North South University

Department of Electrical & Computer Engineering

LAB REPORT

Course Name: **EEE141 Lab**

Experiment Number**: 02**

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

Faculty: **SSH1**

Experiment Date: **17-07-22**

Report Submission Date: **31-07-22**

Section: **08**

Group: **04**

Name and ID: 1.Nasim Anzum Promise 2022655642 2. Mosroor Mofiz Arman 1921079642 3. Sumit Kumar Kar 2021646642 4. Muhammad Raiyan Alam 1831100642	Score
Remarks:	

Experiment - 02: Lab 2: KCL, Current Divider Rule with Parallel and Ladder Circuit

Objective:

In this experiment, we have learned:

- How to connect a parallel circuit on a breadboard
- Validate the current divider rules.
- Verify the theory of Kirchhoff’s Current Law
- Verify KCL and KVL in the ladder circuit.

List of Equipment:

In this experiment, the required component was

- Trainer board
- Resistors:
    - **Circuit-01:**
        - 1K * 1 unit
        - 3.3 KΩ * 1 unit
        - 4.7 KΩ * 1 unit
        - 5.6K * 1 unit
        - 10K * 1 unit
    - **Circuit-02:**
        - 1K * 3 unit
        - 3.3 KΩ * 1 unit
        - 4.7 KΩ * 1 unit
        - 10K * 1 unit
- Digital Multimeter (DMM)
- Connecting Wire

Theory:

Kirchhoff’s Current Law: When the summation of the current junction (or region) of a network must equal the summation of the currents leaving the same junction (or regions) is known as Kirchhoff’s Current Law.

Formula: $\sum I_i = \sum I_o$

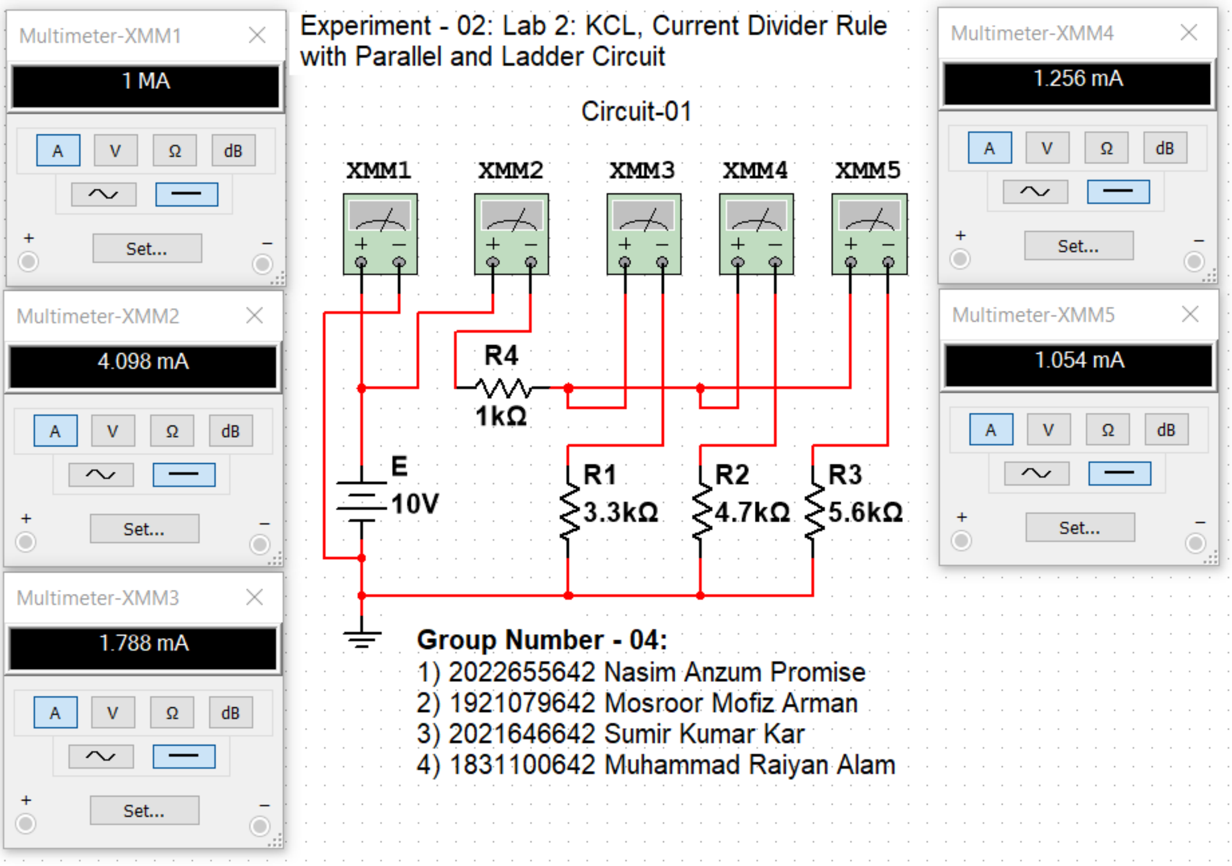
In Parallel Series, the amount of current that gets into a circuit is equal to the amount of current that gets out from the circuit. Voltage remains the same in Parallel circuits.

