Spring 2023

EEE/ETE 141L

Electrical Circuits-I Lab(Sec-19)

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Instructor: Md. Rabiul Karim Khan

**Lab Report 01: Ohm's Law, KVL, and Voltage Divider Rule using Series Circuit**

| | |
|---|---|
| | **<u>Group no. :</u>** |
| Date of Performance : | 1.<br>2. |
| Date of Submission : | 3.<br>4.<br>5. |

## Experiments-I Name : Verification of Ohm's Law.

### Objectives :

- Find the resistance of a resistor from its colour code.
- Measure voltage, current and resistance values using a digital multimeter.
- Verify the validity of Ohm's Law.
- Test the voltage divider rule in a series circuit.

### Apparatus :

- Breadboard
- Resistors (3.3 KΩ, 5.6 KΩ)
- Digital Multimeter (DMM)
- Digital Power Supply
- Wires.

### PRECAUTION

To avoid damage to the DMM:

- Keep it switched off while not in use.
- Before connecting the DMM, the measurement mode must be selected, and its meter range should be placed to its highest value.
- The red probe must connect to the correct terminal.

Circuit Diagram:

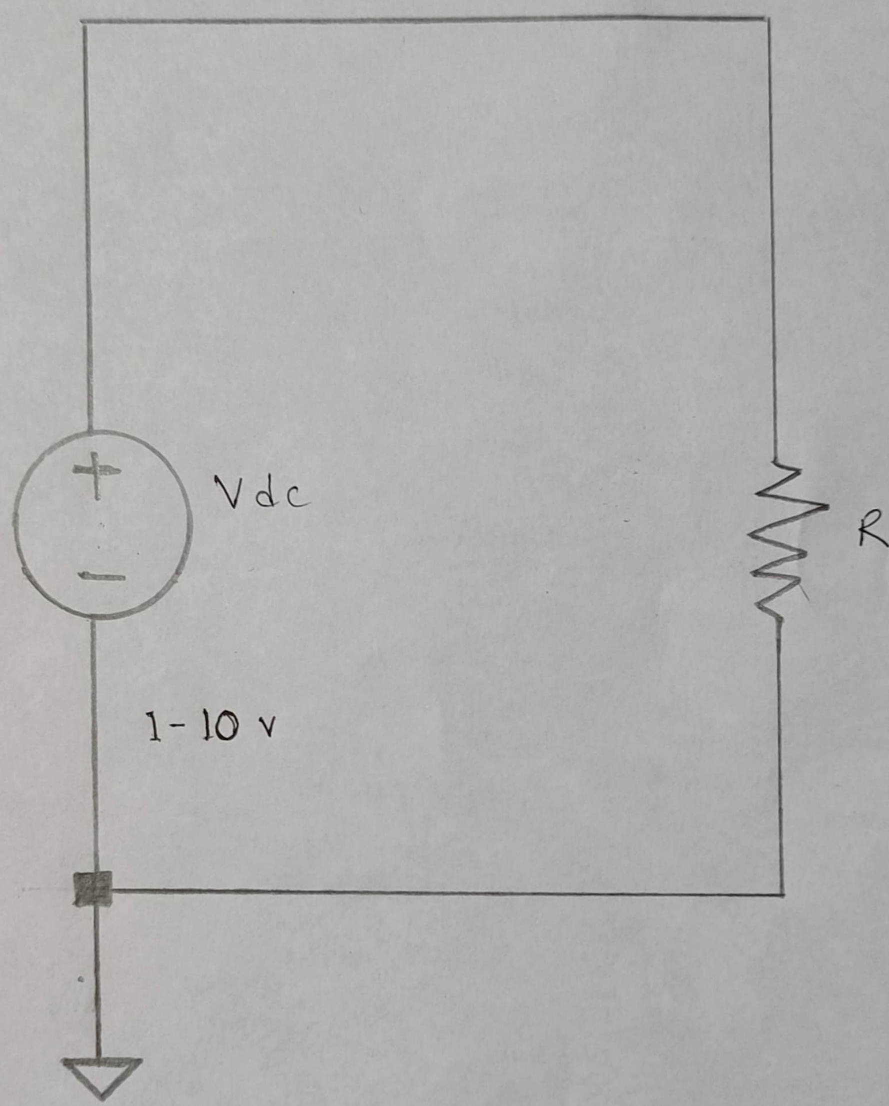


Table 1:

| Resistance using colour coding | | | | | KΩ Resistance using DMM | % Error |
|---|---|---|---|---|---|---|
| Band 1 | Band 2 | Band 3 | Band 4 | Resistance ± tol KΩ | | |
| Orange (3) | Orange (3) | Red (2) | Gold (±5%) | 3.135 — 3.465 | 3.24 | 1.82 |
| Green (5) | Blue (6) | Red (2) | Gold (±5%) | 5.32 — 5.88 | 5.49 | 1.96 |

