AMERICAN INTERNATIONAL UNIVERSITY-BANGLADESH

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Assignment Title:	Verification of Kirchoff's Voltage Law (KVL) and Kirchoff's Current Law (KCL).		
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Course Title:	Introduction to Electrical Circuits Laboratory		
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Semester:	FALL 2022-23	**Course Teacher:**	BISHWAJIT BANIK PATHIK

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Abstract:

The experiment was conducted to investigate the verification of Kirchoff's Voltage Law (KVL) and Kirchoff's Current Law (KCL). There are two sections in this experiment. In the first circuit Kirchoff's voltage Law (KVL) will be verified and in the second Kirchoff's Current Law (KCL) will be verified. Some basic tools like resistor, connecting wire, trainer board, AVO meter or multimeter, DC source etc are used in this experiment. By completing this experiment, we were able to develop an understanding of Kirchoff's Voltage Law (KVL) and Kirchoff's Current Law (KCL) practically. And, finally measured values are going to be verified with calculated values.

Theory:

Kirchoff's voltage Law (KVL):

Kirchoff's voltage Law (KVL) in a DC circuit state that, "the algebraic sum of the voltage drop around any closed path is equal to the algebraic sum of the voltage rises". In other words, "the algebraic sum of the voltage rises and drops around any closed path is equal to zero". A plus (+) sign is assigned for the potential rises (- to +) and minus sign (-) is assigned to a potential drop (+ to -). In symbolic form, Kirchoff's Voltage Law (KVL) can be expressed as,

$\Sigma_c V = 0$, where C is used for closed loop and V is used for the potential rises and drops.

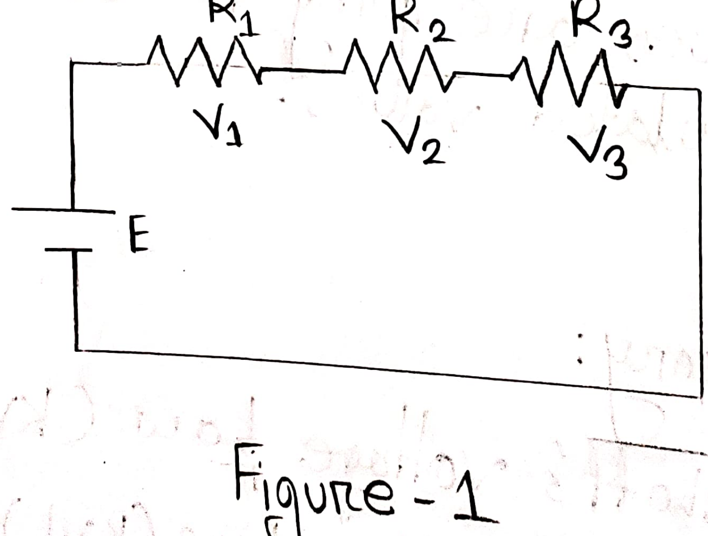

Figure-1

Analysis of KVL circuit:

For doing a complete analysis of KVL, with the given values of circuit parameters follow the following steps: step 1: calculate the value of supply current I:

$$I = \frac{E}{(R_1+R_2+R_3)}$$

step 2: calculate V_1, V_2 and V_3:

$$V_1 = I \times R_1 \quad V_2 = I \times R_2 \quad V_3 = I \times R_3$$

step 3: Use KVL to verify:

$$\Sigma_c V = 0 \quad \text{or} \quad E - V_1 - V_2 - V_3 = 0$$

Kirchoff's Current Law (KCL):

