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

Last Name:	Yang
First Name:	

Student #:	
Signature:	

Section #:	4
Submission date and time:	May 29 2022
Due date and time:	May 30 2022

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. **<u>Note:</u>** *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 <u>will result in an investigation of Academic Misconduct and may result in a "0" on the work,</u> 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.*

ELE 202
Laboratory #2

Basic Concepts, Relationships and Laws of Electric Circuits

1.0 INTRODUCTION

The relationship between *current* (**I**) and *voltage* (**V**) across the terminals of a circuit element defines the behavior of that element within the circuit. The graphical means of representing the terminal characteristics of a circuit element is done by introducing the variable **I** to represent current flowing through the element, while voltage **V** is the *Potential Difference* (**P.D.**) or voltage across the element. If the voltage applied to the element were varied and the resulting current measured, it would be possible to construct a functional relationship between voltage and current known as the ***I-V*** characteristic. Depending on the electrical properties of a circuit element, this ***I-V*** relationship can be "*linear*" or "*non-linear*".
Electrical current, **I** (= $d\mathbf{Q}/dt$) is the rate at which *free* electrons (or charge, **Q**) is made to drift through a material in a particular direction, that is, moved around a circuit. In order to cause the *free* electrons to drift in a given direction, an Electro-Motive Force (**EMF**) must be applied, and which ends up being the driving force in an electrical circuit. The electrical symbol for an EMF is **E**, the unit of measurement is in **volts (V)**, and the typical voltage-sources of EMF are cells, batteries (or power-supplies), and generators.
When current flows through a metal wire or other circuit elements, it encounters a certain amount of *resistance*, the magnitude of which depends on the electrical properties of the material. Practically all circuit elements exhibit some resistance; as a consequence, the current flowing through an element will cause energy to be dissipated in the form of heat. An ideal resistor, **R,** is a circuit element that exhibits "*linear*" resistance properties according to **Ohm's Law**, whereby the voltage across the resistor element is directly proportional to the current flow through it. The unit of electrical resistance (R) is the **ohm (Ω)**. It should be noted that the EMF (the driving force, **E**) causes current to flow in a circuit, whereas a **P.D.** (Potential-Difference) is the result of current flowing through a resistor, **R**. Hence, EMF is a "*cause*" and P.D. is an "*effect*".
These basic concepts of current, voltage and power in an electric circuit are easy to grasp however, to actually determine the values and relationships of these variables in a given circuit requires a sound understanding of some "*fundamental laws*" that govern electric circuits. These laws, known as **Ohm's Law** and **Kirchhoff's Laws** (**KVL** and **KCL**) form the foundation upon which electric circuit analysis is built. So, for this particular lab, the student is urged to review Ohm's and Kirchhoff's laws, and related techniques commonly applied in circuit design and analysis.

References:- (i) Course Textbook: "*Fundamentals of Electric Circuits*" by C. K. Alexander and M. N. O. Sadiku; and (ii) "*Principles and Applications of Electrical Engineering*" by G. Rizzoni.

2.0 OBJECTIVES

- To enhance understanding of the basic electric circuit laws: Ohm's law, Kirchhoff's voltage law (**KVL**), and Kirchhoff's current law (**KCL**)
- To experimentally verify **KVL** and **KCL** in actual circuits.
- To investigate the current-voltage (***I-V***) characteristics of a linear circuit-element (e.g. Resistor) through the use of some simple D.C. circuits.
- To explore and verify the characteristics of ***series*** and ***parallel*** combinations of linear circuit-elements.

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, $\mathbf{I_R}$ 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

$V = iR$

$i = \frac{V}{R}$

$= \frac{3V}{2.2k\Omega} = 1.36mA$ $\quad = \frac{3V}{3.3k\Omega} = 0.909mA$

$= \frac{6V}{2.2k\Omega} = 2.72mA$ $\quad = \frac{6}{3.3k\Omega} = 1.818mA$

$= \frac{9V}{2.2k\Omega} = 4.09mA$ $\quad = \frac{9V}{3.3k\Omega} = 2.727mA$

$= \frac{12V}{2.2k\Omega} = 5.45mA$ $\quad = \frac{12V}{3.3k\Omega} = 3.6mA$

$= \frac{12}{2.2k\Omega} = 5.45mA$

$= \frac{15V}{2.2k\Omega} = 6.8mA$ $\quad = \frac{15}{3.3k} = 4.54$

(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, $\mathbf{I_R}$ and voltage, $\mathbf{V_R}$ when **R** = 2.2 kΩ. Vary the DC source-voltage, **E** such that the voltage, $\mathbf{V_R}$ across the resistor has the values listed in **Table 2.0**. For each listed source-voltage, measure the corresponding current, $\mathbf{I_R}$ and voltage, $\mathbf{V_R}$. 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)**.

