International University

School of Electrical Engineering

Principle of EE1 Laboratory

EE052IU

Lab 2
Kirchhoff's Current and Voltage Laws

Submitted by

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GRADING GUIDELINE FOR LAB REPORT

Number	Content		Score	Comment
1	**Format (max 9%)**			
	- Font type	Yes No		
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	- List of figures (if exists)	Yes No		
	- List of tables (if exists)	Yes No		
	- Lab report structure	Yes No		
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	- Grammar	Yes No		
	- Spelling	Yes No		
3	**Data and Result Analysis (max 85%)**			
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Nomenclature

V_{DD} = DC Voltage Source

V_{dd} = AC Volatge Source

I_{ref} = Reference Current

Etc.

Theoretical Background

1. **The relationship of Ohm's Law:**

Ohm’s Law establishes a fundamental relationship between voltage, current, and resistance in electrical circuits. The equation V=I·R and $V=I \cdot R$ illustrates this relationship.

2. The Kirchhoff’s Current Law (KCL):

Kirchhoff’s Current Law asserts that the total current entering a junction in an electrical circuit is equal to the total current leaving the junction. This principle, expressed as :$\sum I\_in=\sum I\_out$, forms the basis for analyzing current distribution in complex circuits. The laboratory endeavors to experimentally verify and comprehend the application of KCL.

3. The Kirchhoff’s Voltage Law (KVL):

Kirchhoff’s Voltage Law posits that the total voltage around any closed loop in a circuit is equal to the sum of the individual voltage drops. Mathematically represented as

$$\sum V\text{loop}=0$$

KVL aids in understanding voltage relationships within circuits. The objective is to experimentally confirm and grasp the implications of KVL in practical scenarios.

4. The equivalent resistance:

Exploring the concept of equivalent resistance involves determining a single resistance value that represents the combined effect of resistors in a circuit. For series circuits, the equivalent resistance ($R_{\text{eq, series}}$) is the sum of individual resistances. In parallel circuits, the reciprocal of the equivalent resistance (,$1/R_{\text{eq, parallel}}$ is the sum of reciprocals of individual resistances. The laboratory seeks to experimentally determine and analyze equivalent resistances in both series and parallel configurations.

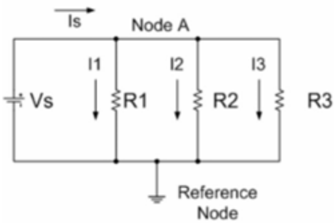
Experimental Procedure:

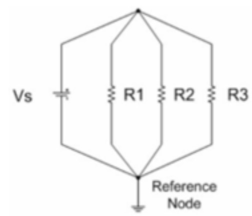
I. Results

<table>
<tr><th>Student A</th><th>Student B</th></tr>
<tr><td colspan="2">

Kirchhoff's Laws

Using the adjustable D.C. power supply and circuit breadboard, connect the resistors into





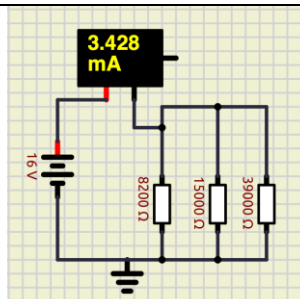
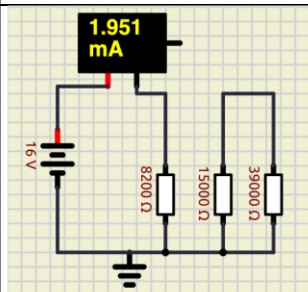
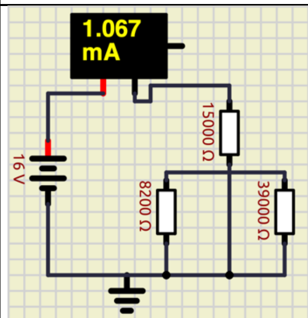
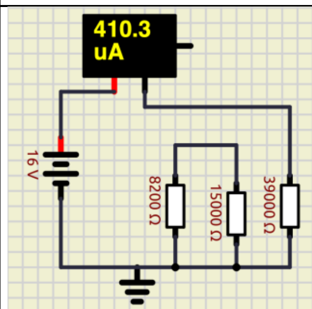
a two-node circuit as shown below. Note that all four circuit elements are connected between those two nodes, and the source voltage V_s is across each of the three resistors. Let R_1 = 8.2 kΩ, R_2 = 15 kΩ, and R_3 = 39 kΩ.

