NAME PERIOD DATE

LIGHT EMITTING DIODES

How does a light emitting diode (LED) respond when a voltage is applied to it? What happens to the current passing through the LED if the voltage changes? What happens if the voltage is reversed? How does an LED's operation compare to an incandescent light bulb? Investigate these questions using an LED circuit with a variable voltage source.

Objectives

- Investigate the characteristics of an LED in a circuit using current and voltage sensors.
- Use the data and observations to describe the behavior of an LED.
- Make comparisons between the operating characteristics of an LED operates and an incandescent bulb.

Materials and Equipment

- Data Collection Software
- PASCO Essential Physics Modular Circuit Kit
- PASCO Wireless AC/DC Module

Safety

Follow regular laboratory safety precautions.

Procedure

1. Construct the circuit shown in Figure 1 using the circuit modules, wireless current sensor module, and the wireless AC/DC module. Note the polarity of wireless current module connections and orientation of LED module. Leave the switch open for now.

2. Connect the wireless voltage sensor across the LED module, making sure the + lead is connected to the side closest to the + terminal of the wireless AC/DC module.

3. Turn on the wireless AC/DC module, the wireless current module, and the wireless voltage sensor.

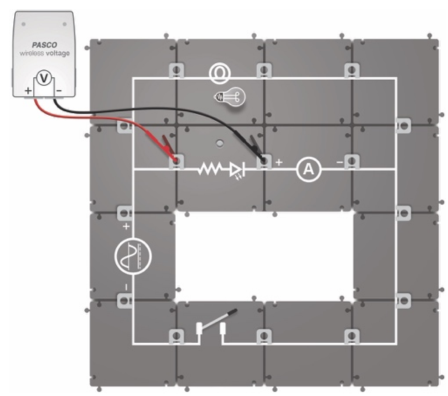

Figure 2

4. Start your data collection system and connect it to the wireless AC/DC module, the wireless current module, and the wireless voltage sensor.

5. Create a graph showing 2 plot areas, wireless voltage sensor voltage, and wireless current module current, all on the same horizontal time axis as shown in Figure 2.

6. Zero the wireless current module and voltage sensor using the data collection software.

7. Select a common rate for data collection of 50 Hz using the data collection software.

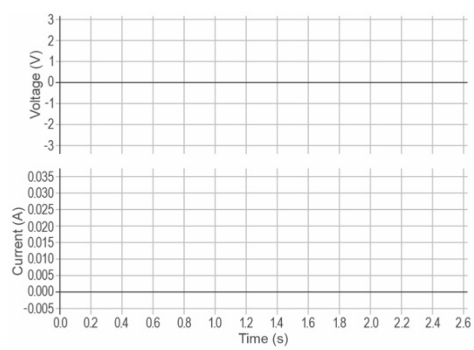

Figure 2

8. Configure the wireless AC/DC module output using the signal generator menu. Select triangle for the waveform, 0.5 Hz for the frequency, and 3 V for the amplitude. Click the On button and close the signal generator tab.

9. Close the switch on the circuit and start data recording. Observe the behavior of the LED and light bulb. Are both lights lit at the same time? What is different about when they are lit? Are they both on when the voltage is negative? Is one bulb a lot brighter than the other, if so, which one?

10. Click stop and open the switch. Check to make sure that when the voltage sensor reading (top graph) is positive that the current (bottom graph) is also positive. If not, double check your circuit and sensor connections and repeat the data collection.

11. Adjust the vertical axes limits of your graphs so that the data fills up most of the screen. Change the x axis so only the first 4 seconds of data is displayed.

Questions and Analysis

1. Study the graph of current (bottom graph). This is the current going through the LED. When the voltage is negative, what is the current through the diode? Does the current have this value at any time where the output voltage is positive?

2. Use the data analysis tools on your software to display the value of the voltage just before the current rises above zero and record it below. A more accurate result will be attained by zooming in on this region of the current graph. This is called the forward voltage. When the applied voltage rises above this value, the LED starts to conduct current.

3. Use the data analysis tools on your software to display the value of the maximum voltage across the LED and the maximum current flowing through it and record them below. LEDs have a resistance that varies with voltage. Use Ohm's Law to find the resistance of the LED module when the voltage is maximum. The resistor in series with the LED in the module is 330Ω (if your module says 100Ω, that is incorrect), what is the resistance of the LED by itself? Show all your work below.

4. When the output voltage is negative across the LED it is called a reverse bias. Describe the current through an LED that has a reverse bias below.

5. When the output voltage is positive across the diode it is called a forward bias. Describe the current through an LED that has a forward bias below.

6. Move the current module one block over to measure the current through the light bulb and attach the wireless voltage sensor to the clips attached to the light bulb module as shown in Figure 3. Collect another set of data for about 4 seconds. Describe the similarities and differences between the graph of current through the lightbulb compared to the LED below.

7. Use the data analysis tools on your software to display the value of the maximum voltage across the light bulb and the maximum current flowing through it and record them below. The resistance of a light bulb varies with voltage. Use Ohm's Law to find the resistance of the light bulb at maximum voltage. Show all your work below.

8. In question 2 you found the minimum voltage required for the current to flow through the LED, also called the forward voltage. This also is the minimum voltage for the LED to emit light. Test the value of the forward voltage by opening the signal generator window and setting waveform to DC and the DC voltage to the value of the forward voltage rounded up to the nearest 0.1 V. Close the switch, click On and look to see if the LED lights up. It will be very dim, try looking at it through a rolled-up piece of paper to block out background light. It can help to open and close the switch to make it blink. If the LED doesn't light up, try raising the DC voltage by 0.1 V. Record the results of your test below.

9. The power used by a component in a circuit is given by this equation: $P = IV$. Find the power used by the LED module (LED and 330Ω resistor together) using the results from question 3. Show all of your work below.

10. Find the power used by the light bulb using the results from question 7. Show all of your work below.

11. Using your results from questions 8 and 9, find how many joules of energy would be used to keep the LED lit for 1 hour and how many to keep the light bulb lit for 1 hour. Use your results to explain why LED based lights are replacing incandescent light bulbs for use in houses, commercial buildings, factories, and streets.

12. Which of the following graphs would best match the current vs voltage graph of an LED as the voltage is increased from zero to +3V? Circle your answer and explain your choice below. You can use your data to check your answer by making your own graph in the data collection software.