Kirchoff's current Law (KCL) in a DC circuit states that, "the algebric sum of the currents entering and leaving an area, system or junction is zero". In other word, "the sum of the currents entering an area, system or junction must be equal the sum of the currents leaving the area, system or junction". In equation form,

$$\Sigma I \text{ Entering} = \Sigma I \text{ Leaving}$$

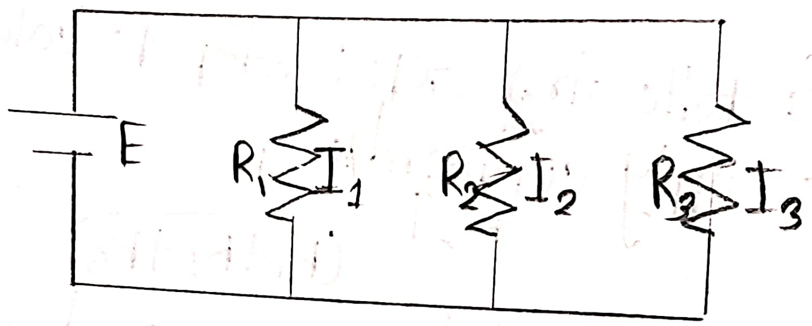

Figure-2

Analysis of KCL circuit:

for doing a complete analysis of KCL, with the given values of circuit parameters follow the following steps:

step 1: calculate the value of equivalent resistance of circuit:

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}$$

step 2: calculate supply current I:

$$I = \frac{E}{R_{eq}}$$

step 3: calculate current through different branches:

$$I_1 = \frac{E}{R_1} \qquad I_2 = \frac{E}{R_2} \qquad I_3 = \frac{E}{R_3}$$

step 4: Use KCL to verify:

$$\Sigma I \text{ Entering} = \Sigma I \text{ Leaving} \quad \text{or} \quad I = I_1 + I_2 + I_3$$

List of Equipment:

1. Resistors
2. Connecting wire
3. Trainer Board
4. AVO meter or multimeter
5. DC source.

Circuit Diagram

precautions:

1. The circuit was connected so carefully
2. The entire connection diagram was checked before connecting the supply to the circuit.

Experimental procedure:

For KVL: The circuit was connected as shown in the figure-1. The voltage was measured across each elements of the circuit. The following table was filled with necessary calculations.

table-1

NO of Obs.	R_1 KΩ	R_2 KΩ	R_3 KΩ	V C (V)	V M (V)	V_1 C (V)	V_1 M (V)	V_2 C (V)	V_2 M (V)	V_3 C (V)	V_3 M (V)	$V=V_1+V_2+V_3$ C (V)	$V=V_1+V_2+V_3$ M (V)	% Error = %(mV-cV)/cV
1	2.2	4.6	3.3	5	4.97	1.089	1.08	2.277	2.30	1.633	1.63	5	5.01	0.2
2	2.2	4.6	3.3	8	8.01	1.742	1.72	3.643	3.69	2.613	2.61	8	8.01	0.25
3	2.2	4.6	3.3	10	9.95	2.178	2.16	4.556	4.61	3.267	3.27	10	9.95	0.4
4	2.2	4.6	3.3	12	11.96	2.613	2.59	5.465	5.54	3.920	3.92	12	11.96	0.41
5	2.2	4.6	3.3	15	15.02	3.267	3.22	6.831	6.90	4.900	4.89	15	15.01	0.06

For KCL: The circuit was connected as shown in the figure-1. The current across each branches of the circuit was measured. The following table was filled with necessary calculations.

Table-2

No of Obs.	R_1	R_2	R_3	I		I_1		I_2		I_3		$I = I_1 + I_2 + I_3$		% Error = %(mv-cv)/cv
				C	M	C	M	C	M	C	M	C	M	
	KΩ	KΩ	KΩ	A	A	A	A	A	A	A	A	A	A	
1	2.2	4.6	3.3	0.004878	0.0048	0.00252	0.0023	0.001086	0.0011	0.001515	0.0015	0.004878	0.0049	0.45
2	2.2	4.6	3.3	0.007804	0.0079	0.00363	0.0037	0.001739	0.0017	0.002424	0.0025	0.007804	0.0079	1.23
3	2.2	4.6	3.3	0.009756	0.0098	0.004545	0.0046	0.002173	0.0022	0.003030	0.003	0.009756	0.0098	0.45
4	2.2	4.6	3.3	0.0011707	0.00117	0.005454	0.0055	0.002608	0.0026	0.003636	0.0036	0.0011707	0.00117	0.05
5	2.2	4.6	3.3	0.0014634	0.00147	0.006818	0.0069	0.003260	0.0032	0.004545	0.0046	0.0014634	0.00147	0.45