Figure II-1

</td></tr>
<tr><td>1. Note the color code on each resistor and match it up with its nominal value.</td><td>1. Measure and record the actual value for each resistor. Fill the table below with the nominal value versus the measured value. Are the measured values within the specified tolerance of the resistor values?</td></tr>
<tr><td>Measure all four currents, (Is, I_1, I_2, and I_3), in your actual circuit with Vs = 16 V D.C. Fill in the table below with the nominal value versus the measured value. Are the measured values within the specified tolerance of the nominal values?</td><td>2. Calculate** and fill in the table below all four currents (Is, I_1, I_2, and I_3), using the actual resistor values, with Vs = 16 V D.C.</td></tr>
</table>

Table II-1

	Color code	Nominal Values	Actual Values
R_1	Grey-Red-Red- Gold	8.2 kΩ ±5%	8k176 Ω
R_2	Brown-Green-Orange-Gold	15 kΩ ±5%	14k955 Ω
R_3	Orange-White-Orange-Gold	39 kΩ ±5%	38k708 Ω
	Simulated Values	Measured Values	% Differences

I_S		3.420mA	0.23%
I_1		2.01mA	2.35%
I_2		1.15mA	7.22%
I_3		0.44mA	6.75%

Use your measured current values to determine if KCL is verified. Make a chart to compare measured current values with calculated values. Include the % differences in this chart. Are the differences found using the nominal values for calculations within the tolerance limits of the resistors?

Apply KCL to these circuits:
Is=I1+I2+I3= 3.588 mA, which is approximately right to the measured values => KCL verified from these measures' values.

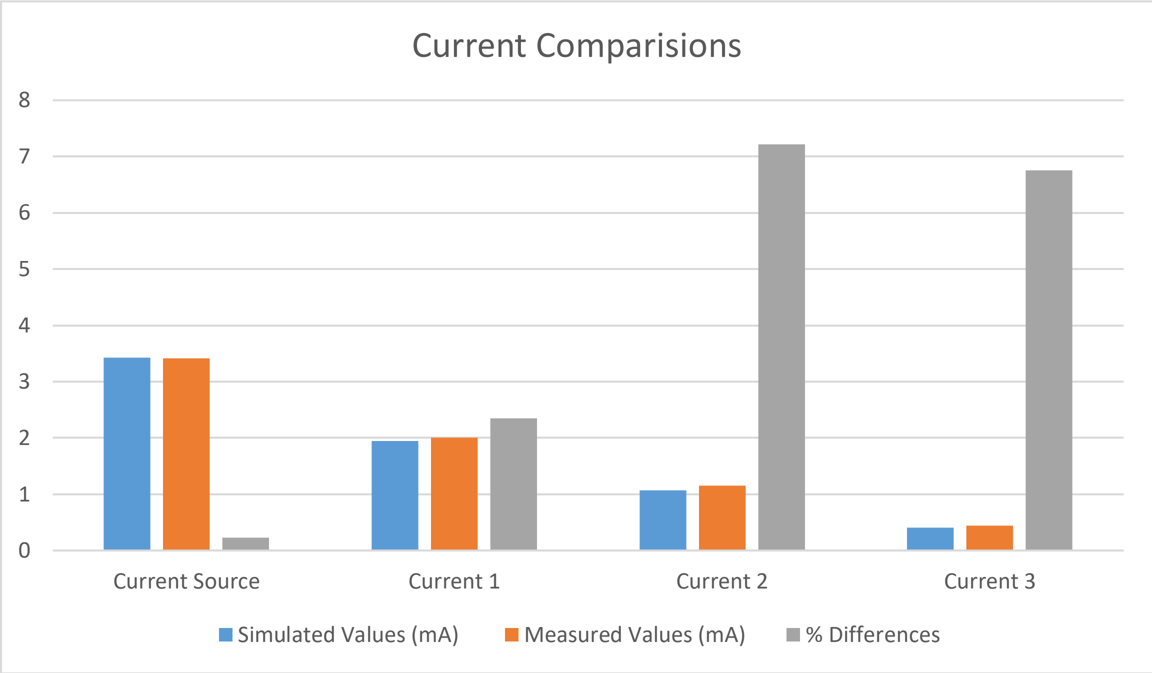


Figure 1

B. Using the adjustable D.C. power supply and the circuit breadboard, connect the resistors into a circuit as shown in Figure II-2. Note that the three resistors are in series so that the same current (I_s) flows through each resistor. Let $R_1 = 1.5$ kΩ, $R_2 = 820$ Ω, and $R_3 = 2.2$ kΩ. Students A and B do the calculations and measurements to fill in Table II-2 below.