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

Pre-Lab workspace

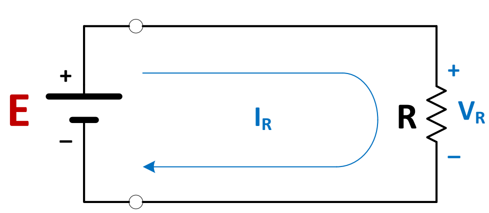


Figure 2.0a: Simple DC Circuit

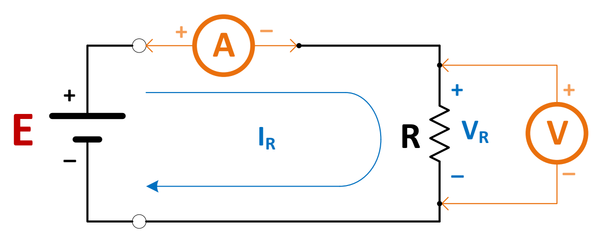


Figure 2.0b: Simple DC Circuit showing Voltmeter & Ammeter connections

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)	1.36	1.36	2.73	2.73	4.1	4.1	5.45	5.4	6.8	6.8
3.3 kΩ	I_R => (mA)	0.91	0.91	1.82	1.82	2.7	2.7	3.6	3.6	4.55	4.55

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**, $\mathbf{R_1}$ = 3.3 kΩ, $\mathbf{R_2}$ = 2.2 kΩ and $\mathbf{R_3}$ = 1.0 kΩ. Determine the expected current, **I** and the voltages across resistors $\mathbf{R_1}$ (=V_{ab}), $\mathbf{R_2}$ (= V_{bc}) and $\mathbf{R_3}$ (=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

$R_{eq} = 3.3k + 2.2k + 1k$
$= 6.5k$

$V = iR$
$i = \frac{V}{R} = \frac{15V}{6.5k\Omega}$

$i = 2.3\,mA$

$V_1 = \frac{3.3k}{6.5k} 15$
$= 7.62\,V$
$V_2 = 5.08\,V$
$V_3 = 2.30\,V$

(ii) On MultiSIM, construct and simulate the circuit of **Figure 2.1a** 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 2.1b**. Record the measured current, **I** and the voltages across resistors $\mathbf{R_1}$ (=V_{ab}), $\mathbf{R_2}$ (= V_{bc}) and $\mathbf{R_3}$ (=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

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

Pre-Lab workspace

they're the same

(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**, $\mathbf{R_1}$, $\mathbf{R_2}$ and $\mathbf{R_3}$ 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 $\mathbf{R_1}$, $\mathbf{R_2}$ and $\mathbf{R_3}$ implement and simulate your circuit design on MultiSIM. Measure the current, **I** and the voltages across resistors $\mathbf{R_1}$ (=V_{ab}), $\mathbf{R_2}$ (=V_{bc}) and $\mathbf{R_3}$ (=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