Table 2:

| 3.3 KΩ Voltage | Experimental readings | | |
|---|---|---|---|
| | Current I | Voltage IR | Power, $I^2R$ |
| 2 1.95 | 0.62 | 2.046 | 1.269 |
| 4 4.01 | 1.24 | 4.092 | 5.074 |
| 6 6.02 | 1.85 | 6.105 | 11.294 |
| 8 7.95 | 2.48 | 8.184 | 20.296 |
| 10 10.00 | 3.10 | 10.23 | 31.713 |

Table 3

| 5.6 KΩ Voltage | Experimental readings | | |
|---|---|---|---|
| | Current $I$ | Voltage $IR$ | Power $I^2R$ |
| 2 1.97 | 0.36 | 2.016 | 0.726 |
| 4 4.02 | 0.72 | 4.032 | 2.903 |
| 6 5.94 | 1.09 | 6.104 | 6.653 |
| 8 7.96 | 1.46 | 8.176 | 11.936 |
| 10 10.02 | 1.82 | 10.192 | 18.549 |

## Graph :

Attached.

## Result Analysis :

From this experiment, we learn about the colour code of resistors. And it's matching with the assigned resistance of this resistor. From the graph, we found a straight line, and it's continuously increasing. That means the larger the voltage applied, the bigger the current becomes. Ohm's Law also declares that. In short, our experiment completely follows Ohm's Law.

## Questions and Answers :

01. Ohm's Law : Ohm's law states that electrical current in a resistive circuit is directly proportional to the applied voltage and inversely proportional to its resistance, provided all physical conditions and temperatures remain constant.

$$I = \frac{V}{R} \text{ in amperes (A)}$$

Where, V is the applied voltage in volts (V).

R is the resistance in ohms ($\Omega$).

I is the current in amperes (A).

The larger the applied voltage is, the larger the current becomes. The Larger the resistance is, the smaller the current becomes.

02. Graph Attached.

03. Yes, our experiment circuit follows ohm's Law. ~~According~~ to Ohm's Law, The larger the applied voltage, the larger the current From the graph V vs I, we found an increasing straight line. Whenever we increase the voltage in our circuit, the current also increases. From the graph, we can say our experiment completely follows Ohm's Law.

04. From the graph of $R_1$.

point - 1 : (4.5, 1.4)
point - 2 : (5.45, 1.7)

$\therefore$ Slope, $m_1 = \frac{1.7 - 1.4}{5.45 - 4.5} = \frac{6}{19}$

$\therefore$ inverse of Slope,

$$m_1^{-1} = r_1 = \frac{19}{6} = 3.17\,k\Omega$$

From DMM,

$$R_1 = 3.24\,k\Omega$$

$$\therefore \text{Error} = \left| \frac{3.24 - 3.17}{3.24} \right| \times 100\,\% = 2.16\,\%$$

From the graph of $R_2$

Point-1 : $(3.3, 0.6)$

Point-2 : $(5.46, 1)$

$\therefore$ Slope, $m_1 = \frac{1-0.6}{5.46-3.3} = \frac{5}{27}$

$\therefore$ inverse of slope,

$$m_2^{-1} = r_2 = \frac{27}{5} = 5.4 \text{ k}\Omega$$

From DMM,

$$R_2 = 5.49 \text{ k}\Omega$$

$$\therefore \text{Error} = \left| \frac{5.49-5.4}{5.49} \right| \times 100 \%$$

$$= 1.64 \%$$

This error happens ~~we~~ because we draw the graph according to the best fit line.

The percentages of error for the graph of $R_1$ is 2.16 % and for the graph of $R_2$ is 1.64 %.

## Discussion:

In this experiment, we don't face any difficulties. We need to take care of the red jack when measuring the current. First, one of our group mates experimented alone then each member practiced it under his observation. From this experiment, we learn how to measure the voltage and current and use DMM and Digital Power Supply.

## Attachment:

1. Graph of V vs I.
2. Simulation using Multisim.
3. Signed Data Table.

Experiment-2 Name: KVL and Voltage Divider Rule using Series Circuit.

Objectives:

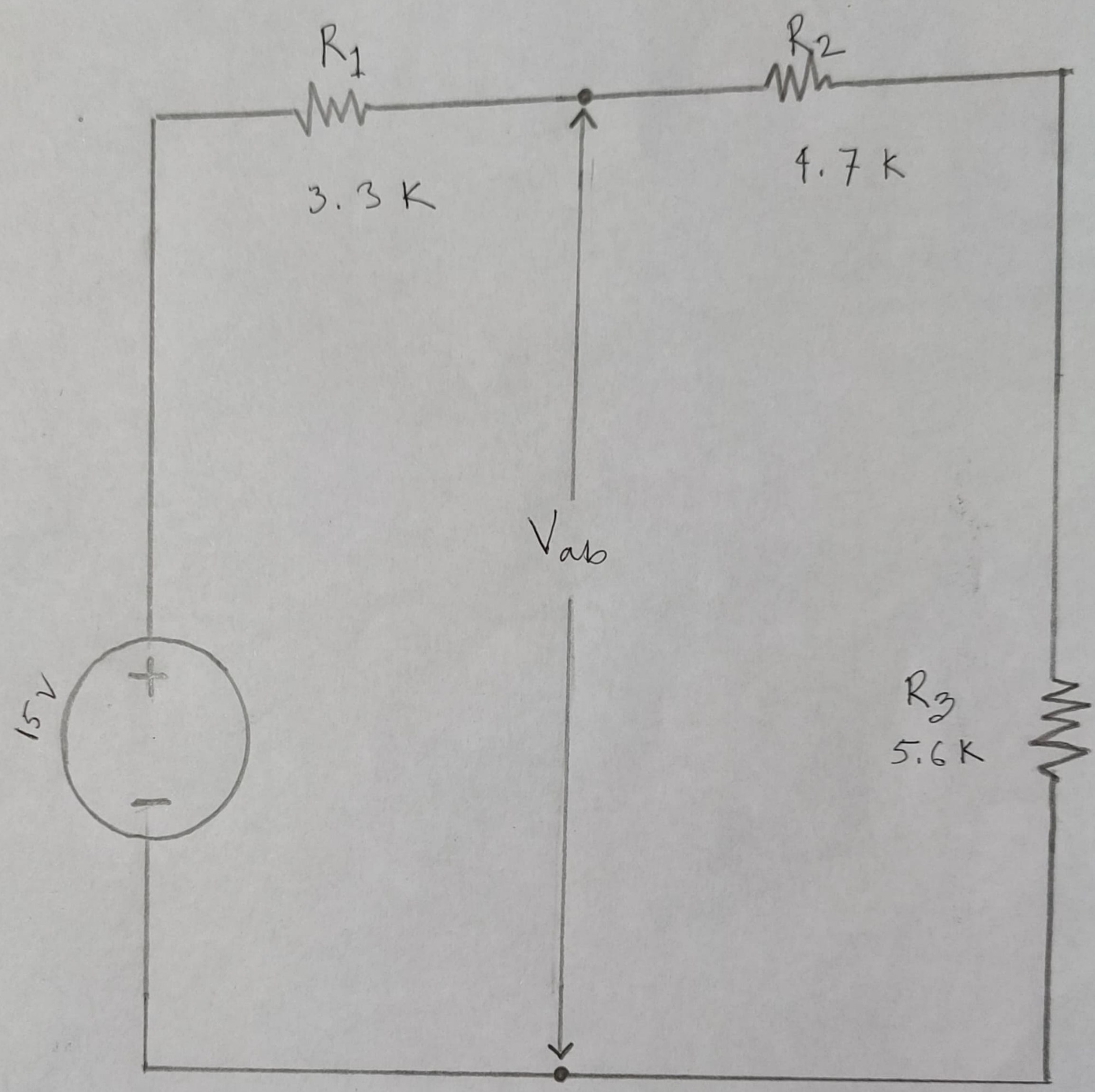
- Learn how to connect a series circuit on a breadboard.
- Validate the voltage divider rules.
- Verify Kirchhoff's voltage law.

Apparatus:

- Bread board
- Resistors ($3.3\ k\Omega$, $4.7\ k\Omega$, $5.6\ k\Omega$)
- DC Power Supply
- Digital Multimeter (DMM)
- Connecting Wires

~~Circuit Diagram:~~

Circuit Diagram:




Circuit 2

## Table I

| | Resistance using colour coding | | | | | KΩ Resistance using DMM | % Error |
|---|---|---|---|---|---|---|---|
| | Band 1 | Band 2 | Band 3 | Band 4 | Resistance ± tol KΩ | | |
| $R_1$ | Orange (3) | Orange (3) | Red (2) | Gold (±5%) | 3.135 – 3.465 | 3.24 KΩ | 1.82 |
| $R_2$ | Yellow (4) | Violet (7) | Red (2) | Gold (±5%) | 4.465 – 4.935 | 4.64 KΩ | 1.28 |
| $R_3$ | Green (5) | Blue (6) | Red (2) | Gold (±5%) | 5.32 – 5.88 | 5.51 KΩ | 1.61 |

## Table 2.

| Experimental readings | | | | Theoretical values | | | |
|---|---|---|---|---|---|---|---|
| $V_s$ | $V_{R1}$ | $V_{R2}$ | $V_{R3}$ | $V_s$ | $V_{R1}$ | $V_{R2}$ | $V_{R3}$ |
| 15.10 | 3.63 | 5.22 | 6.20 | 15.10 | 3.65 | 5.23 | 6.21 |

| % Error | | | |
|---|---|---|---|
| $V_s$ | $V_{R1}$ | $V_{R2}$ | $V_{R3}$ |
| 0 | 0.55% | 0.19% | 0.16% |