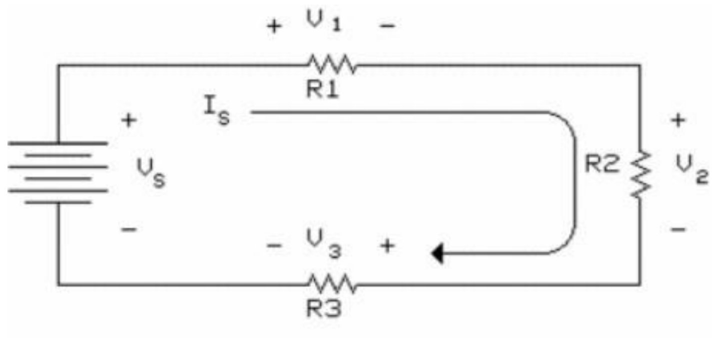
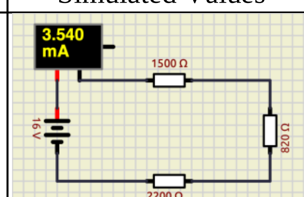
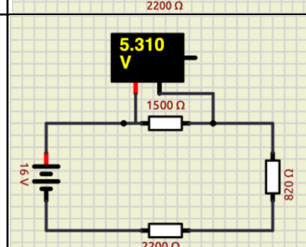
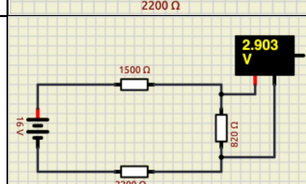
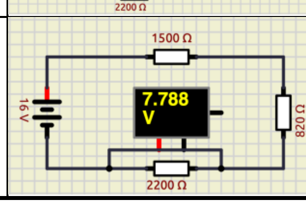


Figure II-2

	Color code	Nominal Values	Actual Values
*R*1	Brown-Green-Red-Gold	1.5k Ω ±5%	1.479k Ω
*R*2	Grey-Red-Brown-Gold	820 Ω ±5%	814.67 Ω
*R*3	Red-Red-Red-Gold	2.2k Ω ±5%	2.194k Ω
	Simulated Values	Measured Values	% Differences
IS		3.565 mA	3.930%
*V*1		5.272 V	0.716%
*V*2		2.825V	2.687%
*V*3		7.567V	2.838%

Use your measured voltage values to determine if KVL is verified. Make **a chart** to compare these calculated voltage values with the measured voltage values. Are all differences within the expected limits of accuracy?

KVL: V1+V2+V3-Vs=0 ⇔ 5.272+ 2.825+ 7.567= Vs => Vs= 15.664V, which can be considered approximately right to the calculated values.