$5V = \frac{R_{eq}}{R_1} \cdot 15$

$\frac{1}{3} = \frac{R_{eq}}{R_1}$

$R_1 = R_2 = R_3$

$V = iR$

$\frac{15V}{5mA} = R$

$3k\Omega = R$

$R_1 = R_2 = R_3 = 1\ k\Omega$

(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

They're the same

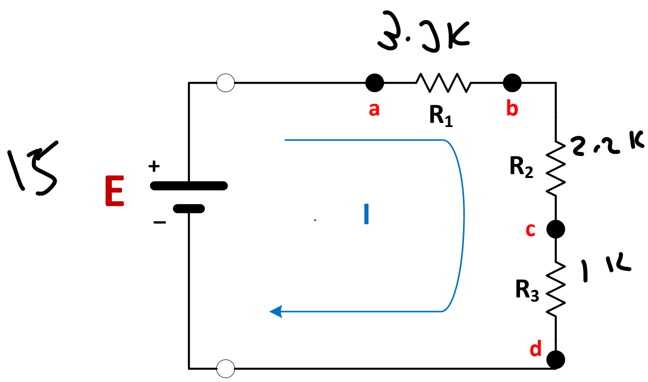


Figure 2.1a: KVL Series Circuit

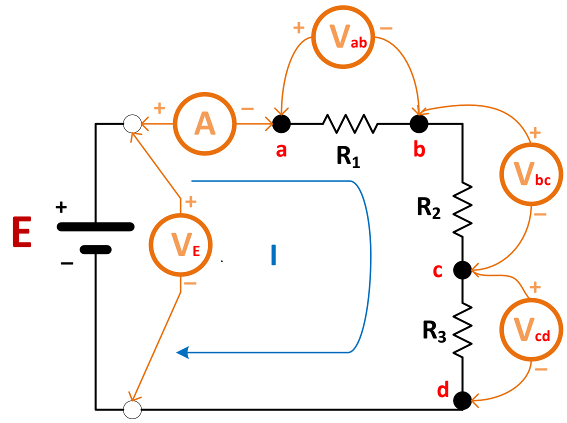


Figure 2.1b: KVL Series Circuit showing Voltmeter & Ammeter connections

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	2.3	2.3	7.62	7.62	5.08	5.08	2.3	2.3	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	5	5	5	5	5	5	5	5

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

$R_{eq} = \dfrac{1}{\frac{1}{2.2k} + \frac{1}{1.0k} + \frac{1}{3.3k}}$

$= 568.96\,\Omega$

$i = \dfrac{15V}{568.96\,\Omega}$

$= 26.36\text{ mA}$

$i_1 = \dfrac{0.57k}{3.3k}\, 26.36\text{ mA}$

$= 4.55\text{ mA}$

$i_2 = \dfrac{0.57k}{2.2k}\, 26.36\text{ mA}$

$= 6.83\text{ mA}$

$i_3 = \dfrac{0.57k}{1.0k}\, 26.36\text{ mA} = 15.02\text{ mA}$

(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

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

Pre-Lab workspace

They're the same

15

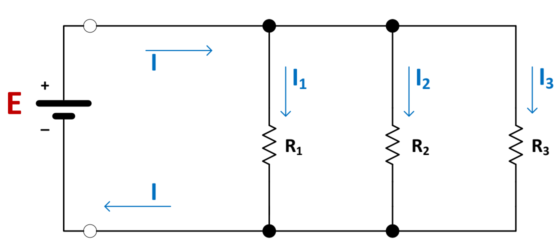


Figure 2.2a: KCL Parallel Circuit

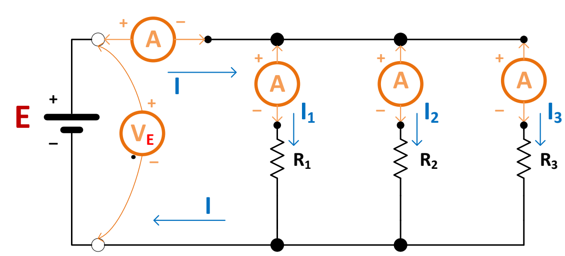


Figure 2.2b: KCL Parallel Circuit with Ammeter & Voltmeter connections

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	26.3	26.3	4.5	4.5	6.8	6.8	15	15.0	26.3	26.3

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

5.0 IN-LAB Experiment: IMPEMENTATION & MEASUREMENTS

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

1. From your lab kit, select 2.2 kΩ and 3.3 kΩ resistors (color-coded values). Use the DMM to measure their actual values. List the measured values in **Table 2.4**.

2. Build and connect the circuit of **Figure 2.0a** with **R =** 2.2 kΩ on the breadboard.
   Note 1: *When using the DMM as a Voltmeter, connect the DMM **in parallel** with the resistor as shown in the Figure 2.0b.* **Note 2:** *When using the DMM as an Ammeter, you must connect it **in series** with the resistor you need to measure the current passing through it as shown in the Figure 2.0b.*

3. Use the **red** and **black** "banana" cables (*available in the Lab room*) to connect the "+" and "-" terminals of the power supply to the **RED** and **GREEN** binding terminals on your breadboard, respectively. Turn ON the power supply.

