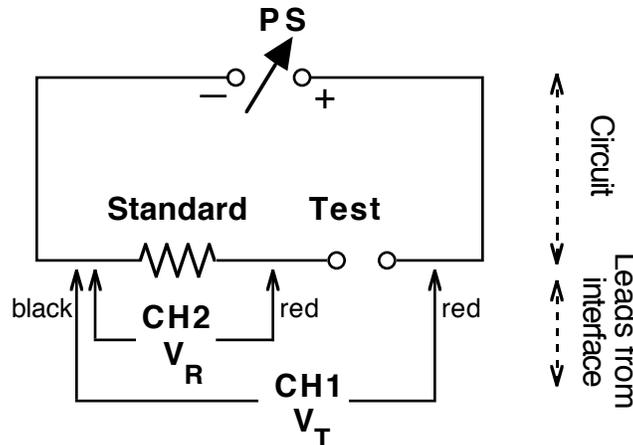# OHM'S LAW IN ACTION - EasyData

When a voltage is applied to a complete circuit current begins to flow. In electrical circuits, the function of a resistor generally is to limit the flow of that current. When current flows through a resistor, energy is converted from electrical energy into heat energy, and a potential difference or voltage appears across the leads of the resistor. The voltage across your sample will be studied as a function of the current flow in the circuit.

Ohm's Law describes the relationship between three important electrical quantities: **I** the current; **V** the potential difference; and **R** the resistance. **I = V/R**, Ohm's Law, holds for a wide range of electrical devices and electrical phenomena.

In this lab, you will vary the amount of voltage being applied to two devices in series, one a "standard" value resistance and the second your "test" sample. We calculate the current by dividing the voltage across the standard, V_R, by the resistance of the standard, **R**.

A second calculation must be made for the voltage across the test sample. In the diagram, the Voltage Probe in CH1 measures the total voltage while the one in CH2 measures the voltage across the standard. By subtracting the second voltage from the first, you determine the voltage across the standard, $V_T - V_R = V_{SAMP}$

PURPOSE
- Observe Ohm's Law in a dynamic situation
- Compare the behavior of different electronic devices

MATERIALS

Variable DC Power Supply (0-10 volts)	Graphing Calculator w/EasyData software
Clip Leads	Voltage Probes (2)
Vernier Interface	Resistors, Diode, LED's

PREPARE FOR DATA COLLECTION

1. Set up the circuit shown in the diagram using 1000 Ω as the standard resistance and 470 Ω as the test sample, but don't turn the power supply on, yet. Before you turn the power supply on, turn the voltage control knob to its lowest setting.
2. During the collection of data, you will adjust the power supply control knob from its lowest value to highest then back once during the 10 seconds. Practice moving the knob smoothly during this collection time.

PROCEDURE:

1. Connect the two Voltage Probes to Channel 1 (CH1) and Channel 2 (CH2) on the interface. Then connect the probes to the circuit, being careful to have the two black leads connected to the same point. Connect the interface to the calculator and launch *EasyData*.
2. Press the button under [File] and choose **New**. This forces EasyData to look for sensors that are connected and to set up a fresh group of settings. Press the button under [Setup] and follow these steps to prepare for data collection:
    • Choose **Time Graph...**, then press the button under [Edit] to change the default values.
    • Set the Sample Interval to 0.1 sec and press [Next], then the number of samples to 100 and press [Next]. After the setup is shown to you and it is correct, press the button under [OK].
3. Press the button under [Start] to begin data collection. Rotate the knob on the potentiometer fully clockwise then return it fully counter-clockwise during the 10 second data collection time.
4. The result should be two graph lines, very similar in shape, going upward to a peak then dropping back to almost zero. One was the total voltage while the other was the voltage across the resistor.
5. Go back to the main menu by pressing the button under [Main]. Press the button under [Quit] and note the columns where the voltages are stored.

CALCULATING

1. Examine your data by pressing the [STAT] button, then [ENTER]. You will note the three columns with Time, V1 and V2 data. [2ND] [QUIT] will get you out of this mode.

2. Voltage on the test sample (V_{SAMP}): Subtract the voltage on the resistor (V_R = CH2 = L3) from the total voltage (V_T = CH1 = L2).
    • On the home screen of the calculator, press this sequence:
      [2ND] [2] [-] [2ND] [3] [STO] [2ND] [4] [ENTER]
      This has the effect of subtracting each of the values in L3 (V_R) from each of the values in L2 (V_T) and storing them in L4 (V_{SAMP}).

