Spring 2023

EEE/ETE 141L

Electrical Circuits-I Lab(Sec-19)

Faculty : Mr. Saif Ahmed (SfA)

Instructor: Md. Rabiul Karim Khan

Lab Report 02: KCL, Current Divider Rule with Parallel and Ladder Circuit.

Date of Performance : 26 February & 05 March, 2023 Date of Submission : 12 March, 2023	**<u>Group no.:</u> 05** 1. Anisa Akter Meem - 2212538042 2. Sarith Chowdhury - 2212551642 3. Anindita Das Mishi - 2211364642 4. Md. Mehedi Hossain - 1922225642 5. Joy Kumar Ghosh - 2211424642

Experiment Name: KCL, Current Divider Rule with parallel and Ladder Circuit.

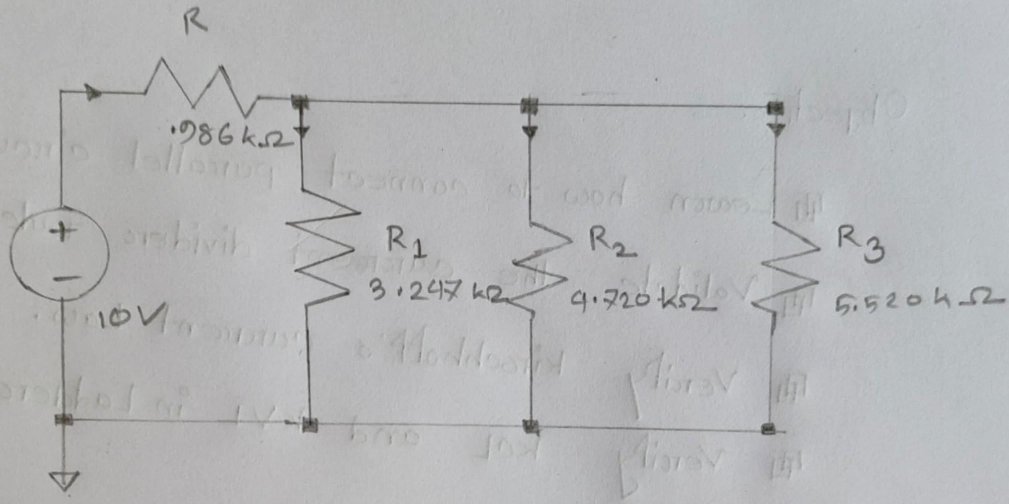
Objectives :

- Learn how to connect parallel circuit on a breadboard.
- Validate the current divider rules.
- Verify kirchhoff's current Law.
- Verify KCL and KVL in Ladder circuit.

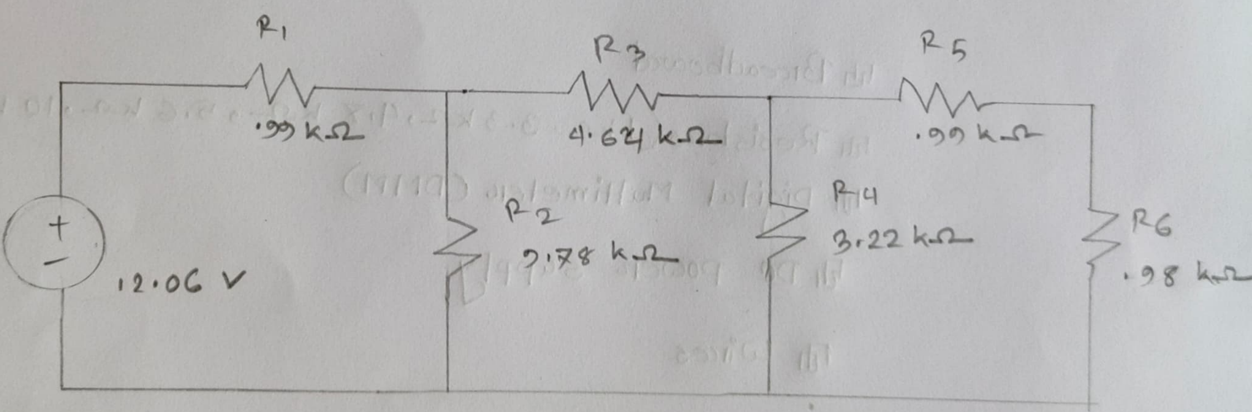
Apparatus:

- Breadboard
- Resistors (1 kΩ, 3.3 kΩ, 4.7 kΩ, 5.6 kΩ, 10 kΩ
- Digital Multimeter (DMM)
- DC power supply
- Wires.