Table 3

| | | |
|---|---|---|
| Potential rise $V_s$ | 15.10 | Are the voltage rises and drops equal? |
| Potential drops $(V_{R1} + V_R + V_{R3})$ | 15.05 | Approximately Equal |

Table 4

| Experimental readings | | Theoretical values | |
|---|---|---|---|
| $V_{ab}$ | $R_{eq}$ | $V_{ab}$ | $R_{eq}$ |
| 11.42 | 13.37 | 11.45 | 13.39 |

| % Error | |
|---|---|
| $V_{ab}$ | $R_{eq}$ |
| 0.26 % | 0.15 % |

## Graph :

N/A

## Result Analysis :

According to Kirchhoff's voltage law, in a circuit loop, voltage rise, and drops are equal. The data table-3 shows that the voltage rise was 15.10V and the voltage drop was 15.05 V. So, the voltage drop was approximately equal to the rise. Data table-4 also showed that it follows the voltage divider rule. In short, we can say that our experiment follows Kirchhoff's voltage law.

## Questions and Answers:

01. Voltage division rule:

the voltage across a resistor in a series circuit is equal to the value of that resistor times the total applied voltage divided by the total resistance of the series configuration.

$$\boxed{V_x = R_x \frac{E}{R_T}}$$

02. Kirchhoff's voltage law (KVL)

the algebraic sum of the potential rises and drops around a closed path (or closed loop) is zero.

In symbolic form it can be written as

$$\boxed{\Sigma_c V = 0}$$ (Kirchhoff's voltage law in symbolic form)

03. Calculation of theoretical values:

$$V_{R_1} = \frac{3.24}{(3.24+4.64+5.51)} \times 15.10$$

$$= \frac{3.24}{13.39} \times 15.10$$

$$= 3.65\ V$$

$$V_{R_2} = \frac{4.64}{13.39} \times 15.10$$

$$= 5.23\ V$$

$$V_{R_3} = \frac{5.51}{13.39} \times 15.10$$

$$= 6.21\ V$$

Error Calculation:

$$V_{R_1} = \left| \frac{3.65-3.63}{3.65} \right| \times 100\% = 0.55\%$$

$$V_{R_2} = \left| \frac{5.23-5.22}{5.23} \right| \times 100\% = 0.19\%$$

$$V_{R_3} = \left| \frac{6.21-6.20}{6.21} \right| \times 100\% = 0.16\%$$

Here,

Potential rises, $V_S = 15.10$ V

Potential drops, $V_T = (3.63 + 5.22 + 6.20)$ V

$= 15.05$ V

Here,

Potential drops is approximately equal to the voltage rise. So, we can say that, our circuit follows KVL.

04. Calculation of theoretical values of $V_{ab}$ :

$$V_{ab} = \frac{4.64 + 5.51}{3.24 + 4.64 + 5.51} \times 15.10$$

$$= 11.45 \text{ V}$$

∵ experimental value of $V_{ab}$ : 11.42 V

$$\therefore \text{error} = \left| \frac{11.45 - 11.42}{11.45} \right| \times 100\,\%$$

$$= 0.26\,\%$$

Here, theoretical value and experimental value approximately equal. So, we can say that, our circuit follows voltage divider rules.

5.

Theoretical value of $R_{eq} = (3.24 + 4.64 + 5.51) k\Omega$

$= 13.39 \ k\Omega$

Experimental value of $R_{eq} = 13.37 \ k\Omega$

$$\therefore \text{Error} = \left| \frac{13.39 - 13.37}{13.39} \right| \times 100\%$$

