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Useful Circuits ~~Lab Title~~

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PES 215 Report

Lab Station:

Objective

The goal of this lab was to continue our experience with circuits and lab equipment. This lab also introduced us to two very practical circuits: The Voltage Divider and The Wheatstone Bridge.

Data and Calculations

Part A – The Voltage Divider:

Part A.1 – The Workings of a Voltage Divider:

For this part of the lab, we set up the following circuit:

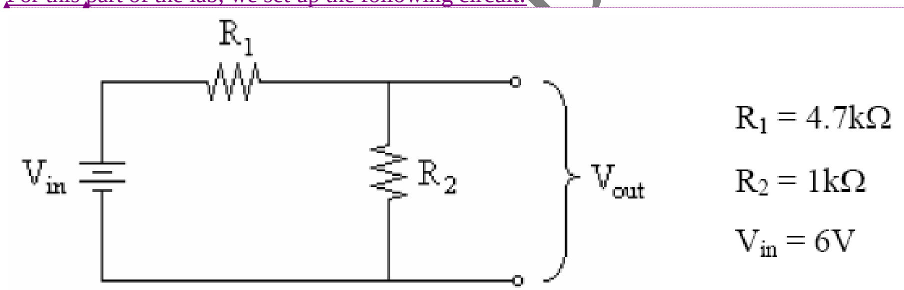

Figure 1: Setup for Part A of Useful Circuits Lab

We used the provided circuit board and put a resistance substitution box in component #1 (for resistor 1) and a 1 kiloohm resistor in component #2 (for resistor 2). Using the Digital Multi-meter set up as a voltmeter, we measured the potential drop across the 1 kiloohm resister to get the output potential.

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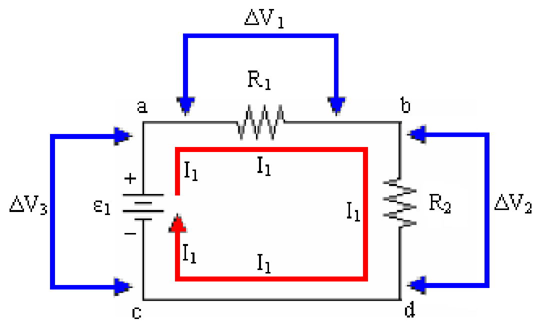

Figure 2: Circuit Diagram for Part A of Useful Circuits Lab

From the pre-lab for this lab, using Kirchhoff's Laws, we found the following for the definition of the current:

$$I_1 = \frac{\varepsilon}{(R_1 + R_2)}$$

Then using Ohm's Law, we calculated the potential drop across resistor 2 to be:

$$\Delta V_2 = -\left(\frac{\varepsilon}{(R_1 + R_2)}\right)R_2 = \frac{-\varepsilon R_2}{R_1 + R_2}$$

We built the above circuit with the following values for the EMF and the resistors:

Theoretical Voltage Supplied (EMF) [V]	Theoretical Value of Resistor 1 [Ω]	Theoretical Value of Resistor 2 [Ω]
6.0 V	4.7 kΩ	1 kΩ

We measured the actual value of the EMF and the resistors using the DMM and got the following results:

DMM Measured Voltage Supplied (EMF) [V]	DMM Measured Value of Resistor 1 [Ω]	DMM Measured Value of Resistor 2 [Ω]
6.0	4.7 kΩ	0.972 kΩ

Using both the Theoretical values and the DMM Measured values, we can calculate the potential drop across resistor 2:

$$\Delta V_{2,Theoretical} = -\left(\frac{6.0\ V}{(4.7\ k\Omega + 1k\Omega)}\right)1k\Omega = -1.053\ V$$

$$\Delta V_{2,Theoretical} = -1.053\ V$$

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$$\Delta V_{2,DMM\ Measured} = -\left(\frac{\varepsilon}{(R_1 + R_2)}\right)R_2 = ?\ V$$

We then measured the potential drop across resistor 2 using the DMM and found that value to be:

Potential Drop Across 1kΩ Resistor [V]
-1.052 V

<Compare the value for the measured potential drop across resistor 2 to BOTH the calculated delta-V using the theoretical components and the DMM measured components. Perhaps it would be appropriate to do a percent difference for the different values and see how they compare. (Chances are that the value calculated for delta-V across resistor 2 using the DMM measurements and the actual measured potential drop across resistor 2 will provide a better percent difference value.)>

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Part A.2 – Getting ½ the Input Potential out of a Voltage Divider:

As per the lecture at the beginning of class, we want delta-V-sub-2 to be exactly 1/2 of the EMF.

