DEPT. OF ELECTRICAL & ELECTRONICS ENGINEERING
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY, Kattankulathur – 603 203

Title of Experiment	: **1. Verification of Kirchhoff's Laws**
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Register Number	: RA2011004010051
Date of Experiment	: 16th April 2021

Sl. No.	Marks Split up	Maximum marks (50)	Marks obtained
1	Pre Lab questions	5	
2	Preparation of observation	15	
3	Execution of experiment	15	
4	Calculation / Evaluation of Result	10	
5	Post Lab questions	5	
Total		**50**	

Staff Signature

PRE LAB QUESTIONS

1. Define Ohm's law.

Ohm's law states that the current through a conductor is directly proportional to the voltage across any two points and inversely proportional to the resistance across the conductor, given that the physical conditions and the temperature remain constant.

2. State KCL and KVL.

Kirchhoff's Current Law or KCL, states that the, "total current or charge entering a junction or node is equal to the charge leaving the node."

Kirchhoff's Voltage Law or KVL, states that, "in any closed loop network, the total voltage around the loop is equal to the sum of all voltage drops within the same loop."

3. Define absolute potential and potential difference

Absolute potential or electric potential is defined as the work that needs to be done to get an object or a particle to a point from an infinite distance.
Potential difference is the difference of the electric potential between any two points.

4. What is the difference between mesh and loop?

A mesh is a closed path in a circuit with no other paths inside it and a loop is any closed path through a circuit where no node more than once is encountered.

5. What is super-node?

A supernode is a theoretical construct that can be used to solve a circuit, it is done by viewing a voltage source on a wire as a point source voltage in a relation to other point voltages located at various nodes in the circuit, relative to a ground node assigned a zero or negative charge.

Experiment No. 1 Date : 16.04.2021	VERIFICATION OF KIRCHOFF'S LAWS

Aim:

To verify Kirchhoff's current law and Kirchhoff's voltage law for the given circuit.

Apparatus Required:

Sl.No.	Apparatus	Range	Quantity
1	RPS (regulated power supply)	(0-30V)	2
2	Resistance	330Ω, 220Ω 1kΩ	6
3	Ammeter	(0-30mA)MC	3
4	Voltmeter	(0-30V)MC	3
5	Bread Board & Wires	--	Required

Statement:

KCL: The algebraic sum of the currents meeting at a node/junction is equal to zero.

KVL: In any closed path / mesh, the algebraic sum of all the voltages is zero.

Precautions:

1. Voltage control knob should be kept at minimum position.
2. Current control knob of RPS should be kept at maximum position.

Procedure for KCL:

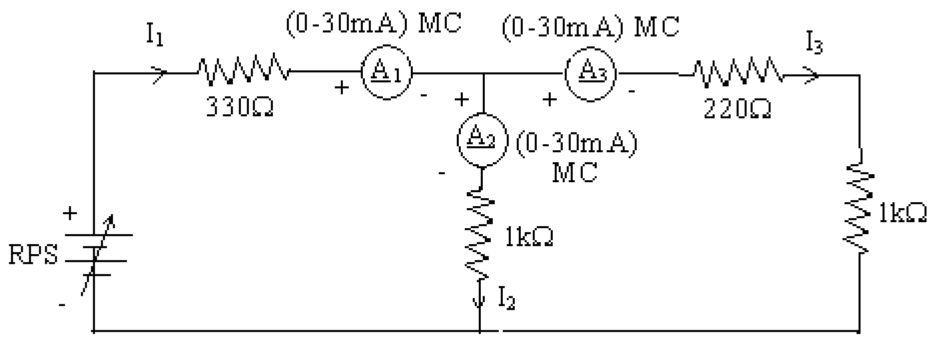
1. Give the connections as per the circuit diagram.
2. Set a particular value in RPS.
3. Note down the corresponding ammeter reading
4. Repeat the same for different voltages

Procedure for KVL:

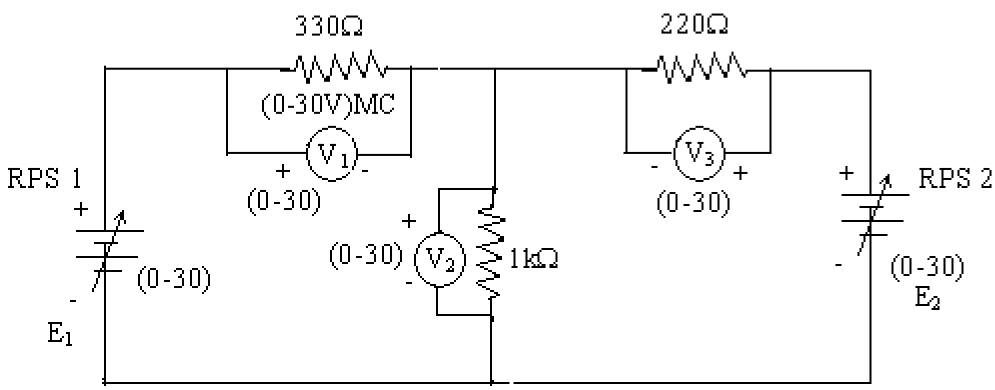
1. Give the connections as per the circuit diagram.
2. Set a particular value in RPS.
3. Note all the voltage reading
4. Repeat the same for different voltages

HARDWARE SETUP:

Circuit for KCL verification:



Circuit for KVL verification:



KCL - Theoretical Values:

Sl. No.	Voltage E	Current			$I_1 = I_2 + I_3$
		I_1	I_2	I_3	
	Volts	mA	mA	mA	mA
1	5	5.68	3.12	2.56	5.68=3.12+2.56
2	10	11.37	6.25	5.12	11.37=6.25+5.12
3	20	22.74	12.5	10.24	22.74=12.5+10.24
4					
5					

KCL - Practical Values:

Sl. No.	Voltage E	Current			$I_1 = I_2 + I_3$
		I_1	I_2	I_3	
	Volts	mA	mA	mA	mA
1	5	5.68	3.12	2.56	5.68=3.12+2.56
2	10	11.37	6.25	5.12	11.37=6.25+5.12
3	20	22.74	12.5	10.24	22.74=12.5+10.24

KVL – Theoretical Values

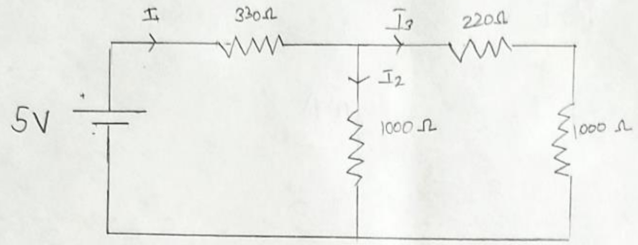
Sl.No.	RPS		Voltage			KVL
	E_1	E_2	V_1	V_2	V_3	$E_1 = V_1 + V_2$
	V	V	V	V	V	V
1	5	5	0.583	4.42	0.583	5=0.582+4.2
2	10	10	1.17	8.83	1.17	10=1.17+8.83
3	20	20	2.33	17.67	2.33	20=2.33+17.67
4						
5						

KVL - Practical Values

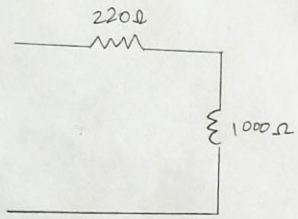
Sl.No.	RPS		Voltage			KVL
	E_1	E_2	V_1	V_2	V_3	$E_1 = V_1 + V_2$
	V	V	V	V	V	V
1	5	5	0.583	4.42	0.583	5=0.582+4.2
2	10	10	1.17	8.83	1.17	10=1.17+8.83
3	20	20	2.33	17.67	2.33	20=2.33+17.67

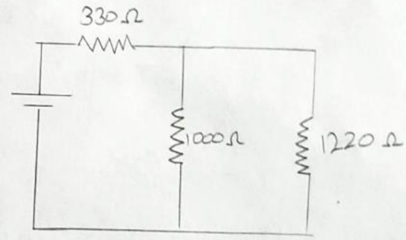
Model Calculations:

For KCL:



Find Total Resistances





In Series

$R_{eq} = 220 + 1000$

$= 1220\,\Omega$

In parallel, then total resistance in series

$R_{eq} = \left[\frac{1}{1000} + \frac{1}{1220}\right]^{-1}$

$\frac{1000 \times 1220}{1000 + 1220} = 549.5$

Total Resistance $= R_T = 330 + 549.5$

$= 879.5\,\Omega$

Total Current and I_2 and I_3 for 5V

$I_1 = \frac{5}{879.5} = 5.68\,mA.$

1

$$I_2 = I_1 \times \frac{\frac{1}{R_1}}{\left[\frac{1}{R_1}+\frac{1}{R_2}\right]} = 5.68 \times \frac{\frac{1}{1000}}{\frac{1}{1000}+\frac{1}{1220}} = 5.68 \times 0.549$$

$$I_2 = 3.12 \text{ mA}$$

$$I_3 = I_1 \times \frac{\frac{1}{R_2}}{\frac{1}{R_1}+\frac{1}{R_2}} = 5.68 \times \frac{\frac{1}{1220}}{\frac{1}{1000}+\frac{1}{1220}} = 5.68 \times 0.450$$

$$I_3 = 2.56 \text{ mA}$$

$$I_1 = I_2 + I_3$$

Total Current, I_2 and I_3 for 10V:

$$I_1 = \frac{10}{879.5} = 11.37 \text{ mA}$$

$$I_2 = I_1 \times \frac{1/R_1}{[1/R_1 + 1/R_2]} = 11.37 \times 0.549 = 6.25 \text{ mA}$$

(from 5V calculations)

$$I_3 = I_1 \times \frac{1/R_2}{[1/R_1 + 1/R_2]} = 11.37 \times 0.450 = 5.12 \text{ mA}$$

$$I_1 = I_2 + I_3$$

2

Total Current, I_2 and I_3 for 20V:

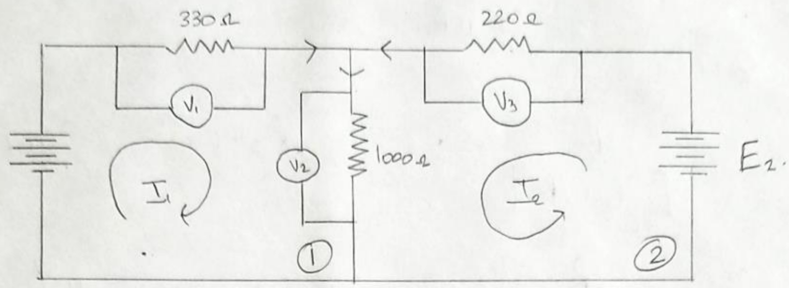
$$I_1 = \frac{20}{879.5} = 22.74 \text{ mA}$$

$$I_2 = I_1 \times \frac{1/R_1}{[1/R_1 + 1/R_2]} = 22.74 \times 0.549 = 12.5 \text{ mA}$$

$$I_3 = I_1 \times \frac{1/R_2}{[1/R_1 + 1/R_2]} = 22.74 \times 0.45 = 10.24 \text{ mA}$$

$$I_1 = I_2 + I_3$$

For KVL:



For $E_1 = E_2 = 5V$:

$V = IR$

L-I $5V = 330 I_1 + 1000(I_1 + I_2)$

$5V = 1330 I_1 + 1000 I_2$ — (1) For Loop - (1)

L-I $5V = 220 I_2 + 1000(I_2 + I_1)$

$5V = 1220 I_2 + 1000 I_1$ — (2) For Loop - (2)

Comparing (1) and (2)

$5V = 1330 I_1 + 1000 I_2$

$-5V = -1000 I_1 - 1220 I_2$

$0 = 330 I_1 - 220 I_2 \Rightarrow I_2 = \frac{33}{22} I_1 = \frac{3}{2} I_1$

(4)

$5V = 1330 I_1 + 500 \times 3 I_1$ — from (1)

$5 = 2830 I_1$

$I_1 = 1.767 \times 10^{-3} A.$ (mA)

$5V = 1330 \times \frac{2}{3} I_2 + 1000 I_2$ — from (2)

$5 = 886.6 I_2 + 1000 I_2$

$5 = 1886.6 I_2$

$I_2 = 2.65 \times 10^{-3} A$ (mA)

$V_1 = I_1 R_1$

$= 1.767\ mA \times 330$

$V_1 = 0.583\ V$ //

$V_2 = I_2 R_2 + I_1 R_2$

$= 1.767 + 2.65$

$V_2 = 4.417\ V$ //

$V_3 = 0.583\ V$ // $= I_2 R_3$

$\therefore\ E_1 = V_1 + V_2$ and $E_1 = E_2$.

