Basic Electrical Science Lab
Course Code: EE152

Laboratory Manual

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Section: B

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National Institute of Technology Goa

CERTIFICATE

This is to certify that Mr./ Ms. _______________________ of Class B.Tech 1st year (2nd Sem), Division Sec A/B, bearing Roll. No.______________, has satisfactorily completed the course experiments in the Laboratory Course Basic Electrical Science Lab (EE152) in the academic year 2020-2021 in the Institution of National Institute of Technology Goa.

Course Instructor

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Experiment 1

Verification of Ohms Law

1. **<u>Aim</u>**: To verify Ohms Law for the given circuit

2. **<u>Software tools required</u>:** MATLAB/SIMULINK

3. **<u>Simulink Block sets Used</u>:** Powergui, DC Voltage Source, Series RLC Branch, Current Measurement, Voltage Measurement, Display, Scope, XY Graph, Controlled Voltage Source, Ramp, Group 1 signal builder

4. **<u>Theory</u>**: Ohms Law states that the voltage across conducting materials is directly proportional to the current through the material. one arrives at the usual mathematical equation that describes this relationship

$$V \propto I$$

$$\Rightarrow V = IR$$

Where, V – Voltage across the element

I – Current flowing through the element

R - Resistance offered by the element

R is also the slope of the straight line when V-I characteristics are plotted. Normally resistance is a positive quantity.

5. **<u>Circuit Diagram</u>:** The considered circuit for Ohms law verification is as given in fig. 1a. The connected circuit in MATLAB/Simulink is given in Fig.1b.

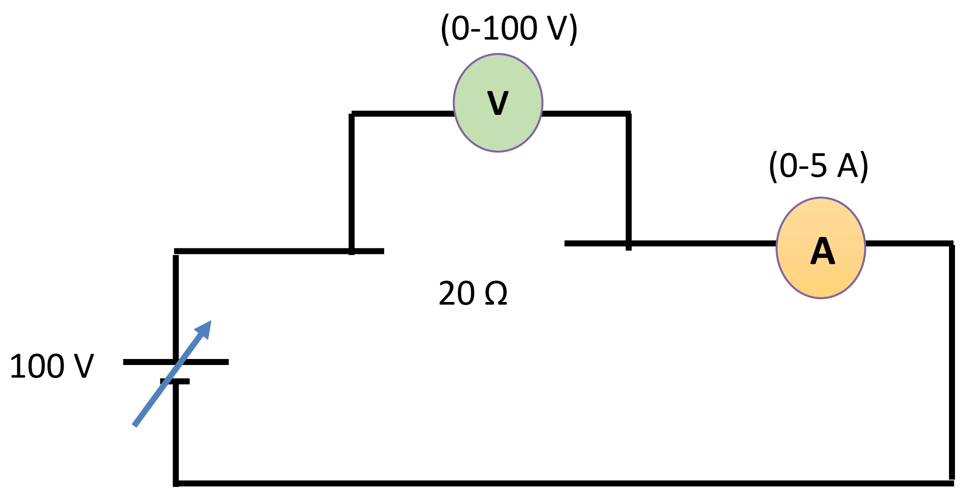


Fig1a: Circuit Diagram

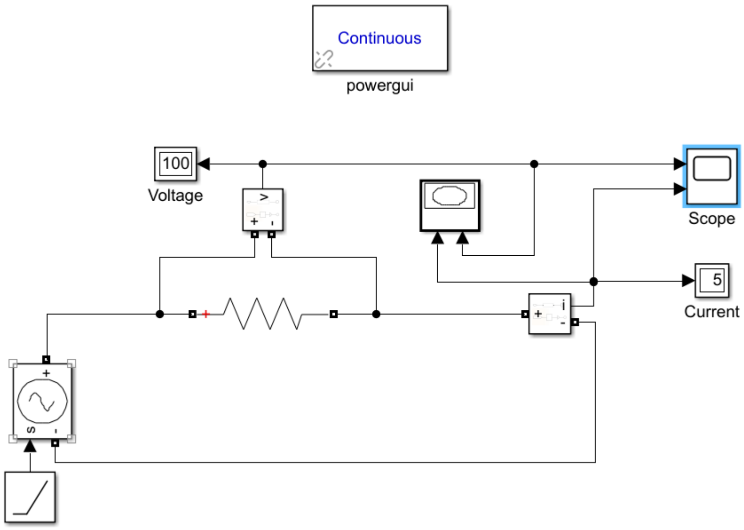


Fig1b: Circuit connections in Simulink

6. Procedure:

i. The mentioned Simulink blocksets are connected as shown in Figure 1b.
ii. Apply the specified voltage across the specified resistance
iii. Measure the current flowing through the resistor
iv. V-t, I-t and V-I plots are generated
v. The same procedure is repeated for specified types of inputs like Constant DC, Ramp, etc.

7. Graphical Results:

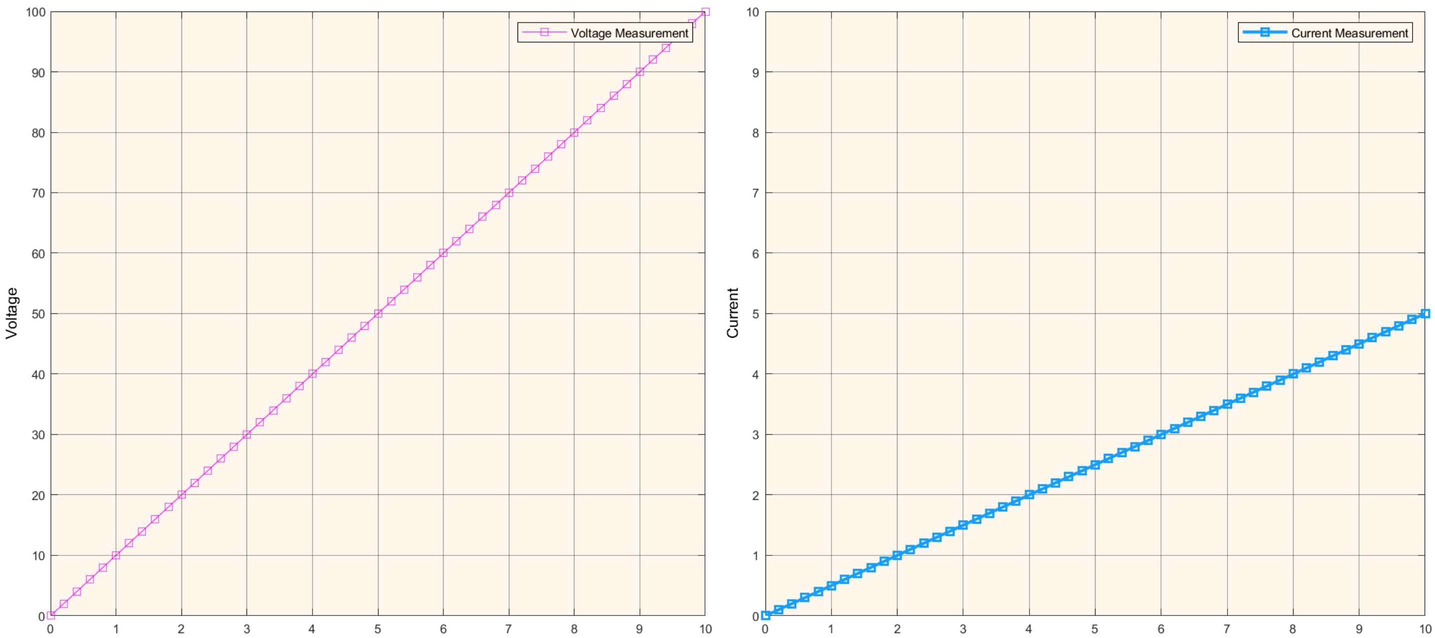


Fig.1c: Voltage Vs Time and Current Vs time Plots

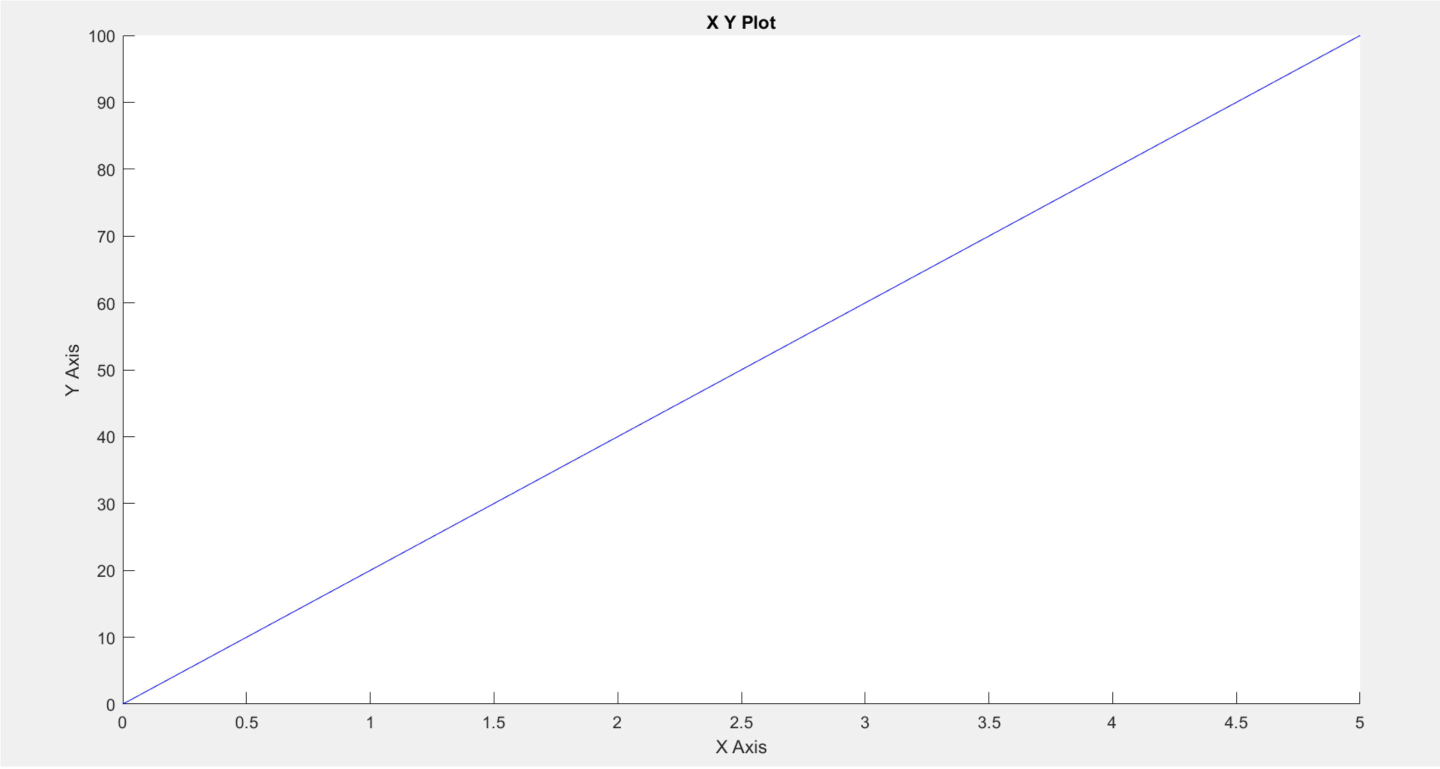


Fig1d: V-I Characteristics

8. **<u>Precautions:</u>**

a) Ensure that 'Powergui' block set is included in the Simulink file.
b) Ensure that connections are properly made.
c) Ensure that the scale of the graphs should be adjusted to the range in which the readings vary.

