Ryerson University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

ELE 202
Electric Circuit Analysis
LAB COVER PAGE for Part I submission.

Lab #:	2	Lab Title:	Basic Concepts, Relationships and Laws of Electric Circuits

Last Name:	Malik
First Name:	Hamza

Student #:	501125445
***Signature*:**	Hamza

Section #:	10
Submission date and time:	Sunday July 17, 11am
Due date and time:	Monday July 18, 2pm

Document submission for Part I:

- A completed and signed "COVER PAGE – **Part I**" has to be included with your submission. The report will not be graded if the signed cover page is not included.
- Your completed handwritten pages of **Section 4.0** should be scanned (via a scanner or phone images), together with the required MultiSIM images. **Note:** *MultiSIM results must be generated using the Department's licensed version of MultiSIM, and the captured screenshots should show your name (at the center-top) and the timestamp (at the bottom-right corner of your screen).*
- Collate and create a ***.pdf*** or ***.docx*** file of the above, and upload it via D2L **any time prior to the start of your scheduled lab**. Upload instructions are provided on D2L.

Zero marks will be assigned for the entire lab if this Part I is not submitted prior to your scheduled lab.

**By signing above, you attest that you have contributed to this submission and confirm that all work you have contributed to this submission is your own work. Any suspicion of copying or plagiarism in this work will result in an investigation of Academic Misconduct and may result in a "0" on the work, an "F" in the course, or possibly more severe penalties, as well as a Disciplinary Notice on your academic record under the Student Code of Academic Conduct, which can be found online at: www.ryerson.ca/senate/current/pol60.pdf.*

3.0 REQUIRED LAB EQUIPMENT & PARTS

- Digital Multimeter (DMM) and Power Supply
- ELE202 Lab Kit:- various components, breadboard, wires and jumpers.

4.0 PRE-LAB: ASSIGNMENT

(a) *I-V* Characteristics of Ohmic Resistor using a simple D.C. Circuit

(i) Assume varying values of the DC source-voltage, **E** applied as shown in **Figure 2.0**. For each source-voltage value, use Ohm's Law to determine the corresponding value of the current, I_R when the resistance, **R** is 2.2 kΩ and when it is 3.3 kΩ. Record your theoretical results in **Table 2.0.**

Pre-Lab workspace

① $I = \frac{V}{R} = \frac{3V}{2.2k\Omega} = 0.0013636A = 1.364mA$

② $I = \frac{V}{R} = \frac{6V}{2.2k\Omega} = 0.0027727A = 2.727mA$

③ $I = \frac{V}{R} = \frac{9V}{2.2k\Omega} = 0.0040909A = 4.091mA$

④ $I = \frac{V}{R} = \frac{12V}{2.2k\Omega} = 0.0054545A = 5.455mA$

⑤ $I = \frac{V}{R} = \frac{15V}{2.2k\Omega} = 0.006818A = 6.818mA$

(ii) Construct and simulate this circuit of **Figure 2.0a** on MultiSIM, and set it up as depicted in **Figure 2.0b** to measure the current, I_R and voltage, V_R when **R** = 2.2 kΩ. Vary the DC source-voltage, **E** such that the voltage, V_R across the resistor has the values listed in **Table 2.0**. For each listed source-voltage, measure the corresponding current, I_R and voltage, V_R. Record these simulation results in **Table 2.0**.

- Copy and paste a screenshot showing one MultiSIM readings on the circuit. Include the MultiSIM circuit file (**.ms14**) in your Pre-Lab submission.
- All screenshots should show your name printed on the center-top of the MultiSIM screen and the timestamp at the bottom-lower corner.

(iii) Change the resistor to **R** = 3.3kΩ, and repeat above **step (ii)**.

