Experiment A3
Electronics I
Procedure

Deliverables: Checked lab notebook, brief technical memo

Overview

Most of the sensors and transducers used in modern engineering applications are electronic, meaning they convert the physical parameter of interest to a voltage or current. The purpose of this lab is to familiarize you with the electronic equipment and techniques that you will need to connect and operate various sensors.

Part I: Let there be Light!

You will begin this lab by learning how to measure basic electrical parameters (resistance, current, and voltage) using a digital multimeter (DMM).

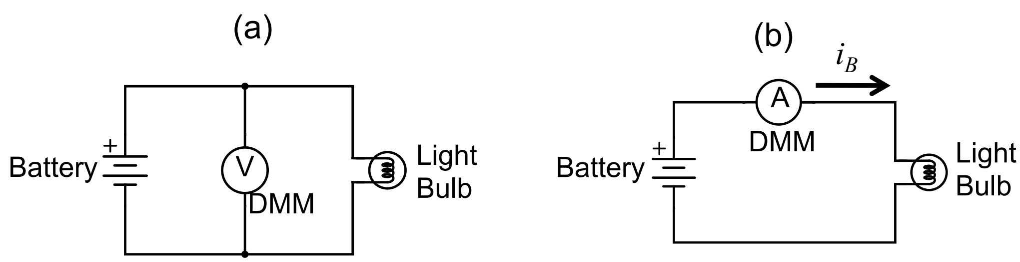

Figure 1 – Circuits used for measuring (a) voltage V_B across and (b) current i_B through the light bulb.

1. Use the orange Extech Handheld DMM to measure the resistance R_{OFF} of the light bulb when the bulb is off. Turn the clicker knob to the appropriate resistance range. Record the value in your lab notebook.
2. Sketch the circuit shown in Figure 1a in your lab notebook.
3. Construct the circuit shown in Figure 1a using the DMM, light bulb, batteries, and alligator cables.
4. Use the DMM to measure the DC voltage V_B, and record the value in your lab notebook.
5. Sketch the circuit shown in Figure 1b in your lab notebook.
6. Construct the circuit shown in Figure 1b using the DMM, light bulb, batteries, and alligator patch cables.
7. Use the DMM with the 200mA setting to measure the DC current i_B, and record the value in your lab notebook.

8. Calculate the resistance of the light bulb when it is on, $R_{ON} = V_B/i_B$, using your **measured** values of current i_B and voltage V_B and record it in your lab notebook.
9. Calculate the power dissipated in the bulb $\dot{q}_B = i_B \cdot V_B$ using your **measured** values of current i_B and voltage V_B and record it in your lab notebook. Be sure to include appropriate units!

Part II: Voltage Divider

The simple circuit in Part I was constructed using long cables. For more complex circuits, long cables can easily become a jumbled rats' nest. To avoid such a mess, engineers typically use a "solderless breadboard" or "proto-board", which greatly reduces the number of cables and wires.

In this portion of the lab, you will construct the circuit shown in Figure 2 using a solderless breadboard. You will then measure V_{out} as a function of the resistance R_2. Copy the circuit diagram and table into your lab notebook.

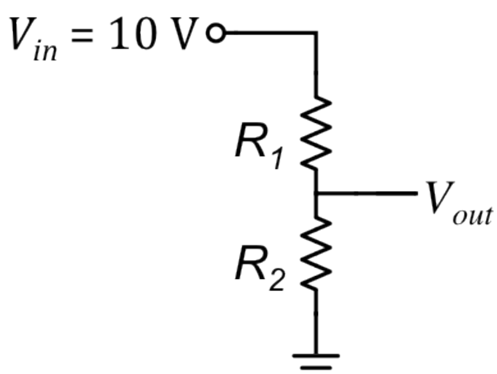

Figure 2 - Voltage divider circuit.

Table 1

R_2 (Ω)	R_2 (measured)	V_{out}
10		
100		
470		
1k		
2k		
10k		

The output voltage V_{out} is related to the input voltage V_{in} by the voltage divider equation

$$V_{out} = \frac{R_2}{R_1 + R_2} V_{in} . \tag{1}$$

Copy this equation down into your lab notebook. Note that $V_{out} \leq V_{in}$, regardless of the values of R_1 and R_2.