$$= 0.15\%$$

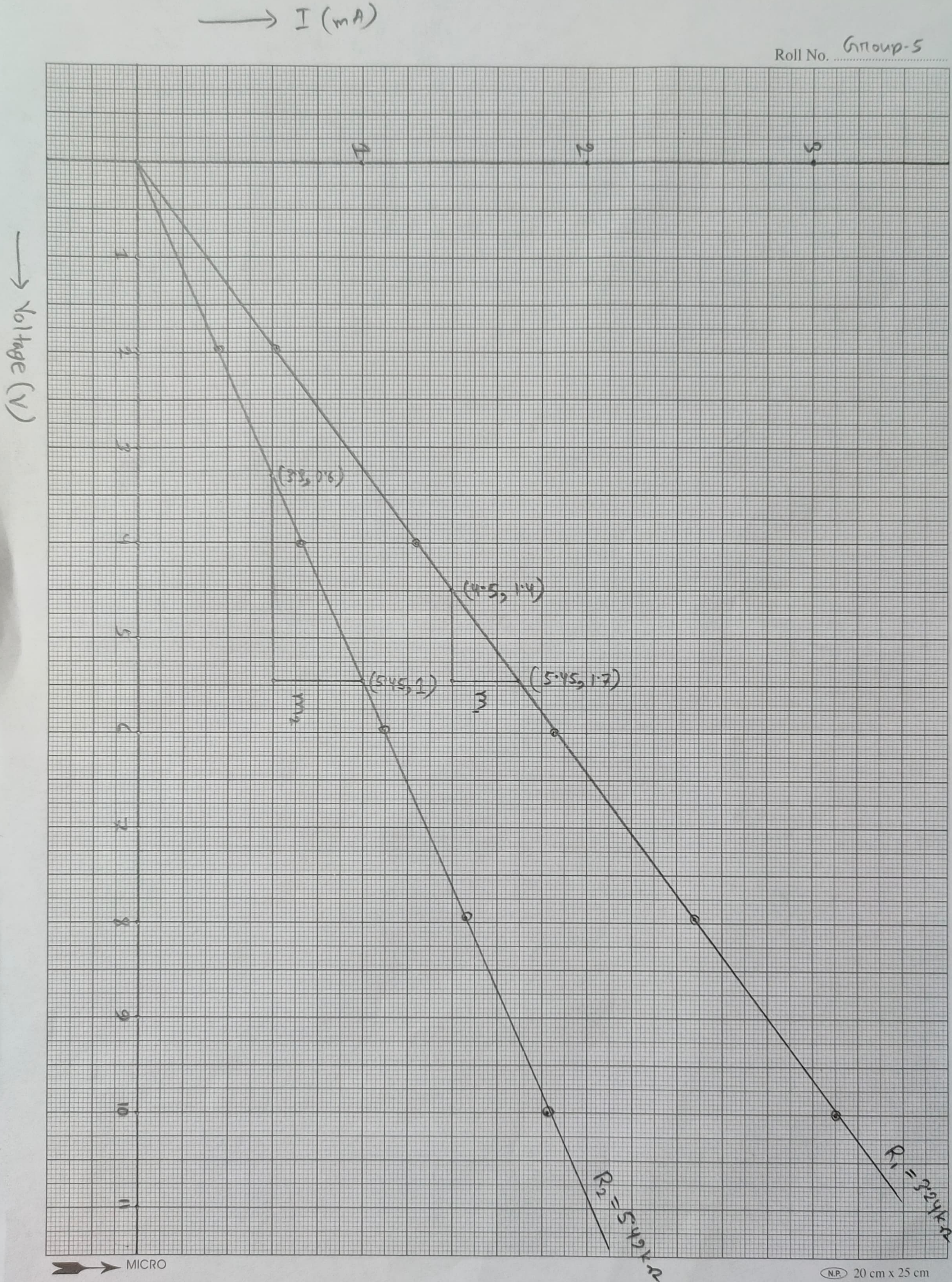
Discussion:

In this experiment, we learn how to make a series circuit using some resistors in a breadboard. Also, we verify Kirchhoff's voltage law and voltage divider rules. While we measured the voltage of R1, we faced some problems; DMM not giving us any stable output. It was slowly increasing. Then Lab Instructor helped us and taught about how to hold the jack of DMM. Then we get a stable result. Then we complete the rest of the experiment together, and we learn a lot.

Attachment:

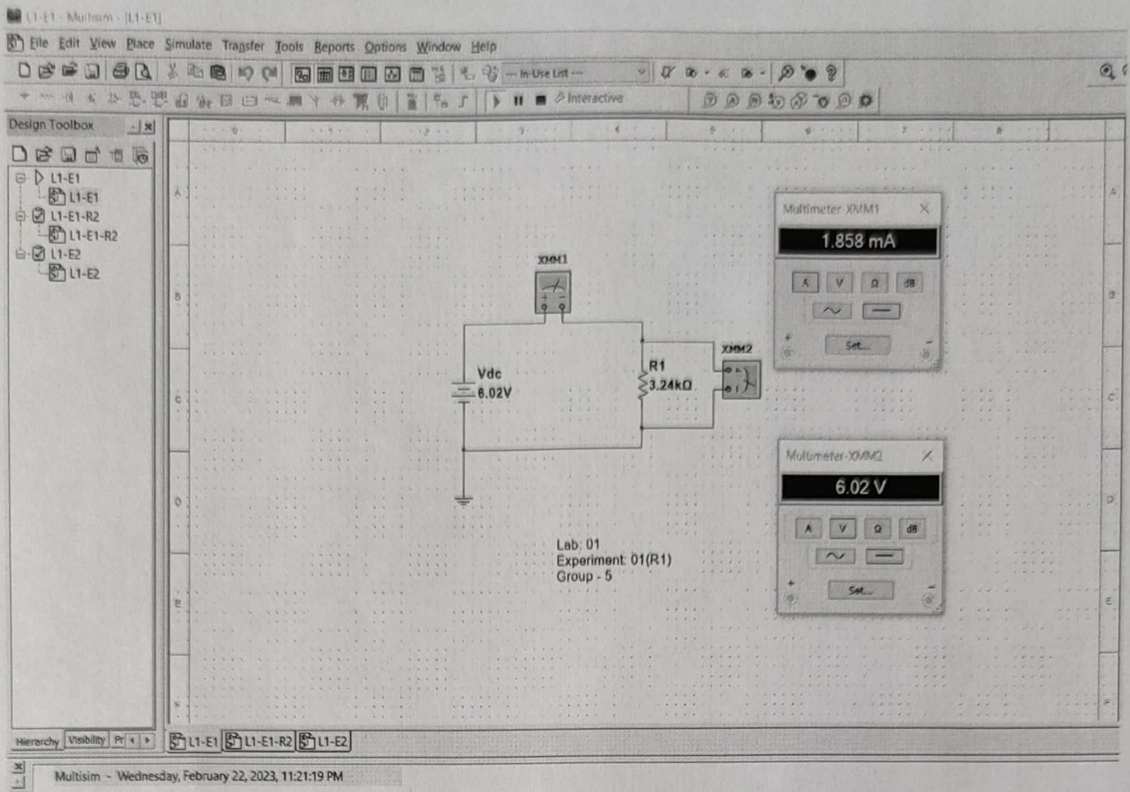
01. Simulation using Multisim.
02. Signed Data Table.

