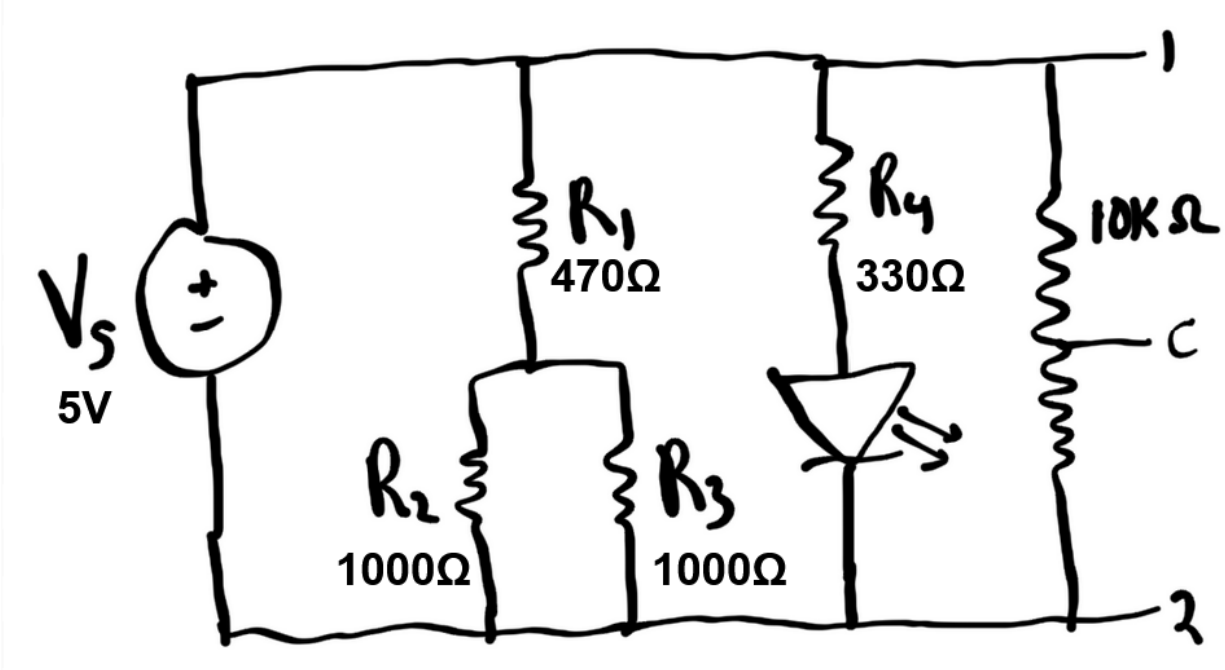
Julia Frothingham
PHY 240

LAB 1 - Intro to building circuits and making measurements - DC CIrcuits

Part ONE - Building resistive circuits, measuring voltage and current

The given circuit (Figure 1) consisted of a 5 volt power supply and four resistors in combination with an LED and a trimpot.

Figure 1. Provided circuit diagram.



