Lab 5: Resistors in Series and Parallel

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1 Purpose

Familiarity with the behavior of resistors in both series and parallel configurations, as well as experimental verification of course material on series and parallel resistors.

2 Materials

- Handheld Digital Multimeter (DMM)
- Breadboard
- Assorted Resistors (270Ω, 330Ω, and 510Ω)
- Power Supply
- Wires
- Alligator Clips

3 Theory

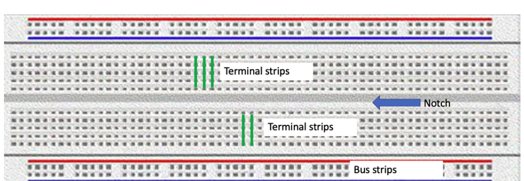
In this lab, we make use of the **ammeter** function in our digital multimeters for the final section. The electrical current is measured in Amperes, which is one coulomb per second ($1.0A = \frac{1.0C}{1.0s}$).

Additionally, we made use of the most useful feature of a digital multimeter, being the **voltmeter**. With this mode, our multimeter is able to measure the potential difference between any two points with the units of volts (ΔV), which gives us an idea of the difference in potential energy between two points in our circuit.

Resistors have the main property of "resistance", measured in Ohms (Ω), which can be thought of as a ratio of Volts over Amperes, or how many volts will be dropped across the resistor for a certain amount of current. Each resistor generally has 4-6 colored bands printed onto them, which indicate the value of its resistance. All but the last two colored bands indicate numbers in decimal increments, the second to last indicates a multiplier, and the last band indicates the tolerance of the resistor with either a silver or gold band.

A **Breadboard** is a useful tool for prototyping small electric circuits, as it lets you consistently connect electrical components together without need for wire nuts or soldering. A breadboard is essentially a grid of termination points, with rows of these points connected together. Using this principle, one row of a standard breadboard can electrically connect 5 different components together in order to make more complex circuits.

Figure 1: Labeled diagram of a breadboard



Resistors in series

$$R_{eq} = R_1 + R_2 + R_3$$

The total Voltage across resistors in series is equal to the sum of voltage drops across each subsequent resistor.

$$V_{eq} = \varepsilon = V_1 + V_2 + V_3 = IR_1 + IR_2 + IR_3$$

Resistors in parallel

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_2} \right)$$

The voltage drop across each resistor in a parallel setup is equal to the potential difference of the battery ε.

$$V_{eq} = \varepsilon = V_1 = V_2 = V_3$$

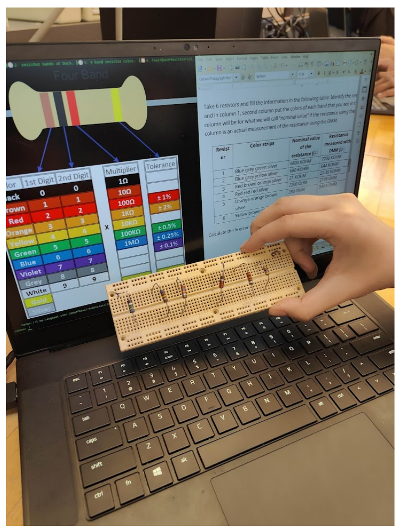
4 Experiment Analysis

When we have resistors in parallel, the potential difference across them are the same.

5 Procedure

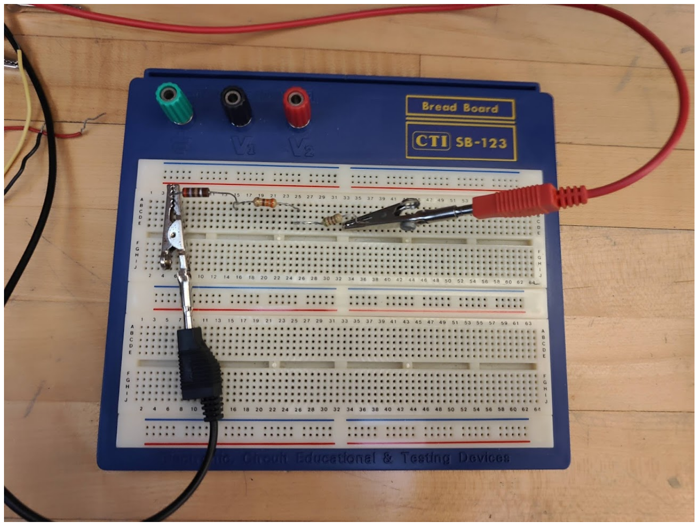
5.1 Measurement of the resistors using DMM