Procedure:

1. Sketch the circuit shown in Figure 2 in your lab notebook.
2. Take a 1 kΩ resistor from the resistor set to use as R_1 in the voltage divider circuit. Use the orange Extech handheld digital multimeter (DMM) to measure its resistance and record the value in your lab notebook.
3. Insert the resistor into the breadboard in the correct position. (Refer to Appendix B for an explanation of the breadboard.)
4. Copy Table 1 into your lab notebook with a column for values of R_2 and a column for V_{out}.
5. Locate the first resistor R_2 in the table. Remove it from the bin. Measure its resistance and record the value in the table in your lab notebook.
6. Insert this resistor into breadboard as R_2 to form the circuit shown in Figure 2. Use the breadboard's built-in power supply to provide V_{in} = 10 V to the circuit. Make sure the other end of the circuit is properly connected to ground.
7. Using the orange Extech handheld DMM, measure V_{out} relative to ground and record the value in your table.
8. Remove the resistor R_2, straighten it out, and **put it back in the appropriate bin.**
9. Repeat the procedure until you have cycled through the entire table of resistors.
10. Turn off the breadboard power supply. Disconnect power supply wires from breadboard.
11. Remove the resistor R_1, straighten it out, and **put it back in the appropriate bin.**

Part III: Photo-sensor

In this portion of the lab, you will wire up a Cadmium Sulfide (CdS) photocell in a voltage divider circuit. The result will be a transducer that converts light intensity to a voltage.

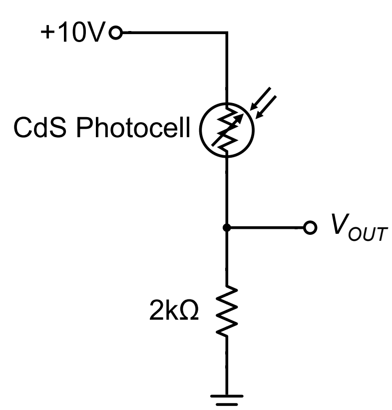

Figure 3 – A CdS photocell is wired up in a voltage divider circuit. The output voltage V_{OUT} depends on the light intensity incident on the photocell.

1. Sketch the circuit diagram shown in Figure 3 in your lab notebook.
2. Take a CdS photocell out of the resistor kit on your lab bench. Use the orange Extech handheld DMM to measure its resistance.
3. Cover the "active area" of the photocell (the zig-zag pattern on top of the cylinder) with your finger and record the resistance R_{dark} in your lab notebook.
4. Expose the active area to light and record the resistance R_{light}.
5. Use the breadboard to create the photocell voltage divider circuit shown in Figure 3.
6. Cover the "active area" of the photocell with your finger. Measure and record the voltage V_{out} in your lab notebook.
7. Expose the active area to light. Measure and record the voltage V_{out}.
8. Compare the resistances and voltages to Eq. (1). Do the values make sense?
9. Demonstrate your circuit to the TA.

Data Analysis and Deliverables

Create plots and other deliverables listed below. Save the plots as PDF or EPS files, import them into either Microsoft Word or LaTeX, and add an intelligent, concise caption. Make sure the axes are clearly labeled with units. Plots with multiple data sets on them should have a legend. Additionally, write 1 – 3 paragraphs describing the items below. Any theoretical formula you used in your analysis should be included as a numbered equation within these paragraphs.

1. A table containing the parameters you measured and calculated for the light bulb (OFF resistance, ON resistance, voltage, current, and power). **Be sure to include units!**
2. Make a plot of the *measured* output voltage V_{out} as a function of the *measured* resistance R_2 with the theoretical curve given by Eq. (1). Make the *theoretical* curve smooth by using 'linspace()' for the variable R_2, and the measured value for the constant R_1. Be sure to include the theoretical equation in one of your paragraphs.

Talking Points - Please address the following writing prompts in your paragraphs.

- Compare the resistance of the bulb when it is ON to the resistance when it is OFF.
- Include the relevant equations used in your analysis/plots.