Result and calculations:

for KVL:

$R_1 = 2.2K\Omega = 2.2\times10^3\Omega$

$R_2 = 4.6K\Omega = 4.6\times10^3\Omega$

$R_3 = 3.3K\Omega = 3.3\times10^3\Omega$

$R = R_1 + R_2 + R_3 = (2.2 + 4.6 + 3.3)$

$= 10.1K\Omega$

$= 10.1\times10^3\Omega$

Observation No: 1

$V = 5V$

$$I = \frac{V}{R} = \frac{5}{10.1\times10^3} = 0.495\times10^{-3}\,A$$

Calculated value:

$V = 5V$

and $V_1 + V_2 + V_3 = 1.089 + 2.277 + 1.633$

$= 5V$

measured value:

$V = 4.97$

and $V_1 + V_2 + V_3 = 1.08 + 2.30 + 1.63$

$= 5.01V$

$$\%\ Error = \frac{5.01 - 5}{5}\times100$$

$= 0.2\ \%$

Observation No : 2

$V = 8V$

$I = \frac{V}{R} = \frac{8}{10.1\times10^3} = 0.792\times10^{-3}A$

$V_1 = IR_1 = 0.792\times10^{-3}\times2.2\times10^3 = 1.742V$

$V_2 = IR_2 = 0.792\times10^{-3}\times4.6\times10^3 = 3.643V$

$V_3 = IR_3 = 0.792\times10^{-3}\times3.3\times10^3 = 2.613V$

Calculated value:

$V = 8V$

and $V_1 + V_2 + V_3 = 1.742 + 3.643 + 2.613 = 8V$

Measured value:

$V = 8V$

and $V_1 + V_2 + V_3 = 1.72 + 3.69 + 2.61 = 8.02V$

$\%\ Error = \frac{8.02 - 8}{8}\times100 = 0.25\%$

Observation No : 3

$V = 10V$

$I = \frac{V}{R} = \frac{10}{10.1\times10^3} = 0.99\times10^{-3}A$

$V_1 = IR_1 = 0.99\times10^{-3}\times2.2\times10^3 = 2.178V$

$V_2 = IR_2 = 0.99\times10^{-3}\times4.6\times10^3 = 4.554V$

$V_3 = IR_3 = 0.99\times10^{-3}\times3.3\times10^3 = 3.267V$

Calculated value:

$V = 10V$

and $V_1 + V_2 + V_3 = 2.178 + 4.554 + 3.267 = 10V$

Measured value:

$V = 9.95$

and $V_1 + V_2 + V_3 = 2.16 + 4.61 + 3.27 = 10.04V$

$\% \text{ Error} = \frac{10.04 - 10}{10} \times 100 = 0.4\%$

Observation No: 4

$V = 12V$

$I = \frac{V}{R} = \frac{12}{10.1 \times 10^3} = 1.188 \times 10^{-3} A$

$V_1 = IR_1 = 1.188 \times 10^{-3} \times 2.2 \times 10^3 = 2.613V$

$V_2 = IR_2 = 1.188 \times 10^{-3} \times 4.6 \times 10^3 = 5.464V$

$V_3 = IR_3 = 1.188 \times 10^{-3} \times 3.3 \times 10^3 = 3.920V$

Calculated value:

$V = 12V$

and $V_1 + V_2 + V_3 = 2.613 + 5.465 + 3.920 = 12V$

Measured Value:

$V = 11.96$

and $V_1 + V_2 + V_3 = 2.59 + 5.54 + 3.92 = 12.05V$

$\% \text{ Error} = \frac{12.05 - 12}{12} \times 100$

$= 0.41\%$

Observation No: 5

$V = 15V$

$I = \frac{V}{R} = \frac{15}{10.1 \times 10^3} = 1.485 \times 10^{-3} A$

$V_1 = IR_1 = 1.485 \times 10^{-3} \times 2.2 \times 10^3 = 3.267\ V$

$V_2 = IR_2 = 1.485 \times 10^{-3} \times 4.6 \times 10^3 = 6.831\ V$

$V_3 = IR_3 = 1.485 \times 10^{-3} \times 3.3 \times 10^3 = 4.900 V$

Calculated value:

$V = 15V$

and $V_1 + V_2 + V_3 = 3.267 + 6.831 + 4.900 = 15V$

Measured value:

$V = 15.02$

and $V_1 + V_2 + V_3 = 3.22 + 6.90 + 4.89 = 15.01V$

$\% \text{ Error} = \frac{15.01 - 15}{15} \times 100 = 0.06\%$

For KCL: $R_1 = 2.2 K\Omega = 2.2 \times 10^3 \Omega$

$R_2 = 4.6 K\Omega = 4.6 \times 10^3 \Omega$

$R_3 = 3.3 K\Omega = 3.3 \times 10^3 \Omega$

$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}$

$R_{eq} = \left(\frac{1}{2.2} + \frac{1}{4.6} + \frac{1}{3.3}\right)^{-1}$

$= 1.025 K\Omega = 1.025 \times 10^3 \Omega$

servation No: 1

$V = 5V$

$$I = \frac{V}{R_{eq}} = \frac{5}{1.025\times10^3} = 4.878\times10^{-3} A$$

$$I_1 = \frac{V}{R_1} = \frac{5}{2.2\times10^3} = 2.252\times10^{-3} A$$

$$I_2 = \frac{V}{R_2} = \frac{5}{4.6\times10^3} = 1.086\times10^{-3} A$$

$$I_3 = \frac{V}{R_3} = \frac{5}{3.3\times10^3} = 1.515\times10^{-3} A$$

Calculated value:

$$I = 4.878\times10^{-3} A$$

and $I_1 + I_2 + I_3 = (2.252\times10^{-3}) + (1.086\times10^{-3}) + (1.1515\times10^{-3}) = 4.878\times10^{-3} A$

Measured value:

$$I = 4.878\times10^{-3} A$$

and $I_1 + I_2 + I_3 = (2.3\times10^{-3}) + (1.1\times10^{-3}) + (1.5\times10^{-3}) = 4.9\times10^{-3} A$

$$\%\ \text{Error} = \frac{(4.9 - 4.878)\times10^{-3}}{4.878\times10^{-3}} \times 100$$

$$= 0.45\ \%$$

Observation NO: 2

$V = 8V$

$$I = \frac{V}{R_{eq}} = \frac{8}{1.025 \times 10^3} = 7.804 \times 10^{-3} A$$

$$I_1 = \frac{V}{R_1} = \frac{8}{2.2 \times 10^3} = 3.636 \times 10^{-3} A$$

$$I_2 = \frac{V}{R_2} = \frac{8}{4.6 \times 10^3} = 1.739 \times 10^{-3} A$$

$$I_3 = \frac{V}{R_3} = \frac{8}{3.3 \times 10^3} = 2.424 \times 10^{-3} A$$

Calculated value:

$$I = 7.804 \times 10^{-3} A$$

$$\text{and } I_1 + I_2 + I_3 = (3.636 + 10^{-3}) + (1.739 \times 10^{-3}) + (2.424 \times 10^{-3}) = 7.804 \times 10^{-3} A$$

Measured value:

$$I = 7.9 \times 10^{-3} A$$

$$\text{and } I_1 + I_2 + I_3 = (3.7 \times 10^{-3}) + (1.7 \times 10^{-3}) + (2.5 \times 10^{-3}) = 7.9 \times 10^{-3} A$$

$$\% \text{ Error} = \frac{(7.9 - 7.804) \times 10^{-3}}{7.804 \times 10^{-3}} \times 100 = 1.23\%$$