3. Current in the circuit, I: Divide the voltage across the resistor (V_R) by the size of the resistance, R.
    • On the home screen of the calculator, press this sequence:
      [2ND] [3] [/] [resistance] [STO] [2ND] [5] [ENTER]
      This has the effect of dividing each of the values in L3 (V_R) by the resistance value, giving you the current and storing it in L5 (I).

ANALYSIS

1. Set up the calculator to show the Sample Voltage vs. Current graph:
    *   Press [2ND] [STAT PLOT]. With plot #1 highlighted, press [ENTER]. Make sure On is toggled by pressing [ENTER] when it is highlighted. It will blink thereafter.
    *   Arrow down to Xlist: and press [2ND] [5] to set the y-axis to L5, the current.
    *   Arrow down to Ylist: and press [2ND] [4] to set the y-axis to L4, the test sample voltage.
    *   Press [GRAPH], then [ZOOM] [9].

2. Describe the graph in general. What is happening to the voltage on the sample as the current flow increases? What kind of relationship exists between these two values? Does this support Ohm's Law, $I = V/R$?

3. Press [STAT] to enter the statistical calculations. Right-arrow to CALC., then down-arrow to LinReg (ax+b), the linear regression. After pressing [ENTER], add [2ND] [5] [,] [2ND] [4] to get the calculator to look specifically at your V_{SAMP} vs. Current data. Press [ENTER] to begin the analysis.

4. When the results are returned, note the values for a (slope) and b (intercept). Do either of these have a relationship to the sample resistance?

REPEAT

5. Repeat the steps in the procedure above but use a different resistor as your sample. Compare the results you obtained this run with those from the first run.

6. In general, the resistors you used are referred to as being "ohmic" which means they obey Ohm's Law. How well did your resistors obey this relationship?

NEW DEVICE

7. Obtain a diode and insert it for your test sample, using the series resistor recommended in the table below. Repeat the procedure steps 1 to 5 in the procedure above. If you get one graph that is essentially zero, it may be due to the diode being turned so it is not conductive. Repeat the procedure but turn the diode in the opposite direction.

8. Once you get two non-zero graphs, go on to CALCULATING steps 1 to 3 and ANALYSIS steps 1 and 2, sketching the graph and discussing its meaning.

9. As you were giving the diode higher and higher voltage (going up the y-axis), how did the diode respond as far as allowing current to flow? At what voltage did the diode "turn on"? A germanium diode has a "knee voltage" approximately 0.3 volt while a silicon diode has a knee voltage approximately 0.45 volt. What type of diode do you think you have?

ANOTHER DEVICE

10. Repeat steps 8-9 above using an LED, light emitting diode. What is the turn-on or knee voltage for your LED? What color was it? If you used a different color LED, is the knee voltage higher or lower than the previous one?

11. Is there a pattern between knee voltage and color? Colors near the blue end of the spectrum have shorter wavelengths and higher frequencies than colors toward the red end of the spectrum. From your work above, is energy of light more likely proportional to the wavelength or to the frequency?

SETTINGS

Sample	Standard Resistance
470 Ω Resistor	1000 Ω
2,200 Ω Resistor	1000 Ω
Diode - 1N4002	330 Ω
LED	330 Ω

DATA TABLE

	trial	Test Sample	Standard Resistance	Slope of V vs. I Graph
units				
	1			
	2			
	3			
	4			
	5			
	6			

REFERENCE

Black	0		
Brown	1		
Red	2		
Orange	3		
Yellow	4		
Green	5	**1st Digit** **2nd Digit** **# of Zeroes** **Tolerance ±%**	**Fourth Band**
Blue	6		
Violet	7		None ±20%
Gray	8		Silver ±10%
White	9		Gold ±5%
			Red ±2%
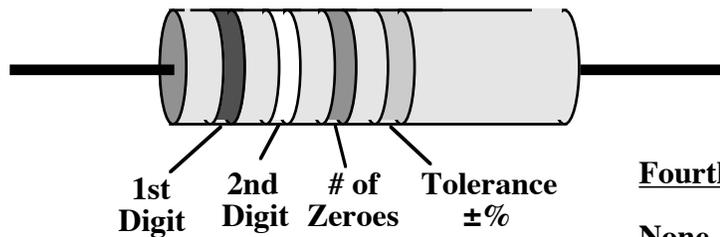
C. Bakken
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