9. **<u>Inferences</u>**: From the output, it can be inferred that as the input ramp is varied from 0-100 V, the current through the resistance varies from 0-5 A.

10. **<u>Conclusion:</u>** The Ohms law is verified for all the specified inputs for the studied resistive network.

Assignment:

a. Consider the below Step function as input with R = 5Ω

$$V(t) = \begin{cases} 50V & 0 \le t \le 5 \text{ sec} \\ -50V & 5 \le t \le 10 \text{ sec} \end{cases}$$

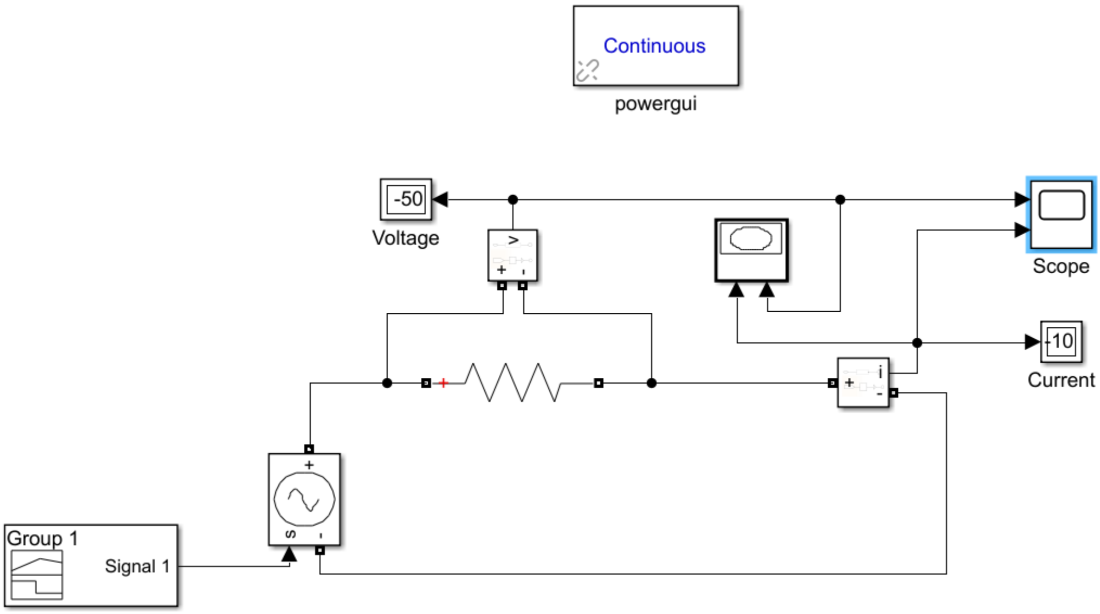


Fig1e: Circuit connections in Simulink

Procedure:

1. The mentioned Simulink blocksets are connected as shown in Figure 1e.
2. Connect the Group 1 signal builder with the controlled voltage source to apply the specified voltage across the specified resistance.
3. Measure the current flowing through the resistor.
4. V-t, I-t and V-I plots are generated.

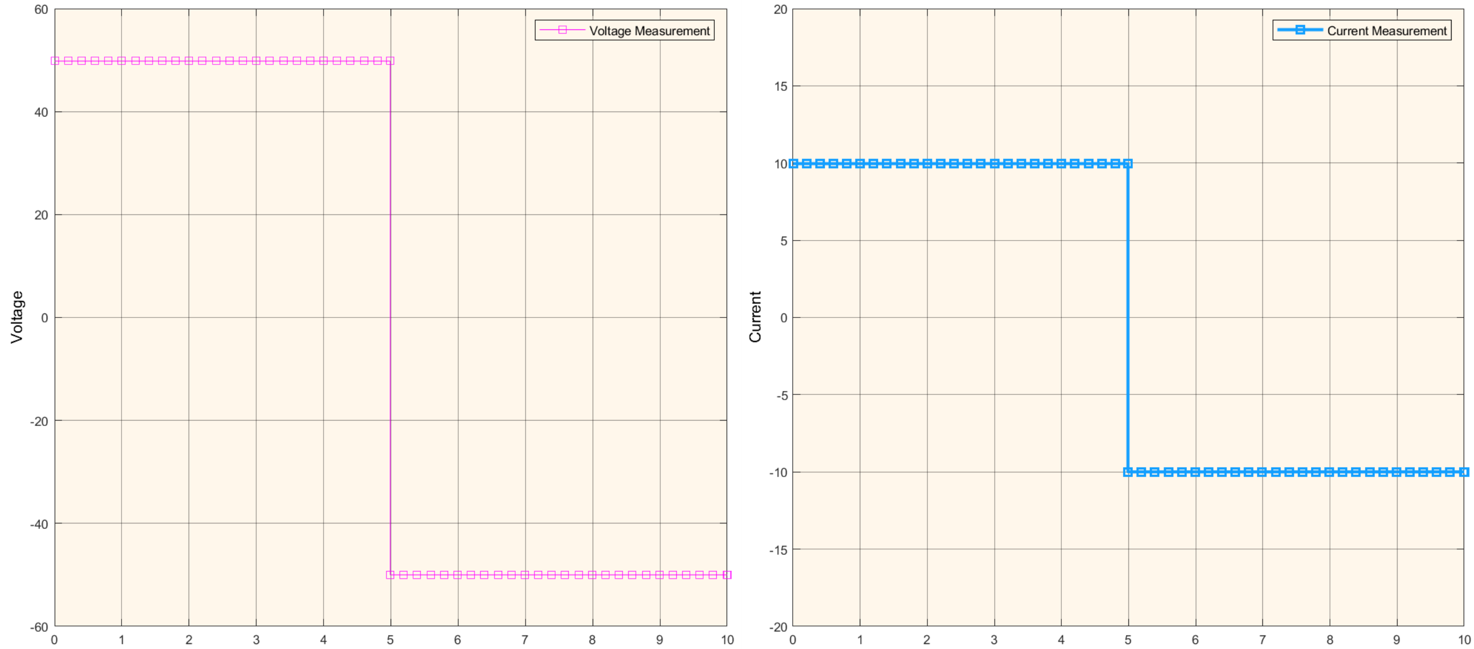


Fig.1f: Voltage Vs Time and Current Vs time Plots

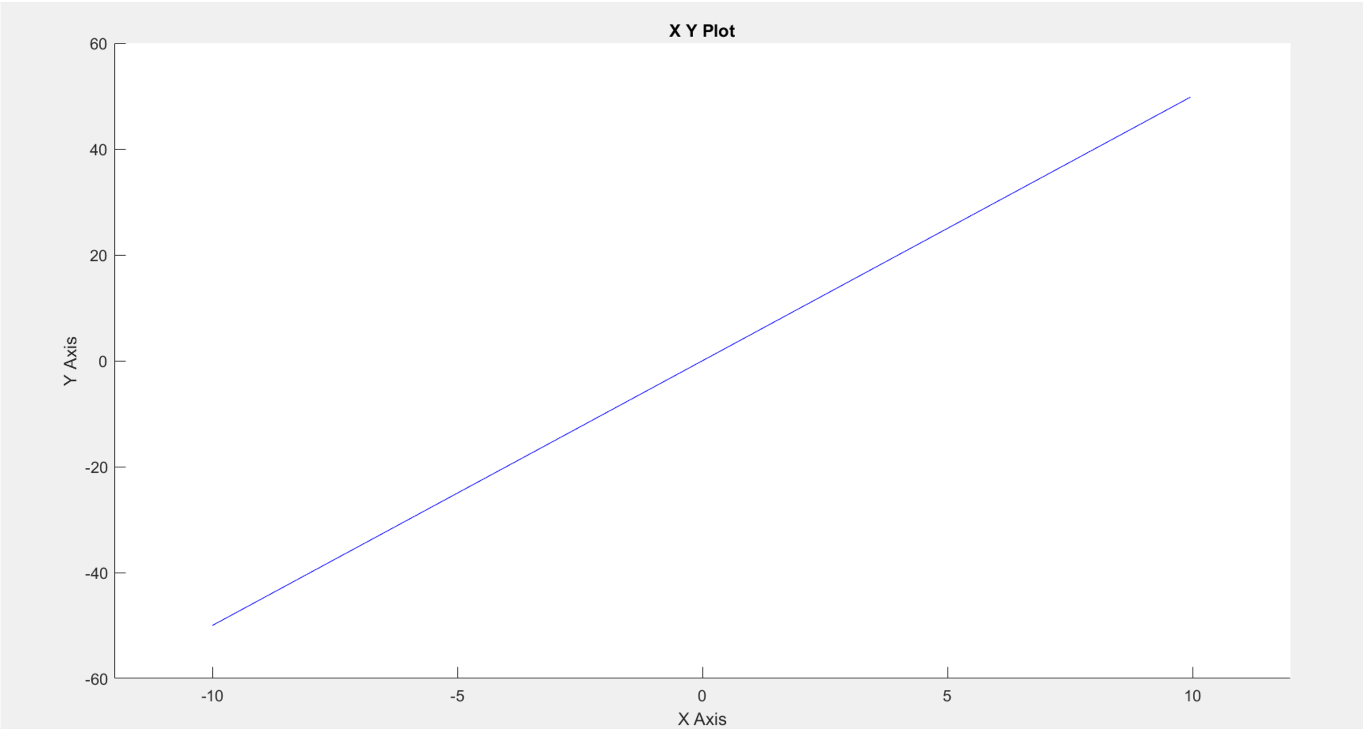


Fig1g: V-I Characteristics

<u>Inferences:</u> From the output, it can be inferred that, as the input voltage is fixed at 50V in first half of simulation, the current remained fixed at 10A and in the second half as the input voltage is fixed at -50V the current remained fixed at -10A, keeping the V/I ratio constant throughout the simulation.