$E_2 = V_2 + V_3$

(5)

For $E_1 = E_2 = 10V$:

From above Calculations,

$I_1 = \frac{2}{3} I_2$ and $I_2 = \frac{3}{2} I_1$

Substituting them in,

$10\ V = 1330\ I_1 + 1000\ I_2$ — from loop-(1)

$10\ V = 1220\ I_2 + 1000\ I_1$ — from loop-(2)

Solving,

(1); $10 = 1330\ I_1 + \cancel{1000}^{500} \times \frac{3}{\cancel{2}} I_1$

$10 = 2830\ I_1$

$I_1 = 3.583\ mA$ //

(2); $10 = 886.6\ I_2 + 1000\ I_2$

$I_2 = 5.3\ mA$ //

$V_1 = I_1 R_1$

$= 3.583\ mA \times 330$

$V_1 = 1.17\ V$;

$V_3 = I_2 R_3$

$= 5.3 \times 10^{-3} \times 220$

$= 1.17\ V$ /

$V_2 = I_1 R_2 + I_2 R_2$

$V_2 = 8.83\ V$ //

$E_1 = V_1 + V_2$ and $E_1 = E_2$ //

$E_2 = V_2 + V_3$

(6)

For $E_1 = E_2 = 20V$:

$I_2 = \frac{3}{2} I_1$ and from above calculations substituting in,

$20V = 1330 I_1 + 1000 I_2$ – from loop-1

$20V = 1220 I_2 + 1000 I_1$ – from loop 2

Solving;

1; $20 = 1330 I_1 + 500 \times 3 I_1$

$I_1 = 7.067 \text{ mA}$

2; $20 = 886.6 I_2 + 1000 I_2$

$I_2 = 10.6 \text{ mA}$

$V_1 = I_1 R_1$

$= 7.067 \text{ mA} \times 330$

$V_1 = 2.33 V$

$V_2 = I_1 R_2 + I_2 R_2$

$= 10.6 + 7.067$

$V_2 = 17.67 V$

$V_3 = I_2 R_3$

$= 10.6 \text{ mA} * 220$

$V_3 = 2.33 V$

$E_1 = V_1 + V_2$

$E_2 = V_2 + V_3$ and $E_1 = E_2$

Hence Proved!

