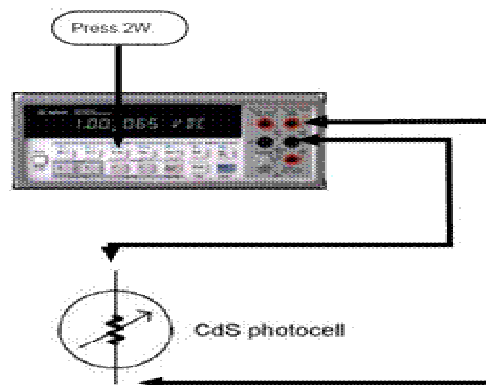


Figure 5- CdS photocell symbols and its resistance measurement.

In order to use the photocell, we will need to calibrate our instruments to its resistance value over the possible intensities of light it will be exposed to.

To determine this, connect the probes of the DMM to the CdS. With the resistor covered and exposed to ambient light, measure the resistance value in ohms. This provides the range of

possible values that a circuit including this CdS resistor will experience under varying light intensities.

2. Setting a Darkness Threshold Translating to Voltage

In order to allow the computer to interpret the light conditions experienced by the CdS cell, we will need to find a way to convert the change in resistance of the cell into a change in voltage that the computer can read. This can be accomplished with a voltage divider circuit, which makes use of the proportional voltage drops over resistors in series to vary the voltage between two resistors as the one resistance varies.

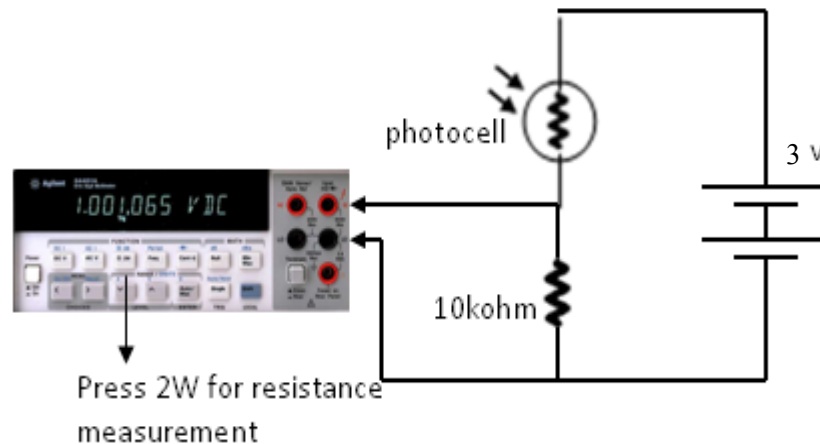


Figure 6- Converting the resistance of photocell to voltage

Build the above circuit on your protoboard, using the 2 AA battery pack (3V) to power the circuit. Then, measure and record the voltage output when the photocell is exposed to ambient light. Repeat with your finger over the photocell and record the new voltage output to the DMM.

3. Interfacing with the Computer

- Once you know the voltages at which the resistor will operate, you can connect the circuit to the computer and use the sensor as a form of digital control. The PCs in ESE Undergraduate Labs are equipped with boards that can read voltages. The boards are interfaced with software called LabVIEW, which has an easy-to-use interface to allow measurement and control of voltages. Refer to Figure 3 at this time.
- You will need one connector for CH 0 of 'Analog Input'. Connect the positive probe of the analog input to the voltage output of the voltage divider (where the DMM was connected earlier) and the negative probe to ground.
- Connect another connector to CH 0 of "Analog Output". Connect the positive probe to the positive end of an LED and the negative probe to ground. Also make sure the other lead of the LED is also connected to ground.
- From the Blackboard, download **Light_Intensity_08_Final.vi file**, which will launch the LabVIEW software and show the *virtual instrument (VI)* as shown below.