Circuit Diagram :



Circuit 1



circuit - 2

Data table:

Table 1:

Experimental readings				Theoretical values			
I_s	I_{R_1}	I_{R_2}	I_{R_3}	I_s	I_{R_1}	I_{R_2}	I_{R_3}
4.05	1.78	1.23	1.05	4.15	1.82	1.25	1.08

% Error

I_s	I_{R_1}	I_{R_2}	I_{R_3}
2.41	2.10	1.6	2.78

Table 2:

I_s	4.05	Is total current equal to sum individual current?
Sum of Individual current ($I_{R_1}+I_{R_2}+I_{R_3}$)	4.06	Approximately Equal

Table 3:

Experimental Req	Theoretical Req	% Error
2.42	2.41	0.41

Calculation (Theoretical values):

Here,

R_1, R_2 and R_3 are in parallel connection.

$$R_T' = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}$$

$$= \left(\frac{1}{3.247} + \frac{1}{4.720} + \frac{1}{5.520}\right)^{-1}$$

$$= 1.427 \text{ k}\Omega$$

R and R_T' are in series connection

$$R_{eq} = R + R_T'$$

$$= .986 + 1.427$$

$$= 2.41 \text{ k}\Omega$$

$$\therefore I_s = \frac{10}{2.413} = 4.15 \text{ A}$$

$$\therefore I_1 = \frac{I_s R_T'}{R_1} = \frac{4.15 \times 1.427}{3.247} = 1.82 \text{ A}$$

Errors calculation:

$$I_s = \left|\frac{\text{Theoretical } I_s - \text{Measured } I_s}{\text{Theoretical } I_s}\right| \times 100\%$$

$$= \frac{4.15 - 4.05}{4.15} \times 100\%$$

$$= 2.41\%$$

$$I_{R_1} = \left|\frac{1.82 - 1.78}{1.82}\right| \times 100\% = 2.20\%$$

$$R_{eq} = \left|\frac{2.41 - 2.42}{2.41}\right| \times 100\% = .414\%$$

Table 4:

Component	Voltage (V)	Current (mA)
E	12.06 (V)	2.58 mA
R1 (1k) (.99 kΩ)	2.37	2.58
R2 (9.78 kΩ)	9.46	.97
R3 (4.64 kΩ)	7.42	1.62
R4 (3.22 kΩ)	1.98	.62
R5 (.99 kΩ)	.99	1.00
R6 (.98 kΩ)	.96	1.01

Table 5:

Component	voltage	% of error	current (mA)	% of Error
E	12		2.58	0%
R1 (.99 kΩ)	2.55	.784%	2.58	0%
R2 (9.78 kΩ)	9.49	.32%	~~2.58~~ .97	0%
R3 (4.64 kΩ)	7.47	.67%	1.61	0%
R4 (3.22 kΩ)	1.96	1.02%	.61	1.64%
R5 (.99 kΩ)	.98	1.02%	.99	1.01%
R6 (.98 kΩ)	.97	1.03%	.99	2.02%

Calculation (Theoretical values):

$$R_T = R_1 + (R_2 \parallel (R3 + (R4 \parallel (R5 + R6))))$$

$$= R_1 + (R2 \parallel (R3 + (R4 \parallel 1.97)))$$

$$= R_1 + \left(R_2 \parallel \left(R3 + \left(\frac{1}{3.22} + \frac{1}{1.97}\right)^{-1}\right)\right)$$