b. Consider the Ramp function varying from 0-200 V as input with R = 50Ω

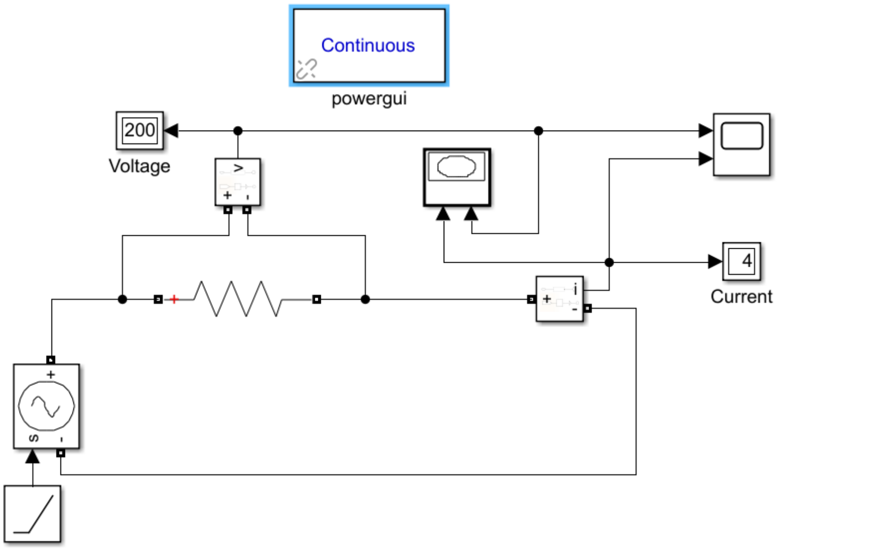


Fig1h: Circuit connections in Simulink

Procedure:

1. The mentioned Simulink blocksets are connected as shown in Figure 1h.
2. Connect the ramp blockset with the controlled voltage source to apply the specified voltage across the specified resistance.
3. Measure the current flowing through the resistor.
4. V-t, I-t and V-I plots are generated.

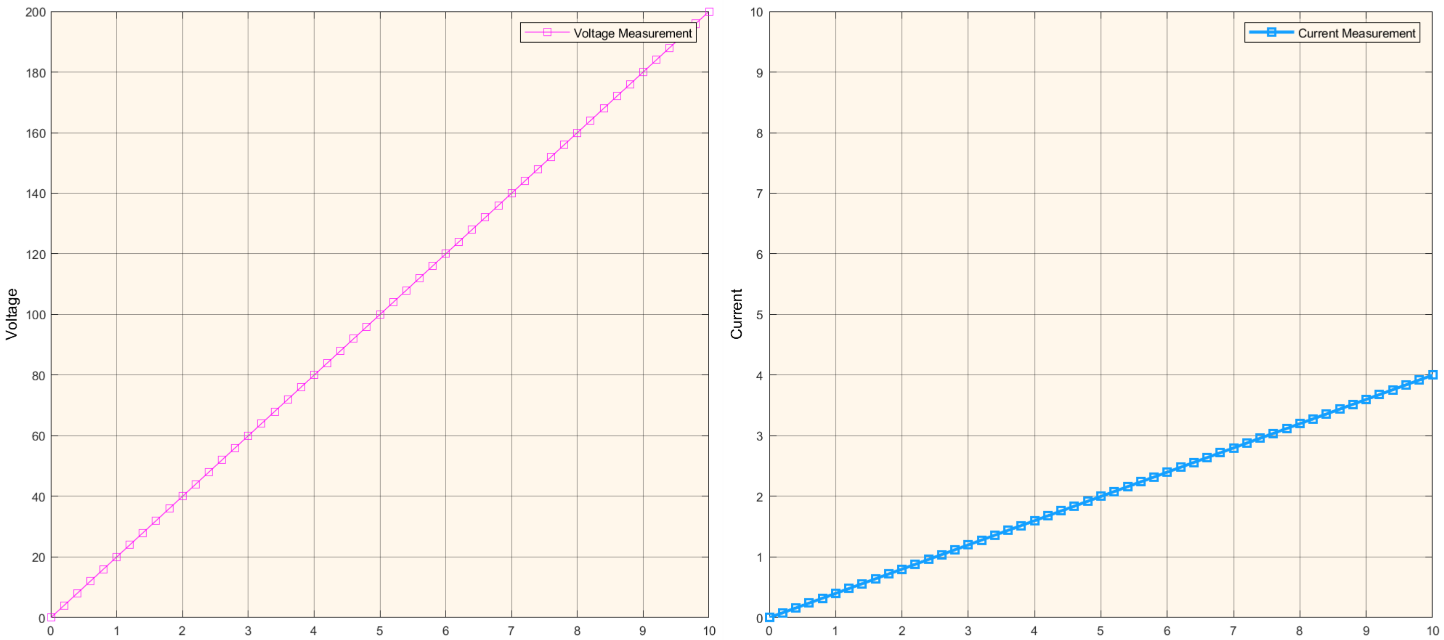


Fig:1i: Voltage Vs Time and Current Vs time Plots

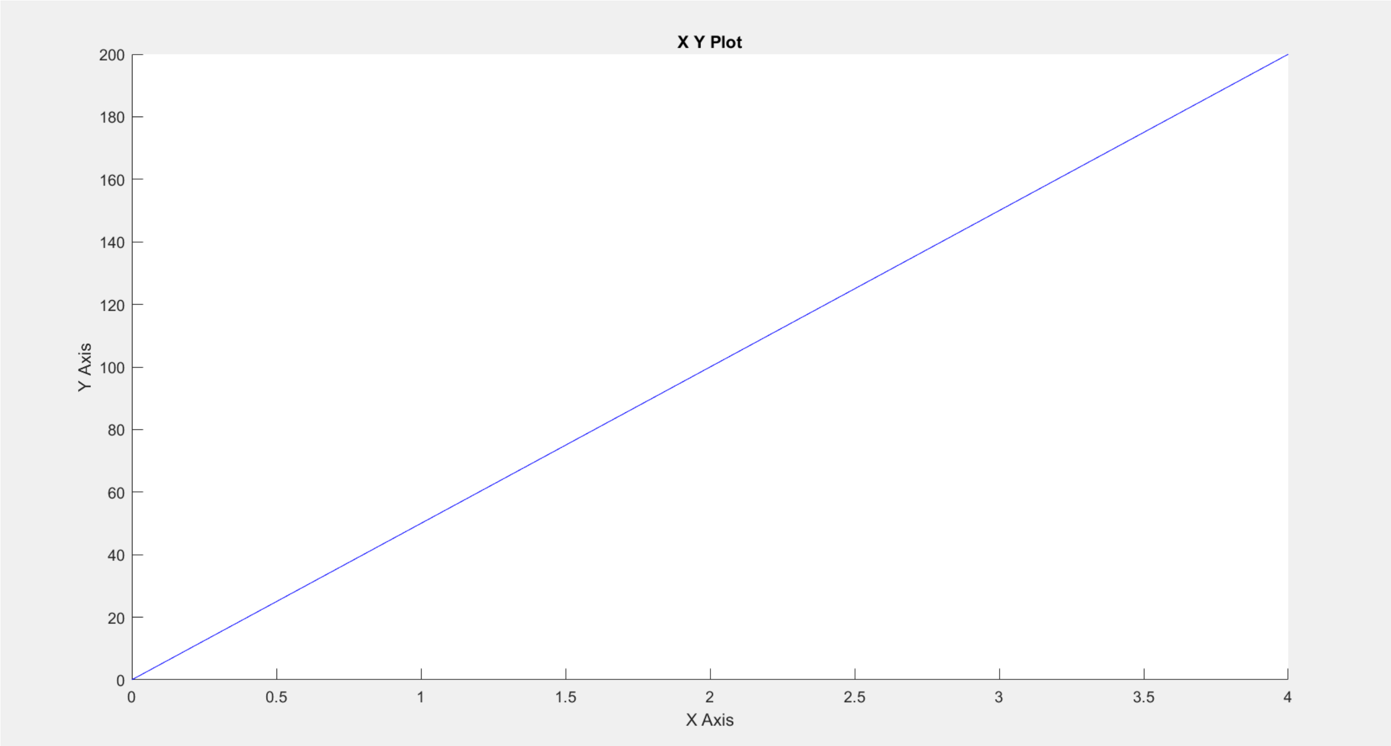


Fig1j: V-I Characteristics

Inferences: From the output, it can be inferred that as the input ramp is varied from 0-200 V, the current through the resistance varies from 0-4 A.

Experiment 2

Verification of Kirchhoff's Laws – KVL and KCL

1. **Aim**: To verify Kirchoff's voltage law and Kirchoff's current law for the given circuit.
2. **Software tools required:** MATLAB/SIMULINK
3. **Simulink Block sets Used:** Powergui, DC Voltage Source, Series RLC Branch, Current Measurement, Voltage Measurement, Display, Scope, XY Graph, Controlled Voltage Source, Ramp, Group 1 signal builder,
4. **Theory:** Kirchoff's voltage law states that the algebraic sum of the potential differences in any loop must be equal to zero. Mathematically, $\Sigma V = 0$ where V is the potential difference between a loop element. KVL deals with conservation of energy.

   Kirchoff's current law states that current entering a node is equal to current leaving the node. Mathematically, $\Sigma I = 0$, where I is the current entering the node from a particular direction.
5. **Circuit Diagram:** The considered circuit for Kirchoff Voltage law verification is as given in fig. 2a. The considered circuit for Kirchoff Current law verification is as given in fig. 2b. The connected circuit of KVL and KCL in MATLAB/Simulink is given in Fig.2c and Fig.2d.