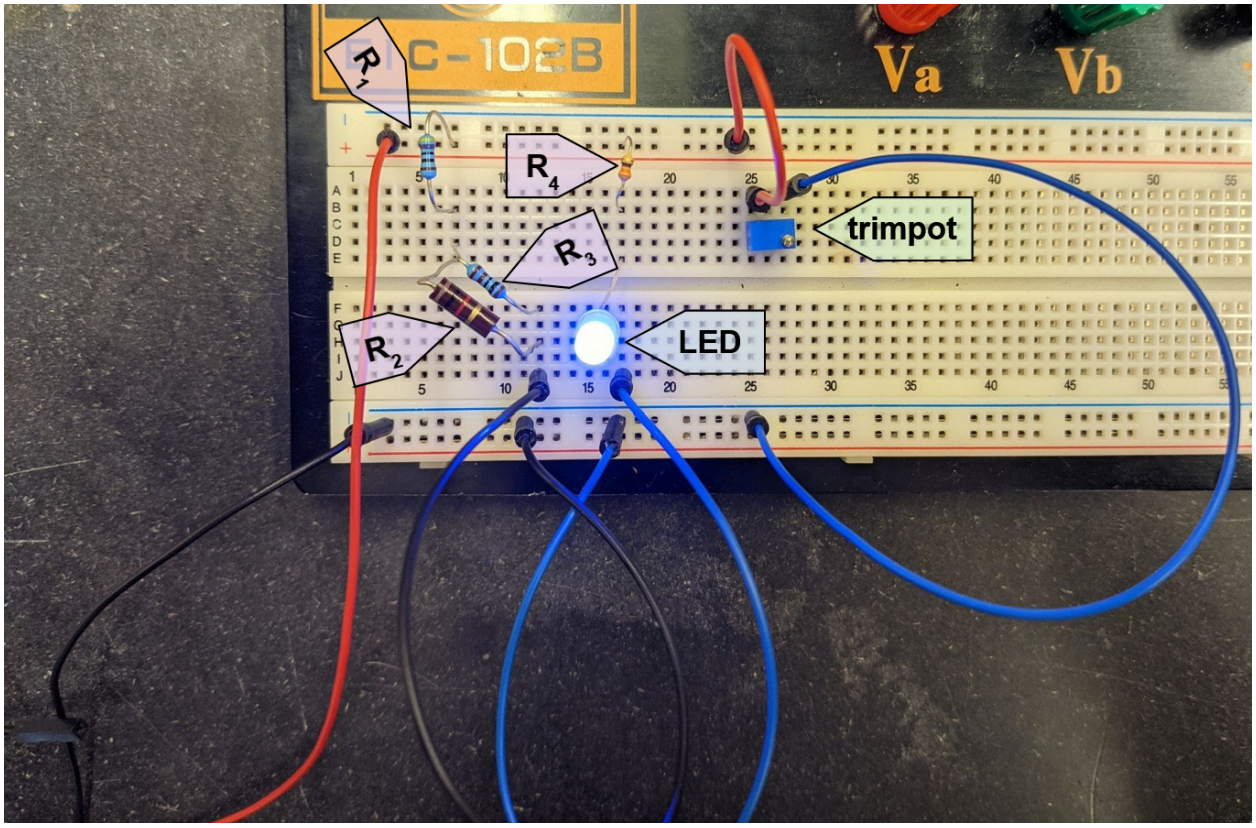
The actual resistances of the resistors were measured using a Digital MultiMeter (DMM) before the circuit was constructed. All measured resistances were within tolerance for the respective resistors, evaluated using the equation:

$$\%\, difference \;=\; 100 \times \frac{measured\ resistance - ideal\ resistance}{ideal\ resistance}$$

Figure 2. Table of ideal and actual resistances.

Label in circuit diagram	Ideal resistance (Ω)	Tolerance (%)	Measured resistance (Ω)	% difference (%)	Within tolerance?
R_1	470	±1	468	-0.43	Yes
R_2	1000	±5	1015	+1.5	Yes
R_3	1000	±1	995	-0.50	Yes
R_4	330	±5	324	-1.8	Yes

Figure 3. The circuit constructed on a protoboard.



The voltages across the power supply, the LED, and each resistor were measured using the DMM. To measure voltage, the DMM was set to measure voltages up to 20V DC, with its red probe connected to the port labeled with “VΩ” and its black probe connected to the port labeled “COM.”

Figure 4. DMM settings used to measure voltages in the circuit.

Figure 5. Measuring the voltage across resistor R_4 with the DMM.