$$= R_1 + (R_2 \parallel (R_3 + 1.22))$$

$$= Ri + (R2 \parallel 5.86)$$

$$= R_1 + \left(\frac{1}{9.78} + \frac{1}{5.86}\right)^{-1}$$

$$= R1 + 3.665$$

$$= .99 + 3.665$$

$$= 4.66 \text{ k}\Omega$$

$\therefore I_s = \frac{12}{4.66} = 2.58$ mA

$\therefore I_{R_1} = I_s = 2.58$ mA

$\therefore V_{R_1} = I_{R_1} . R_1 = 2.58 \times .99 = 2.55$ v

$\therefore I_{R_2} = \frac{3.665 \times 2.58}{9.78} = .97$ mA

$\therefore V_{R_1} = .97 \times 9.78 = 9.49$ v

$\therefore I_{R_3} = \frac{3.665 \times 2.58}{5.86} = 1.61$ mA

$\therefore V_{R_3} = 1.61 \times 4.64 = 7.47$ v

$\therefore I_{R_4} = \dfrac{1.61 \times 1.22}{3.22} = .61\ mA$

$\therefore V_{R_4} = .61 \times 3.22 = 1.96\ V$

$\therefore I_{R_5} = \dfrac{1.61 \times 1.22}{1.97} = .99\ mA$

$\therefore V_{R_5} = .99 \times .99 = .98\ V$

$\therefore I_{R_6} = I_{R_5} = .99\ mA$

$\therefore V_{R_6} = .99 \times .98 = .97\ V$

Error Calculation:

Error of $I_{R_4} = \left| \dfrac{.61 - .62}{.61} \right| \times 100\%$

$= 1.646\%$

Error of $V_{R_4} = \left| \dfrac{1.96 - 1.98}{1.96} \right| \times 100\%$

$= 1.02\%$

Graph:

N/A

Result Analysis:

After completing this experiment, we found that in every node sum of entering current and the sum of the leaving current are the same. We also found that in every closed loop sum of the voltage rise and voltage drop is approximately zero. That means we verify the KCL and KVL in our ladder circuit.

Questions and Answers:

01: KCL:

Kirchoff's current Law (KCL) states that the algebraic sum of currents entering and Leaving any node in an electrical circuit is always zero. In other words, the total current flowing into a node must be equal to the total currents flowing out of that node.

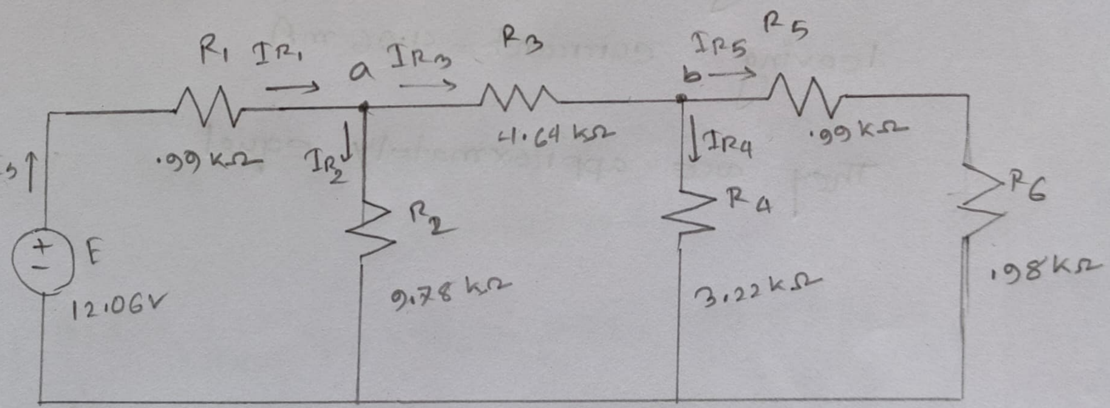
This law is based on the principle of conservation of charge. which states that charge cannot be created or destroyed, but can only be transferre from one location to another. Thus, any current that enters a node must eventually leave that node to maintain the balance of charge in the circuit

KCL can be expressed mathmatically as;

$\Sigma i = 0$

Where Σi is the algebraic sum of currents entering and Leaving a node and is equal to zero.

(2)



In node a,

$$I_{R_1} = I_{R_2} + I_{R_3}$$

$$\Rightarrow 2.58 = .97 + 1.61$$

$$\therefore 2.58 = 2.58$$

In node b,

$$I_{R_3} = I_{R_4} + I_{R_5}$$

$$1.61 = .62 + 1.00$$

$$\therefore 1.61 \approx 1.62$$

(Approximately Equal)

According to kirchhoff's current Law, entering to the leaving current, Here for node a and b entering current and the leaving current are the same.