Appendix A

Equipment - 2 sets of equipment per lab bench

- 1.5V AA Battery
- Single Christmas light
- 2 – 12” red/black minigrabber patch cables
- Extech Handheld Multimeter (DMM) w/ minigrabber cables
- Powered Breadboard
- Breadboard jumper wires
- Jameco Resistor kit w/ CdS photocell

Appendix B

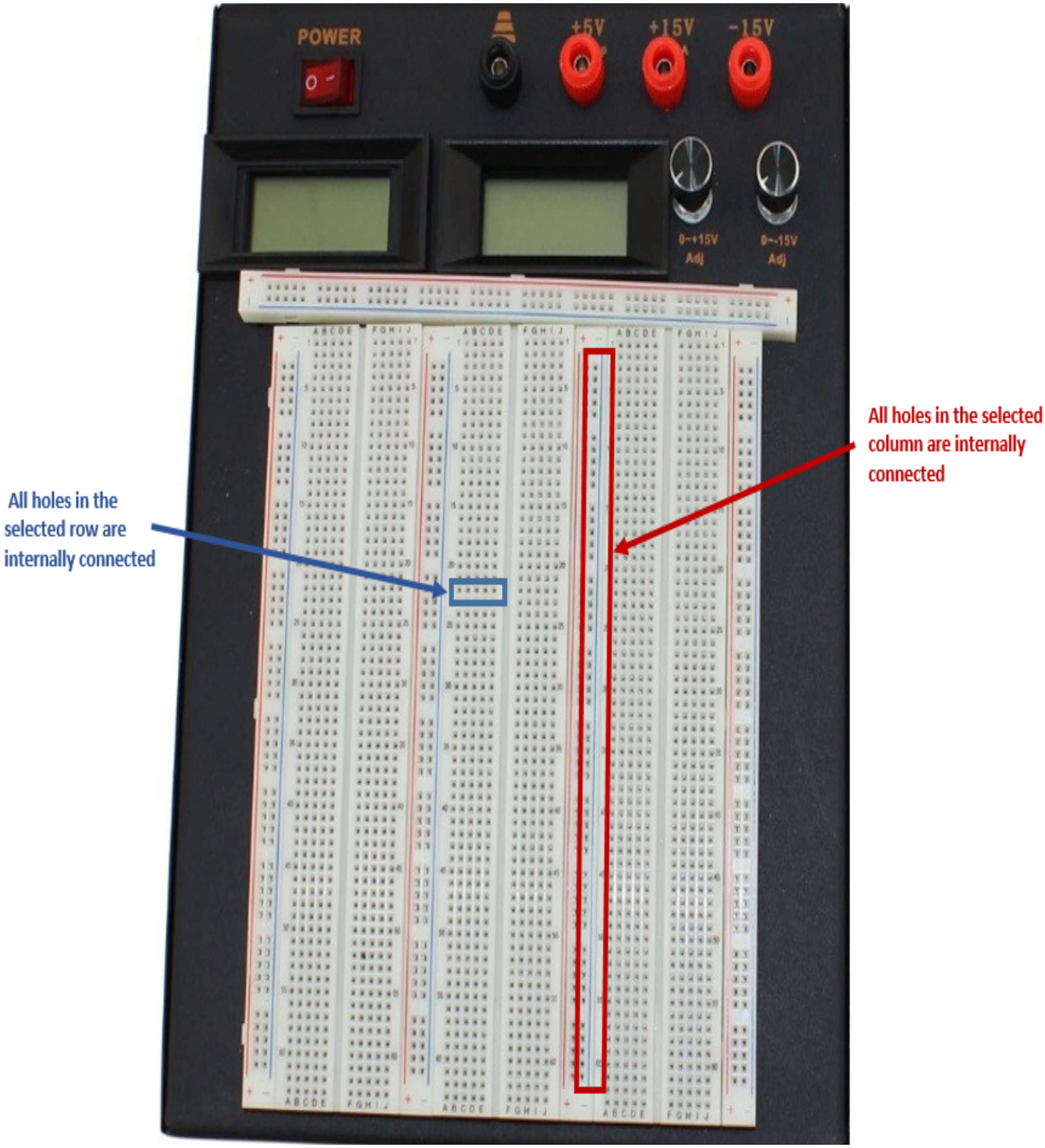

Figure 5 – Shown in blue, any 5 holes in a horizontal row are electrically connected, but they are NOT connected to the adjacent row of 5. Shown in red, all 50 holes in any vertical column or "bus bar" are electrically connected.