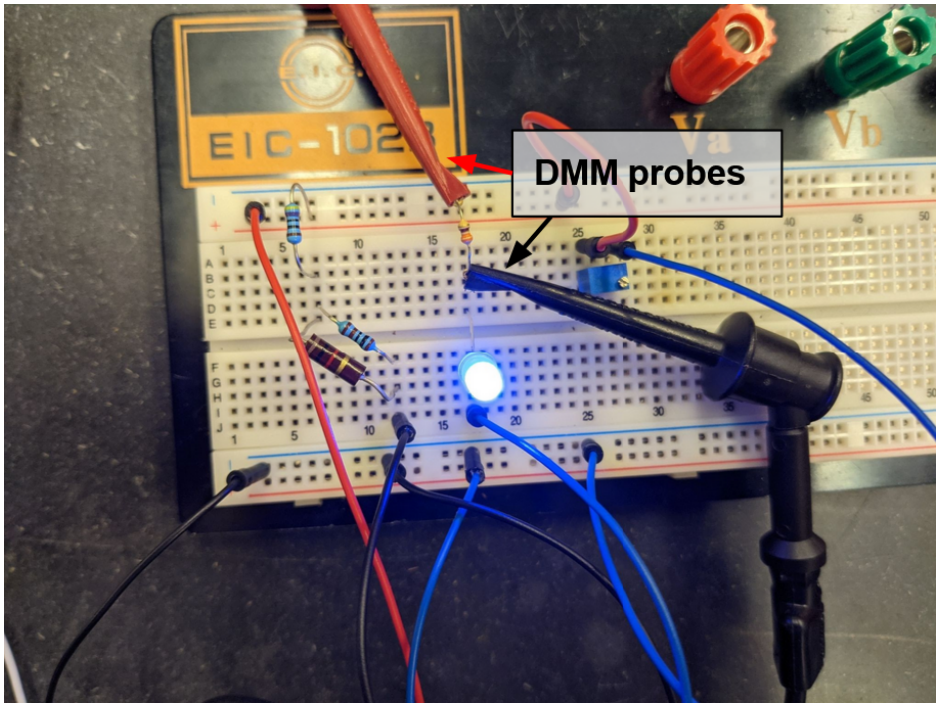


Figure 6. Voltages across various circuit components. Measured with the DMM.

Component	**Measured voltage (V)**
Power supply	4.99
R_1	2.41
R_2	2.58
R_3	2.58
R_4	2.11
LED	2.88

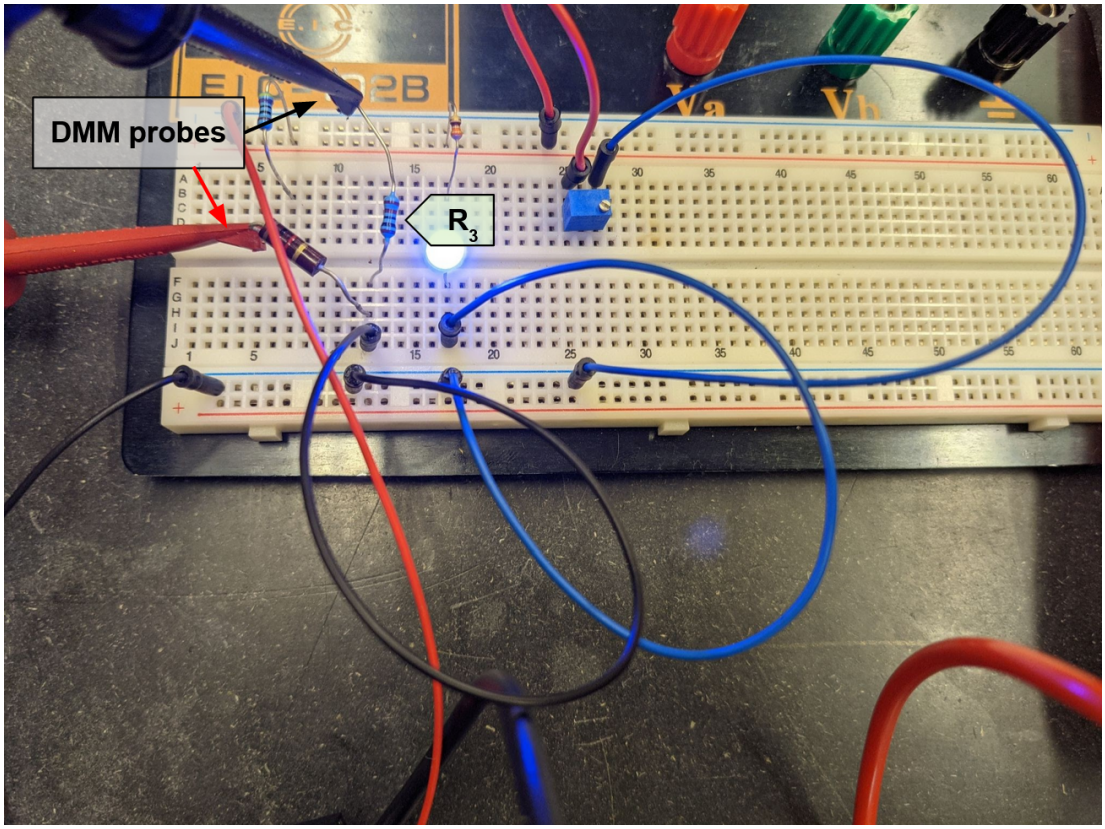
The sum of voltages across R_1 and R_2, the sum of voltages across R_1 and R_3, and the sum of voltages across R_3 and the LED are all equal to 4.99V, the voltage across the power supply. This is expected based on the circuit diagram and Kirchoff's Voltage Law.