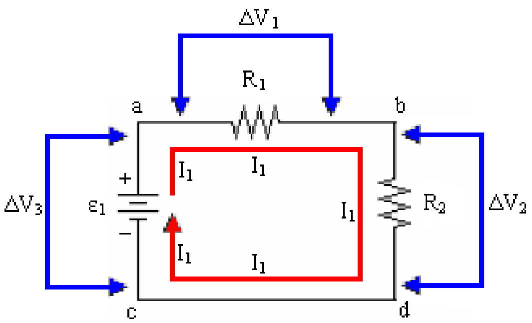
That is:

$$\Delta V_2 = \frac{R_2}{R_1 + R_2}(\varepsilon) = \frac{1}{2}\varepsilon$$

$$\frac{R_2}{R_1 + R_2} = \frac{1}{2}$$

$$2R_2 = R_1 + R_2$$

$R_2 = R_1$ **or** $R_1 = R_2$



We built the above circuit with the following values for the EMF and the resistors:

DMM Measured Value of Resistor 1 [Ω]	DMM Measured Value of Resistor 2 [Ω]
1 kΩ	0.972 kΩ

DMM Measured Voltage Supplied (EMF) [V]	Potential Drop Across 1kΩ Resistor [V]
6.0 V	2.9 V

Part A.3 – Getting 5V out of a 12V EMF using a Voltage Divider:

Again, as per the lecture at the beginning of class, we want delta-V-sub-2 to be exactly 5V, while the EMF is exactly 12V.

$$\Delta V_2 = \frac{R_2}{R_1 + R_2}(\varepsilon)$$

$$5\,V = \frac{R_2}{R_1 + R_2}(12\,V)$$

$$\frac{R_2}{R_1 + R_2} = \frac{5}{12}$$

$$12R_2 = 5R_1 + 5R_2$$

$$7R_2 = 5R_1$$

$R_1 = \frac{7}{5}R_2$ **or** $R_2 = \frac{5}{7}R_1$

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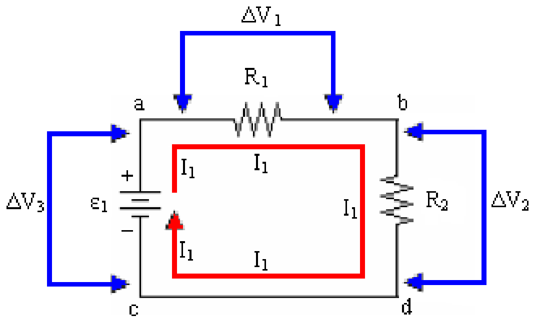

We built the above circuit with the following values for the EMF and the resistors:

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DMM Measured Value of Resistor 1 [Ω]	DMM Measured Value of Resistor 2 [Ω]
1.4 kΩ	0.972 kΩ

DMM Measured Voltage Supplied (EMF) [V]	Potential Drop Across 1kΩ Resistor [V]
12.0 V	4.8 V

<Explain the advantages and disadvantages of using a voltage divider.>

Part B – The Wheatstone Bridge:

For this part of the lab, we set up the following circuit:

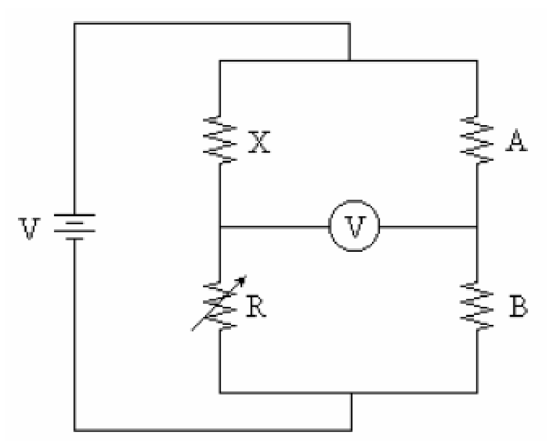

Figure 5: Circuit Diagram for Part B of Useful Circuits Lab

The intent of this part of the lab was to effectively build an Ohmeter. Before setting up the wheatstone bridge, we measured the actual resistance of the resistors in the circuit.

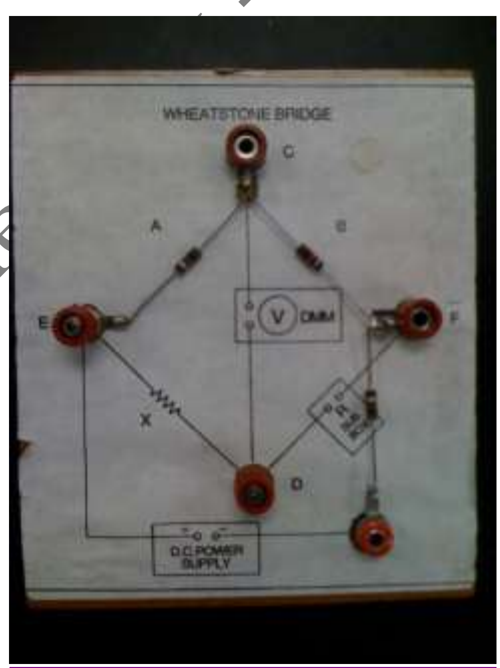

Figure 6: Circuit Board for Part B of Useful Circuits Lab

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DMM Measured Value of Resistor A [Ω]	DMM Measured Value of Resistor B [Ω]
96.3 Ω	9.39 kΩ