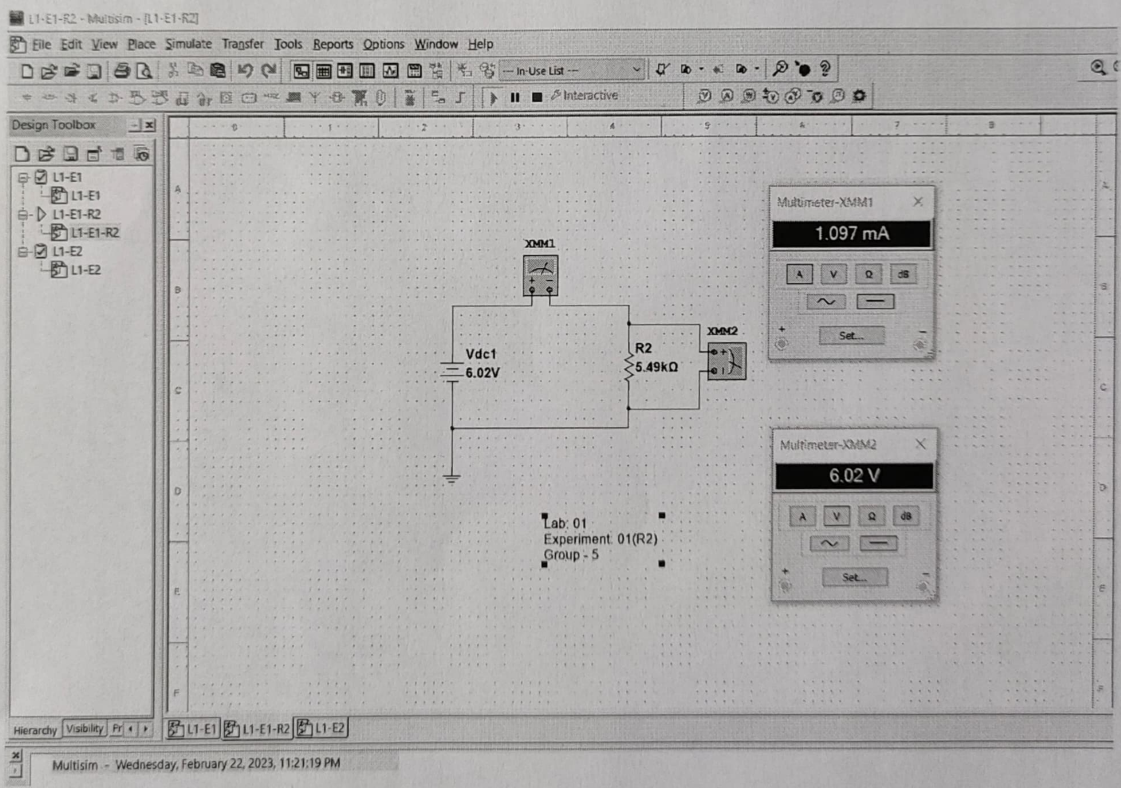
Roll No. Group-5




MICRO

N.P. 20 cm x 25 cm


L1-E1 - Multisim - [L1-E1]
File Edit View Place Simulate Transfer Tools Reports Options Window Help
Design Toolbox
L1-E1
L1-E1-R2
L1-E2
XMM1
Vdc
6.02V
R1
3.24kΩ
XMM2
Multimeter-XMM1
1.858 mA
Multimeter-XMM2
6.02 V
Lab: 01
Experiment: 01(R1)
Group - 5
Multisim - Wednesday, February 22, 2023, 11:21:19 PM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File Edit View Place Simulate Transfer Tools Reports Options Window Help
Design Toolbox
L1-E1
L1-E1-R2
L1-E2
XMM1
Vdc1
6.02V
R2
5.49kΩ
XMM2
Multimeter-XMM1
1.097 mA
Multimeter-XMM2
6.02 V
Lab: 01
Experiment: 01(R2)
Group - 5
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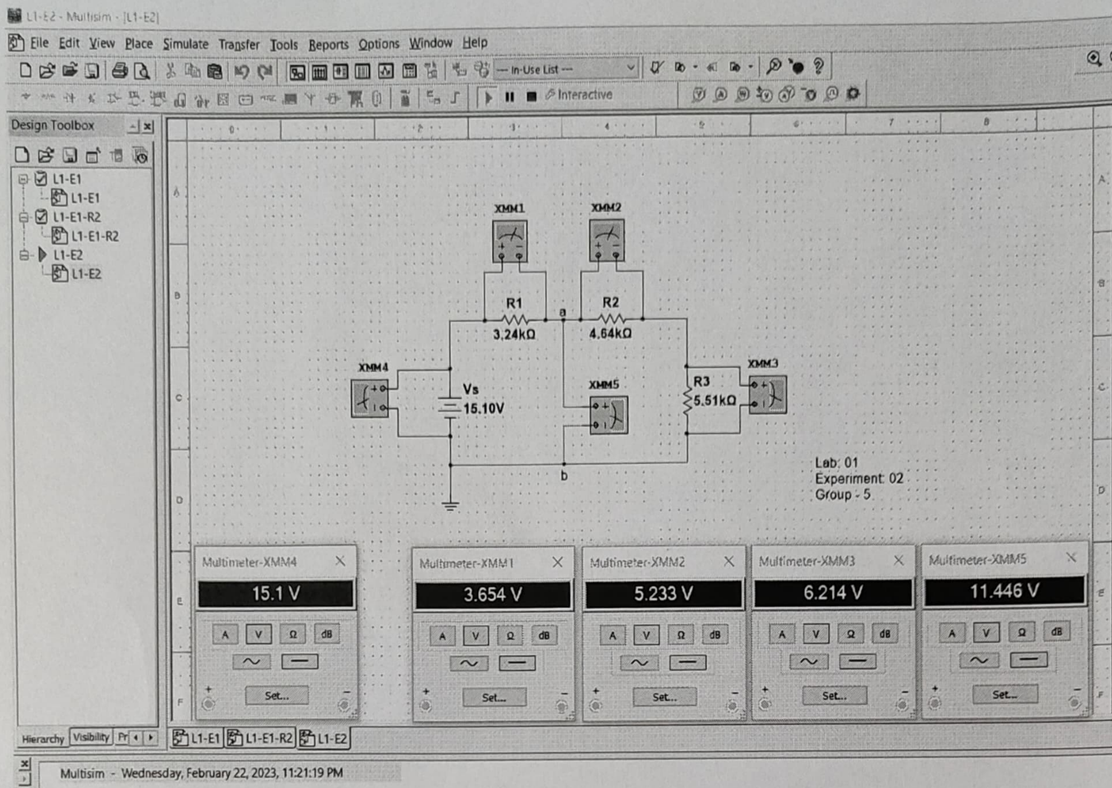
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File Edit View Place Simulate Transfer Tools Reports Options Window Help