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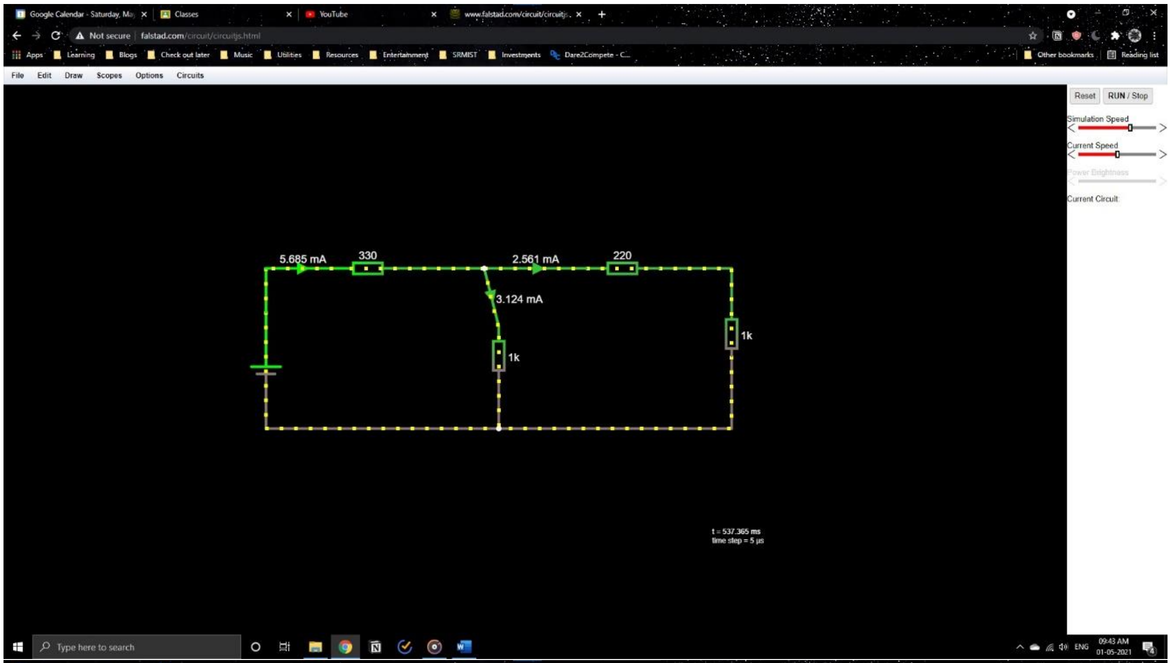
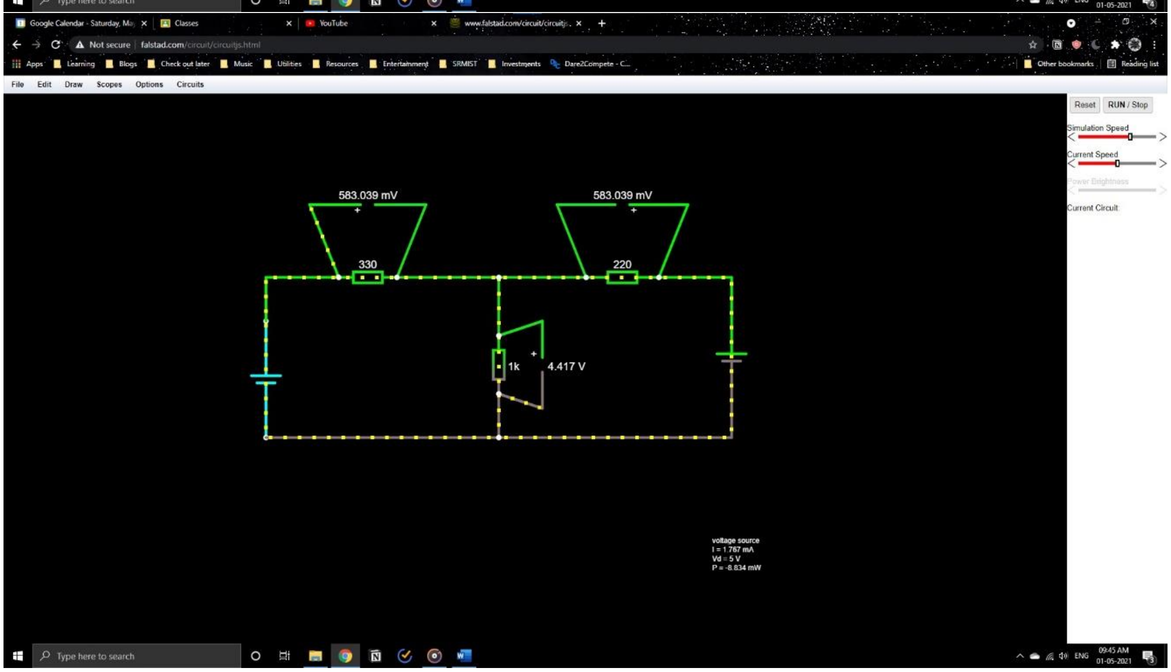
Result:

From the theoretical and practical values, Kirchhoff's Current law and Kirchhoff's Voltage Law is verified in the above circuits.

POST LAB QUESTIONS

1) Illustrate KCL and KVL.





2) Express the limitations of Ohm's law?

Ohm's law is applicable only for metal conductors, provided that the temperature and other physical conditions remain constant. Ohm's law is not applicable for gaseous conductors and semiconductors such as silicon and germanium.

3) What is the practical application of Kirchhoff's law?

Kirchhoff's law is valuable in analyzing electrical circuits. KCL is used to identify the current flowing through various branches within a circuit and then KVL can be used to find out the algebraic sum of the voltage drop across loops in a circuit.

4) Compare series and parallel circuits

In a series circuit, the current across each component remains the same whereas in a parallel circuit, the voltage across each component remains the same. It makes sense when we analyze these circuits using Kirchhoff's law. The current will not split until and unless a junction is encountered and also the sum of the voltage drop across a loop in a circuit should be equal to the total voltage provided to the loop.

5) What is the difference between series and parallel connection of batteries?

In a series connection, batteries are connected to increase the voltage applied on the circuit and in a parallel connection the capacity of the battery is increased, i.e. it can run for a longer interlude.