After, measuring the resistors on the board, the following image was how the circuit looked after being set up (using the copper coil as the unknown resistor:

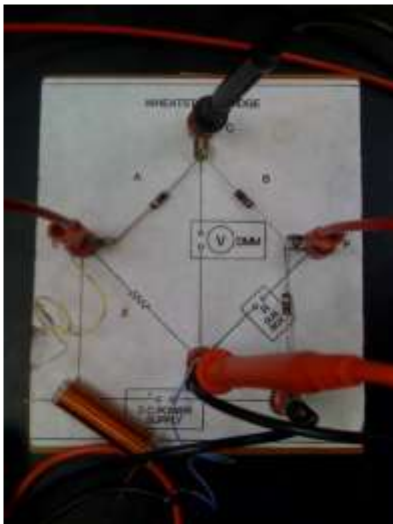

Figure 7: Setup for Part B of Useful Circuits Lab

The purpose of the wheatsone bridge was to adjust the resistance substitution box (varying the resistance) to balance the potential on either side of the bridge. This means that the potential read across points C and D should read zero. The following image shows how the entire circuit was set up once the balance occurred.

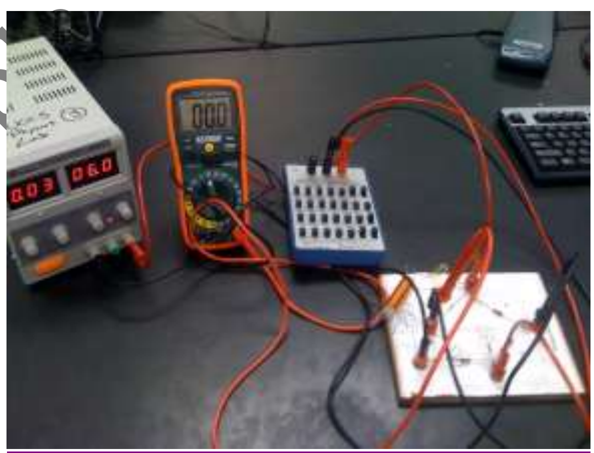

Figure 8: Measurement in Progress for Part B of Useful Circuits Lab

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We tested three unknowns in the X position of the bridge. Here are the results we obtained using the reading off the power supply and the resistance substitution box, the calculated resistance of resistor X and the measured resistance of the resistor using the DMM.

Part B.1 – Measuring the Resistance of an Unknown Resistor using a Wheatstone Bridge:

EMF [V]	Value of RSB [Ω]
6.0	65.70 kΩ

$$X = \frac{RA}{B} = \frac{(65.7\,k\Omega)(9.63\,\Omega)}{(9.39\,k\Omega)} = 673.8\,\Omega$$

Calculated Value of Resistor X [Ω]	DMM Measured Value of Resistor X [Ω]
673.8 Ω	674.0 Ω

Part B.2 – Measuring the Resistance of a Copper Coil using a Wheatstone Bridge:

EMF [V]	Value of RSB [Ω]
6.0	53.5 Ω

$$X = \frac{RA}{B} = \frac{(53.5\,\Omega)(9.63\,\Omega)}{(9.39\,k\Omega)} = 0.55\,\Omega$$

Calculated Value of Resistor X [Ω]	DMM Measured Value of Resistor X [Ω]
0.55 Ω	1.0 Ω

Part B.3 – Measuring the Resistance of a Known Resistor using a Wheatstone Bridge:

EMF [V]	Value of RSB [Ω]
6.0	94.70 kΩ

$$X = \frac{RA}{B} = \frac{(94.7\,k\Omega)(9.63\,\Omega)}{(9.39\,k\Omega)} = 971.2\,\Omega$$

Calculated Value of Resistor X [Ω]	DMM Measured Value of Resistor X [Ω]
971.2 Ω	972.0 Ω

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Conclusion:

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** NOTE: There are several components of error which could significantly modify the results of this experiment. Some of these are listed below:

- Heat
- Age
- Humidity
- Short circuit
- Fuse
- Bad power supply (recall we used the DMM to attempt to alleviate this problem.)
- Bad connections (in protoboard)
- Insulation
- Length of wire and Gauge accuracy of wire (copper)
- Bad power supply (recall we used the DMM to attempt to alleviate this problem.)
- Buckling, bending, etc… of wire
- Elemental components/material makeup of the wire
- ??

It is recommended that you take these and explain the ***"why"*** part of each for your results and conclusions sections – and possibly what could have been done (if anything) to minimize the effects of these errors.