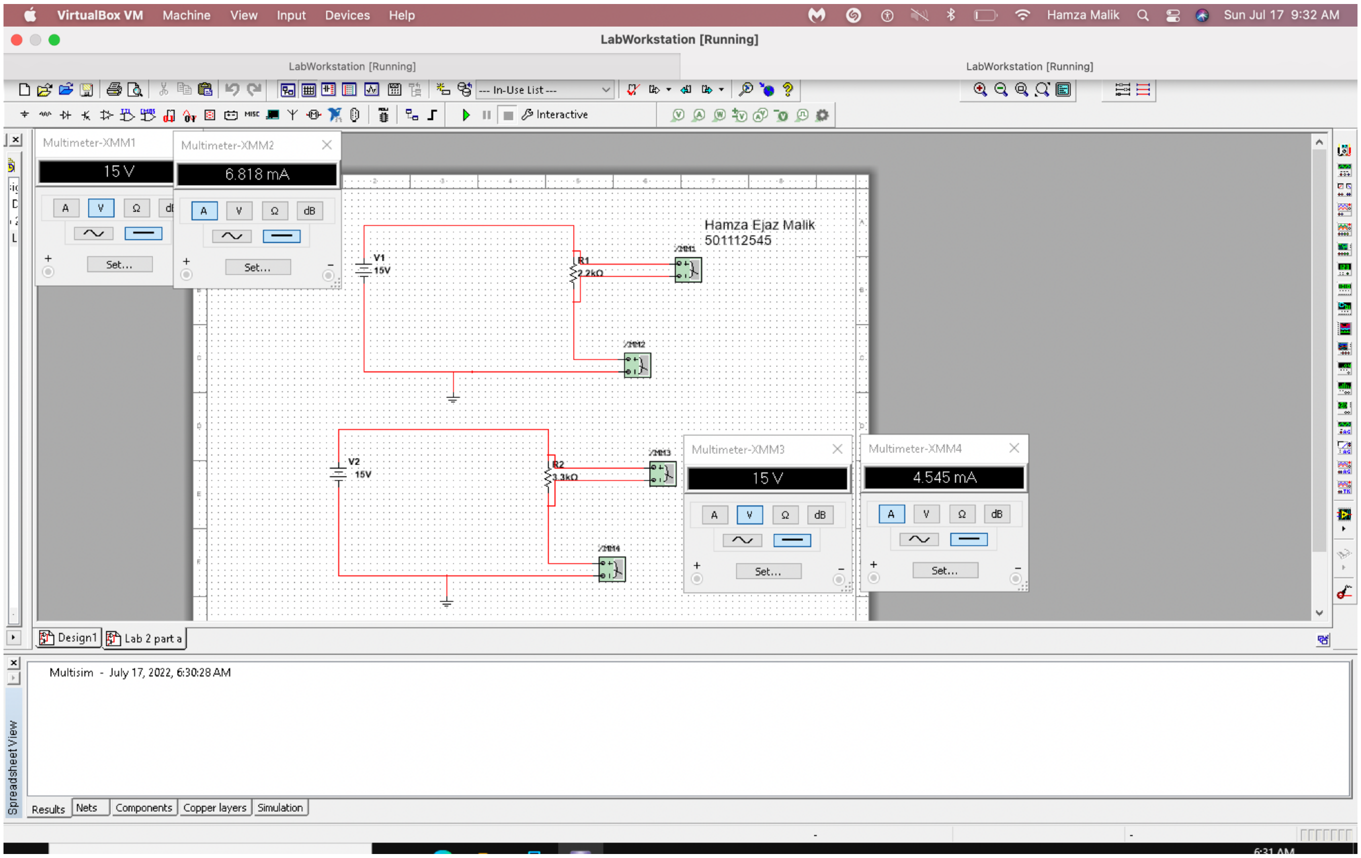
① $I = \frac{V}{R} = \frac{3V}{3.3k\Omega} = 0.00909A = 0.909mA$

② $I = \frac{V}{R} = \frac{6V}{3.3k\Omega} = 0.00181A = 1.818mA$

③ $I = \frac{V}{R} = \frac{9V}{3.3k\Omega} = 0.002727 = 2.727mA$

④ $I = \frac{V}{R} = \frac{12V}{3.3k\Omega} = 0.003636A = 3.636mA$

⑤ $I = \frac{V}{R} = \frac{15V}{3.3k\Omega} = 0.004545A = 4.545mA$


VirtualBox VM Machine View Input Devices Help
Hamza Malik
Sun Jul 17 9:32 AM
LabWorkstation [Running]
Multimeter-XMM1
15 V
Multimeter-XMM2
6.818 mA
Hamza Ejaz Malik
501112545
V1
15V
R1
2.2kΩ
V2
15V
R2
3.3kΩ
Multimeter-XMM3
15 V
Multimeter-XMM4
4.545 mA
Design1
Lab 2 part a
Multisim - July 17, 2022, 6:30:28 AM
Results
Nets
Components
Copper layers
Simulation

(iv) Compare your Theory results with the MultiSIM results from **Table 2.0**, and comment on your observations.

Pre-Lab workspace

comparing both the theory results and the multisim results from table 2.0 we can conclude that the results are exactly the same. Differences that could occur could really be due to uncertainty.