Current Divider Rule: In a parallel circuit, the equal dividing of two or more parallel elements with equal value is known as the Current Divider Rule.

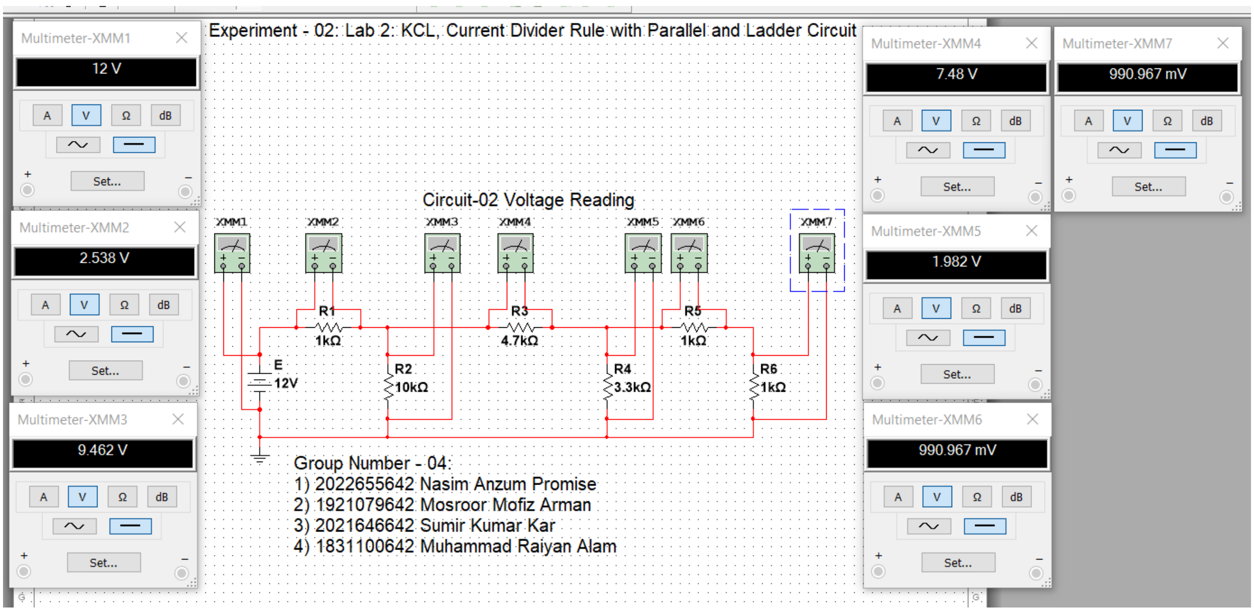
Formula: $I_x = (R_T/R_X) * I_T$

CDR is used to calculate the divided current of the current source into every single branch of a parallel circuit. CDR can be used to calculate and find out the source current of a Parallel Circuit.

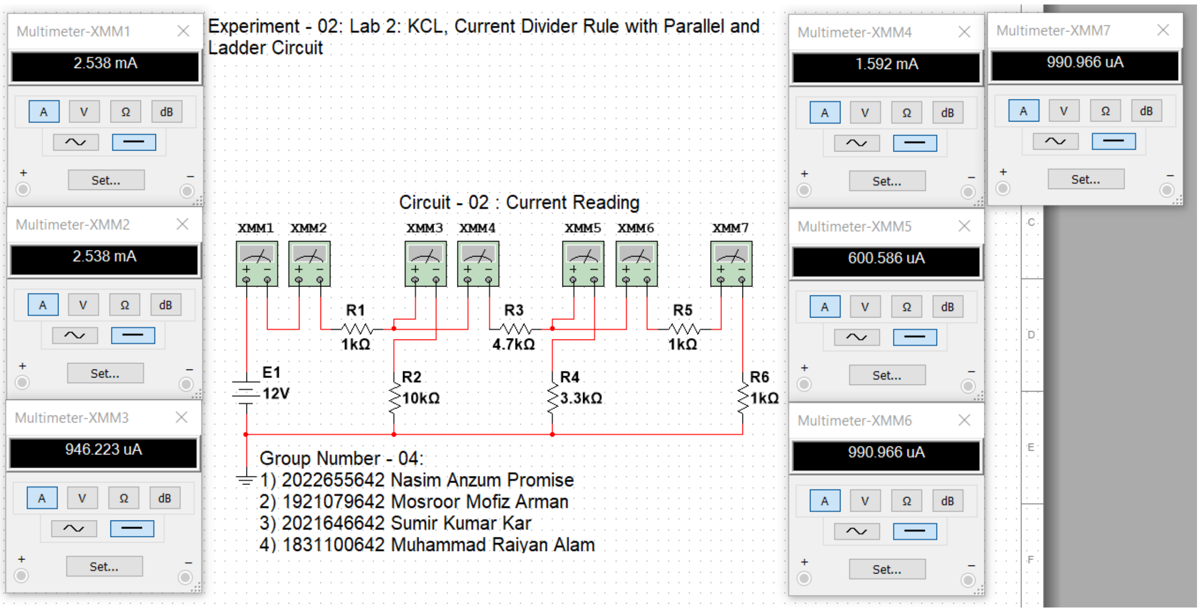
Circuit Diagram



Circuit -01 (above)



Circuit-02: Voltage Reading (above)



Circuit-3 Current Reading (above)

Questions and Answers

1) State the Current Division Rule.