The voltages across the trimpot terminals 1 and C as well as across the trimpot terminals 2 and C were measured using channels one and two of the ADALM2000 as the potentiometer knob was turned. A video of both voltages over time displayed in Scopy is available here: https://youtu.be/yDQFz4Ebw08

The sum of voltages across terminals 1 and C and across terminals 2 and C also equaled approximately 4.99V. As the voltage across one set of terminals increased, the voltage across the other set of terminals decreased to maintain that relation.

The current through resistor R_3 was measured as 2.6 mA using the DMM. To measure current through a component, the circuit must be broken at that component and the probes of the DMM attached to close the gap created by the break. One lead of the component should be removed from the circuit and attached to a DMM probe. The other DMM probe should be connected to the point in the circuit where the component's lead was removed.

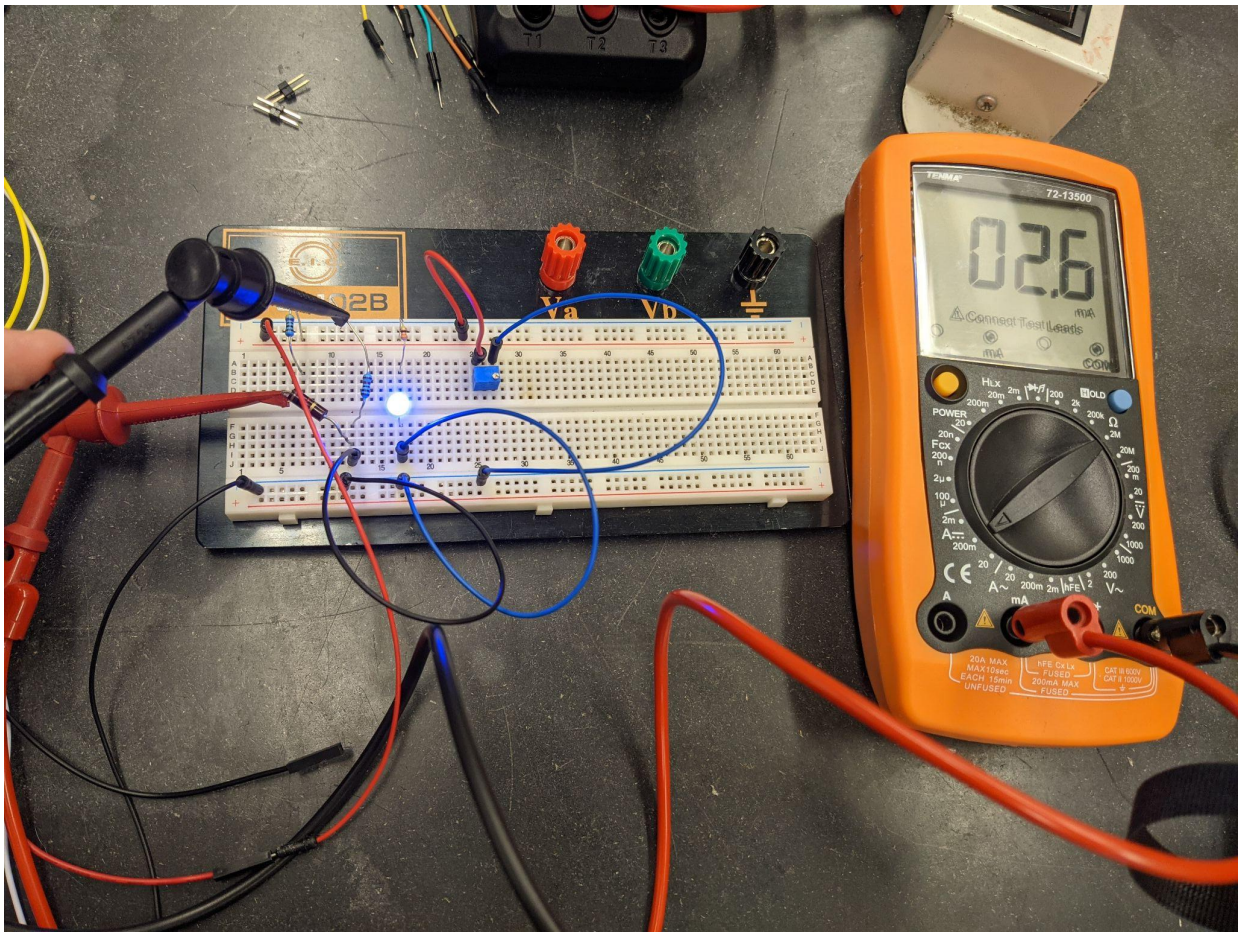
Figure 7. Measuring the current through resistor R_3 using the DMM.



Measuring current instead of voltage with the DMM also requires different settings. To measure current, the DMM was set to measure currents up to 200mA DC, with its red probe connected to the port labeled with "mA" and its black probe connected to the port labeled "COM."

Figure 8. DMM settings used to measure current through resistor R_3.

Figure 9. The measured current through resistor R_3 was 2.6mA.



Part TWO - how does the resistance meter work?

A DMM and LCR measure resistance by supplying a current through the component being measured. The voltage across the component is measured, and the relation $V = IR$ described by Ohm's Model is used to determine the resistance from the known current and measured voltage. If this is the case, then it should be possible to measure a nonzero voltage across the resistor while the DMM or LCR is in use.

Channel two of the ADALM2000 was used to measure the voltage across resistor R_2 while the DMM was completing a resistance measurement. It showed a nonzero voltage, which supports the idea that a supplied current and measured voltage are how the DMM can determine resistance.

Figure 10. Measuring voltage across resistor R_2 using the ADALM2000 while simultaneously measuring its resistance using the DMM.

