Laboratory 3

Resistor Combinations, KCL, KVL, Voltage and Current Dividers, and Wheatstone Bridge

Objectives

- Verify KCL and KVL
- Measure the equivalent resistance of a resistive circuit
- Measure the branch currents and node voltages
- Use the Wheatstone bridge circuit to directly measure resistance

Equipment and components

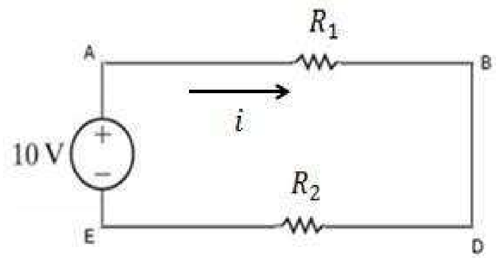
- 2x Multimeter for each team
- Power supply
- One Breadboard
- variable resistor:10 kΩ
- Fixed Resistors 100 Ω, 270 Ω, 470 Ω, 680 Ω, 1k Ω, 2.2 k Ω, 3.3k Ω, 5.6k Ω, 10k Ω, 100k Ω, 4.7M Ω, 10M Ω.
- Cables and wires as needed

Preliminary Work

1. **Read** "Electrical Measurements" uploaded in the catcourses (see folder "Labs/")
2. **Read** Chapter 2 of the textbook.
3. **Complete the theoretical calculations and fill out the tables in this document before the lab.**

Lab Procedure

1. Select $R_1 = 470\ \Omega$, $R_2 = 100\ \Omega$, and $R_3 = 100\ k\Omega$. Construct the circuit shown below and measure the indicated quantities given in the table below.



Variable	Theoretic Calculation*	Measured Value
v_{AE}	10V	10.04 V
v_{AB}	8.246 V	8.28 V
v_{BD}	0V	3.6 mV
v_{DE}	1.754 V	1.768 V
i	0.0175 A	0.01448 A

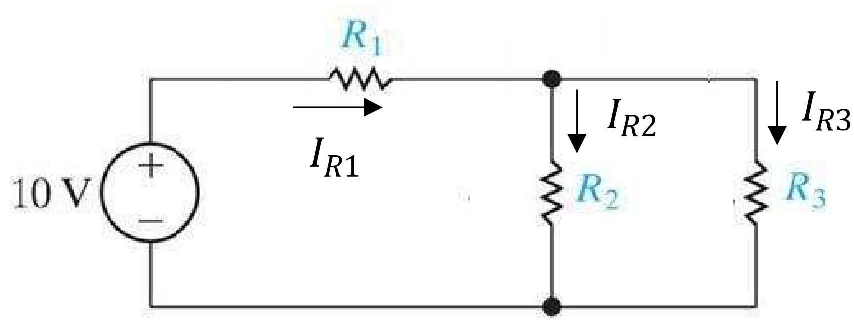
Note: voltage v_{XY} represents the voltage drop between point X and point Y. To measure v_{XY}, the red lead of the DMM (Digital Multimeter) should be at point X and the black lead at point Y of the circuit. For example, to measure v_{AE}, the red lead of the DMM should be at point A and the black lead at point E of the circuit.)

a. What is the sum of v_{AB}, v_{BD} and v_{DE} ? Sum = 10 V. Explain why.

According to the summation law within circuit theory, the measured individual voltage segment of a circuit is the total voltage within each resistor of the circuit within a series.

b. Can you explain the value of v_{BD}?

c. Consider the circuit shown below. The currents I_{R1}, I_{R2} and I_{R3} denote the currents flowing in each resistor (you are free to select the reference direction for the currents). Measure I_{R1}, I_{R2} and I_{R3}. Are they different from your theoretical calculations? Explain why.



	Theoretic Calculation*	Measured Value
I_{R1}	0.0175 A	0.01342 A

I_{R2}	0.0175A	0.01349 A
I_{R3}	0.0000175 A	0.0000176 A

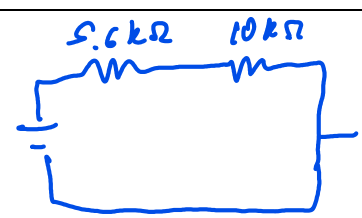
2. Select $R_1 = 470\ \Omega$, $R_2 = 680\ \Omega$, $and\ R_3 = 1\ k\Omega$. Repeat step 1 and note down the obtained results.