Design Toolbox
L1-E1
L1-E1-R2
L1-E2
XMM1
XMM2
R1
3.24kΩ
a
R2
4.64kΩ
XMM4
Vs
15.10V
XMM5
R3
5.51kΩ
XMM3
b
Lab: 01
Experiment: 02
Group - 5
Multimeter-XMM4
15.1 V
Multimeter-XMM1
3.654 V
Multimeter-XMM2
5.233 V
Multimeter-XMM3
6.214 V
Multimeter-XMM5
11.446 V
Multisim - Wednesday, February 22, 2023, 11:21:19 PM

# NORTH SOUTH UNIVERSITY

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Electrical Circuit I Lab

## Data Collection for Exp1:

Lab 1: Exp1
Group No. 05
Instructor's Signature

05/02/23

Table 1:

| Resistance using colour coding | | | | | kΩ Resistance using DMM | % Error |
|---|---|---|---|---|---|---|
| Band 1 | Band 2 | Band 3 | Band 4 | Resistance ± tol kΩ | | |
| Orange (3) | Orange (3) | Red (2) | Gold (±5%) | 3·135 – 3·465 | 3·24 | 1·82 |
| Green (5) | Blue (6) | Red (2) | Gold (±5%) | 5·32 – 5·88 | 5·49 | 1·96 |