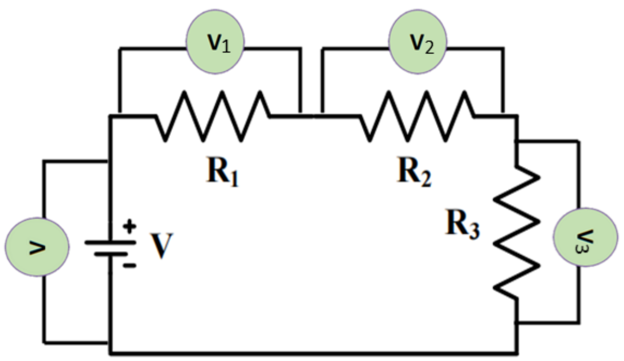


Fig2a: Circuit Diagram for KVL

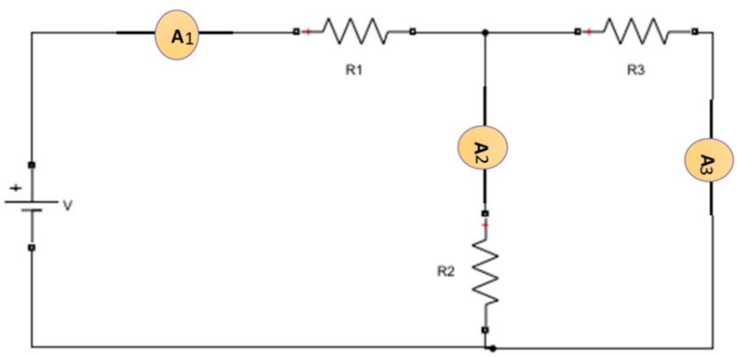


Fig2b: Circuit Diagram for KCL

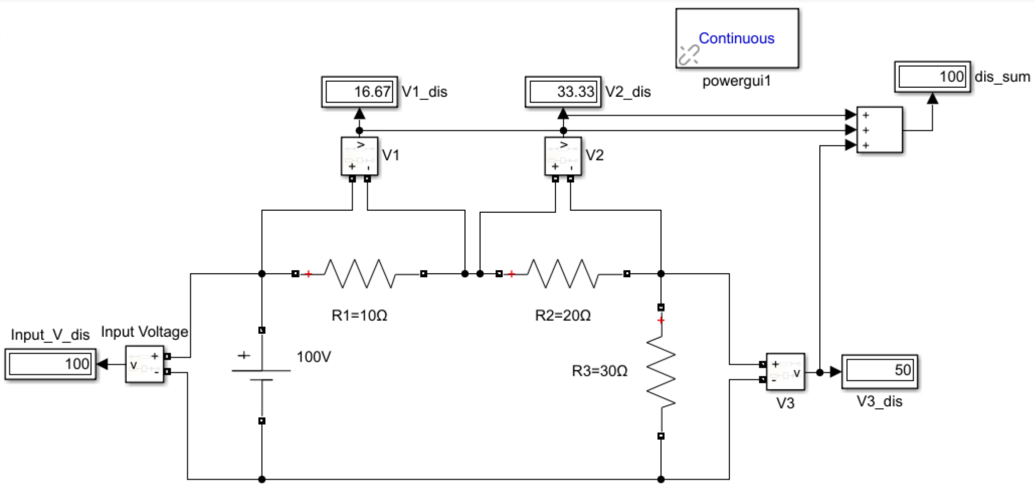


Fig2c: Circuit connections in Simulink for KVL

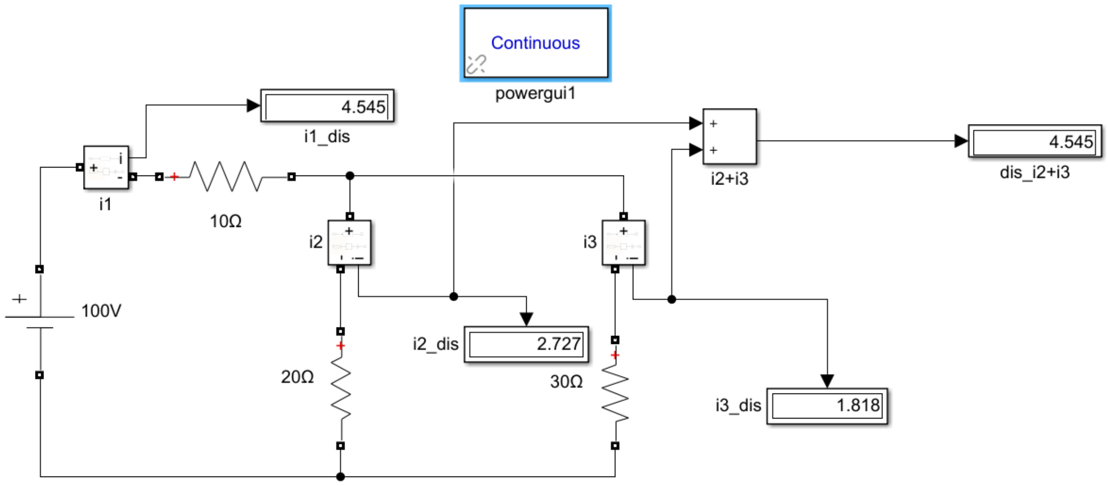


Fig2d: Circuit connections in Simulink for KCL

6. **Procedure:**

a. Convert the circuit shown in Fig. 2 into experimental circuit (necessary measuring instruments are to be incorporated in the circuit).

b. Construct the experimental circuits in MATLAB/Simulink domain, and simulate it.

c. Based on the simulation, fill up the Table-2.1 for KVL. Similarly, prepare a table for KCL experiment, and fill it.

7. **Observations:**

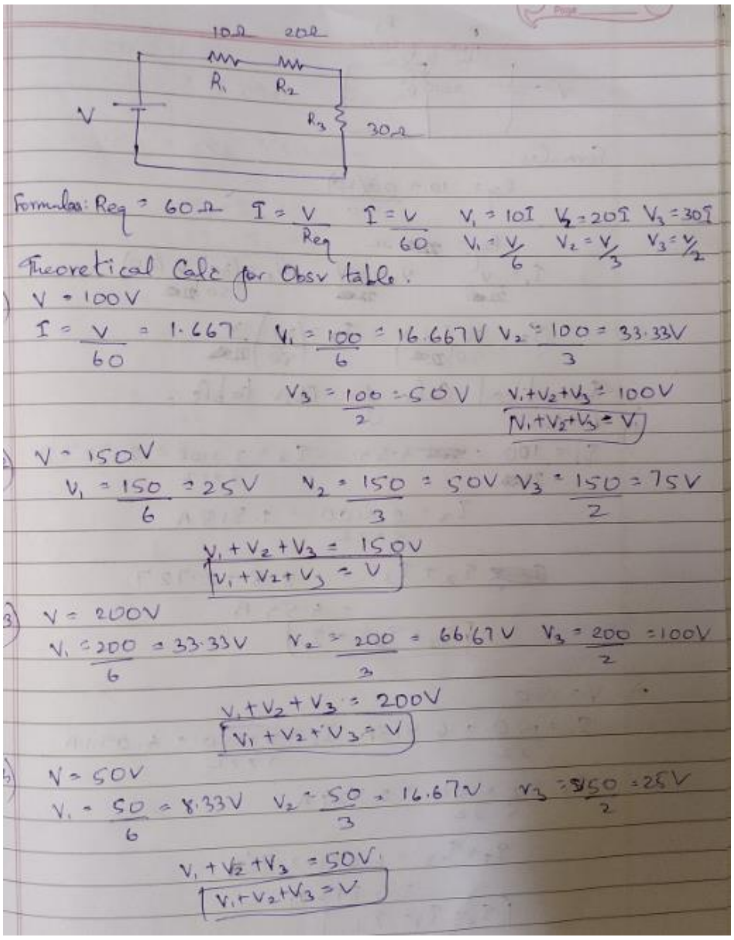
Observation No.	Applied Voltage V (volts)	Voltage across R_1 (volts) (V_1)		Voltage across R_2 (volts) (V_2)		Voltage across R_3 (volts) (V_3)		$V_1+V_2+V_3$ (volts)	
		Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated
1	100	16.67	16.67	33.33	33.33	50	50	100	100
2	150	25	25	50	50	75	75	150	150
3	200	33.33	33.33	66.67	66.67	100	100	200	200
4	50	8.33	8.33	16.67	16.67	25	25	50	50

Table 2.1: Observation table for KVL

Observation No.	Applied Voltage V (volts)	Current through R_1 i1 (Amperes)		Current through R2 i2 (Amperes)		Current through R3 i3 (Amperes)		i2+i3 (Amperes)	
		Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated
1	100	4.545	4.545	2.727	2.727	1.818	1.818	4.545	4.545
2	150	6.818	6.818	4.091	4.091	2.729	2.729	6.818	6.818
3	200	9.091	9.091	5.455	5.455	3.636	3.636	9.091	9.091
4	50	2.273	2.273	1.364	1.364	0.9091	0.9091	2.273	2.273

Table 2.2: Observation table for KCL

8. **Theoretical Calculation Working**:



Formulas: $R_{eq} = 60\Omega$ $I = \frac{V}{R_{eq}}$ $I = \frac{V}{60}$ $V_1 = 10I$ $V_2 = 20I$ $V_3 = 30I$ $V_1 = \frac{V}{6}$ $V_2 = \frac{V}{3}$ $V_3 = \frac{V}{2}$

Theoretical Calc for Obsv table:

1) $V = 100V$

$I = \frac{V}{60} = 1.667$ $V_1 = \frac{100}{6} = 16.667V$ $V_2 = \frac{100}{3} = 33.33V$

$V_3 = \frac{100}{2} = 50V$ $V_1+V_2+V_3 = 100V$

$\boxed{V_1+V_2+V_3 = V}$

2) $V = 150V$

$V_1 = \frac{150}{6} = 25V$ $V_2 = \frac{150}{3} = 50V$ $V_3 = \frac{150}{2} = 75V$

$V_1+V_2+V_3 = 150V$

$\boxed{V_1+V_2+V_3 = V}$

3) $V = 200V$

$V_1 = \frac{200}{6} = 33.33V$ $V_2 = \frac{200}{3} = 66.67V$ $V_3 = \frac{200}{2} = 100V$