Variable	**Theoretic Calculation***	Measured Value
v_{AE}	10V	10.05 V
v_{AB}	4.087 V	4.10 V
v_{BD}	0V	2.7 mV
v_{DE}	5.913 V	5.95 V
i	0.0869A	0.0719 A

	Theoretic Calculation*	**Measured Value**
I_{R1}	0.0114 A	0.00941 A
I_{R2}	0.00680 A	0.00559 A
I_{R3}	0.00463 A	0.00383 A

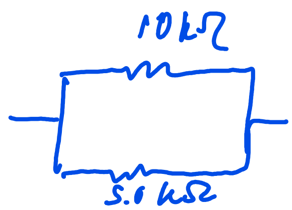
3. A) Connect the $5.6\ k\Omega$ and the $10\ k\Omega$ resistors in series on the breadboard and measure the equivalent resistance of the combination. Show circuit schematic diagrams and your calculations in your report.

Circuit Schematic (Series)



Theoretical equivalent resistance* =	15600 Ohm
Measured equivalent resistance	A = 627 uA, V = 10.04 V, R = 16012 Measured: 15.47 kOhm

B) Connect the two resistors in a parallel connection on the breadboard. Measure the equivalent resistance. Show circuit schematic diagrams and your calculations in your report.

Circuit Schematic (Series)	
Theoretical equivalent resistance* =	3590 Ohm
Measured equivalent resistance	V = 10.03 V, A = 3.35 mA, R = 4272 Measured: 3.553 kOhm

Are the values what you expected?

The measured values is 3.553 kOhm; the measurement we got from using the formula R = V/I the computed value from the measured data with voltage as 10.03 and ampere as 3.35 mA, the value recieved is 3.390 which is very close to the theoretical value, confirming the result.

4. A) Measure the resistance of the $10\ M\Omega$ resistor by connecting the test leads of a multimeter to the resistor leads.

   R= 9.92 mOhm

   B) Next, hold the two leads of the resistor and the test leads of the multimeter together with your hands and then measure the resistance. Compare the two readings. Are they different? Why?

R= 306.7 kOhm

C) Measure the hand-to-hand resistance of each lab partner by firmly gripping the test leads of the multimeter.

R= 306.7 kOhm , 366 kOhm , 132.5 kOhm

What are the implications with respect to making accurate measurements of high resistance resistors and circuits?

5. A) Pick three resistors rated at 2.2kΩ, 3.3kΩ, and 5.6kΩ. Use them to construct a Wheatstone bridge circuit with a variable resistor (potentiometer), rated at 10kΩ on the breadboard. The Wheatstone bridge circuit is shown below, with
   - $R_1 = 3.3k\Omega$,
   - $R_2 = 2.2k\Omega$, and
   - $R_x = 5.6k\Omega$.

   The resistance value of R_x is what you are supposed to find.

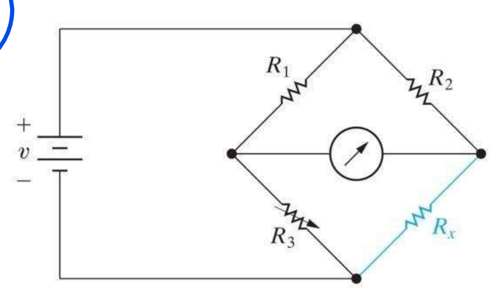
   B) Adjust the variable resistor until the ammeter (your multimeter is set as an ammeter) shown in the circuit below reaches zero. Record the resistance value of the **variable resistor** (8.28 kOhm)

   C) Calculate the resistance of R_x by using the following formula,

$$R_x = \frac{R_2}{R_1} R_3 = \text{8.4 kOhm}$$

6. Compare and discuss the measured and rated value of the resistor R_x. Show circuit diagrams and your calculations.

$R_x = \frac{3.3(5.6)}{2.2}$



Questions and conclusions

- Use tables and graphs to explain your results.
- Summarize your findings and explanations in response to the questions posed in this lab.

As per the instruction and objective of this lab, we have constructed three different circuits, for the sole purpose of honing our measuring and circuit composition skills. The goal is to find specific voltage that is running into between each segment - then, by using the resistance formula to find the total resistance of the circuit which will be compared to the computational data that we have derived within the prelab partition of the lab. Furthermore, the lab also requires use to compute the current that is running through each resistor by using the Kirchoff's current formula which is also compared to the computed measured current values from the circuit. Lastly, the final section consists of finding a variable resistor in the case that three other resistors are given - first, we need to construct the circuit, break the circuit to measure each individual resistor, then apply the formula, $R_X = (R_2/R_1)R_3$ this value will be compared to the computed value which we have derived using the formula and given resistors.