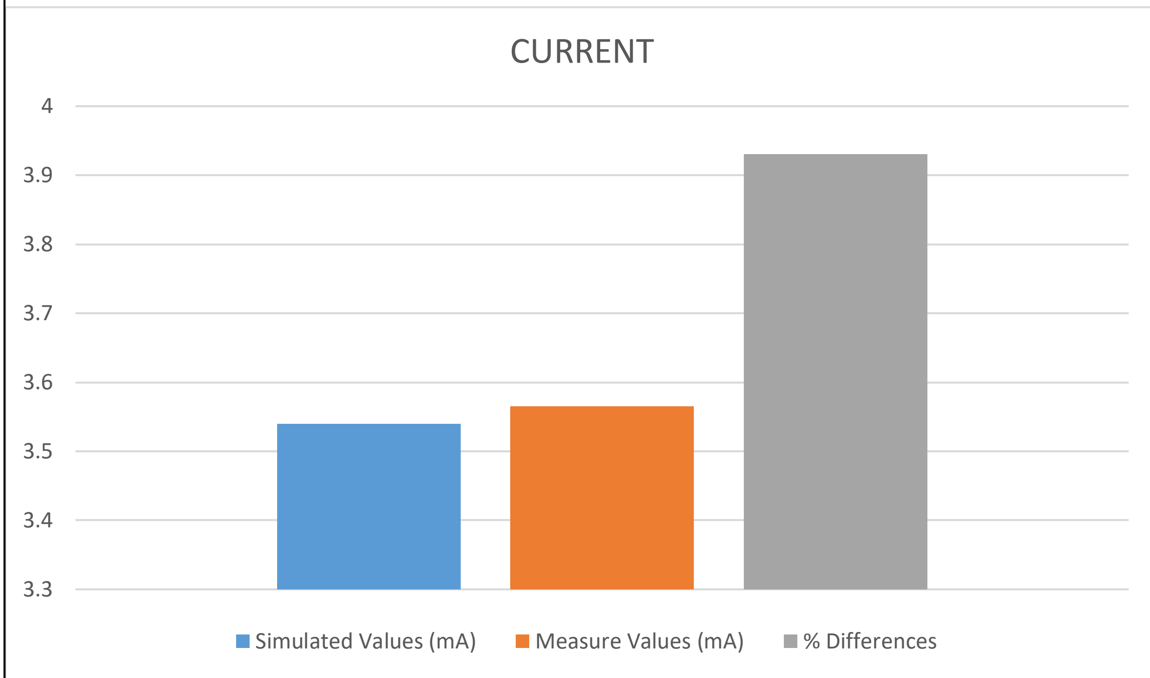
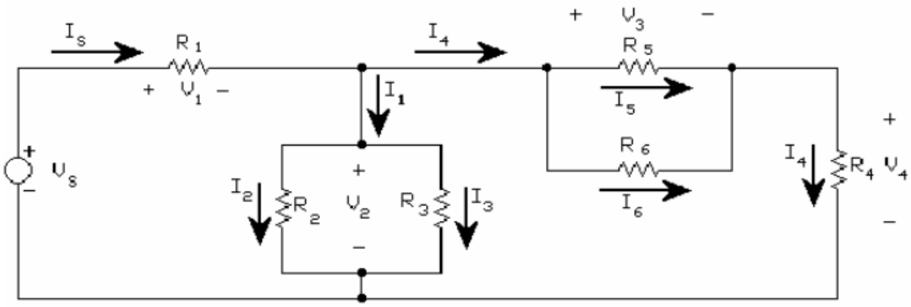
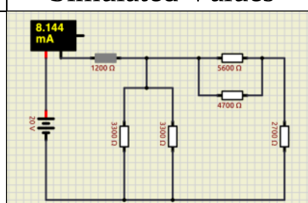
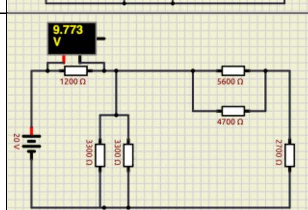
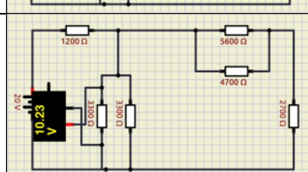
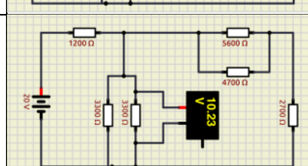
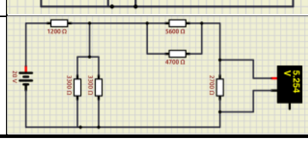
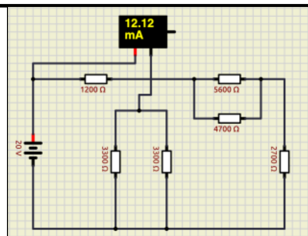
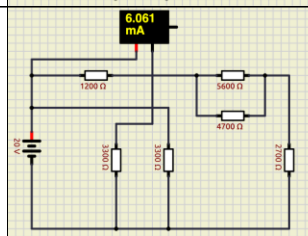
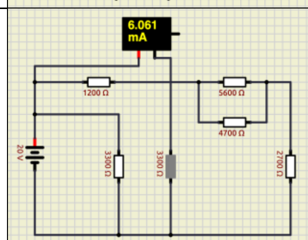
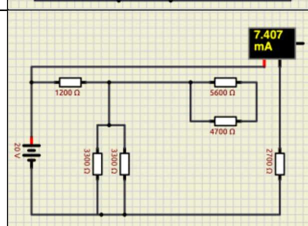
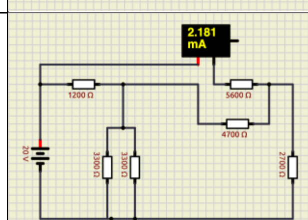
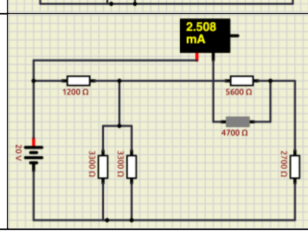


Figure 2

C. Series-parallel circuit



	Color code	Nominal Values	Actual Values
R_1	Brown-Red-Red	1.2kΩ	1.197 kΩ
R_2	Orange-Orange-Red	3.3kΩ	3.291 kΩ
R_3	Orange-Orange-Red	3.3kΩ	3.288 kΩ
R_4	Red-Violet-Red	2.7kΩ	2.690 kΩ
R_5	Green-Blue-Red	5.6kΩ	5.579 kΩ
R_6	Yellow-Violet-Red	4.7kΩ	4.680 kΩ
	Simulated Values	Measured Values	% Differences
I_S		8.158 mA	0.17%
V_1		9.790V	0.20%
V_2		13.461V	31.64%
V_3		13.461V	31.64%
V_4		5.534V	5.33%

I_1		16.67mA	27.3%
I_2		4.079mA	32.7%
I_3		4.079mA	32.7%
I_4		7.068mA	4.58%
I_5		2.216mA	1.60%
I_6		2.573mA	2.59%

Calculate**, measure, and record all the currents and voltages in Circuit 3 setting V_s =20 V DC.