   Ans: In a parallel circuit, the equal dividing of two or more parallel elements with equal value is known as the Current Divider Rule.

2) State the Kirchhoff's Current Law (KCL).

   Ans: When the summation of the current junction (or region) of a network must equal the summation of the currents leaving the same junction (or regions) is known as **Kirchhoff's Current Law.**

3) With the experimental data, verify Kirchhoff's voltage law within each independent closed loop of the circuit.

   Solution:

   $V = IR$
   $V_s = IR_s = (4.06 * 10^{-3}) * (0.983 * 10^3) = 3.991$ V
   $V_1 = IR_1 = (1.85 * 10^{-3}) * (3.23 * 10^3) = 5.976$ V
   $V_2 = IR_2 = (1.28 * 10^{-3}) * (4.63 * 10^3) = 5.927$ V
   $V_3 = IR_s = (1.06 * 10^{-3}) * (5.53 * 10^3) = 5.884$ V

   Applying KVL in order to verify:
   In Loop-I: 10 - 3.991 - 5.976 = 0.033 (almost 0)
   In Loop-II: 10 - 3.991 - 5.927 = 0.082 (almost 0)
   In Loop-III: 10 - 3.991 - 5.884 = 0.125 (almost 0)

4) With the experimental data, verify Kirchhoff's current law at nodes a and b of the circuit.

   Solution:

   At Node A:
   Cin = Cout
   or, 2.57mA = 0.94mA + 1.63mA

   At Node B:
   Cin = Cout
   or, 1.63mA = 0.62mA + 1.01mA

5) Showing all steps, calculate the theoretical values in Table 2. Compare theoretical values to your experimental values and explain whether your circuit follows KCL or not.
   Solution:

Here R_1, R_2, R_3 is in parallel so total resistance R_{123} will be

$$R_{123} = \frac{1}{\frac{1}{3.3*10^3}+\frac{1}{4.7*10^3}+\frac{1}{5.6*10^3}} = 1.44 * 10^3\Omega$$

$$R_t = 1.44 * 10^3 + 1 * 10^3 = 2.44 * 10^3\ \Omega$$

$$I_t = \frac{V}{R_t} = \frac{10\ V}{2.44 * 10^3} = 4.09\ mA$$

Here,

$I_s = I_t$

$I_s = 4.09\ mA$

$$\boldsymbol{I_1} = \frac{I_S R_{123}}{R_1} = \frac{(4.09)(1.44 * 10^3)}{3.3 * 10^3} = 1.79\ \mathbf{mA}$$

$$\boldsymbol{I_2} = \frac{I_S R_{123}}{R_2} = \frac{(4.09)(1.44 * 10^3)}{4.7 * 10^3} = 1.25\ \mathbf{mA}$$

$$\boldsymbol{I_3} = \frac{I_S R_{123}}{R_3} = \frac{(4.09)(1.44 * 10^3)}{5.6 * 10^3} = 1.05\ \mathbf{mA}$$

$\boldsymbol{I_s = I_1 + I_2 + I_3 =}$ (1.79 + 1.25 + 1.05) **mA** = 4.09 **mA**

$$\%\ Error = \frac{|(Experimental\ Value - Theoretical\ Values)|}{Theoretical\ Values} * 100\%$$

$$I_s = \frac{|(4.06 - 4.09)|}{4.09} * 100\% = 0.73\%$$

$$I_1 = \frac{|(1.85 - 1.79)|}{1.79} * 100\% = 3.35\%$$

$$I_2 = \frac{|(1.28 - 1.25)|}{1.25} * 100\% = 2.4\%$$

$$I_3 = \frac{|(1.06 - 1.05)|}{1.05} * 100\% = 0.95\%$$

The experimental values of our experiment follow KCL.