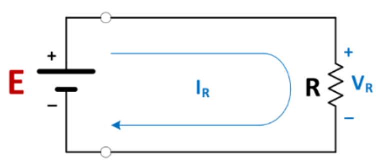


Figure 2.0a: Simple DC Circuit

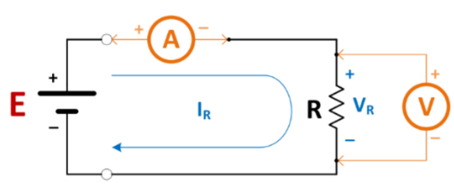


Figure 2.0b: Simple DC Circuit showing Voltmeter & Ammeter connections

R	V_R =>	3V		6V		9V		12V		15V	
		Theory result	MultiSIM result	Theory result	MultiSIM result	Theory result	MultiSIM result	Theory result	MultiSIM result	Theory result	MultiSIM result
2.2 kΩ	I_R => (mA)	1.364mA	1.364mA	2.727mA	2.727mA	4.091mA	4.091mA	5.455mA	5.455mA	6.818mA	6.818mA
3.3 kΩ	I_R => (mA)	0.909mA	0.909mA	1.818mA	1.818mA	2.727mA	2.727mA	3.636mA	3.636mA	4.545mA	4.545mA

Table 2.0: Theoretical and MultiSIM results of the Simple DC Circuit in Figure 2.0

(b) Series Resistors Circuit - KVL

(i) For the circuit of **Figure 2.1a**, assume the source-voltage, **E = 15V**, R_1 = 3.3 kΩ, R_2 = 2.2 kΩ and R_3 = 1.0 kΩ. Determine the expected current, **I** and the voltages across resistors R_1 (=V_{ab}), R_2 (= V_{bc}) and R_3 (=V_{cd}) for the respective values of resistors shown. Record your theoretical results in **Table 2.1**. Determine the sum ΣV = (V_{ab} + V_{bc} + V_{cd}) to verify the KVL law.

Pre-Lab workspace

RT = 6.5 kΩ　IT = 2.308 mA　VT = 15 V
R1 = 3.3 kΩ　I1 = 2.308 mA　V1 = 7.615 V
R2 = 2.2 kΩ　I2 = 2.308 mA　V2 = 5.077 V
R3 = 1.0 kΩ　I3 = 2.308 mA　V3 = 2.308 V

RT = R1 + R2 + R3
= 3.3 kΩ + 2.2 kΩ + 1.0 kΩ
= 6.5 kΩ
I = V/R = 15V/6.5kΩ = 0.0023076A = 2.308 mA

V1 = I1 × R1
= 33 kΩ × 0.0023076
= 7.615 V
V2 = I2 × R2
= 2.2 kΩ × 0.0023076
= 5.077 V
V3 = I3 × R3
= 1 kΩ × 0.0023076
= 2.308 V

VT = 7.615 + 5.077 + 2.308
= 15 V

(ii) On MultiSIM, construct and simulate the circuit of **Figure 2.1a** using a DC source-voltage, **E = 15V**, R_1 = 3.3 kΩ, R_2 = 2.2 kΩ and R_3 = 1.0 kΩ. The measurement setup for the simulator is depicted in **Figure 2.1b**. Record the measured current, **I** and the voltages across resistors R_1 (=V_{ab}), R_2 (= V_{bc}) and R_3 (=V_{cd}) for the respective values of resistors shown. Record your simulation results in **Table 2.1**. Determine the sum ΣV = (V_{ab} + V_{bc} + V_{cd}) to verify the KVL law.

- Copy and paste a screenshot showing one MultiSIM readings on the circuit. Include the MultiSIM circuit file (**.ms14**) in your Pre-Lab submission.
- All screenshots should show your name printed on the center-top of the MultiSIM screen and the timestamp at the bottom-lower corner.

