Lab Report: Arduino Setup and Ohm's Law

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1 Nomenclature

- V = voltage (volts)
- I = amperage (amperes)
- R = resistance (ohms)
- Ohm's Law: $V=I*R$

2 Another Opening

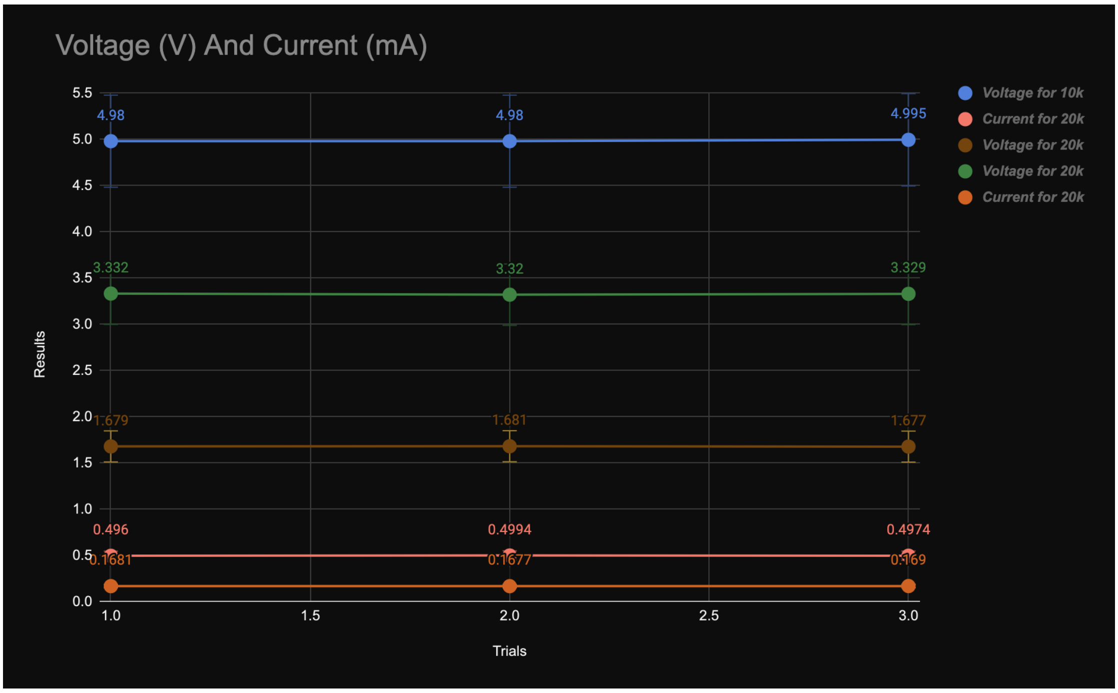
- The actual voltage measured from the Digital Multi-meter was 4.980(V) which is within the tolerance rate of the 10(kΩ) resistor. We used the equation:

3 Discussion of Uncertainty and Graph

The values in the equation are v_{true} = 4.980 (V), v_{analog} = 5(V) and b = 0 due to ground, we know that a = 0.996.

- We used an online data sheet to calculate our uncertainty as accurate as possible. The values we found useful were +/- 0.03% in voltage due to the measuring device (Digital Multi-meter) and +/- 0.2% in amperage due to measuring the measuring device (Digital Multi-meter), we used these while conducting the experiment. With that said from those resources we found the following value useful, +/- 5% in resistors due to resistor manufacturing tolerance. these allowed us to to calculate the tolerance for the Voltage for 10k, Current for 20k, Voltage for 20k, Voltage for 20k, and lastly the Current for 20k. We also noticed that the uncertainties in the resistors will propagate into voltage and amperage readings due to the resistance directly affecting current flow and voltage drop. The uncertainty we calculated from our measurements we recorded from the Digital Multi-meter device and 10kΩ and 20kΩ are shown below in the graph presented with data points.

-In addition, uncertainties due to the measuring devices will not propagate this is all due to it having no actual effect on the circuit itself.
Graph -



Graph: The results of the 10kΩ and 20kΩ from experiment.