$V_1+V_2+V_3 = 200V$

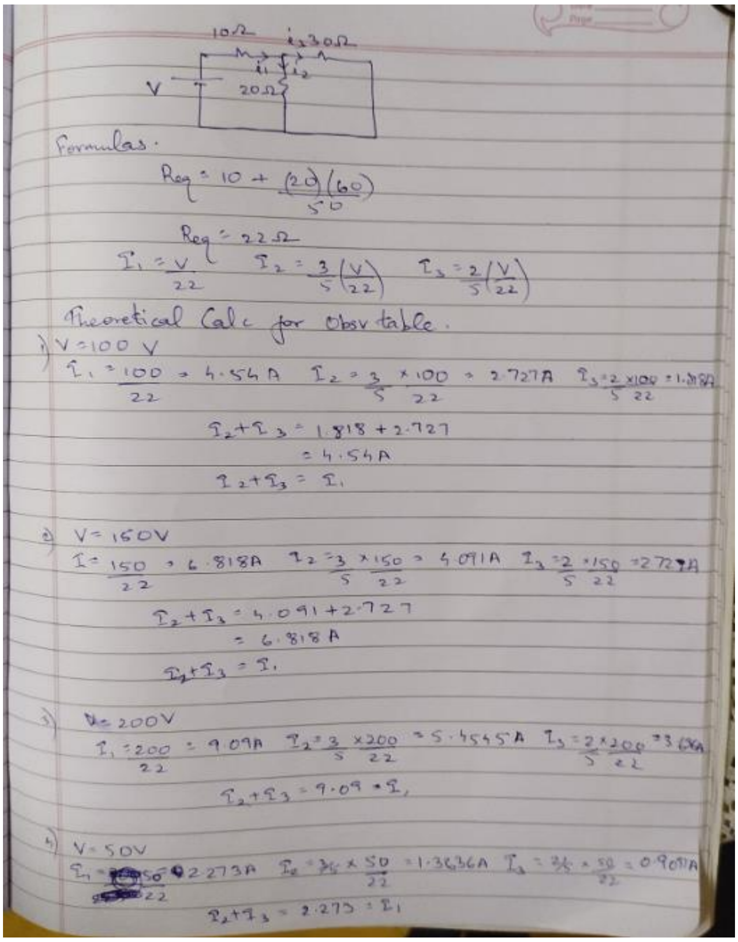
$\boxed{V_1+V_2+V_3 = V}$

4) $V = 50V$

$V_1 = \frac{50}{6} = 8.33V$ $V_2 = \frac{50}{3} = 16.67V$ $V_3 = \frac{50}{2} = 25V$

$V_1+V_2+V_3 = 50V$

$\boxed{V_1+V_2+V_3 = V}$



Formulas:

$R_{eq} = 10 + \frac{(20)(60)}{50}$

$R_{eq} = 22\Omega$

$I_1 = \frac{V}{22}$ $I_2 = \frac{3}{5}\left(\frac{V}{22}\right)$ $I_3 = \frac{2}{5}\left(\frac{V}{22}\right)$

Theoretical Calc for Obsv table.

1) $V = 100V$

$I_1 = \frac{100}{22} = 4.54A$ $I_2 = \frac{3}{5} \times \frac{100}{22} = 2.727A$ $I_3 = \frac{2}{5} \times \frac{100}{22} = 1.818A$

$I_2 + I_3 = 1.818 + 2.727$
$= 4.54A$
$I_2 + I_3 = I_1$

2) $V = 150V$

$I = \frac{150}{22} = 6.818A$ $I_2 = \frac{3}{5} \times \frac{150}{22} = 4.091A$ $I_3 = \frac{2}{5} \times \frac{150}{22} = 2.727A$

$I_2 + I_3 = 4.091 + 2.727$
$= 6.818A$
$I_2 + I_3 = I_1$

3) $V = 200V$

$I_1 = \frac{200}{22} = 9.09A$ $I_2 = \frac{3}{5} \times \frac{200}{22} = 5.4545A$ $I_3 = \frac{2}{5} \times \frac{200}{22} = 3.636A$

$I_2 + I_3 = 9.09 = I_1$

4) $V = 50V$

$I_1 = \frac{50}{22} = 2.273A$ $I_2 = \frac{3}{5} \times \frac{50}{22} = 1.3636A$ $I_3 = \frac{2}{5} \times \frac{50}{22} = 0.909A$

$I_2 + I_3 = 2.273 = I_1$

9. **Precautions:**

a) Ensure that 'powergui' block set is included in the Simulink file.
b) Ensure that connections are properly made.
c) Ensure that the scale of the graphs should be adjusted to the range in which the readings vary.

10. **Inferences:**

- From the observation table 2.1, it can be inferred that sum of V1+V2+V3 is always equal to V.
- From the observation table 2.2, it can be inferred that sum of i2+i3 is always equal to i1.
- All the theoretical readings match with the simulated readings.

11. **Conclusion:**

- Kirchoff's voltage law and Kirchoff's current law are hence verified.

Assignment:

1. Replace constant voltage source by constant current source with the same magnitude in Fig. 2.a & 2.b, do the simulation again.

Circuit Diagram:

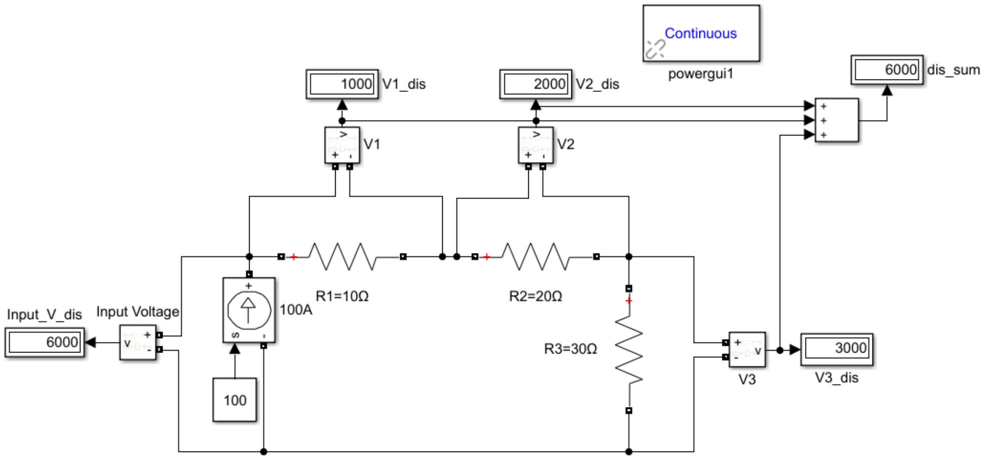


Fig2e: Circuit connections in Simulink for KVL with constant current source

Observations:

Observation No.	Current Source input I (Amperes)	Voltage across Current Source V (kVolts)		Voltage across R1 V1 (kVolts)		Voltage across R2 V2 (kVolts)		Voltage across R3 V3 (kVolts)		V1+V2+V3 (kVolts)	
		Theoretical	Simulation	Theoretical	Simulation	Theoretical	Simulation	Theoretical	Simulation	Theoretical	Simulation
1	100	6	6	1	1	2	2	3	3	6	6
2	150	9	9	1.5	1.5	3	3	4.5	4.5	9	9
3	200	12	12	2	2	4	4	6	6	12	12
4	50	3	3	0.5	0.5	1	1	1.5	1.5	3	3

Table 2.3: Observation table for KVL using constant current source

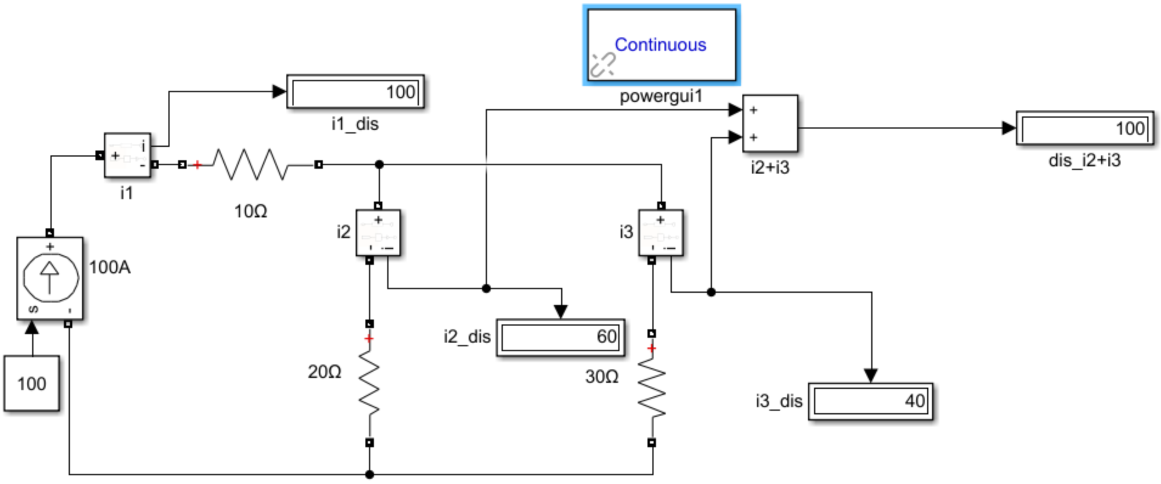


Fig2f: Circuit connections in Simulink for KCL with constant current source

Observations:

Observation No.	Current Source input I (Amperes)	Current through R_1 i1 (Amperes)		Current through R2 i2 (Amperes)		Current through R3 i3 (Amperes)		i2+i3 (Amperes)	
		Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated
1	100	100	100	60	60	40	40	100	100
2	150	150	150	90	90	60	60	150	150
3	200	200	200	120	120	80	80	200	200
4	50	50	50	30	30	20	20	50	50

Table 2.4: Observation table for KCL using constant current source

Inferences:

- From the observation table 2.3, it can be inferred that sum of V1+V2+V3 is always equal to V.
- From the observation table 2.4, it can be inferred that sum of i2+i3 is always equal to i1.
- All the theoretical readings match with the simulated readings.
- KCL and KVl is verified using constant current source.

2. Replace constant voltage source by variable voltage source (sinusoidal source with the same magnitude, ramp input with slope 1) in Fig. 2.a & 2.b, do the simulation again.