Observation No:- 3

$V = 10V$

$$I = \frac{V}{R_{eq}} = \frac{10}{1.025 \times 10^3} = 9.756 \times 10^{-3} A$$

$$I_1 = \frac{V}{R_1} = \frac{10}{2.2 \times 10^3} = 4.545 \times 10^{-3} A$$

$$I_2 = \frac{V}{R_2} = \frac{10}{4.6 \times 10^3} = 2.173 \times 10^{-3} A$$

$$I_3 = \frac{V}{R_3} = \frac{10}{3.3\times10^3} = 3.030\times10^{-3}A$$

calculated value:

$$I = 9.756\times10^{-3}A$$

and $I_1+I_2+I_3 = (4.545\times10^{-3})+(2.173\times10^{-3}) + (3.030\times10^{-3}) = 9.756\times10^{-3}A$

Measured value:

$$I = 9.8\times10^{-3}A$$

and $I_1+I_2+I_3 = (4.6\times10^{-3})+(2.2\times10^{-3}) + (3.0\times10^{-3}) = 9.8\times10^{-3}A$

$$\%\text{ Error} = \frac{(9.8-9.756)\times10^{-3}}{9.756\times10^{-3}}\times100 = 0.45\%$$

Observation No: 4:

$$V = 12V$$

$$I = \frac{V}{R_{eq}} = \frac{12}{1.025\times10^3} = 11.707\times10^{-3}A$$

$$I_1 = \frac{V}{R_1} = \frac{12}{2.2\times10^3} = 5.454\times10^{-3}A$$

$$I_2 = \frac{V}{R_2} = \frac{12}{4.6\times10^3} = 2.608\times10^{-3}A$$

$$I_3 = \frac{V}{R_3} = \frac{12}{3.3\times10^3} = 3.636\times10^{-3}A$$

Calculated value:

$$I = 11.707\times10^{-3}A$$

and $I_1+I_2+I_3 = (5.454\times10^{-3})+(2.608\times10^{-3}) + (3.636\times10^{-3}) = 11.707\times10^{-3}A$

Measured value:

$$I = 11.7 \times 10^{-3} A$$

and $I_1 + I_2 + I_3 = (5.5 \times 10^{-3}) + (2.6 \times 10^{-3}) + (3.6 \times 10^{-3}) = 11.7 \times 10^{-3} A$

$$\% \text{ Error} = \frac{(11.7 - 11.707) \times 10^{-3}}{11.707 \times 10^{-3}} \times 100 = 0.05\%$$

Observation No: 5

$V = 15V$

$$I = \frac{V}{Req} = \frac{15}{1.025 \times 10^{3}} = 14.634 \times 10^{-3} A$$

$$I_1 = \frac{V}{R_1} = \frac{15}{2.2 \times 10^{3}} = 6.818 \times 10^{-3} A$$

$$I_2 = \frac{V}{R_2} = \frac{15}{4.6 \times 10^{3}} = 3.260 \times 10^{-3} A$$

$$I_3 = \frac{V}{R_3} = \frac{15}{3.3 \times 10^{3}} = 4.545 \times 10^{-3} A$$

Calculated value:

$$I = 14.634 \times 10^{-3} A$$

and $I_1 + I_2 + I_3 = (6.818 \times 10^{-3}) + (3.260 \times 10^{-3}) + (4.545 \times 10^{-3}) = 14.634 \times 10^{-3} A$

Measured value:

$$I = 14.7 \times 10^{-3} A$$

and $I_1 + I_2 + I_3 = (6.9 \times 10^{-3}) + (3.2 \times 10^{-3}) + (4.6 \times 10^{-3}) = 14.7 \times 10^{-3} A$

$$\% \text{ Error} = \frac{(14.7 - 14.634) \times 10^{-3}}{14.634 \times 10^{-3}} \times 100$$

$$= 0.45\%$$

Discussion:

1. The trainer board and multimeter were checked before the start of the experiment.
2. Both calculated and measured value were taken carefully.
3. All the data was placed in the data table.
4. The ways of the study could have been improved, investigated and described.

Conclusion:

In this experiment, Kirchoff's Voltage Law (KVL) and Kirchoff's Current Law (KCL) was checked and verified both calculating and measuring, so the experiment was successful.

Reference:

1. Robert L. Boylested, "Introductory Circuit Analysis", 10th Edition.
2. Introduction to Electrical Circuit Laboratory, Experiment - Lab Manual.