Pre-Lab workspace

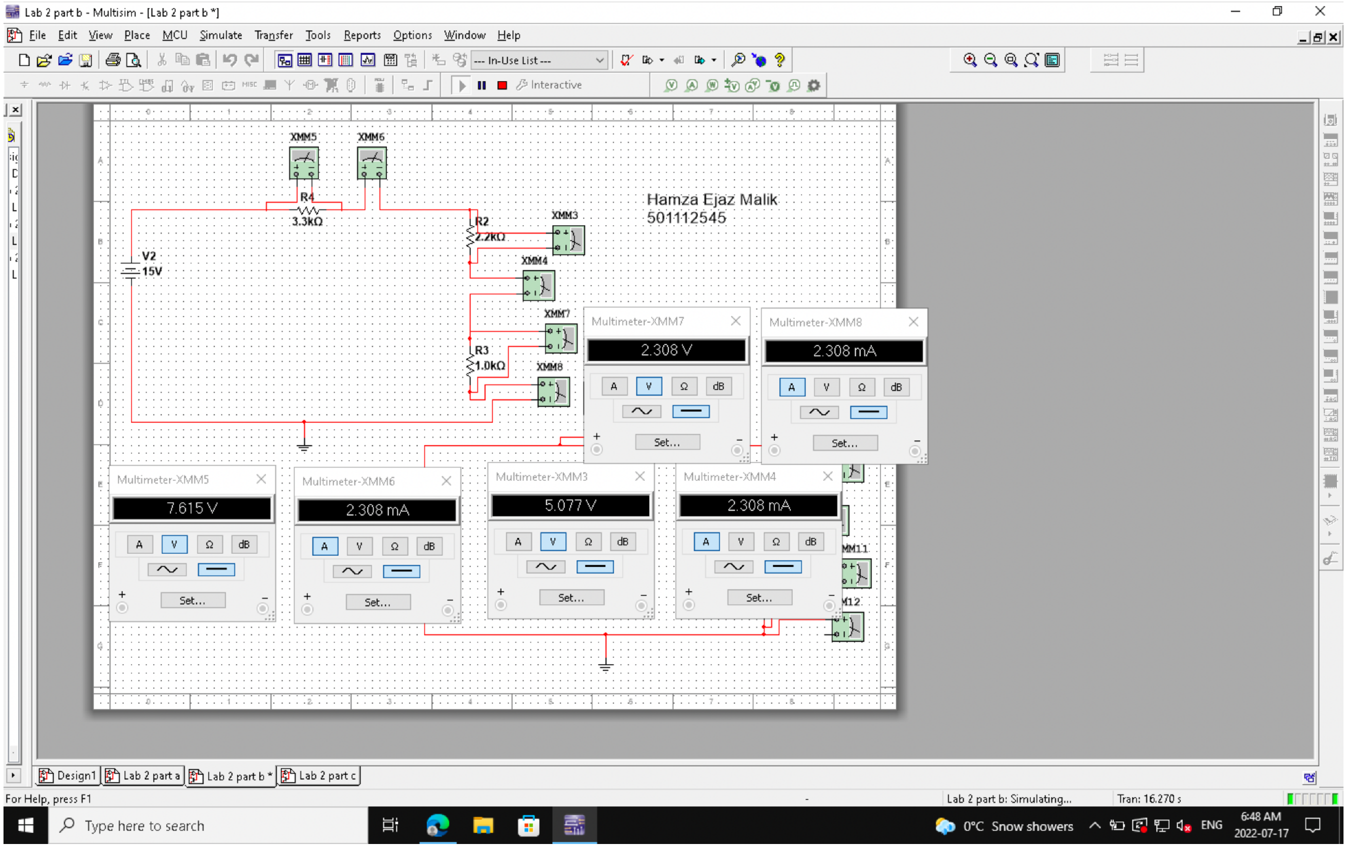
Vab = 7.615 V
Vbc = 5.077 V
Vcd = 2.308 V

ΣV = 7.615 + 5.077 + 2.308
= 15 V

(iii) Compare your Theory results with the MultiSIM results from **Table 2.1**, and comment on your observations.

Pre-Lab workspace

By looking at the theory values and comparing them to the multisim results, the measured and calculated values are the same. Therefore proves the "KVL" calculations. Any sort of errors could be due to uncertainty in rounding.

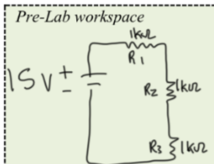

Lab 2 part b - Multisim - [Lab 2 part b *]
File Edit View Place MCU Simulate Transfer Tools Reports Options Window Help
Hamza Ejaz Malik
501112545
XMM5
XMM6
R4
3.3kΩ
R2
2.2kΩ
XMM3
XMM4
V2
15V
XMM7
R3
1.0kΩ
XMM8
Multimeter-XMM7
2.308 V
Multimeter-XMM8
2.308 mA
Multimeter-XMM5
7.615 V
Multimeter-XMM6
2.308 mA
Multimeter-XMM3
5.077 V
Multimeter-XMM4
2.308 mA
Design1
Lab 2 part a
Lab 2 part b *
Lab 2 part c
For Help, press F1
Lab 2 part b: Simulating...
Tran: 16.270 s
Type here to search
0°C Snow showers
ENG
6:48 AM
2022-07-17

(iv) **<u>Design Problem:</u>** Referring to the circuit of **Figure 2.1a**, a designer wishes to create three *equal* potential differences (i.e. $V_{ab} = V_{bc} = V_{cd}$) of **5V** each from a source-voltage, **E = 15V.** The **maximum** source-current, **I** available from the **E** battery-source is **5mA**, and so the designer must ensure the current value stays within this requirement, and **not exceed**. Using KVL concept, analyse and determine a set of values for **I**, R_1, R_2 and R_3 the designer can use to meet the above design specifications. ***Use standard resistor values available in your lab kit in your design.*** Record the results of your design analysis in **Table 2.2**.