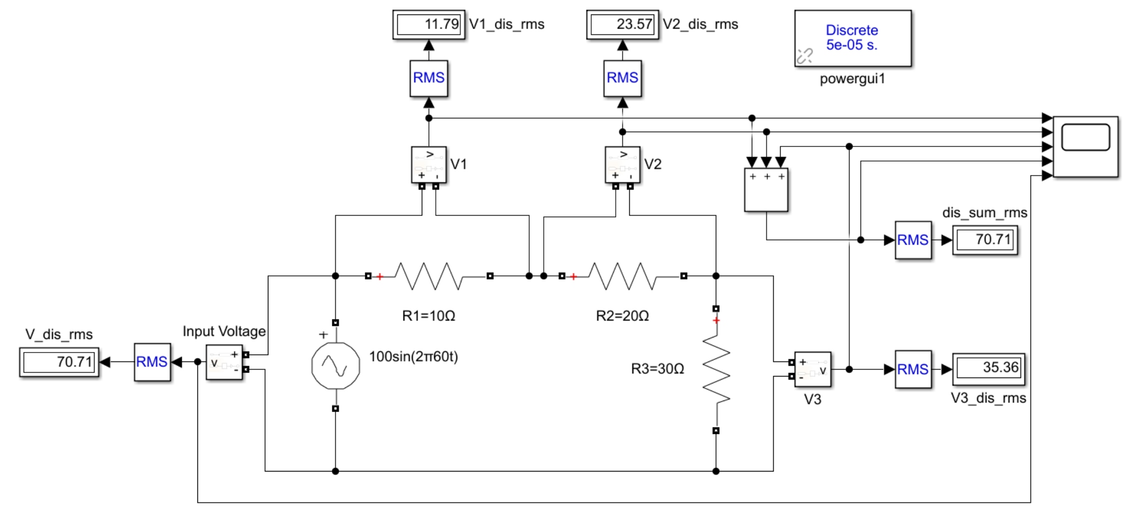
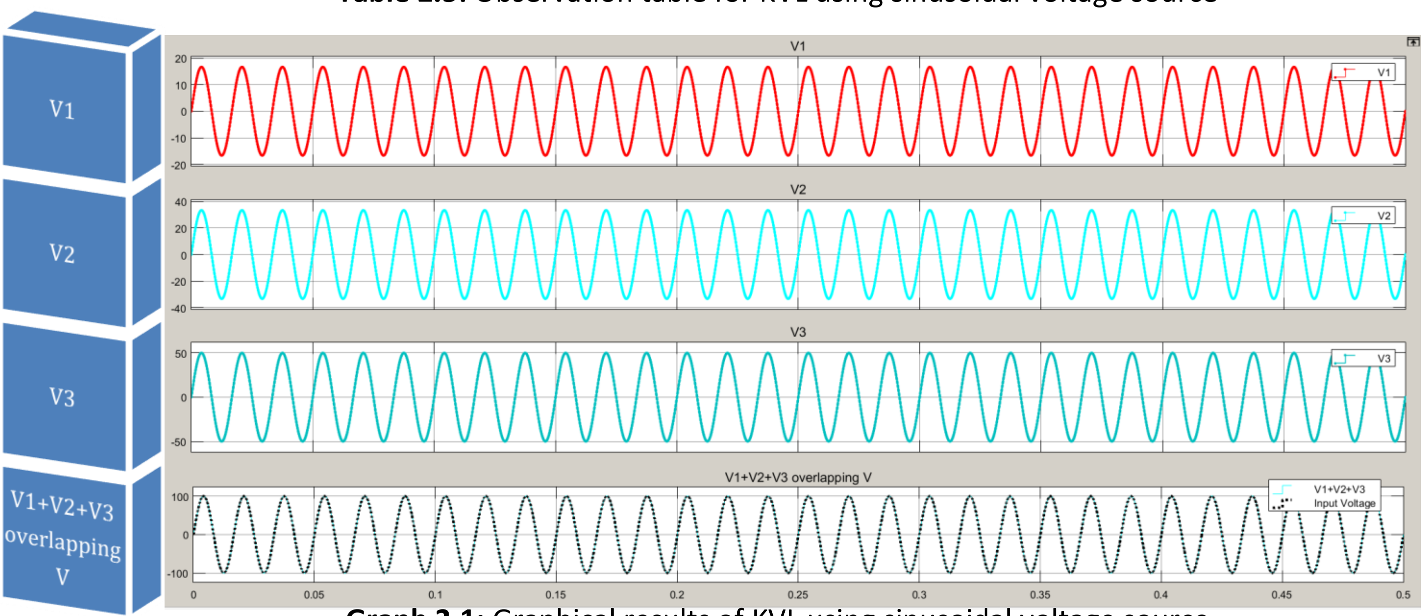


Fig2g: Circuit connections in Simulink for KVL using sinusoidal voltage source

Observation No.	Input Voltage V (Volts)	V RMS (Volts)		RMS Voltage across R1 V1 (Volts)		RMS Voltage across R2 V2 (Volts)		RMS Voltage across R3 V3 (Volts)		V1+V2+V3 (Volts)	
		Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated
1	100sin(2π60t)	70.71	70.71	11.79	11.79	23.57	23.57	35.36	35.36	70.71	70.71
2	200sin(2π60t)	141.4	141.4	23.57	23.57	47.14	47.14	70.17	70.17	141.4	141.4
3	150sin(2π60t)	106.1	106.1	17.68	17.68	35.36	35.36	70.71	70.71	106.1	106.1
4	50sin(2π60t)	35.36	35.36	5.893	5.893	11.79	11.79	17.68	17.68	35.36	35.36

Table 2.5: Observation table for KVL using sinusoidal voltage source



Graph 2.1: Graphical results of KVL using sinusoidal voltage source

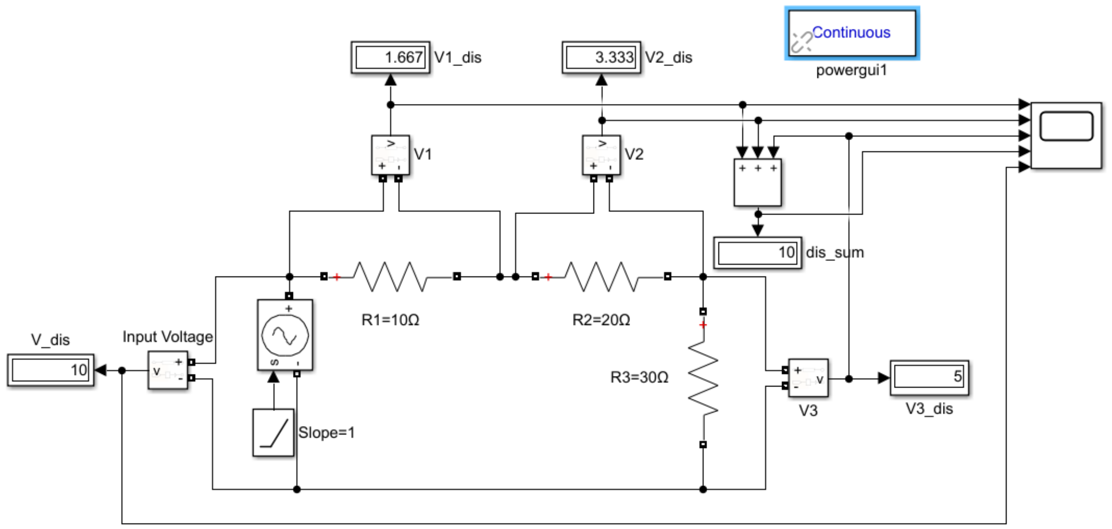
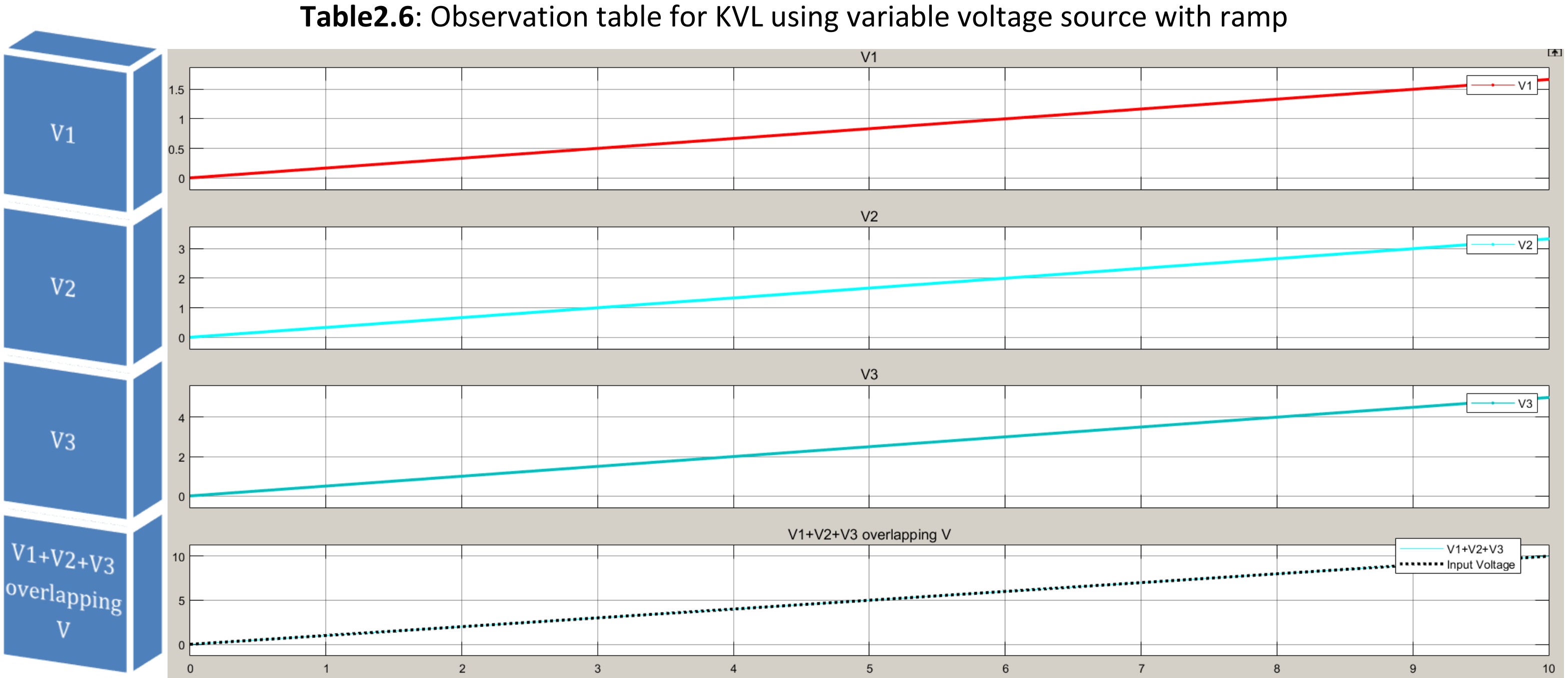


Fig2h: Circuit connections in Simulink for KVL using variable voltage source with ramp