3. Calculation already showed

From Table-1:

Source current, $I_s = 4.05$ mA

Sum of Individual current

$I_{R_1} + I_{R_2} + I_{R_3} = (1.78 + 1.23 + 1.05)$

$= 4.06$ mA

Here,

entering current $= 4.05$ mA

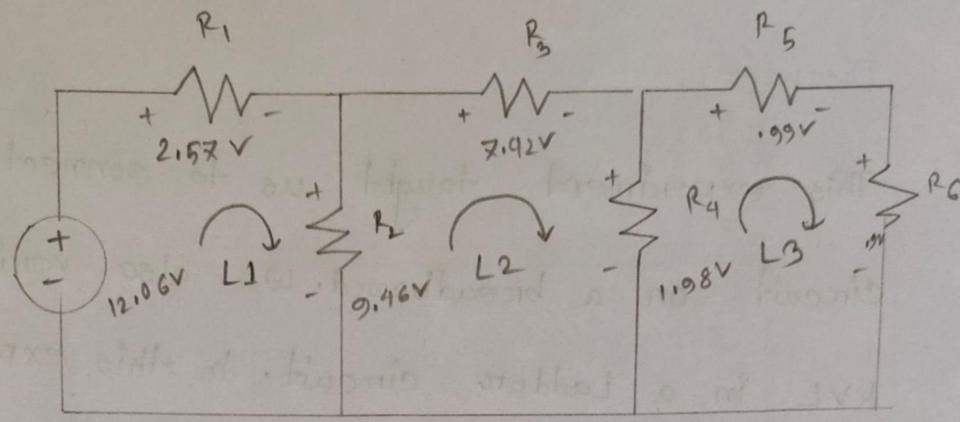
leaving current $= 4.06$ mA

They are approxmately equal

04. Already showed in Data Table Section.

05. Already showed in Data Table Section.

06.



Loop-1:

$$E - V_{R1} - V_{R2} = 12.06 - 2.57 - 9.46$$
$$= .03 \approx 0$$

Loop-2: $V_{R2} - V_{R3} - V_{R4} = 9.46 - 7.42 - 1.98$
$$= .06 \approx 0$$

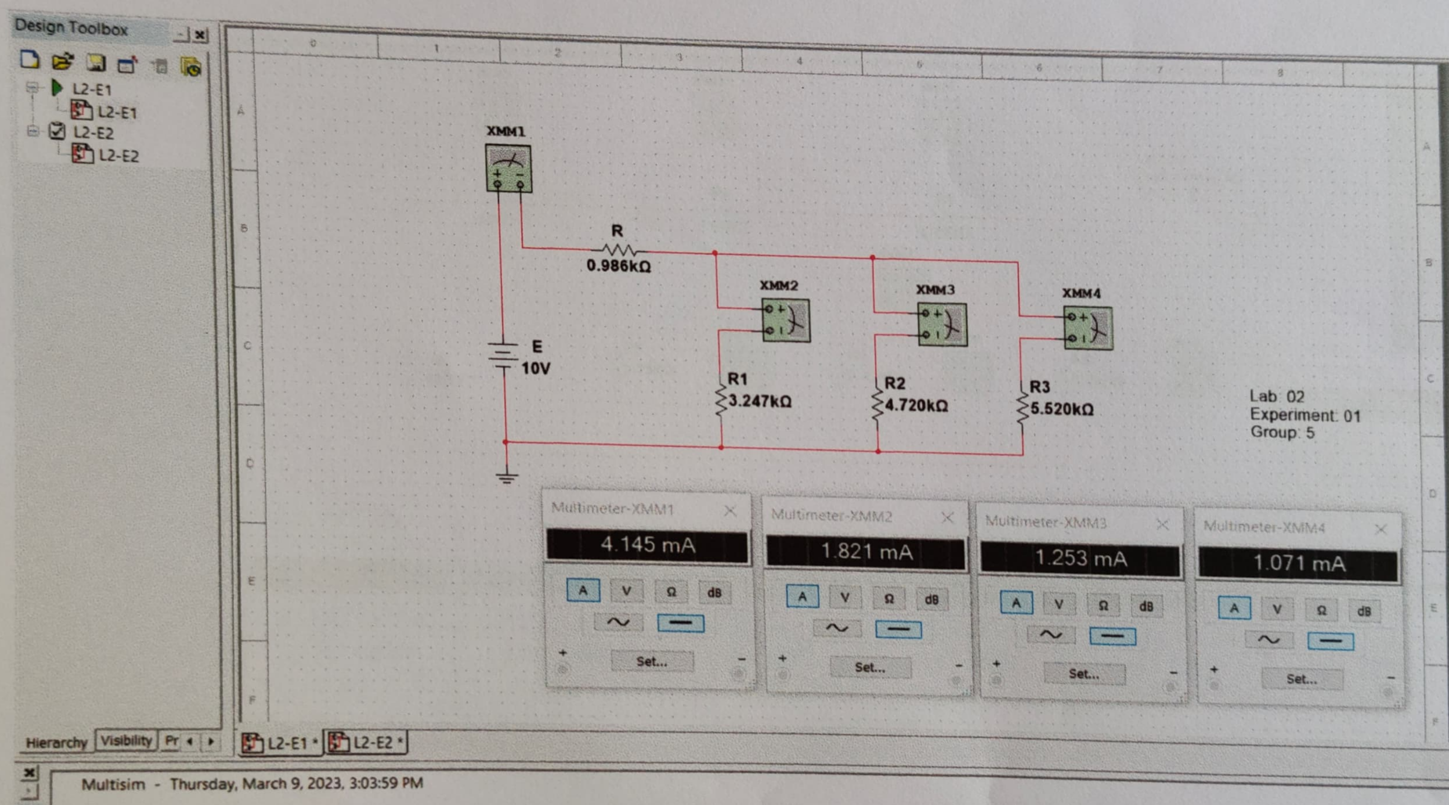
Loop-3: $V_{R4} - V_{R5} - V_{R6} = 1.98 - .99 - .96$
$$= .03 \approx 0$$