Using your design values of R_1, R_2 and R_3 implement and simulate your circuit design on MultiSIM. Measure the current, **I** and the voltages across resistors R_1 ($=V_{ab}$), R_2 ($=V_{bc}$) and R_3 ($=V_{cd}$), and record the results in **Table 2.2**.

- Copy and paste a screenshot showing one MultiSIM readings on the circuit. Include the MultiSIM circuit file (**.ms14**) in your Pr-Lab submission.
- All screenshots should show your name printed on the center-top of the MultiSIM screen and the timestamp at the bottom-lower corner.

Pre-Lab workspace



KVL

KVL = -15 + i1 + i2 + i3 = 0
= 3i = 15
= i = 5mA

V = ir
= (5mA)(1kΩ)
= 5V

ΣV = 5V + 5V + 5V
= 15V

RT = 3.0kΩ IT = 5mA VT = 15V
R1 = 1.0kΩ I1 = 5mA V1 = 5V
R2 = 1.0kΩ I2 = 5mA V2 = 5V
R3 = 1.0kΩ I3 = 5mA V3 = 5V

RT = R1 + R2 + R3
= 1 + 1 + 1
= 3kΩ

$I_T = \frac{V_T}{R_T}$
$= \frac{15V}{3k\Omega}$
= 5mA

V1 = I1 × R1
= 5mA × 1.0kΩ
= 5V

V2 = I2 × R2
= 5mA × 1.0kΩ
= 5V

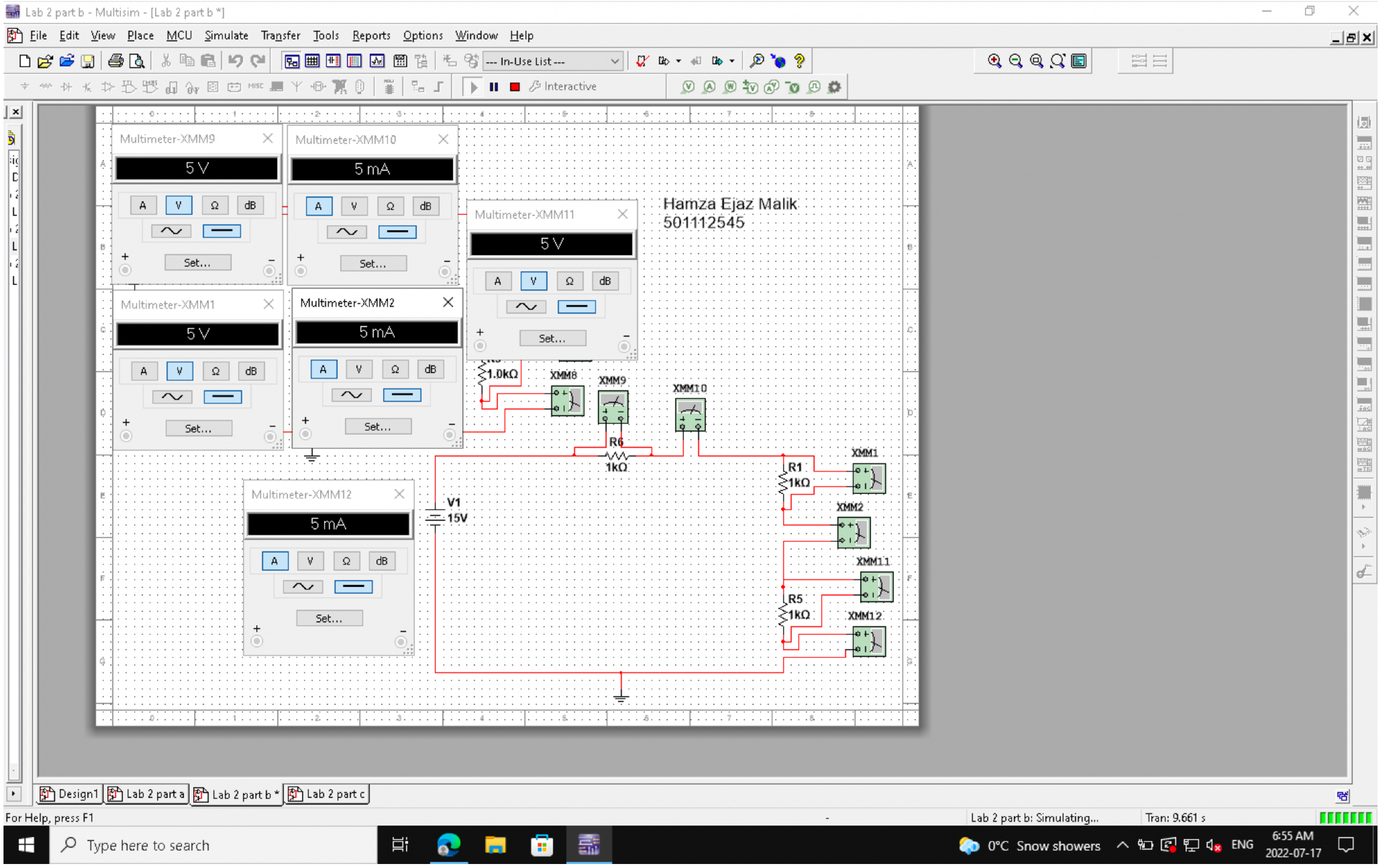
V2 = I2 × R2
= 5mA × 1.0kΩ
= 5V

VT = 5V + 5V + 5V
= 15V

(v) Compare your Theory results with the MultiSIM results from **Table 2.2**, comment on your observations and explain any discrepancies in your design outcome.

Pre-Lab workspace