Observation No.	Input Voltage V slope	Voltage across voltage source at t=5s V (Volts)		Voltage across R1 at t=5s V1 (Volts)		Voltage across R2 at t=5s V2 (Volts)		Voltage across R3 at t=5s V3 (Volts)		V1+V2+V3 at t=5s (Volts)	
		Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated
1	1	5	5	0.833	0.833	1.677	1.677	2.5	2.5	5	5
2	2	10	10	1.667	1.667	3.33	3.33	5	5	10	10
3	3	15	15	2.5	2.5	5	5	7.5	7.5	15	15
4	4	20	20	3.33	3.33	6.667	6.667	10	10	20	20

Table2.6: Observation table for KVL using variable voltage source with ramp



Graph 2.2: Graphical results of KVL using variable voltage source using ramp

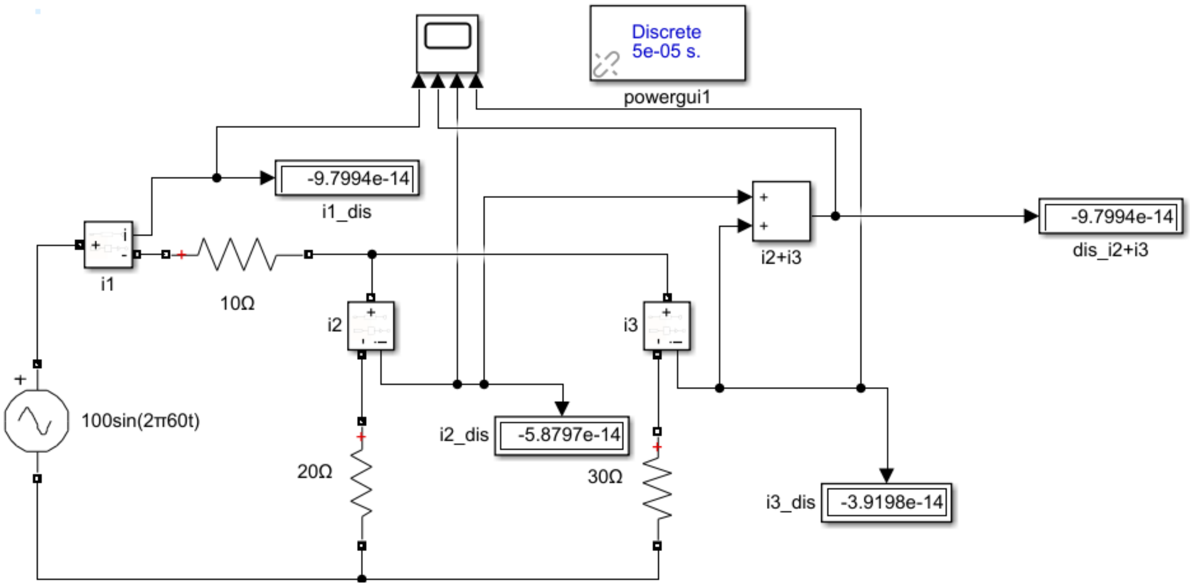
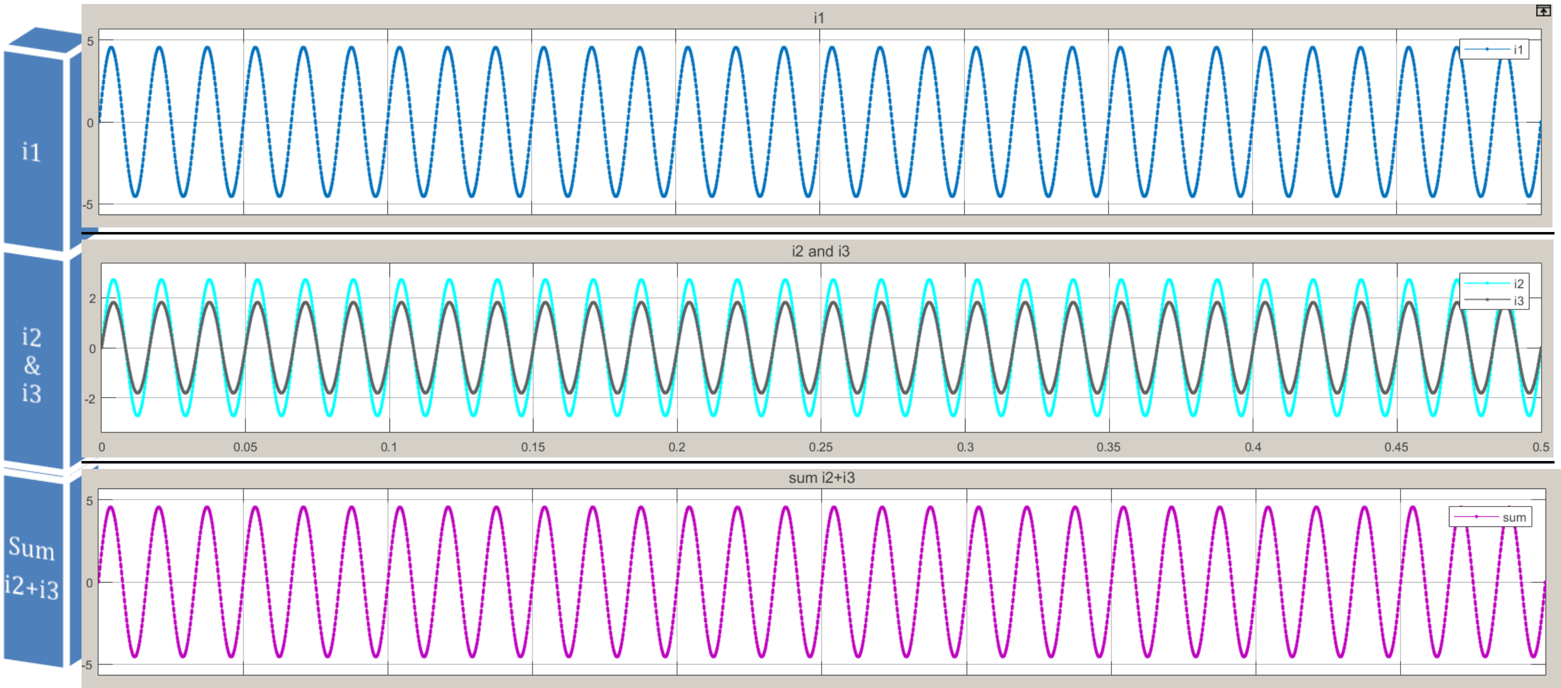


Fig2i: Circuit connections in Simulink for KCL with sinusoidal voltage source

Observation No.	Current Source input I (Amperes)	Current through R_1 i1 RMS (Amperes)		Current through R2 i2 RMS (Amperes)		Current through R3 i3 RMS (Amperes)		i2+i3 RMS (Amperes)	
		Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated
1	100sin(2π60t)	3.214	3.214	1.928	1.928	1.286	1.286	3.214	3.214
2	150sin(2π60t)	4.821	4.821	2.893	2.893	1.928	1.928	4.821	4.821
3	200sin(2π60t)	6.428	6.428	3.857	3.857	2.571	2.571	6.428	6.428
4	50sin(2π60t)	1.607	1.607	0.9642	0.9642	0.6428	0.6428	1.607	1.607

Table 2.7: Observation table for KCL using sinusoidal current source



Graph 2.3: Graphical results of KCL using sinusoidal voltage source

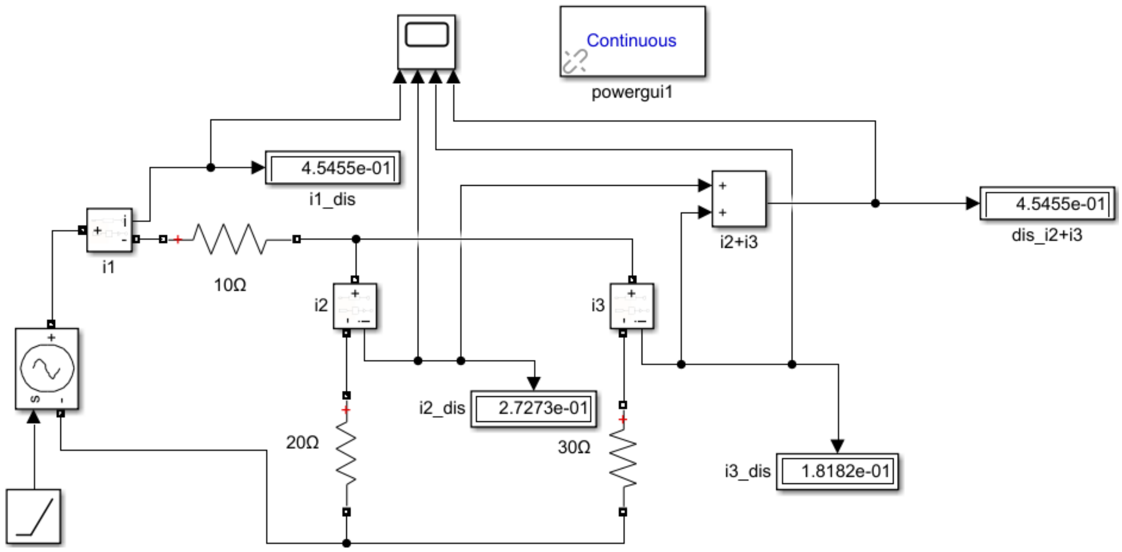
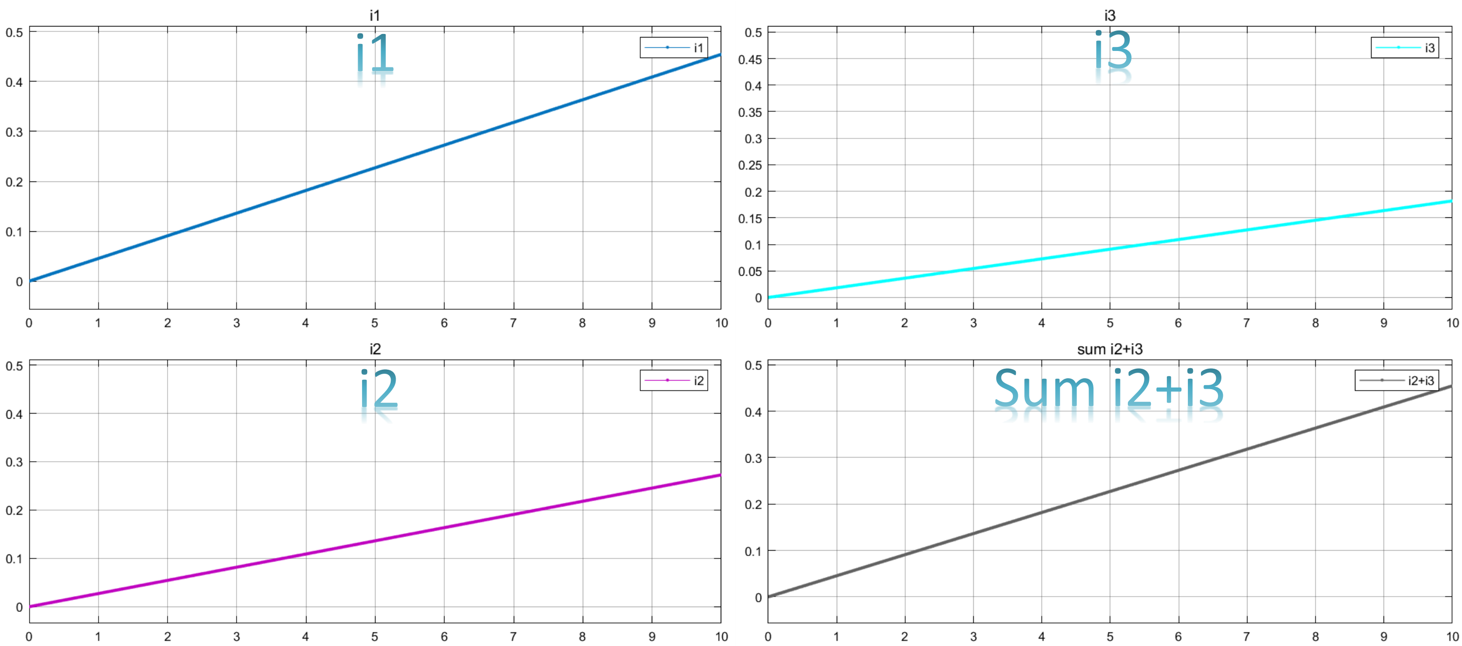