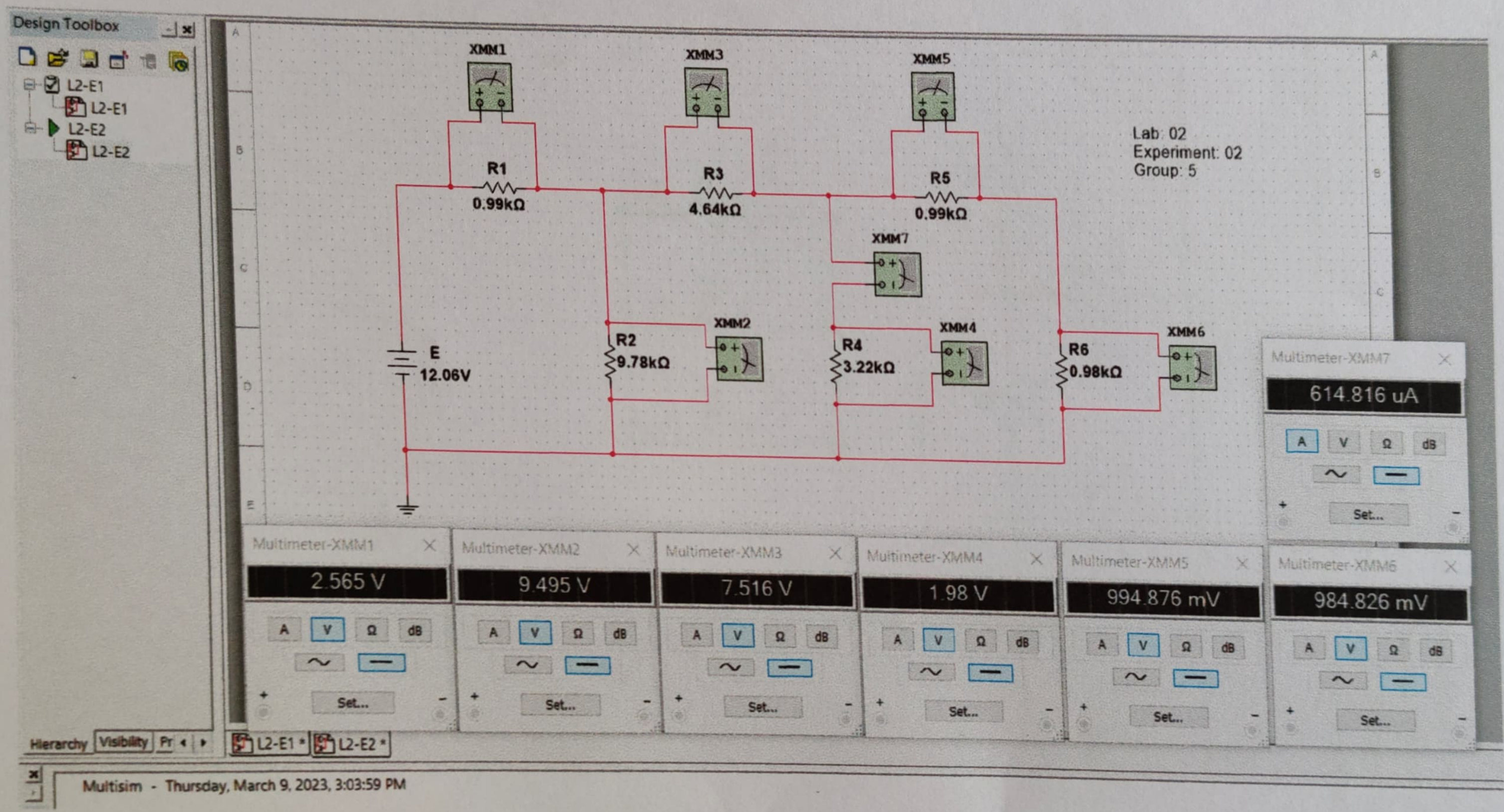
According to Kirchhoff's voltage Law (KVL), the sum of all voltages around any closed loop in an eletrical circuit is always zero. In other words, the algebraic sum of all the voltage drops and gains around a closed loop must be equal to zero.