4. Vary the power-supply source voltage, **E** such that the voltage across the resistor has the voltage, V_R values as listed in **Table 2.4** [*refer to the **Pre-Lab 4(a)***]. Use the Voltmeter to monitor the V_R voltage. Measure and record the corresponding current (I_R) values in **Table 2.4a**.

5. Turn OFF the power supply. Replace the 2.2kΩ resistor in circuit of **Figure 2.0a** with 3.3kΩ resistor. Repeat the above **Step 4,** and list your results in **Table 2.4b**.

6. Turn OFF the power supply.

Color-coded value of **R** = 2.2kΩ => Actual measured value of **R** = 2.15 KΩ					
V_R (Volts)	**3V**	**6V**	**9V**	**12V**	**15V**
I_R (mA) **as measured**	1.39	2.79	4.19	5.59	7.0
I_R (mA) **as calculated** in Pre-Lab using color-coded R value	1.36	2.73	4.07	5.45	6.82
Deviation (%) = 100.(measured - calculated)/(calculated)	2.2%	2.2%	2.95%	2.57%	2.64%

Table 2.4a: Experimental results of the Simple DC Circuit in Figure 2.0 with **R** = 2.2 kΩ

Color-coded value of **R** = 3.3kΩ => Actual measured value of **R** = 3.22 KΩ					
V_R (Volts)	**3V**	**6V**	**9V**	**12V**	**15V**
I_R (mA) **as measured**	0.93	1.86	2.79	3.73	4.66
I_R (mA) **as calculated** in Pre-Lab using color-coded R value	0.909	1.82	2.73	3.64	4.55
Deviation (%) = 100.(measured - calculated)/(calculated)	2.31%	2.2%	2.2%	2.47%	2.42%

Table 2.4b: Experimental results of the Simple DC Circuit in Figure 2.0 with **R** = 3.3 kΩ

(b) Series Resistors Circuit - KVL

1. Using R_1 =3.3 kΩ, R_2 = 2.2 kΩ and R_3 = 1.0 kΩ, construct on your breadboard the series circuit shown in **Figure 2.1**.

2. Turn ON the power supply. Adjust to set the source voltage, **E** to **15 V**. Measure the current **I** and the voltages V_{ab}, V_{bc}, and V_{cd}. Record the values in **Table 2.5**. **Note:** *Make sure the DMM is set to the right function before using it as Voltmeter or Ammeter, and accordingly connected to the circuit.*

3. Turn OFF the power supply.

4. **Design Problem Circuit**: Implement on your breadboard the re-designed circuit of **Figure 2.1** of Pre-Lab section [**4(b)(iii)**] using the standard-resistance value(s) that you had determined for R_1, R_2 and R_3 to meet the requirements.

   4.0.1 Turn ON the power supply. Set the source voltage, **E** to **15 V**.

   4.0.2 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 2.6**.

   4.0.3 Turn OFF the power supply.

V_E	I (mA)	V_{ab} (Volts)	V_{bc} (Volts)	V_{cd} (Volts)	$\Sigma V = (V_{ab} + V_{bc} + V_{cd})$
15V	2.36	7.60	5.07	2.32	14.99

Table 2.5: Experimental results of the Series Circuit of Figure 2.1

Design values used => R_1 = 0.98kΩ R_2 = 0.99kΩ R_3 = 0.98kΩ				
V_E	I (mA)	V_{ab} (Volts)	V_{bc} (Volts)	V_{cd} (Volts)
15V	5.08	4.98	5.02	4.99

Table 2.6: Experimental results of the ***re-designed*** Series Circuit in Figure 2.1

(c) Parallel Resistors Circuit - KCL

1. Using $\mathbf{R_1}$ = 3.3 kΩ, $\mathbf{R_2}$ = 2.2 kΩ and $\mathbf{R_3}$=1.0 kΩ, construct the parallel circuit shown in **Figure 2.2**.
2. Turn ON the power supply. Adjust the source voltage to **15V**.
3. Measure the currents **I**, $\mathbf{I_1}$, $\mathbf{I_2}$ **and** $\mathbf{I_3}$ as depicted in **Figure 2.2b**, and record your experimental results in **Table 2.7**. **Note:** *Make sure the DMM is set to the Ammeter function, and accordingly connected.*
4. Turn OFF the power supply.