6) Showing all the steps, theoretically calculate Req. Compare with the experimental value.
Solution:
Theoretical Values:

Here R_1, R_2, R_3 is in parallel so total resistance R_{123} will be

$$R_{123} = \frac{1}{\frac{1}{3.3*10^3}+\frac{1}{4.7*10^3}+\frac{1}{5.6*10^3}} = 1.44 * 10^3\Omega$$

Here R_s and R_{123} is in series so,

$R_{123s} = (1.44 \text{ x } 10^3 + 1 \text{ x } 10^3)\ \Omega = 2.44 \text{ x } 10^3\ \Omega$

$$\%\, Error = \frac{|(2.4 - 2.44)|}{2.44} * 100\% = 1.64\%$$

7) Calculate all the theoretical values for Table 5. Show all steps.
Solution:

R_5 and R_6 are in series so
$R_{56} = R_5 + R_6$
$R_{56} = 1\text{ k}\Omega + 1\text{ k}\Omega = 2\text{ k}\Omega$
R_4 and R_{56} are in parallel so

$$R_{456} = \frac{1}{\frac{1}{R_4}+\frac{1}{R_{56}}}$$

$$R_{456} = \frac{1}{\frac{1}{3.3}+\frac{1}{2}} = 1.25\text{ k}\Omega$$

R_3 and R_{456} are in series so
$R_{3456} = R_3 + R_{456}$
$R_{3456} = 1.25\text{ k}\Omega + 4.7\text{ k}\Omega = 5.95\text{ k}\Omega$
R_2 and R_{3456} are in parallel so

$$R_{23456} = \frac{1}{\frac{1}{R_{3456}}+\frac{1}{R_2}}$$

$$R_{23456} = \frac{1}{\frac{1}{5.95}+\frac{1}{10}} = 3.73\text{ k}\Omega$$

R_1 and R_{23456} are in series so
$R_t = R_1 + R_{23456}$
$R_t = 1\text{ k}\Omega + 3.73\text{ k}\Omega = 4.73\text{ k}\Omega$

Now for E Voltage is V_E = 12V

Current will be $I_E = \frac{V_E}{R_T} = \frac{12}{4.73} =$ 2.54 mA

At R_1 using Voltage Divider Rule

$V_1 = \frac{V_E\, R_1}{R_T} = \frac{(12\ V)(1 k\Omega)}{4.73\ k\Omega} =$ 2.54 V

$I_1 = \frac{V_1}{R_1} = \frac{2.54\ V}{1\ k\Omega} =$ 2.54 mA

At R_2 using Current Divider Rule

$I_2 = \frac{I_1\, R_{23456}}{R_2} = \frac{(2.54\ mA)(3.73\ k\Omega)}{10\ k\Omega} =$ 0.947 mA

$V_2 = I_2 * R_2$ = 0.947 mA * 10 kΩ = 9.47 V

At R_3 using Voltage Divider Rule

$V_3 = \frac{V_2\, R_3}{R_{3456}} = \frac{(9.47\ V)(4.7\ k\Omega)}{5.95\ k\Omega} =$ 7.48 V

$I_3 = \frac{V_3}{R_3} = \frac{7.48\ V}{4.7\ k\Omega} =$ 1.59 mA

At R_4 using Current Divider Rule

$I_4 = \frac{I_3\, R_{456}}{R_4} = \frac{(1.59\ mA)(1.25\ k\Omega)}{3.3\ k\Omega} =$ 0.602 mA

$V_4 = I_4 * R_4$ = 0.602 mA * 3.3 kΩ = 1.98 V

At R_5 using Voltage Divider Rule

$V_5 = \frac{V_4\, R_5}{R_{56}} = \frac{(1.98\ V)(1\ k\Omega)}{2\ k\Omega} =$ 0.99 V

$I_5 = \frac{V_5}{R_5} = \frac{0.99\ V}{1\ k\Omega} =$ 0.99 mA

At R_6

$I_6 = I_5 =$ 0.99 mA

$V_6 = V_5 =$ 0.99 V

Result analysis & Discussion

In this lab, we learned the practical implementation of KCL, Current Divider Rule with Parallel and Ladder Circuit. This might be because of the Internal Resistance of each and every component. Practical use of Current Divider Rule $I_s = I_{s1} + I_{s2}$, KVL: $\sum I_i = \sum I_o$ and KCL were done in the experiment.

In the equipment, we were provided 1K, 3.3 KΩ, 4.7 KΩ, 5.6K, and 10K resistors with a DMM (Digital Multimeter). First, we checked the resistors using color coding and filled them in Table 1. Then we measured the resistance of the resistors using DMM and filled in the column in Table 1. Then, we took the resistors and completed circuit 1. Then we measured currents I_s, I_1, $I_{2,}$, and I_3. We filled it up in Table 2. Then we calculated I_s (Total current). Now, we disconnected the voltage source from the circuit and measured the total load resistance R_{eq} of the course using DMM and Noted down the values in Table 4. That was the end of circuit 1. Next, we built circuit 2. Using DMM, we measured the potential differences across all the resistors in circuit 2 and recorded all the readings in Table 5. After that,, we measured the current through all the resistors and recorded them in Table 5. That was the end of the experiment. During this lab, we faced some problems. Our DMM was not working correctly. Sometimes it gave us the correct value; sometimes, it didn't. We changed our DMM four times to get accurate current and voltage values.

Table of Contributions
Group Number - 04

During the experiment in Class:

1) **2022655642 Nasim Anzum Promise and 2021646642 Sumit Kumar Kar:** Building the Circuit
2) **1831100642 Muhammad Raiyan Alam:** Wrote data in Lab Manual and helped group members with the steps
3) **1921079642 Mosroor Mofiz Arman:** Checked whether all the circuits were built correctly or not and whether all the data were written carefully and accurately or not.