Comparing the theory and multisim values I saw that they were exactly the same. This basically indicates that the theory values calculated were correct for the design problem.



Lab 2 part b - Multisim - [Lab 2 part b *]
File Edit View Place MCU Simulate Transfer Tools Reports Options Window Help
Multimeter-XMM9
5 V
Multimeter-XMM10
5 mA
Multimeter-XMM11
5 V
Multimeter-XMM1
5 V
Multimeter-XMM2
5 mA
Multimeter-XMM12
5 mA
Hamza Ejaz Malik
501112545
1.0kΩ
XMM8
XMM9
XMM10
R6
1kΩ
V1
15V
XMM1
R1
1kΩ
XMM2
XMM11
R5
1kΩ
XMM12
Design1
Lab 2 part a
Lab 2 part b *
Lab 2 part c
For Help, press F1
Lab 2 part b: Simulating...
Tran: 9.661 s
Type here to search
0°C Snow showers
ENG
6:55 AM
2022-07-17

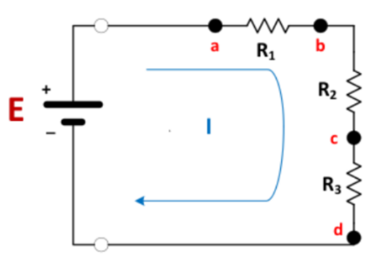


Figure 2.1a: KVL Series Circuit

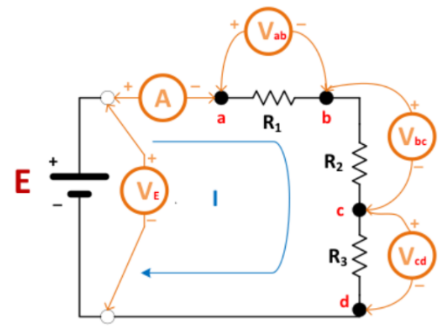


Figure 2.1b: KVL Series Circuit showing Voltmeter & Ammeter connections

V_E	I (mA)		V_{ab} (Volts)		V_{bc} (Volts)		V_{cd} (Volts)		$\Sigma V = (V_{ab} + V_{bc} + V_{cd})$	
	Theory result	MultiSIM result	Theory result	MultiSIM result	Theory result	MultiSIM result	Theory result	MultiSIM result	Theory result	MultiSIM result
15V	2.308mA	2.308mA	7.615V	7.615V	5.077V	5.077V	2.308V	2.308V	15V	15V

Table 2.1: Theoretical and MultiSIM results of the Series Circuit in Figure 2.1

Design values => R_1 = 1kΩ ? R_2 = 1kΩ ? R_3 = 1kΩ ?