4 Discussion of Results

After initially constructing the circuit using a 10kΩ resistor, voltage drop was measured across the resistor. The expected voltage value was 5V, given 5V is the source voltage, but the measured voltage was found to be 4.980V. This value falls outside of the tolerance of +/-0.05% error when measuring voltage using the DMM. Using the equation:

$$V_{true} = aV_{analog} + b \tag{1}$$

$$4.980 = a5 + b \tag{2}$$

$$a = 0.996 \tag{3}$$

Can be used to calibrate for any inconsistencies in our voltage readings. In addition to these inconsistencies, some errors in our measured error values when compared to calculated values can come from uncertainty in the measuring device, as well as the manufacturing tolerances in the resistance values of the resistors. Now, the uncertainty due to manufacturing tolerance will propagate into both voltage and amperage readings due to resistance directly affecting both current flow and voltage drops. The Uncertainty due to measuring device error will not propagate into other values, but it will need to be taken into account when measuring the circuits. The uncertainty values for the meter used in lab were 0.05% for the voltage and 0.2% for the current. When measuring voltage the meter is placed in parallel with the circuit and has a very high internal resistance, which causes a very low error in voltage reading. When measuring current the meter is placed in series and has a very low resistance, causing only a small amount of uncertainty in measured values. Propagated uncertainty was found using the equations:

$$\Delta V = \sqrt{(\frac{\partial V}{\partial R} * \Delta R)^2} \tag{4}$$

$$\Delta I = \sqrt{(\frac{\partial I}{\partial R} * \Delta R)^2} \tag{5}$$

And those values are added to the uncertainty of the measuring device to find the total uncertainty.

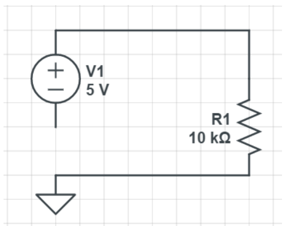


Figure 1: Diagram of circuit with one 10kΩ resistor

After setting up the circuit as sketched out above, voltage measurements were taken three different times, yielding the results:

- 4.980V
- -4.980V
- 4.995V

Switching the leads resulted in negative reading during second test. The "push" from the voltage is only in one direction, so when it's measured in the opposite direction it becomes a "pull", or negative voltage. All of these readings fell with in the total uncertainty value of 5(V)+/-0.2505(V). The meter was then hooked in series with the circuit and amperage was measured. Using Ohm's Law, the amperage value with uncertainty was calculated to be 0.498(A)+/-0.0260(mA). The actual measured values were:

- 0.4960mA
- 0.4996mA
- 0.4974mA

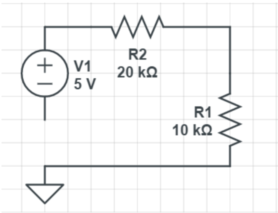


Figure 2: Diagram of circuit with 10kΩ and 20kΩ resistors wired in series

Leaving the meter in series, the above circuit was then constructed and current was measured. The addition of the second resistor added more uncertainty to the circuit, and the calculated current value with uncertainty was calculated at 0.166mA+/-0.00866mA, and the measurements were:

- 0.1677mA
- 0.1677mA
- 0.1690mA

The meter was then removed from the circuit and voltage across each resistor was measured. The calculated values across the 20kΩ resistor including uncertainty were 3.32V+/-0.167V. The measurements were:

- 3.332V
- 3.332V
- 3.329V

And the calculated voltage across the 10kΩ resistor including uncertainty was found to be 1.67V+/-0.0835V. The measurements were:

- 1.680V
- 1.681V
- 1.678V

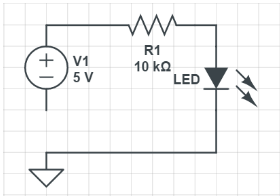


Figure 3: Diagram of 10kΩ resistor and LED wired in series

The above circuit was then constructed and Matlab was used to flash LED. Voltage values were taken over the resistor, but were not recorded due to having no information on the LED to compare to.

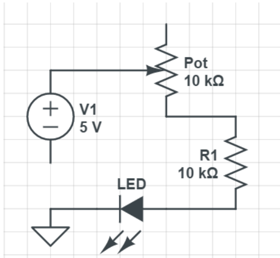


Figure 4: Diagram of 10kΩ resistor, potentiometer, and LED wired in series

Finally, the above circuit was constructed and the potentiometer was used to control the LED. Again voltage measurements were taken across the resistor, but were not recorded due to having no information on the LED or potentiometer to compare to.

5 References

CALTEST Instruments LTD, 4 1/2 and 3 1/2 DIGITAL MULTIMETER, accessed 10/10/22
⟨ https://www.caltest.co.uk/wp-content/uploads/2018/05/GDM-81458135-1.pdf ⟩