V_E	**I** (mA)	I_1 (mA)	I_2 (mA)	I_3 (mA)	$\Sigma I = (I_1 + I_2 + I_3)$
15V	27.03	4.67	7.0	15.39	27.07

Table 2.7: Experimental results of the Parallel Circuit in Figure 2.2

6.0 POST-LAB: OBSERVATIONS AND ANALYSIS OF RESULTS

1. Compare your theoretical values and MultiSIM simulation measurements listed in **Table 2.0** with the experimental values of **Table 2.4a** and **Table 2.4b**. Relate the actual deviation obtained to the resistance tolerance band of the resistor. Explain your observations.

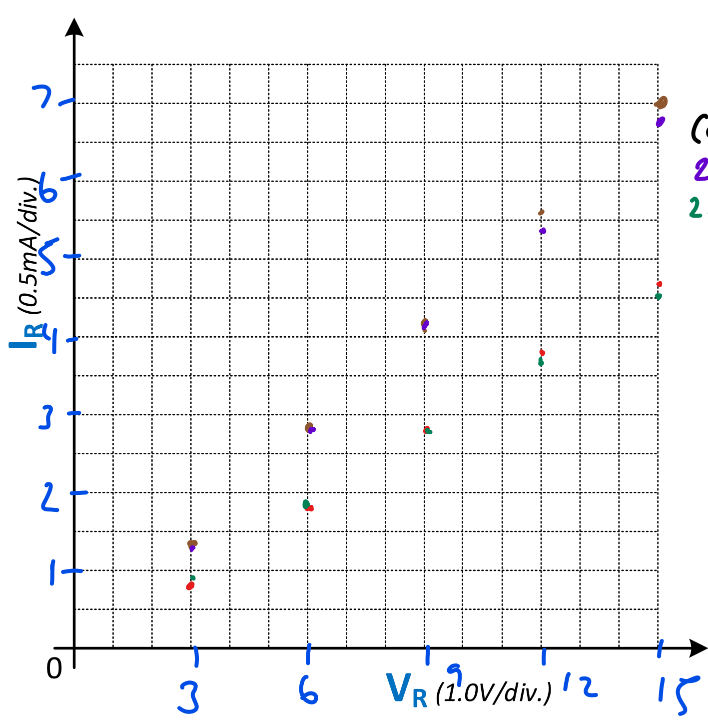
workspace

The values differ by ~2%. This is close to the percentage deviation of the resistor. This means the value deviation is the result of the resistor deviation.

2. Use the below Graph to <u>plot</u> the ***I-V*** characteristics **for each resistor** using the calculated and measured values listed in **Table 2.4a and Table 2.4b**, respectively. Then:-

(a) For the experiment values plotted, estimate the slope of each ***I-V*** graph and determine the resistance from the slope. Compare these values with your DMM measured (actual) resistance values. Explain any discrepancies.

(b) Is the ***I-V*** characteristics of each resistor consistent with the Ohm's law? Explain.



workspace

Measure:
2.4a
2.4b
Calc:
2.4a
2.4b

a) $R = \frac{V}{i}$

$m_a = \frac{15-3}{7-1.39} = 2.14k\Omega$

$m_b = \frac{15-3}{4.66-0.93} = 3.22k\Omega$

$M_a = \frac{15-3}{6.82-1.36} = 2.20k\Omega$

$M_b = \frac{15-3}{4.55-0.909} = 3.30k\Omega$

All values are the same, other than m_a, which is slightly off. Likely due to rounding differences.

b) Yes, if all values were entered into the $R = \frac{v}{i}$ formula they would produce a R close to 2.2K or 3.3K

3. For the KVL experiment, how well did your experimental results of **Table 2.5** conform to the Kirchhoff's Voltage Law? Explain.
Compare the experimental results of **Table 2.5** with your theoretical and simulated Pre-Lab values shown in **Table 2.1**, and explain reason(s) for any relative discrepancies/deviations observed.

workspace

Although most values differed slightly, the total voltage was ~15V in the end. Discrepancies could've been due to the resistors not having a perfect resistance value.