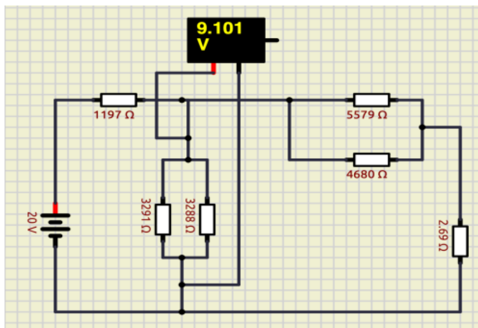
Table II-3

Apply KVL or KCL. How closely do the voltages and currents add up to the values predicted? Were Kirchhoff's laws verified? A Comparison chart is required.

Apply node-voltage method

At node 1: $\frac{V1-20}{R1} + \frac{V1}{(\frac{R2R3}{R2+R3})} + \frac{V1}{(\frac{R5R6}{R5+R6}+R4)} = 0$

⇨ V= 9.158 V, can be consider approximately right to the acceptable range of error

Verify for simulation: 

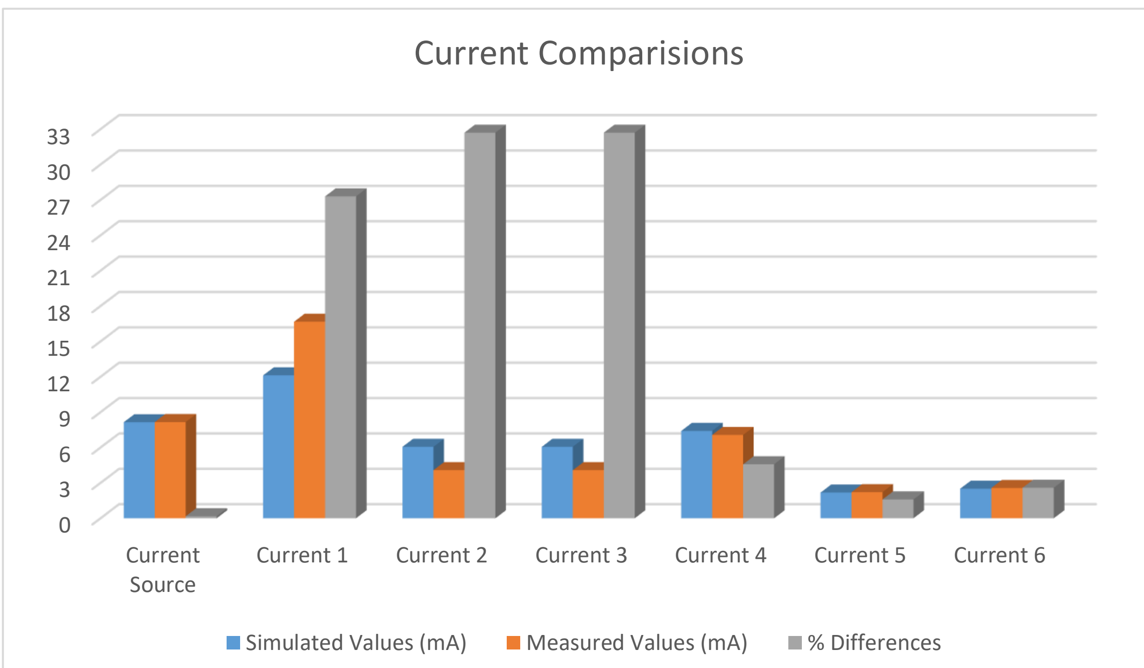


Figure 3

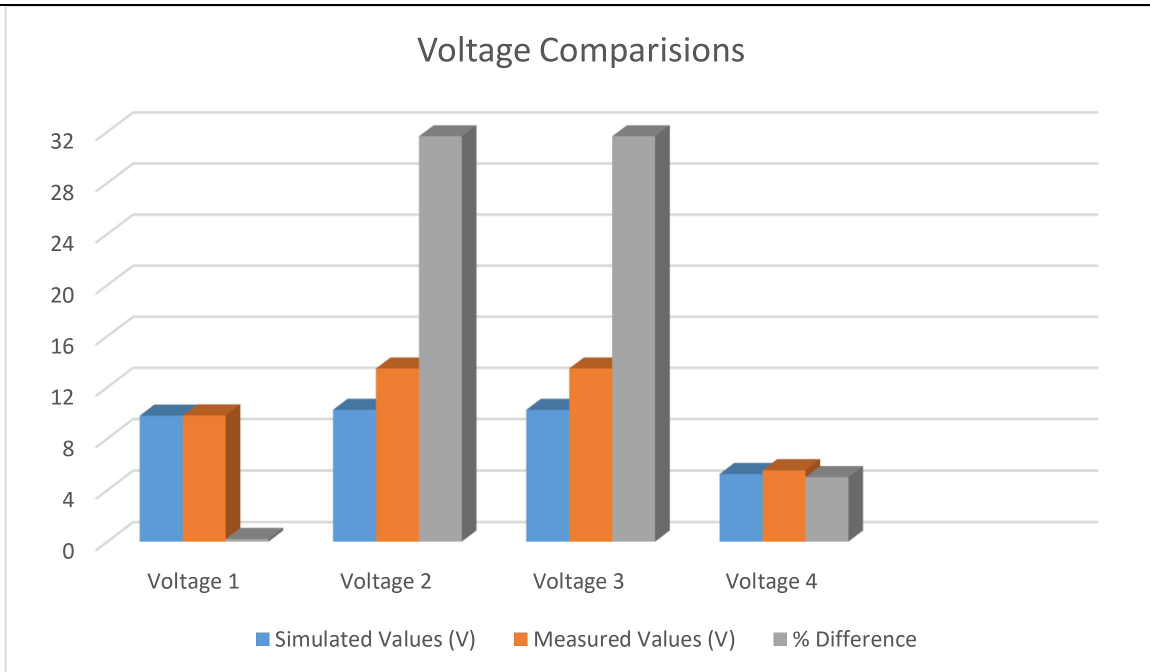

Voltage Comparisions
32
28
24
20
16
12
8
4
0
Voltage 1
Voltage 2