Table 2:

| 3.3 KΩ | Experimental readings | | | |
|---|---|---|---|---|
| Voltage | Current, I | Voltage, IR | Power, $I^2R$ | |
| 2 1·95 | 0·62 | 2·046 | ~~6·752~~ | 1·269 |
| 4 4·01 | 1·24 | 4·092 | ~~13·504~~ | 5·074 |
| 6 6·02 | 1·85 | 6·105 | ~~20·147~~ | 11·294 |
| 8 7·95 | 2·48 | 8·184 | ~~27·007~~ | 20·296 |
| 10 10·00 | 3·10 | 10·23 | ~~33·759~~ | 31·713 |

$$IR = 0{\cdot}62 \times 3{\cdot}3 = 2{\cdot}046$$

$$I^2R = (0{\cdot}62)^2 \times 3{\cdot}3 = 1{\cdot}269$$

Table 3

| 5.6 KΩ | Experimental readings | | |
|---|---|---|---|
| Voltage | Current, I | Voltage, IR | Power, $I^2R$ |
| 2 1·97 | 0·36 | 2·016 | 0·726 |
| 4 4·02 | 0·72 | 4·032 | 2·903 |
| 6 5·94 | 1·09 | 6·104 | 6·653 |
| 8 7·96 | 1·46 | 8·176 | 11·936 |
| 10 10·02 | 1·82 | 10·192 | 18·549 |

$$IR = 0{\cdot}36 \times 5{\cdot}6 = 2{\cdot}016$$

$$I^2R = (0{\cdot}36)^2 \times 5{\cdot}6 = 0{\cdot}726$$

# NORTH SOUTH UNIVERSITY

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Electrical Circuit I Lab

## Data Collection for Exp2:

Lab 1: Exp2
Group No. 05
Instructor's Signature 19/2/23

Table 1:

| | Resistance using colour coding | | | | | (kΩ) | |
|---|---|---|---|---|---|---|---|
| | Band 1 | Band 2 | Band 3 | Band 4 | Resistance ± tol kΩ | Resistance using DMM | % Error |
| $R_1$ | Orange (3) | Orange (3) | Red (2) | Gold (±5%) | 3.135 — 3.465 | 3.24 kΩ | 1.82 |
| $R_2$ | Yellow (4) | Violet (7) | Red (2) | Gold (±5%) | 4.465 — 4.935 | 4.64 kΩ | 1.28 |
| $R_3$ | Green (5) | Blue (6) | Red (2) | Gold (±5%) | 5.32 — 5.88 | 5.51 kΩ | 1.61 |
| | | | | | | | |

Table 2:

| Experimental readings | | | | Theoretical values | | | |
|---|---|---|---|---|---|---|---|
| $V_S$ | $V_{R1}$ | $V_{R2}$ | $V_{R3}$ | $V_S$ | $V_{R1}$ | $V_{R2}$ | $V_{R3}$ |
| 15.10 | ~~3.99~~ 3.63 | ~~5.16~~ 5.22 | 6.20 | 15.10 | 3.65 | 5.23 | 6.21 |

| % Error | | | |
|---|---|---|---|
| $V_S$ | $V_{R1}$ | $V_{R2}$ | $V_{R3}$ |
| 0 | 0.55% | 0.19% | 0.16% |

Table 3:

| | | |
|---|---|---|
| Potential rise Vs | 15.10 | Are the voltage rises and drops equal? |
| Potential drops ($V_{R1} + V_{R1} + V_{R3}$) | 15.05 | Approximately Equal |

Table 4

| Experimental readings | | Theoretical values | |
|---|---|---|---|
| $V_{ab}$ | $R_{eq}$ | $V_{ab}$ | $R_{eq}$ |
| 11.42 | 13.37 | 11.45 | 13.39 |
| % Error | | | |

| $V_{ab}$ | |
| --- | --- |
| 0.26% | $R_{eq}$ |
| | 0.151. |

Report

**Experiment 1:**

1. State Ohm's law.
2. Plot V vs I graph for each resistor value in same graph.
3. Does your experimental circuit follow ohm's law? Explain how did you figure it out.
4. Calculate the resistance of each circuit using the slope of your V vs I graphs. Compare these Rgraph values to the measured R values using DMM. Find the percent difference.

**Experiment 2:**

1. State the voltage division rule.
2. State the Kirchhoff's voltage law (KVL).
3. Showing all steps, calculate the theoretical values in Table 2. Compare theoretical values to your experimental values and explain whether your circuit follows KVL or not.
4. Showing all the calculations, theoretically calculate Vab. Compare with the experimental value and verify the voltage division rule at the terminal a-b.
5. Showing all the steps, calculate Req. Compare with the experimental value.

**Useful Formula:**

Voltage Divider Rule: $V_X = E R_X / R_T$

% Error = (Theoretical value – Experimental Value) / Theoretical Value