Figure 2: Six labeled resistors on a breadboard



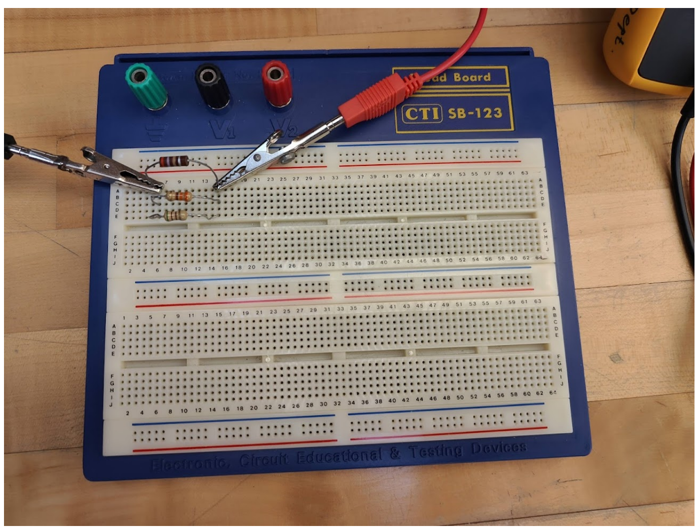
5.2 Series Circuit

Figure 3: Resistors in a series configuration



5.3 Parallel Circuit

Figure 4: Resistors in a parallel configuration



6 Data and Graphs

6.1 Part 1

6.2 Part 2

6.3 Part 3

7 Calculations & Results

7.1 Part 1

For calculating the equivalent resistance

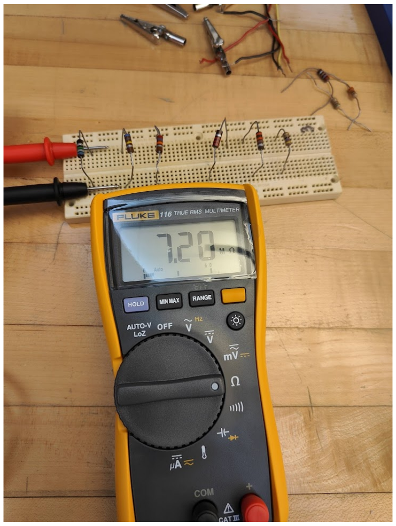
7.2 Part 2

8 Questions

Part 1 - Measurement of Resistors

1. Include here a picture of the set-up of just one measurement of resistance (showing the value in the display of the DMM)

Figure 5: Resistance measurement setup



(There is a hand maintaining pressure on the probes for optimal contact just outside of the frame)

2. Do some research about the meaning of the tolerance (gold or silver colors). Are the resistors within specification? Explain

Part 2 - Series Circuit

1. Did you get the same value of current across all the resistors?
Yes sir!

2. What is the equivalent resistance of the circuit
$\mathbf{R_{eq} = 1221.2\Omega}$

3. Did the voltage drop across the resistors add up to the value of the power supply? What is the percent error?
Nearly, we had 0.75% error, off by 0.03 Volts

Part 3 - Parallel Circuit

1. Do you obtain the same voltage across each resistor?
Yes sir!
2. Calculate the equivalent resistance of the circuit

$$\mathbf{R_{eq} = 1218.8\Omega}$$

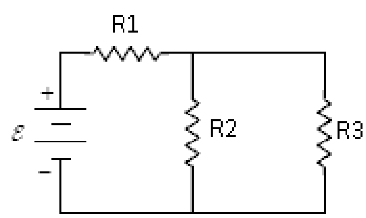
3. Calculate the current through the battery using the power supply value and the equivalent resistance

$$\mathbf{I = \frac{V}{R} = \frac{4.0V}{1218.8\Omega} = 3.28mA}$$

4. Is the power dissipated through each resistor the same? If no, through what resistor is the power the greatest?
No chief, it isn't. R2 has the greatest power dissipation

Part 4 - Series and Parallel Circuit

Figure 6: Series and parallel circuit diagram



- Battery Voltage: $\varepsilon = \mathbf{3.88V}$
- Resistor values
$$\mathbf{R_1 = 368.2\Omega,\ R_2 = 328.7\Omega,\ R_3 = 521.9\Omega}$$
- What is the equivalent resistance?
$$\mathbf{R_{eq} = 0.575k\Omega}$$
- Potential difference across each resistor
$$\mathbf{V_1 = 2.472V,\ V_2 = 1.406V,\ V_3 = 1.406V}$$
- Current flowing through each resistor
$$\mathbf{I_1 = 6.80mA,\ ,I_2 = 4.13mA,\ I_3 = 2.62mA}$$
- Power dissipated by each resistor
$$\mathbf{P_1 = 16.8mW, P_2 = 5.81mW, P_3 = 3.68mW}$$
- Total current supplied by battery
$$\mathbf{I_{total} = 6.8mA}$$

9 Conclusion