Voltage 3
Voltage 4
Simulated Values (V)
Measured Values (V)
% Difference

Figure 4

Build the following circuit.

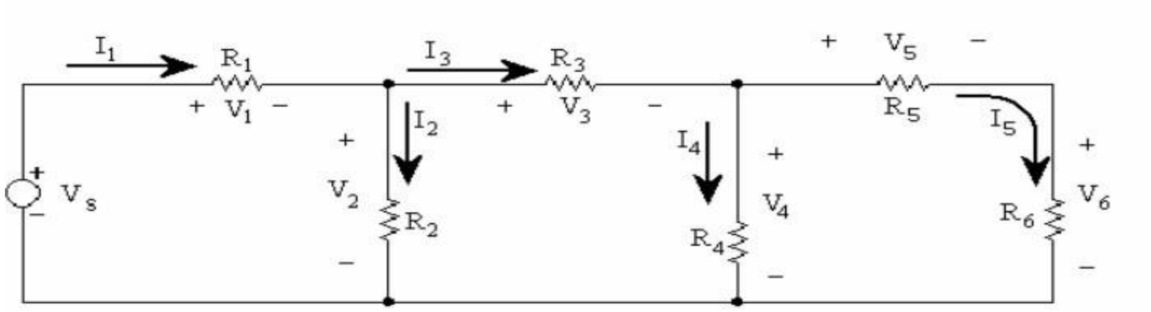
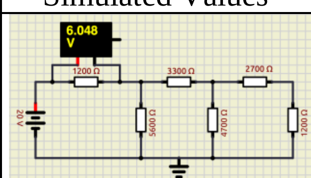
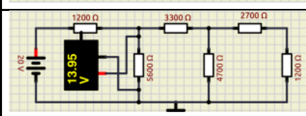
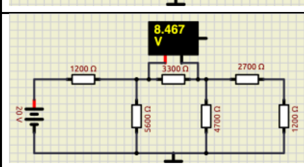
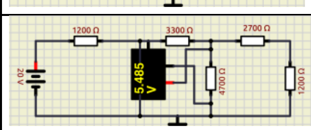
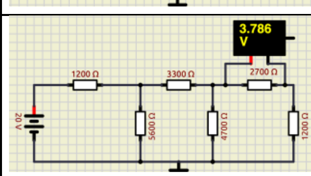
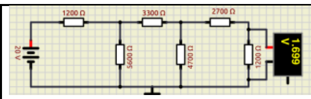
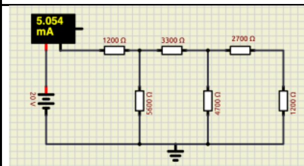
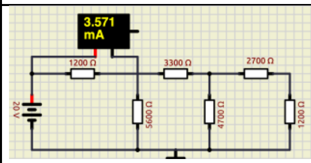
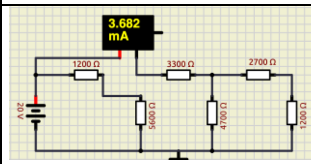
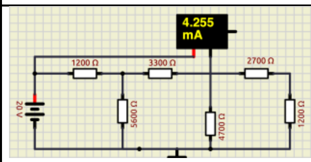
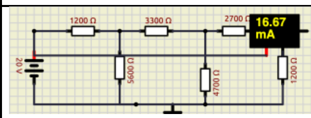