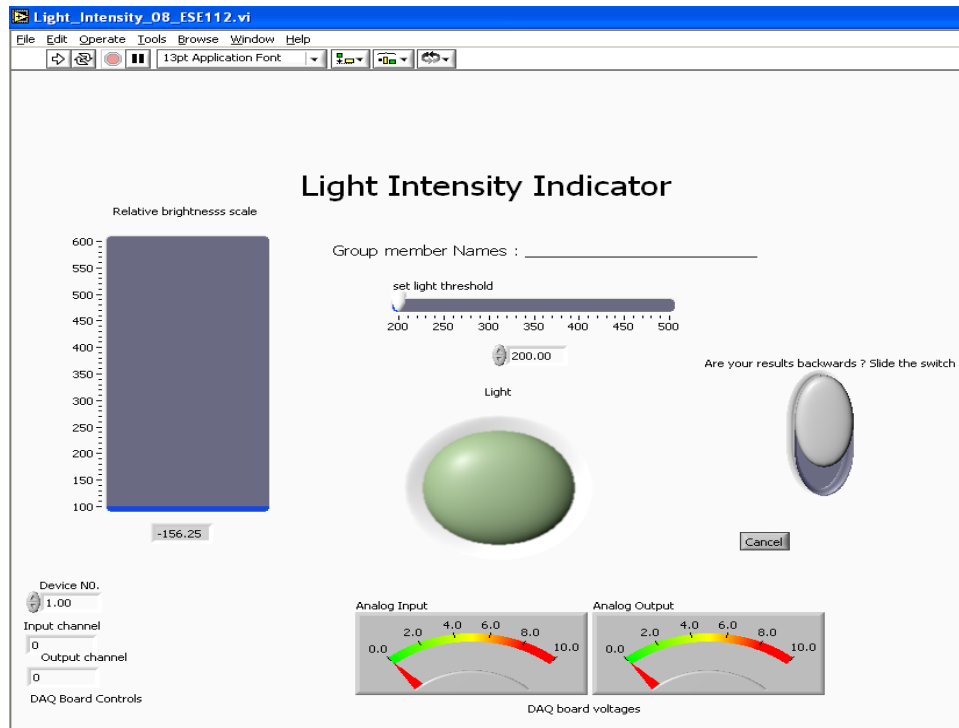


Fig 7- LabVIEW software front panel

- e. When you open the VI, you will be presented with this bar at the top of your screen. Press the 'play' button to start the simulation and begin receiving data.



Figure 8- Runing the program in LabVIEW

- f. Cover the photo sensor with your finger and note the change in the measured voltage on the screen. The "relative darkness scale" indicator will vary proportional to light. Note down the numbers from the "relative darkness scale" for the maximum and minimum readings of the voltages measured from photocell, based on the amount of ambient light the photocell is exposed to. Since the voltage is now converted into a digital number, the software can be set to control an indicator light that illuminates when the ambient light level falls below a set threshold. You can adjust the threshold by dragging the slider. It is through these principles that computers can receive input from external sensors and dynamically set output to respond to changing conditions.
- g. What happens to the LED when the threshold is met?

4. Multisim

- a. Open the Multisim software. Follow the arrows in the diagram below to create the circuit depicted in Figure 9. Save the file as ESE112_circuit1.ms7. Note: To change value on the components by double clicking on the individual component.

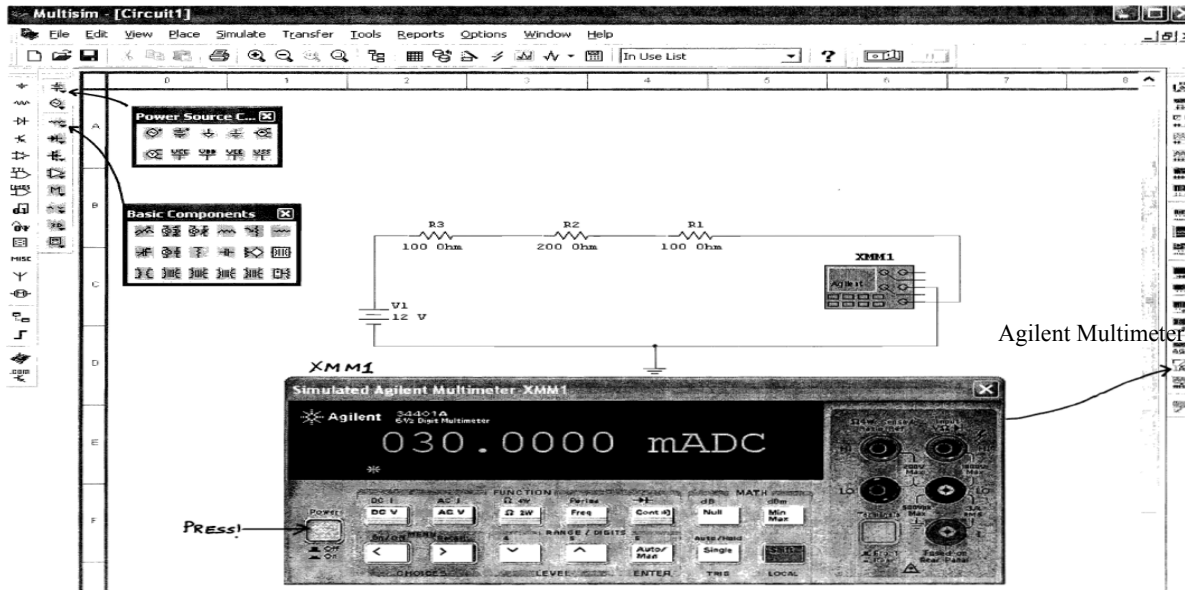


Figure 9 – Circuit Simulation in Multisim

- b. Use the virtual multimeter to measure the current running through the circuit (make sure to turn it on and set to measure DC current). Then press the switch near the “?” icon or click on Simulate > Run (F5).
- c. Change the values of the resistors to 200Ω, 400 Ω, and 200Ω and repeat the measurement. Save this circuit as ESE112_circuit2.ms7
- d. Repeat the two measurements above by replacing the three resistors with one resistor of equivalent value (again the save the modified circuits as ESE112_circuit3.ms7 and ESE112_circuit4.ms7). Are the measurements consistent with what you had expected?
- e. Now modify the circuit in step (a) i.e. ESE112_circuit1.ms7 to have input voltage of 3V and measure current using virtual multimeter. Now build this circuit on protoboard and measure the current using actual multimeter. Note: to measure current, you need let the current pass through the multimeter. Do you see in difference in simulated current value and measured current value from circuit with actual components?

Questions

1. Describe carefully the step by step operation of the system created with the photocell circuit, the LabVIEW virtual instrument, and the LED.
2. Describe your experience with using circuit simulation software vs. building circuit using actual components on protoboard.