In Lab Report:

1) **2022655642 Nasim Anzum Promise:** Wrote objective, theory part and Discussion.
2) **1921079642 Mosroor Mofiz Arman:** Report Writing according to the Guideline given in the canvas.
3) **2021646642 Sumit Kumar Kar:** Helped with Question and Answer
4) **1831100642 Muhammad Raiyan Alam:** Drew Multisim and Solved Questions and Answers

Experiment - 02: Lab 2: KCL, Current Divider Rule with Parallel and Ladder Circuit

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In this experiment, we have learned:

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        - 4.7 KΩ * 1 unit
        - 10K * 1 unit
- Digital Multimeter (DMM)
- Connecting Wire

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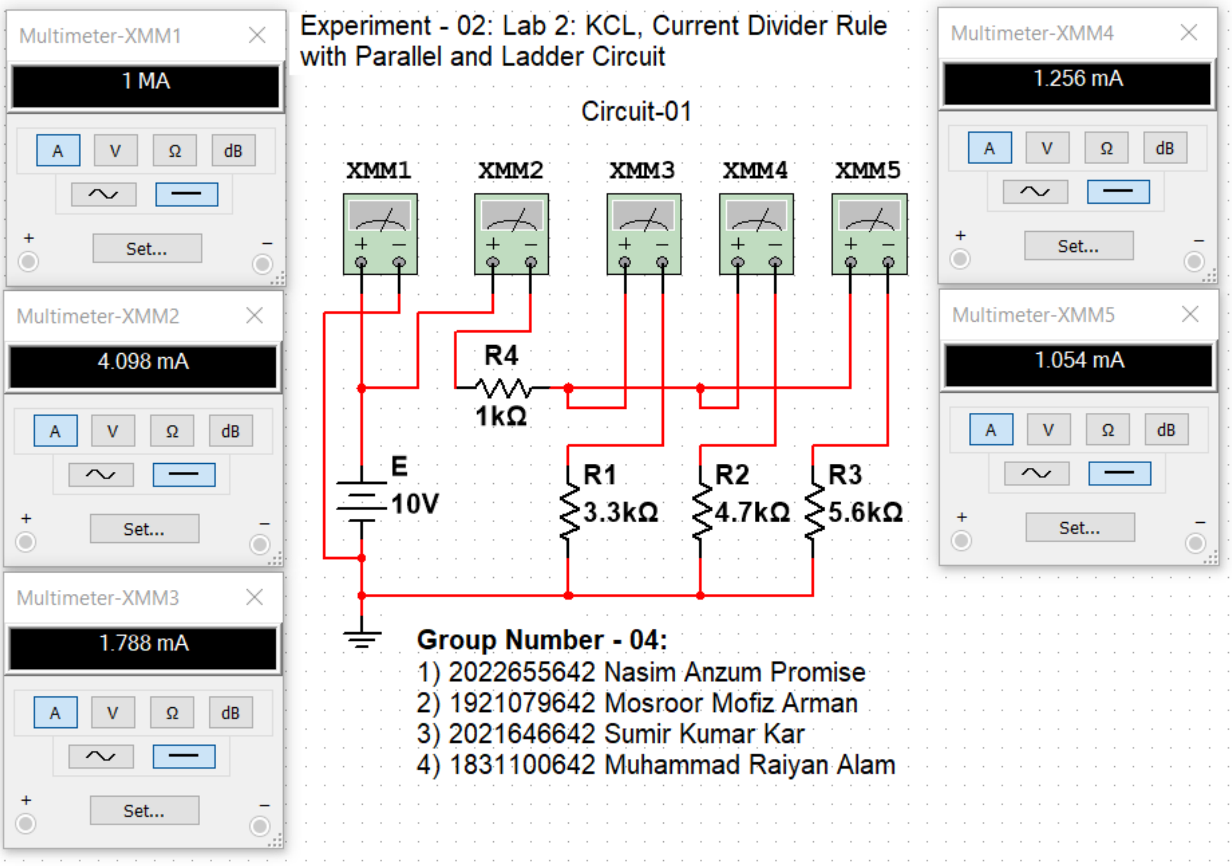