Fig2j: Circuit connections in Simulink for KCL using variable voltage source with ramp

Observation No.	Current Source input I (Ramp Slope)	Current through R_1 i1 (Amperes) at t=5s		Current through R2 i2 (Amperes) at t=5s		Current through R3 i3 (Amperes) at t=5s		i2+i3 (Amperes) at t=5s	
		Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated
1	1	0.2273	0.2273	0.1364	0.1364	0.09031	0.09031	0.2273	0.2273
2	2	0.4545	0.4545	0.2727	0.2727	0.1818	0.1818	0.4545	0.4545
3	3	0.6818	0.6818	0.4091	0.4091	0.2727	0.2727	0.6818	0.6818
4	4	0.9091	0.9091	0.5455	0.5455	0.3636	0.3636	0.9091	0.9091

Table 2.8: Observation table for KCL using variable current source with ramp



Graph 2.4: Graphical results of KCL using variable voltage source using ramp

<u>**Inferences**</u>: From the observation table 2.5 & 2.6, it can be inferred that sum of V1+V2+V3 is always equal to V.

- From the observation table 2.7 & 2.8, it can be inferred that sum of i2+i3 is always equal to i1.
- All the theoretical readings match with the simulated readings.
- KCL and KVl is verified using variable voltage source such as voltage with constant slope and sinusoid voltage

3. Using circuit shown in figure besides, do the experiment again.

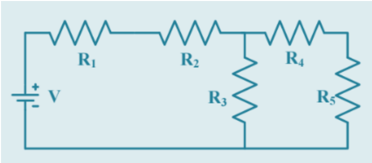


Fig. 2.c

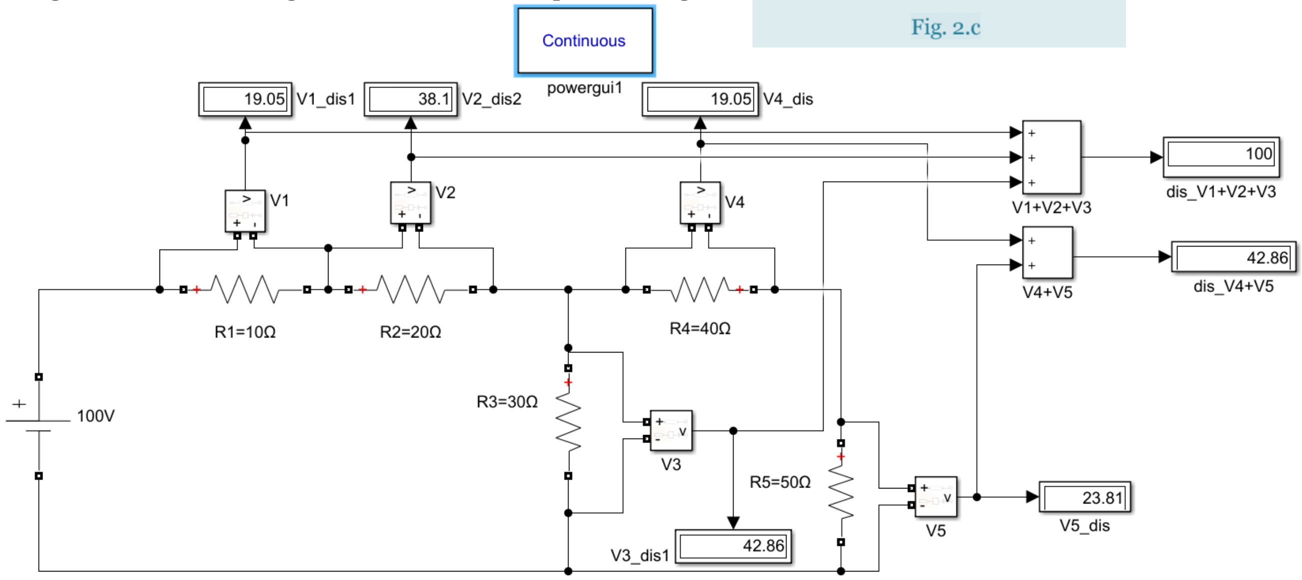


Fig2k: Circuit connections in Simulink for KVL

Observation No.	Applied Voltage V (Volts)	Voltage across R1 V1 (Volts)		Voltage across R2 V2 (Volts)		Voltage across R3 R3 (Volts)		V1+V2+V3 (Volts)	
		Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated
1	100	19.05	19.05	38.1	38.1	42.86	42.86	100	100
2	150	28.57	28.57	57.14	57.14	28.57	28.57	150	150
3	200	38.1	38.1	76.19	76.19	85.71	85.71	200	200
4	50	9.524	9.524	19.05	19.05	21.43	21.43	50	50

Table 2.9: Observation table for KVL for first loop

Observation No.	Applied Voltage V (Volts)	Voltage across R3 V3 (Volts)		Voltage across R4 V4 (Volts)		Voltage across R5 R5 (Volts)		V4+V5 (Volts)	
		Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated
1	100	42.86	42.86	19.05	19.05	23.81	23.81	42.86	42.86
2	150	28.57	28.57	57.14	57.14	28.57	28.57	150	150
3	200	64.29	64.29	28.59	28.59	35.71	35.71	64.29	64.29
4	50	21.43	21.43	9.524	9.524	11.9	11.9	21.43	21.43

Table 2.10: Observation table for KVL for second loop

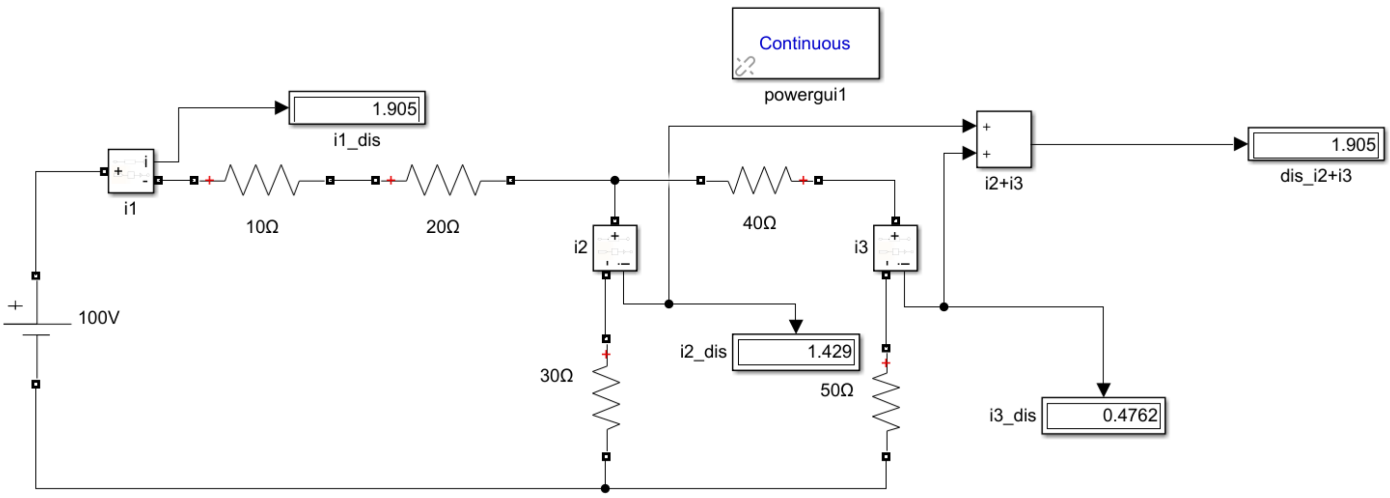


Fig2l: Circuit connections in Simulink for KCL

Observation No.	Applied Voltage V (Volts)	Current through R1 & R2 i1 (Amperes)		Current through R3 i2 (Amperes)		Current through R4 & R5 i3 (Amperes)		i2+i3 (Amperes)	
		Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated
1	100	1.905	1.905	1.429	1.429	0.4762	0.4762	1.905	1.905
2	150	2.857	2.857	2.143	2.143	0.7143	0.7143	2.857	2.857
3	200	3.81	3.81	2.851	2.851	0.9524	0.9524	3.81	3.81
4	50	0.9524	0.9524	0.7143	0.7143	0.2381	0.2381	0.9524	0.9524

Table 2.11: Observation table for KCL using constant voltage source for ckt fig

Inferences:

- From the observation table 2.9, it can be inferred that sum of V1+V2+V3 is always equal to V.
- From the observation table 2.10, it can be inferred that sum of V4+V5 is always equal to V3.
- From the observation table 2.11, it can be inferred that sum of i2+i3 is always equal to i1.
- All the theoretical readings match with the simulated readings.
- KCL and KVL is verified for the given circuit.