In loop 1, 2 and 3 here sum of the voltage raise and voltage drop is approximately zero.

Discussion:

This experiment taught us to connect a parallel circuit on a breadboard. We also verify KCL and KVL in a Ladder circuit. In this experiment, we face some difficulties in current measurement on circuit-1. DMM shows the much less current than the theoretical value. Then we tried to solve this problem and found that a wire was slightly broken, and the current measurements was not accurate. After changing the wire, we get the correct result. In the ladder circuit, we don't face any difficulties and complete it at first.


Design Toolbox
L2-E1
L2-E1
L2-E2
L2-E2
XMM1
R
0.986kΩ
E
10V
XMM2
R1
3.247kΩ
XMM3
R2
4.720kΩ
XMM4
R3
5.520kΩ
Lab: 02
Experiment: 01
Group: 5
Multimeter-XMM1
4.145 mA
Multimeter-XMM2
1.821 mA
Multimeter-XMM3
1.253 mA
Multimeter-XMM4
1.071 mA
Set...
Hierarchy
Visibility
L2-E1 *
L2-E2 *
Multisim - Thursday, March 9, 2023, 3:03:59 PM


Design Toolbox
L2-E1
L2-E1
L2-E2
L2-E2
XMM1
R1
0.99kΩ
XMM3
R3
4.64kΩ
XMM5
R5
0.99kΩ
Lab: 02
Experiment: 02
Group: 5
XMM7
E
12.06V
R2
9.78kΩ
XMM2
R4
3.22kΩ
XMM4
R6
0.98kΩ
XMM6
Multimeter-XMM7
614.816 uA
Multimeter-XMM1
2.565 V
Multimeter-XMM2
9.495 V
Multimeter-XMM3
7.516 V
Multimeter-XMM4
1.98 V
Multimeter-XMM5
994.876 mV
Multimeter-XMM6
984.826 mV
Hierarchy
Visibility
Multisim - Thursday, March 9, 2023, 3:03:59 PM

NORTH SOUTH UNIVERSITY

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Lab 2: KCL, Current Divider Rule with Parallel and Ladder Circuit.

Objectives

- Learn how to connect a parallel circuit on a breadboard.
- Validate the current divider rules.
- Verify Kirchhoff's current law.
- Verify KCL and KVL in ladder circuit.