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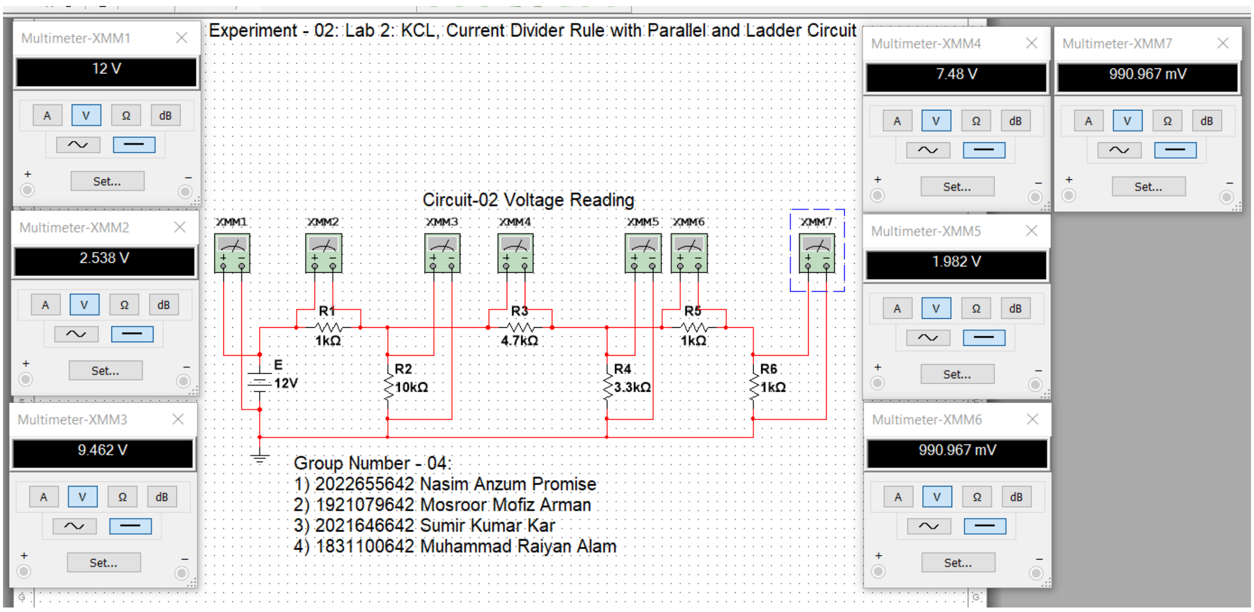
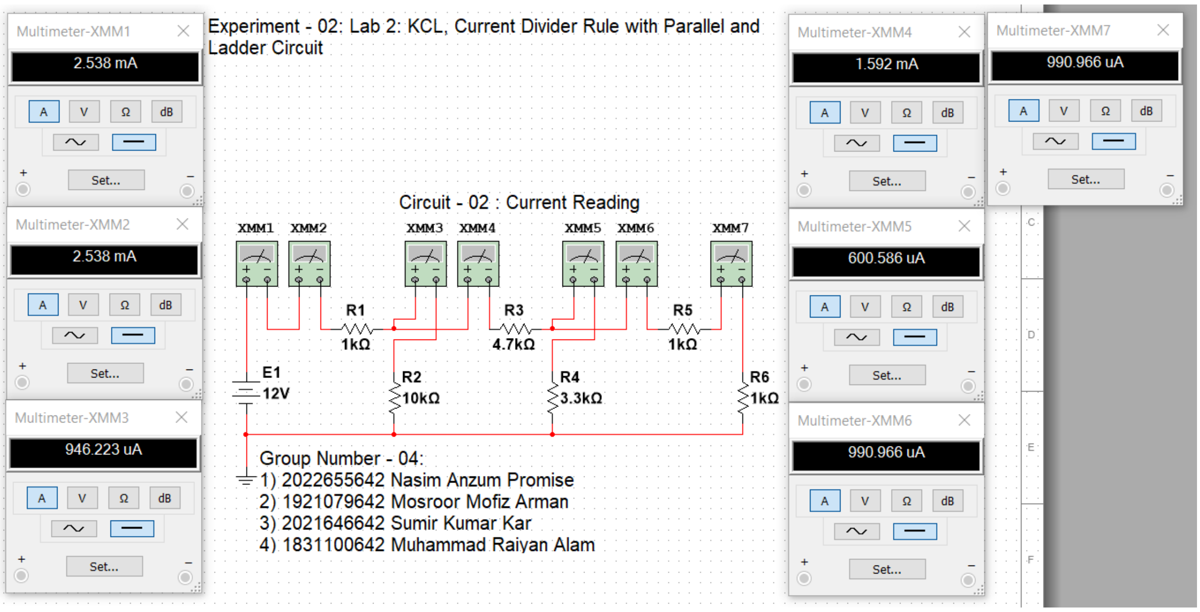


Circuit-02: Voltage Reading (above)



Circuit-3 Current Reading (above)

Data and Table

North South University

Department of Electrical & Computer Engineering

EEE/ETE141

Data Collection

Lab 2

Group No. 4

Instructor's Signature [signature]

$\frac{|P-T|}{T} \times 100$

Table 1:

Resistance using colour coding					Resistance using DMM	% Error
Band 1	Band 2	Band 3	Band 4	Resistance ± tol		
Brown 1	Black 0	Red ×100 Ω	Golden ±5%	±5%	0.983 kΩ	1.73%
orange 3	orange 3	Red ×100 Ω	Golden ±5%	±5%	3.23 kΩ	2.13%
Yellow 4	Violet 7	Red ×100 Ω	Golden ±5%	±5%	4.63 kΩ	1.489%
Green 5	Blue 6	Red ×100 Ω	Golden ±5%	±5%	5.55 kΩ	0.893%
Brown 1	Black 0	orange ×1k Ω	Golden ±5%	±5%	9.96 kΩ	±0.4%
Brown 1	Black 0	Red ×100 Ω	Golden ±5%	±5%	0.988 kΩ	1.2%
Brown 1	Black 0	Red ×100 Ω	±5%	±5%	0.975 kΩ	2.5%