4. For the KVL experiment, using your measured voltages and currents of **Table 2.5**, calculate the power absorbed (dissipated) by **each** series resistor, and the total power delivered by the input-source.
How does the sum of power absorbed by the resistances in this series circuit compare to the amount delivered by the source? Explain.

workspace

$\mathbf{P}_{R1}$ = $vi = (7.6)(2.36) = 17.94$ W

$\mathbf{P}_{R2}$ = $vi = (5.07)(2.36) = 11.97$ W

$\mathbf{P}_{R3}$ = $vi = (2.32)(2.36) = 5.48$ W

$\mathbf{P}_{VE}$ = $vi = (15V)(2.36) = 35.4$ W

The sum of power ~ P_{VE}

5. For the KVL "**Design Problem**" experiment, do your results in **Table 2.6** confirm the design requirements of $V_{ab} = V_{bc} = V_{cd} = 5V$; and the current $I \leq 5mA$? How do these experimental results compare to your theoretical and simulation Pre-Lab values of **Table 2.2**. Explain reason(s) for any discrepancies/deviations.

workspace

yes, my results conform to the requirements.
The values differ by a few thousandths, likely because the resistors used also differed from the perfect 1.0kΩ value.

6. For the KCL experiment, how well did your experimental results of **Table 2.7** conform to the Kirchhoff's Current Law? Explain.
Compare the experimental results of **Table 2.7** with your theoretical and simulated Pre-Lab values shown in **Table 2.3**, and explain reason(s) for any relative discrepancies/deviations observed.

workspace

Measured & calculated values differed by a few hundreths, likely due to imperfect resistors, however in both tables the final summation value was similar to the I value.

2.7

7. For the KCL experiment, using your measured voltages and currents of ~~**Table 2.5**~~, calculate the power absorbed (dissipated) by **each** series resistor, and the total power delivered by the input-source.

workspace

$\mathbf{P}_{R1}$ = $i^2R = (4.67\ mA)^2(3.3k\Omega) = 0.0719\,6937\ W$

$\mathbf{P}_{R2}$ = $i^2R = (7.0\ mA)^2\ (2.2k\Omega) = 0.1078\ W$

$\mathbf{P}_{R3}$ = $i^2R = (15.39\ mA)^2\ (1.0k\Omega) = 0.2368521\ W$

$\mathbf{P}_{VE}$ (source) = $vi = (15)(27.07\ mA) = 0.406\ W$

How does the sum of power absorbed by the resistances in this series circuit compare to the amount delivered by the source? Explain.

The sum is 0.417 W, while the Power delivered is 0.406 W. These values should be the same, since theorectically $P_{supply} = P_{Absorbed}$. The discrepency between measured & calculated resulted from imperfect resistors.

7.0 LAB REPORT REQUIREMENTS & GUIDELINES

Lab reporting is to be completed and submitted separately as **Part I** and **Part II**, noted below:

Part I (**Pre-Lab Work**) => represents **40%** of the pre-assigned Lab weight.

Pre-Lab Work (assignment) of **Section 4.0** that includes handwritten calculations, MultiSIM results, and analysis is to be completed and submitted **prior to the start** of your scheduled lab. *The grading is commensurate with completeness and accuracy of your handwritten calculations, analysis and MultiSIM simulation circuits/plots.*

Note the following requirements for the document submission for Part I:

- A completed and signed "COVER PAGE – **Part I**" has to be included with your submission, a copy of which is available on D2L. 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.

Part II (**In-Lab Work** and **Post-Lab Work**) => represents **60%** of the pre-assigned Lab weight.

In-Lab Work (**Section 5.0**) and **Post-Lab Work** (**Section 6.0**) that include in-lab results, handwritten analysis and observations are to be completed and submitted individually. The lab report should be completed and submitted **within 24 hours after the lab session** is done. For example, if you have a lab on May 3, Tuesday 12 - 2 pm, then the in-lab and post-lab submission will be due by May 4, Wednesday 2:00 pm. No e-mail or late submissions.

Note the following requirements for the document submission for Part II:

- A completed and signed "COVER PAGE – **Part II**" has to be included with your submission, a copy of which is available on D2L. The report will not be graded if the signed cover page is not included.
- Scan your completed pages of **Section 5.0** and **Section 6.0** (via a scanner or phone images), together with any required In-Lab Oscilloscope screen-shot images.

Collate and create a .pdf or .docx file of the above, and upload it via D2L (https://my.ryerson.ca/). Late submissions will not be graded.