Figure II-4

Calculate, measure and record all the currents and voltages in Circuit 4 setting Vs = 20 V DC**

Table II-4

	Color code	Nominal Values	Actual Values
*R*1	Brown-Red-Red	1.2kΩ	1.186 kΩ
*R*2	Green-Blue-Red	5.6kΩ	5.589 kΩ
*R*3	Orange-Orange-Red	3.3kΩ	3.258 kΩ
*R*4	Yellow-Violet -Red	4.7kΩ	4.667 kΩ
*R*5	Red-Violet -Red	2.7kΩ	2.687 kΩ
*R*6	Brown-Red-Red	1.2kΩ	1.151kΩ
	Simulated Values	Measured Values	% Differences
V_1		8.196V	26.2%
V_2		7.455V	5.68%
V_3		4.345V	3.80%
V_4		5.130 V	6.47%
V_5		3.599 V	4.95%

V_6		1.550 V	8.92%
I_1		4.569 V	9.60%
I_2		3.369 mA	6.01%
I_3		3.535 mA	3.98%
I_4		3.948 mA	7.21%
I_5		16.223 mA	2.68%

Apply KVL to each loop and KCL to each node. How closely do the voltages and currents add up to the values predicted? Were Kirchhoff's laws verified? Comparison charts are required.

Apply the Mesh-Current method to find current is flowing in each loop:

Loop 1: $-20 + 1200\, i1 + 5600(\, i1 - i2) = 0$

Loop 2: $5600\ (i2 - i1) + 3300\ i2 + 4700(i2 - i3) = 0$

Loop 3: $4700(i3 - i2) + i3(2700 + 1200) = 0$

By solving this system of equation, we obtain: $i1 = 5.054mA\ , i2 = 2.57mA, i3 = 1.40mA$