V_E	I (mA)		V_{ab} (Volts)		V_{bc} (Volts)		V_{cd} (Volts)	
	Theory result	MultiSIM result	Theory result	MultiSIM result	Theory result	MultiSIM result	Theory result	MultiSIM result
15V	5mA	5mA	5V	5V	5V	5V	5V	5V

Table 2.2: Theoretical and MultiSIM results of the ***re-designed*** Series Circuit in Figure 2.1

(c) Parallel Resistors Circuit - KCL

(i) For the circuit of **Figure 2.2a**, assume the source-voltage, **E = 15V**, $\mathbf{R_1}$ = 3.3 kΩ, $\mathbf{R_2}$ = 2.2 kΩ and $\mathbf{R_3}$ = 1.0 kΩ. Determine the expected currents **I**, $\mathbf{I_1}$, $\mathbf{I_2}$ and $\mathbf{I_3}$ as shown in **Figure 2.2a**. Record your theoretical results in **Table 2.3**. Determine the sum ΣI = ($\mathbf{I_1}$ + $\mathbf{I_2}$ + $\mathbf{I_3}$) to verify the KCL law.

Pre-Lab workspace

KCL @ node a

$-15 + 3.3 i = 0$

$i_1 = \frac{15}{3.3}$

$\boxed{I_1 = 4.545 mA}$

$\Sigma I = 26.313 mA$

KCL @ node b

$-15 + 2.2 i_2 = 0$

$i_2 = \frac{15}{2.2}$

$\boxed{I_2 = 6.818 mA}$

KCL @ node c

$-15 + 1 i_3 \; i = 0$

$i_3 = \frac{15}{1}$

$\boxed{I_3 = 15 mA}$

$V_T = 15V$ $\quad R_T = 568.966\Omega$

$V_1 = 15V$ $\quad R_1 = 3.3k\Omega$

$V_2 = 15V$ $\quad R_2 = 2.2k\Omega$

$V_3 = 15V$ $\quad R_3 = 1.0k\Omega$

$R_T = 1/R_1 + 1/R_2 + 1/R_3$

$= 1/3.3k\Omega + 1/2.2k\Omega + 1/1.0k\Omega$

$= 1/0.00175757 58$

$= 568.966\Omega$

(ii) On MultiSIM, construct and simulate the circuit of **Figure 2.2a** using a DC source-voltage, **E = 15V,** $\mathbf{R_1}$ = 3.3 kΩ, $\mathbf{R_2}$ = 2.2 kΩ and $\mathbf{R_3}$ = 1.0 kΩ. The measurement setup for the simulator is depicted in **Figure 2.2b**. Record the measured currents **I**, $\mathbf{I_1}$, $\mathbf{I_2}$ **and** $\mathbf{I_3}$ as shown in **Figure 2.2a**. Record your simulation results in **Table 2.3**. Determine the sum ΣI = ($\mathbf{I_1}$ + $\mathbf{I_2}$ + $\mathbf{I_3}$) to verify the KCL law.

- Copy and paste a screenshot showing one MultiSIM readings on the circuit. Include the MultiSIM circuit file (**.ms14**) in your Pre-Lab submission.
- All screenshots should show your name printed on the center-top of the MultiSIM screen and the timestamp at the bottom-lower corner.