List of Components:

- Trainer board
- Resistors (1K, 3.3 KΩ, 4.7 KΩ, 5.6K, 10K)
- Digital Multimeter (DMM)
- Connecting Wire

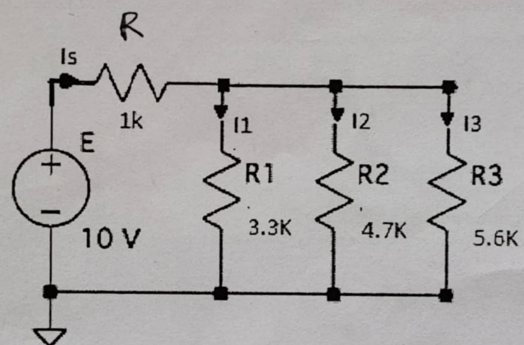
$R = 0.986\ k\Omega$

$R_1 = 3.247\ k\Omega$

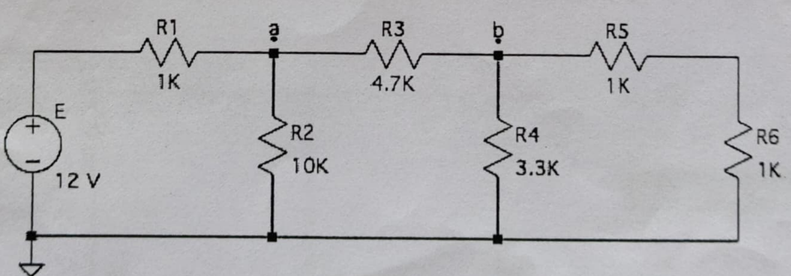
$R_2 = 4.720\ k\Omega$

$R_3 = 5.520\ k\Omega$

Circuit Diagram:



Circuit 1



Circuit 2

Procedure:

1. Identify all the given resistors using color coding and fill in the required columns in Table 1.
2. Measure the resistances of the resistors using the DMM and fill in the required column in Table 1.
3. Calculate the percentage error of the resistance values.
4. Percentage Error = |(Practical value – Theoretical value)| / Theoretical value
5. Build the circuit 1
6. Using the DMM, measure the currents I_s, I_1, I_2, and I_3. Record the readings in Table 2.
7. Fill in Table 3.

8. Now, disconnect the voltage source from the circuit and measure the total load resistance, Req of the circuit using DMM. Note down values in Table 4.
9. Construct Circuit 2.
10. Using a DMM, measure the potential differences across all the resistors in circuit 2. Record all the readings in Table 5
11. Using a DMM, measure the current through all the resistors and record in Table 5.

NORTH SOUTH UNIVERSITY

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Data Collection
Lab 2
Group No. ________
Instructor's Signature Rabin 26/02/23

Table 1:

Experimental readings				Theoretical values			
Is	I_{R1}	I_{R2}	I_{R3}	Is	I_{R1}	I_{R2}	I_{R3}
4.05	1.78	1.23	1.05	4.15	~~4~~ 1.82	1.25	1.08
% Error							
Is	I_{R1}	I_{R2}	I_{R3}				
2.41	2.20	1.6	2.78				

Table 2:

Is	4.05	Is Total Current equal to sum individual current?
Sum of individual Current ($I_{R1} + I_{R2} + I_{R3}$)	4.06	Approximately Equal

Measurement of Equivalent Resistance:

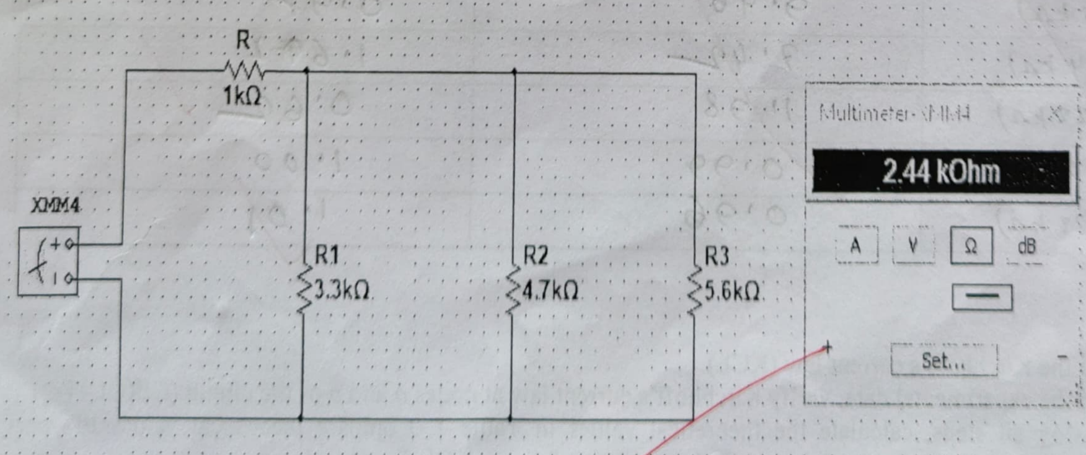


Table 3:

Experimental Req	Theoretical Req	% Error
~~2.54~~ 2.42	2.41	0.41

NORTH SOUTH UNIVERSITY

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Ladder Circuit:

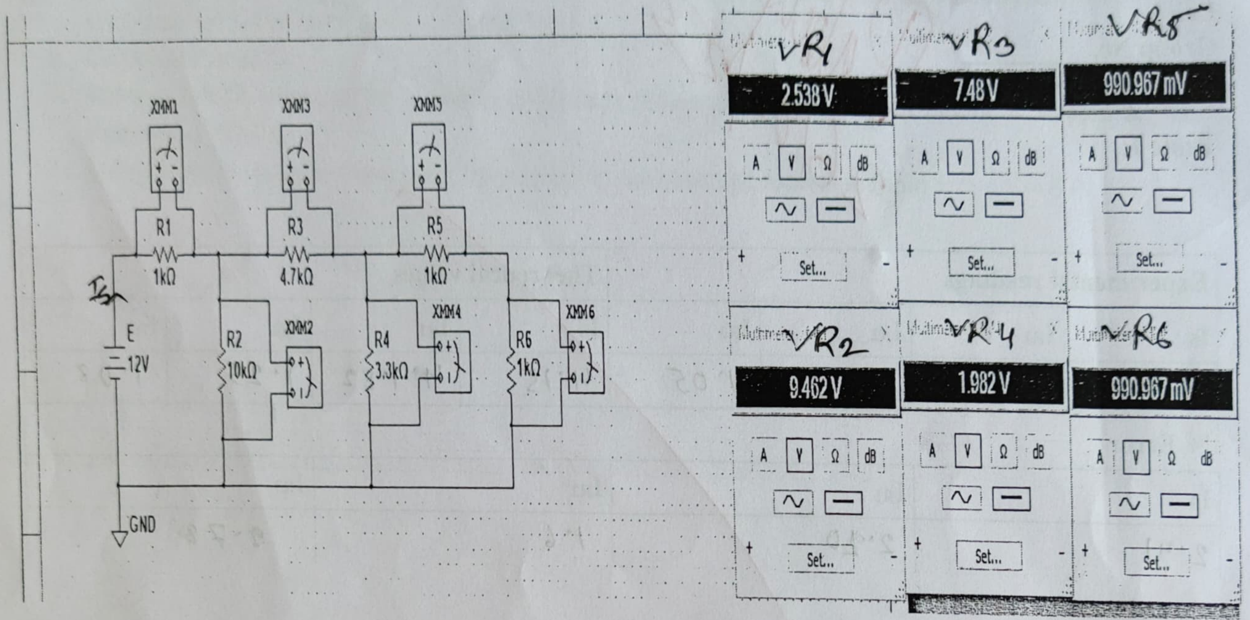


Table 4:

Component	Voltage (V)	Current (mA)
E	12.06 (V)	2.58 mA
R1(1k) (0.99 kΩ)	2.57	2.58 ~~mA~~
R2 (9.78 kΩ)	9.46	0.97
R3 (4.64 kΩ)	7.42	1.61
R4 (3.22 kΩ)	1.98	0.62
R5 (0.99 kΩ)	0.99	1.00
R6 (0.98 kΩ)	0.96	1.01

Report

1. State the Kirchhoff's current law (KCL).
2. With the experimental data, verify Kirchhoff's current law at nodes *a* and *b* of the circuit.(CIRCUIT-2)
3. Showing all steps, calculate the theoretical values in Table 1. Compare theoretical values to your experimental values and explain whether your circuit follows KCL or not.
4. Showing all the steps, theoretically calculate Req. Compare with the experimental value.
5. Calculate all the theoretical values for Table 4. Show all steps. (CIRCUIT-2)

Rakin
5/3/23

6. With the experimental data, verify Kirchhoff's voltage law within each independent closed loop of the circuit-02. (CIRCUIT-2)

Discussion:

Useful Formula:
Current Divider Rule : $I_X = I_S R_T / R_X$
% Error = (Theoretical value – Experimental Value) / Theoretical Value