Experiment A3
Electronics I
Procedure

Deliverables: Checked lab notebook, demonstration of working circuit, 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.

The following lab exercises are to be performed *individually*.

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).

1. Use the orange Extech Handheld DMM to measure the resistance R_B of the light bulb. 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 patch 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. Use the resistance R_B and voltage V_B with Ohm's Law to calculate the current. Record the calculation in your lab notebook. Based on your calculated current, should you use the 10 Amp range or the 200 mA range?
7. Construct the circuit shown in Figure 1b using the DMM, light bulb, batteries, and alligator patch cables.
8. Use the DMM to measure the DC current i_B, and record the value in your lab notebook.
9. Calculate the power dissipated in the bulb and record the value in your lab notebook. **Be sure to include appropriate units!**

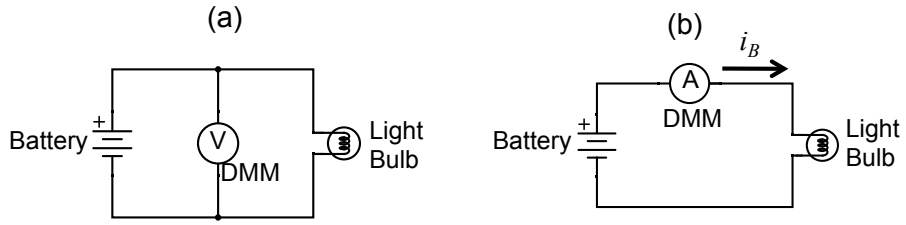


Figure 1 – Circuits used for measuring (a) voltage across and (b) current through the light bulb.

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.

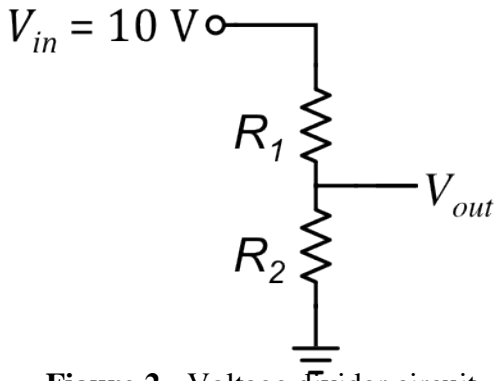


Figure 2 - Voltage divider circuit.

Table 1

R_2 (Ω)	R_2 (measured)	V_{out}
10		
100		
470		
1k		
2k		
10k		
47k		

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

$$V_{out} = \frac{R_2}{R_1 + R_2} V_{in} . \qquad (1)$$

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.

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

Part III: 3-Way Light Switch

Long hallways and staircases in houses typically will have the ceiling lights wired up to a "3-way switch circuit". Such a circuit allows the lights to be turned ON or OFF from separate switches on opposite ends of the hallway or staircase. This circuit requires special switches called "single pole, double throw" (SPDT).

1. Sketch the circuit diagram shown in Figure 3 in your lab notebook.
2. Use the handheld DMM to measure the resistance between the different wires coming off of the SPDT switch. Play around with it until you figure out how it works.
3. Use the breadboard to construct the 3-way switch circuit shown below.
4. **Demonstrate the working circuit to the Lab Instructor. Failure to build a working circuit before the end of lab will result in a zero for this week's lab notebook score.**

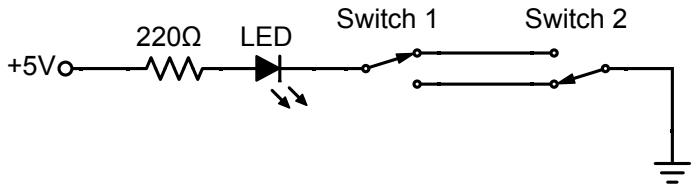


Figure 3 – A 3-way switch circuit allows the LED to be turned ON and OFF using either switch.

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 measure for the light bulb (resistance, voltage, current, and power). **Be sure to include units!**
2. Plot your measured data from Part I, V_{out} **vs.** R_2, with the theoretical voltage divider equation plotted on top. Be sure to mention the theoretical equation in your caption.