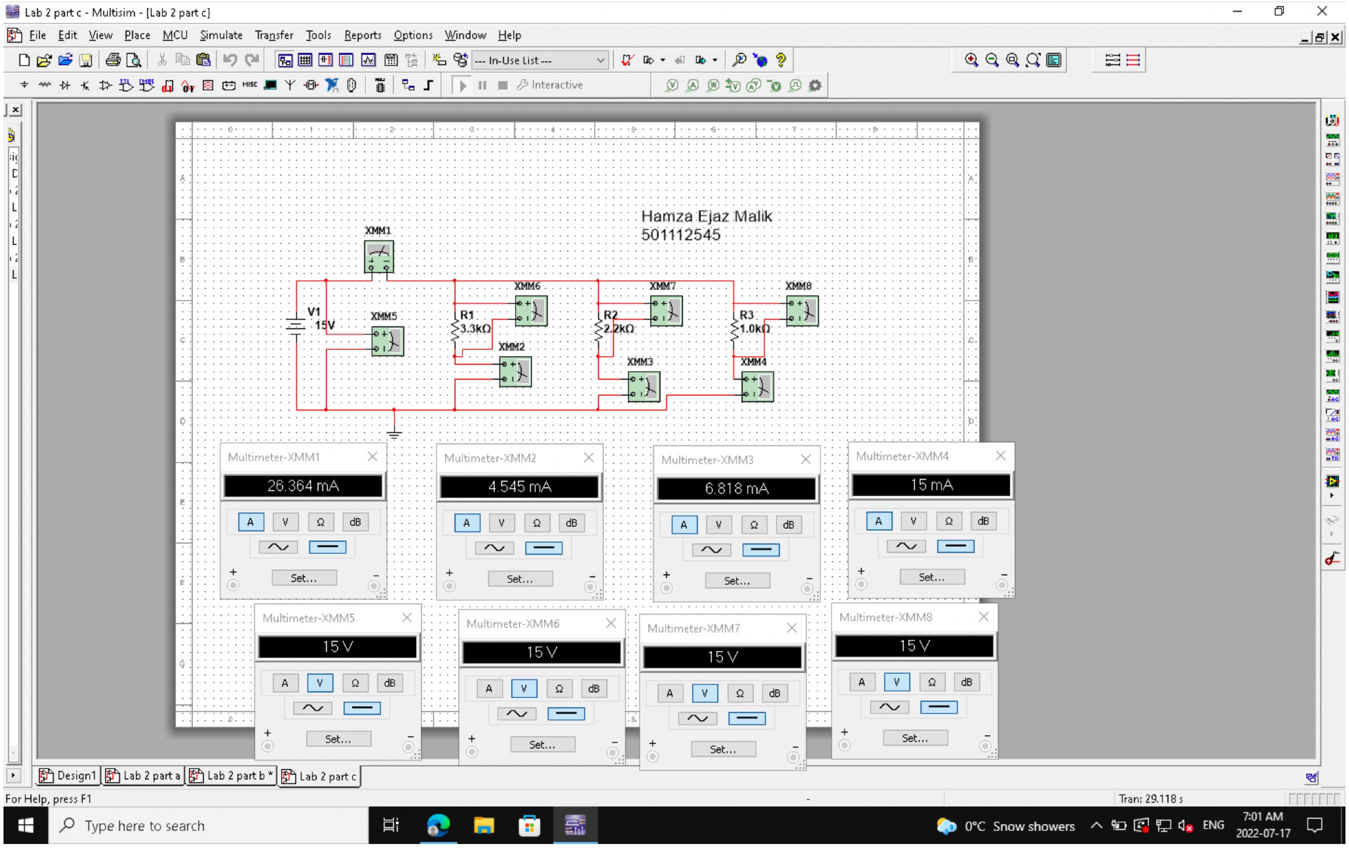
Pre-Lab workspace

$I_1 = 4.545 mA$

$\Sigma I = 26.364$

$I_2 = 6.818 mA$

$I_3 = 15 mA$


Lab 2 part c - Multisim - [Lab 2 part c]
Hamza Ejaz Malik
501112545
XMM1
XMM5
XMM6
XMM7
XMM8
XMM2
XMM3
XMM4
V1
15V
R1
3.3kΩ
R2
2.2kΩ
R3
1.0kΩ
Multimeter-XMM1
26.364 mA
Multimeter-XMM2
4.545 mA
Multimeter-XMM3
6.818 mA
Multimeter-XMM4
15 mA
Multimeter-XMM5
15 V
Multimeter-XMM6
15 V
Multimeter-XMM7
15 V
Multimeter-XMM8
15 V
For Help, press F1
Tran: 29.118 s
Type here to search
0°C Snow showers
7:01 AM
2022-07-17

(iii) Compare your Theory results with the MultiSIM results from **Table 2.3**, and comment.

Pre-Lab workspace

While comparing the theoritical and multisim values, I saw the values for both are very similar but difference could occur due to uncertainty present in the calculated values.

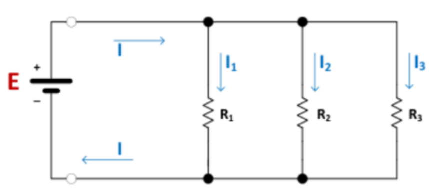


Figure 2.2a: KCL Parallel Circuit

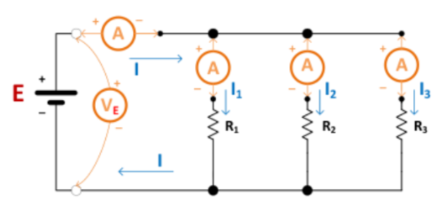


Figure 2.2b: KCL Parallel Circuit with Ammeter & Voltmeter connections

V_E	I (mA)		I_1 (mA)		I_2 (mA)		I_3 (mA)		$\Sigma I = (I_1 + I_2 + I_3)$	
	Theory result	MultiSIM result	Theory result	MultiSIM result	Theory result	MultiSIM result	Theory result	MultiSIM result	Theory result	MultiSIM result
15V	26.363mA	26.364mA	4.545mA	4.545mA	6.818mA	6.818mA	15mA	15mA	26.363mA	26.364mA

Table 2.3: Theoretical and MultiSIM results of the Parallel Circuit in Figure 2.2