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Table 2:

Experimental readings				Theoretical values			
I_S	I_{R1}	I_{R2}	I_{R3}	I_S	I_{R1}	I_{R2}	I_{R3}
4.06 mA	1.85 mA	1.28 mA	1.06 mA				

% Error			
I_S	I_{R1}	I_{R2}	I_{R3}

Table 3:

I_S	4.06 mA	Is Total Current equal to sum individual current?
Sum of individual Current ($I_{R1} + I_{R1} + I_{R3}$)	$(1.85 + 1.28 + 1.06)$ mA $= 4.19$ mA	Yes.

Table 4:

Experimental Req	Theoretical Req	% Error
2.4 kΩ		

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Table 5:

Component	Voltage	Current
E	12.08V	2.58mA
R1	2.53V	2.58mA
R2	0.51V	0.94mA
R3	7.53V	1.63mA
R4	2.00V	0.62mA
R5	0.99V	1.01mA
R6	0.98V	1~~.01mA~~

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Questions and Answers

1) State the Current Division Rule.

   Ans: In a parallel circuit, the equal dividing of two or more parallel elements with equal value is known as the Current Divider Rule.

2) State the Kirchhoff's Current Law (KCL).

   Ans: When the summation of the current junction (or region) of a network must equal the summation of the currents leaving the same junction (or regions) is known as **Kirchhoff's Current Law.**

3) With the experimental data, verify Kirchhoff's voltage law within each independent closed loop of the circuit.

   Solution:

   $V = IR$
   $V_s = IR_s = (4.06 * 10^{-3}) * (0.983 * 10^3) = 3.991$ V
   $V_1 = IR_1 = (1.85 * 10^{-3}) * (3.23 * 10^3) = 5.976$ V
   $V_2 = IR_2 = (1.28 * 10^{-3}) * (4.63 * 10^3) = 5.927$ V
   $V_3 = IR_s = (1.06 * 10^{-3}) * (5.53 * 10^3) = 5.884$ V

   Applying KVL in order to verify:
   In Loop-I: 10 - 3.991 - 5.976 = 0.033 (almost 0)
   In Loop-II: 10 - 3.991 - 5.927 = 0.082 (almost 0)
   In Loop-III: 10 - 3.991 - 5.884 = 0.125 (almost 0)

4) With the experimental data, verify Kirchhoff's current law at nodes a and b of the circuit.

   Solution:

   At Node A:
   Cin = Cout
   or, 2.57mA = 0.94mA + 1.63mA

   At Node B:
   Cin = Cout
   or, 1.63mA = 0.62mA + 1.01mA

5) Showing all steps, calculate the theoretical values in Table 2. Compare theoretical values to your experimental values and explain whether your circuit follows KCL or not.

Solution:

Here R_1, R_2, R_3 is in parallel so total resistance R_{123} will be

R_{123} = $\frac{1}{\frac{1}{3.3*10^3}+\frac{1}{4.7*10^3}+\frac{1}{5.6*10^3}} = 1.44 * 10^3 \Omega$

R_t = $1.44 * 10^3 + 1 * 10^3 = 2.44 * 10^3\ \Omega$

I_t = $\frac{V}{R_t} = \frac{10\ V}{2.44 * 10^3} = 4.09\ mA$

Here,

$I_s = I_t$

$I_s = 4.09\ mA$

$\boldsymbol{I_1} = \frac{I_S R_{123}}{R_1} = \frac{(4.09)(1.44 * 10^3)}{3.3 * 10^3}$ = 1.79 **mA**

$\boldsymbol{I_2} = \frac{I_S R_{123}}{R_2} = \frac{(4.09)(1.44 * 10^3)}{4.7 * 10^3}$ = 1.25 **mA**

$\boldsymbol{I_3} = \frac{I_S R_{123}}{R_3} = \frac{(4.09)(1.44 * 10^3)}{5.6 * 10^3}$ = 1.05 **mA**

$\mathbf{I_s = I_1 + I_2 + I_3 =}$ (1.79 + 1.25 + 1.05) **mA** = 4.09 **mA**

$$\%\ Error = \frac{|(Experimental\ Value - Theoretical\ Values)|}{Theoretical\ Values} * 100\%$$

$I_s = \frac{|(4.06 - 4.09)|}{4.09} * 100\%$ = 0.73%

$I_1 = \frac{|(1.85 - 1.79)|}{1.79} * 100\%$ = 3.35%

$I_2 = \frac{|(1.28 - 1.25)|}{1.25} * 100\%$ = 2.4%

$I_3 = \frac{|(1.06 - 1.05)|}{1.05} * 100\%$ = 0.95%

The experimental values of our experiment follow KCL.