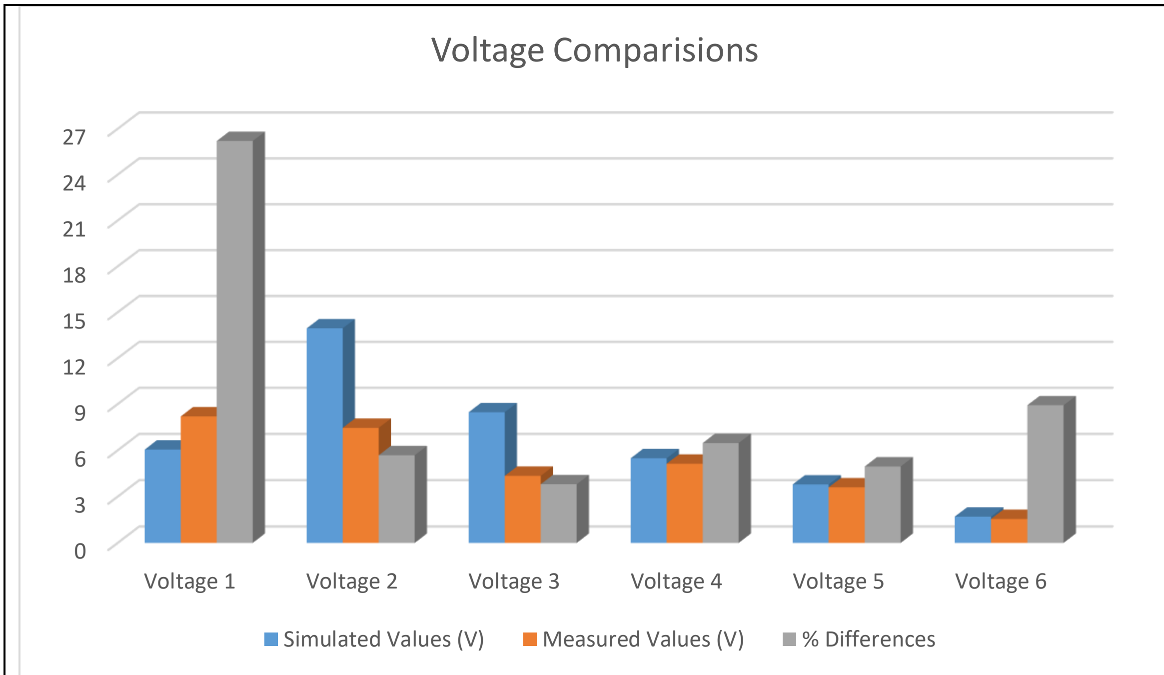


Figure 5

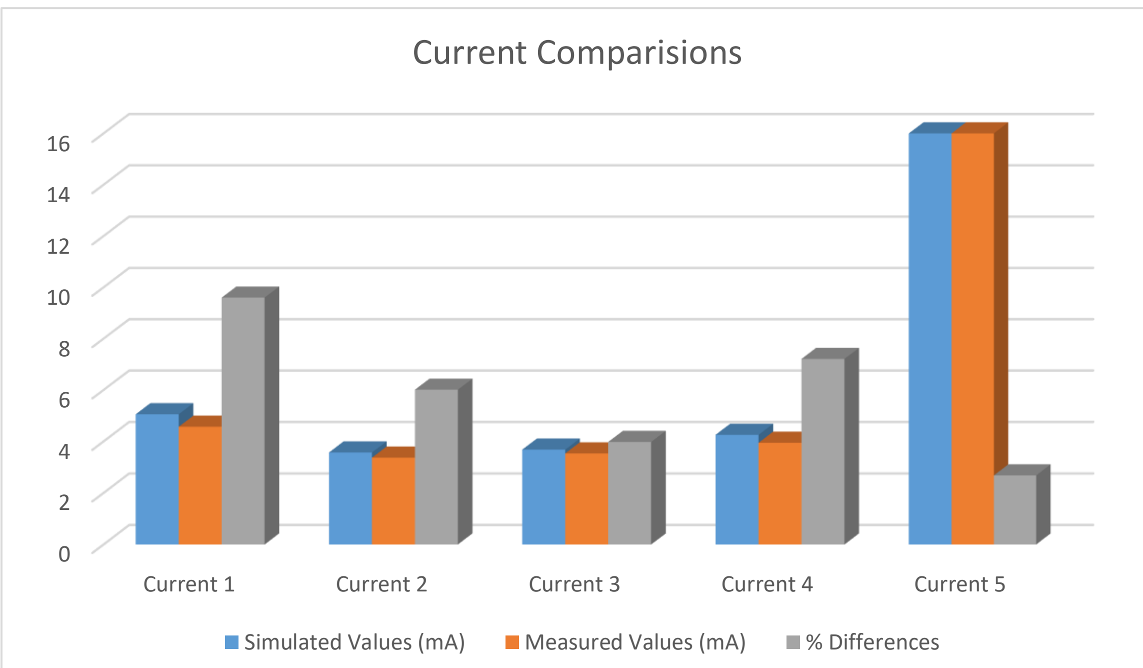


Figure 6

Discussion of Results

- **Section 1A:**

  The precision of our measurements underscores the success of the experimental setup. While there may be slight deviations, these can be attributed to factors such as resistor tolerances, subtle variations in experimental conditions, or inherent limitations in the measurement apparatus.

- **Section 1B:**

  The measured values of current and voltage in the series circuit, with resistors R1 = 1.5 kΩ, R2 = 820 Ω, and R3 = 2.2 kΩ, closely mirror the calculated values, showing a range of differences between 2.838% to 3.930%. This consistency validates the application of Kirchhoff's Voltage Law (KVL) in explaining voltage distribution within the series configuration. Minor variations within this range can be attributed to practical factors like wire resistances and measurement limitations.

- **Section 1C:**

  We can conclude that with a parallel resistor, there are the same % differences of measured values on current and voltage. Otherwise, with the first try, we make mistake on setting Output voltage (not the directly 16V), so they seem to be a large error on this section.

- **Section 2:**

  After performing calculations and comparing them to the actual values, it is evident that there is a noticeable increase in the errors of the figures. It is acknowledged that the pace at which we worked on this lab segment was slow, particularly when attempting to identify resistors based on the provided table.

Due to the limited time available before the conclusion of the section, we were able to complete the task, albeit with some resulting errors.