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

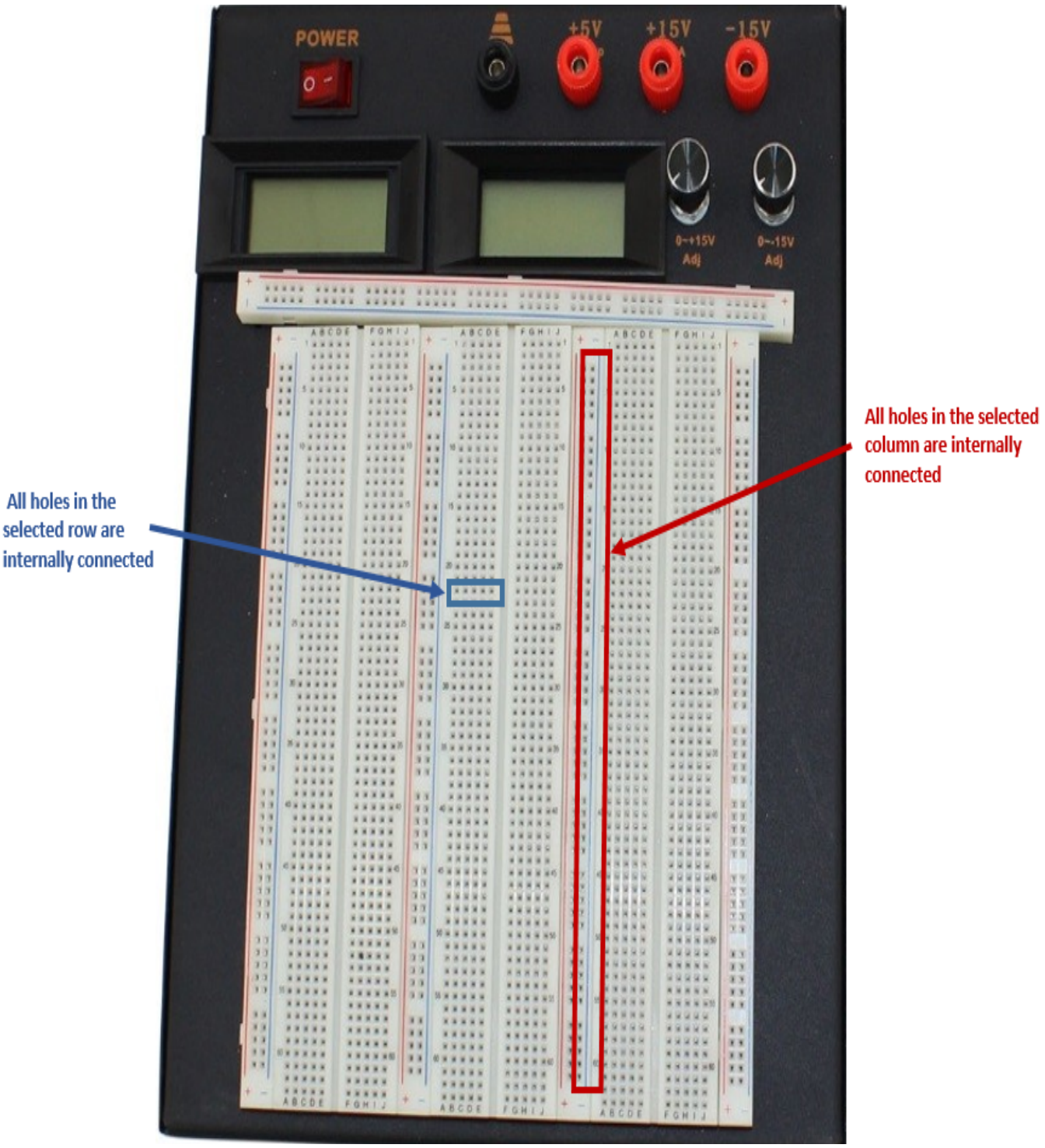
- Describe the circuits you built and the techniques used to build them.
- Include the relevant equations used in your analysis/plots.

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
- LED
- SPDT switches wired and mounted in panel

Appendix B


POWER
+5V
+15V
-15V
0~+15V Adj
0~-15V Adj
All holes in the selected row are internally connected
All holes in the selected column are internally connected