6) Showing all the steps, theoretically calculate Req. Compare with the experimental value.
Solution:
Theoretical Values:

Here R_1, R_2, R_3 is in parallel so total resistance R_{123} will be

$R_{123} = \dfrac{1}{\frac{1}{3.3*10^3}+\frac{1}{4.7*10^3}+\frac{1}{5.6*10^3}} = 1.44 * 10^3\Omega$

Here R_s and R_{123} is in series so,

$R_{123s} = (1.44 \text{ x } 10^3 + 1 \text{ x } 10^3)\ \Omega = 2.44 \text{ x } 10^3\ \Omega$

$\% \, Error \; = \dfrac{|(2.4 - 2.44)|}{2.44} \; * \; 100\%$ = 1.64%

7) Calculate all the theoretical values for Table 5. Show all steps.
Solution:

R_5 and R_6 are in series so
$R_{56} = R_5 + R_6$
R_{56} = 1 kΩ + 1 kΩ = 2 kΩ
R_4 and R_{56} are in parallel so

$R_{456} = \dfrac{1}{\frac{1}{R_4}+\frac{1}{R_{56}}}$

$R_{456} = \dfrac{1}{\frac{1}{3.3}+\frac{1}{2}} =$ 1.25 kΩ

R_3 and R_{456} are in series so
$R_{3456} = R_3 + R_{456}$
R_{3456} = 1.25 kΩ + 4.7 kΩ = 5.95 kΩ
R_2 and R_{3456} are in parallel so

$R_{23456} = \dfrac{1}{\frac{1}{R_{3456}}+\frac{1}{R_2}}$

$R_{23456} = \dfrac{1}{\frac{1}{5.95}+\frac{1}{10}} =$ 3.73 kΩ

R_1 and R_{23456} are in series so
$R_t = R_1 + R_{23456}$
R_t = 1 kΩ + 3.73 kΩ = 4.73 kΩ

Now for E Voltage is V_E = 12V

Current will be $I_E = \frac{V_E}{R_T} = \frac{12}{4.73} = 2.54$ mA

At R_1 using Voltage Divider Rule

$V_1 = \frac{V_E\,R_1}{R_T} = \frac{(12\,V)(1k\Omega)}{4.73\,k\Omega} = 2.54$ V

$I_1 = \frac{V_1}{R_1} = \frac{2.54\,V}{1\,k\Omega} = 2.54$ mA

At R_2 using Current Divider Rule

$I_2 = \frac{I_1\,R_{23456}}{R_2} = \frac{(2.54\,mA)(3.73\,k\Omega)}{10\,k\Omega} = 0.947$ mA

$V_2 = I_2 * R_2$ = 0.947 mA * 10 kΩ = 9.47 V

At R_3 using Voltage Divider Rule

$V_3 = \frac{V_2\,R_3}{R_{3456}} = \frac{(9.47\,V)(4.7\,k\Omega)}{5.95\,k\Omega} = 7.48$ V

$I_3 = \frac{V_3}{R_3} = \frac{7.48\,V}{4.7\,k\Omega} = 1.59$ mA

At R_4 using Current Divider Rule

$I_4 = \frac{I_3\,R_{456}}{R_4} = \frac{(1.59\,mA)(1.25\,k\Omega)}{3.3\,k\Omega} = 0.602$ mA

$V_4 = I_4 * R_4$ = 0.602 mA * 3.3 kΩ = 1.98 V

At R_5 using Voltage Divider Rule

$V_5 = \frac{V_4\,R_5}{R_{56}} = \frac{(1.98\,V)(1\,k\Omega)}{2\,k\Omega} = 0.99$ V

$I_5 = \frac{V_5}{R_5} = \frac{0.99\,V}{1\,k\Omega} = 0.99$ mA

At R_6

$I_6 = I_5 = 0.99$ mA

$V_6 = V_5 = 0.99$ V

Result analysis & Discussion

In this lab, we learned the practical implementation of KCL, Current Divider Rule with Parallel and Ladder Circuit. This might be because of the Internal Resistance of each and every component. Practical use of Current Divider Rule $I_s = I_{s1} + I_{s2}$, KVL: $\sum I_i = \sum I_o$ and KCL were done in the experiment.

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During the experiment in Class:

1) **2022655642 Nasim Anzum Promise and 2021646642 Sumit Kumar Kar:** Building the Circuit
2) **1831100642 Muhammad Raiyan Alam:** Wrote data in Lab Manual and helped group members with the steps
3) **1921079642 Mosroor Mofiz Arman:** Checked whether all the circuits were built correctly or not and whether all the data were written carefully and accurately or not.

In Lab Report:

1) **2022655642 Nasim Anzum Promise:** Wrote objective, theory part and Discussion.
2) **1921079642 Mosroor Mofiz Arman:** Report Writing according to the Guideline given in the canvas.
3) **2021646642 Sumit Kumar Kar:** Drew Multisim
4) **1831100642 Muhammad Raiyan Alam:** Solved Questions and Answers