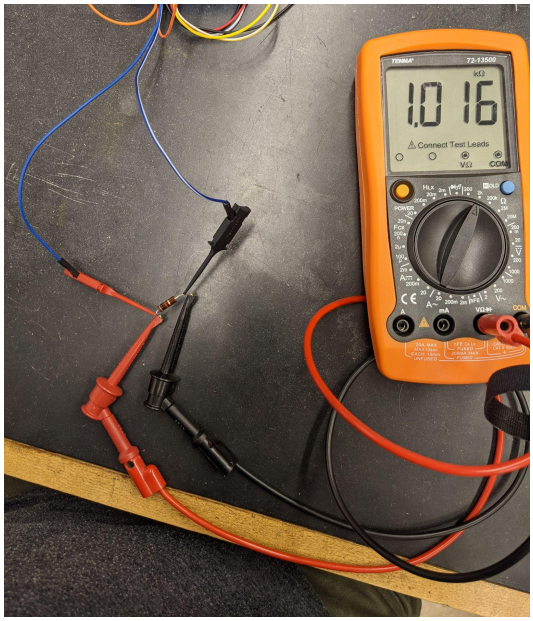
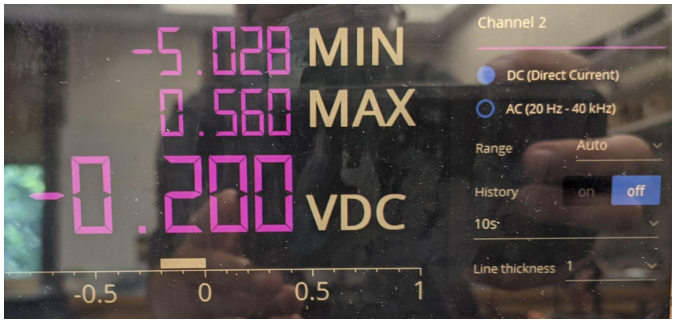


Figure 11. Measured voltage across resistor R_2 during DMM resistance measurement, displayed in Scopy.



As a check, the voltage across the resistor when the DMM was not in use was also measured using channel two of the ADALM2000. Since no current was being supplied, the expected voltage across the resistor was 0V. The measured voltage matched this expected value. Since the baseline voltage across the resistor is 0V, a measurable, nonzero voltage across the resistor during a resistance measurement indicates a change in the current through the resistor happens during the resistance measurement.

Figure 12. Measuring voltage across resistor R_2 using the ADALM2000.

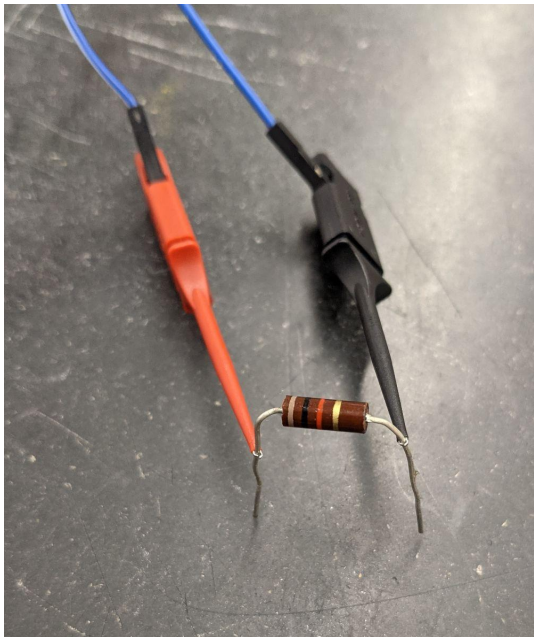
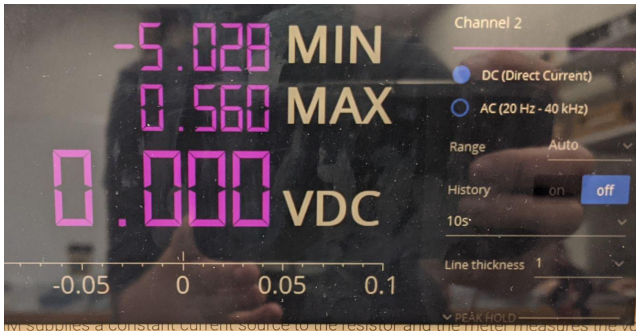


Figure 13. Measured voltage across resistor R_2, displayed in Scopy.



The DMM supplies direct current, while the LCR supplies alternating current. So the measured voltage across a resistor during a DMM resistance measurement is constant, while the measured voltage across an LCR measurement varies. Using channel two of the ADALM2000, the voltage across the resistor was measured during an LCR measurement and displayed in Scopy. A video of those displayed voltages is available here: https://youtu.be/q_3GpD3WSRM