SIMATS SCHOOL OF ENGINEERING

SAVEETHA INSTITUTE OF MEDICAL AND TECHNICAL SCIENCES

CHENNAI-602105

MASTER RECORD

EEA01 – BASIC ELECTRICAL AND ELECTRONICS ENGINEERING

DO’S AND DON’T’S

DO’S

1. Follow the dress code strictly.
2. Be thorough with the experiment procedure. Identify the different leads or terminals or pins of the component before making connections
3. Know the biasing voltage required for different families of components and connect the power supply voltage and ground terminals to the respective pins.
4. Come with the completed observation and record notebook.
5. Maintain discipline in the lab at all times.
6. Enter the details in the components register before the start of the lab exercise.
7. Students should handle all the equipment carefully.
8. Report any breakage or damage to the Lab −in-charge immediately.
9. Get the signature in the observation from the faculty before proceeding to the experiment
10. Return the components after the completion of the experiments before leaving the lab.
11. Keep the lab neat and switch off the fans and lights when not in use.
12. Do not eat food in the laboratory.
13. Be present in the lab at the scheduled time.

DONT’S

1. Avoid loose connections and short circuits
2. Do not exceed the voltage rating of component
3. Don’t move inside the lab without permission and interchange the equipment.
4. Don’t cut and throw connecting wires and waste papers in the lab unnecessarily.
5. Don’t leave the lab without arranging the chairs and cleaning the work station.
6. Don’t manipulate the readings.
7. Protect yourself from getting electric shock.

LIST OF EXPERIMENTS

1. Verification of Ohm's law & Kirchhoff's law.
2. Calculate the individual branch currents and total current drawn from the power supply for the following set of resistors connected together in a parallel using current and voltage division rules.
3. Verification of star-delta transformation using resistance reduction technique.
4. Verification of Thevenin's and Norton's Theorems.
5. Verification of Superposition and Maximum power transfer Theorems.
6. Load test on Single Phase Transformer.
7. To obtain equivalent circuit, efficiency and voltage regulation of a single phase transformer using O.C. and S.C. tests.
8. Calculation of Secondary turns and Current in a transformer.
9. Load test on Single phase Induction Motor.
10. To determine the output characteristics of LVDT and calibrate the measuring instruments.
11. Power measurement using two wattmeter methods.
12. Calculate the energy consumption using the Energy meter.
13. Load test on DC shunt Motor.
14. Staircase Wiring & Fluorescent tube wiring
15. Find Stability of a System Using Routh Hurwitz Criterion.
16. Investigating the Performance of Three-Phase Induction Motor Drive Systems in Electric Vehicle Applications.
17. Write SCILAB program to generate the following signals:
    (a) Unit step signal
    (b) Unit Impulse signal
    (c) Unit ramp signal
    (d) Sinusoidal signal
    (e) Exponential signal
18. Write a SCILAB program to obtain the following:
    (a) DIT-FFT Algorithm
    (b) DIF-FFT Algorithm
19. Design a filter using the Transformation Method.

(a) Bilinear Transformation

(b) Impulse Invariant Transformation

20. Write the SCILAB program to design the following Butterworth filters
(a)Low pass filter

(b)High pass filter

(c)Band pass filter

(d)Band reject filter.

Expt. No.1	Verification of Ohm’s law & Kirchhoff’s law

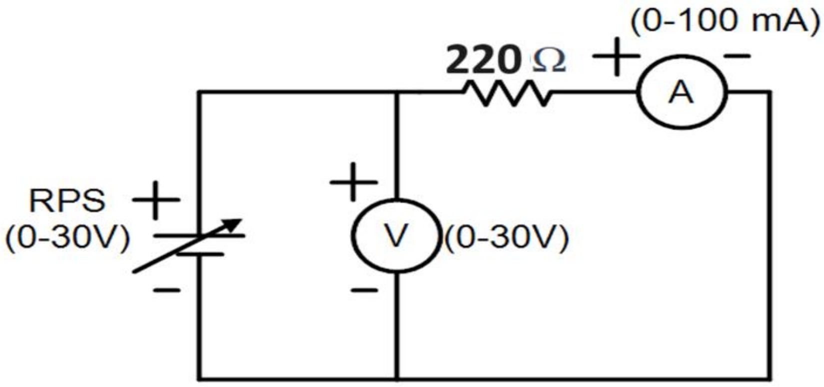
1. (a) Verification of Ohm’s law

AIM:
To verify Ohm’s law for a given resistive network.

APPARATUS REQUIRED:

S.No.	Apparatus Name	Range	Quantity
1	RPS	(0-30)V	1
2	Ammeter	(0-200)mA	1
3	Voltmeter	(0-30)V	1
4	Resistor	1KΩ	1
5	Rheostat	300Ω/2A	1
6	Bread board & Connecting wires	--	Required

CIRCUIT DIAGRAM:



PROCEDURE:
1. Make the connections as per circuit diagram.
2. Switch ON the power supply to RPS and apply a voltage (say 10V) and take the reading of voltmeter and ammeter.
3. Adjust the rheostat in steps and take down the readings of ammeter and voltmeter.
4. Plot a graph with V along x-axis and I along y-axis.
5. The graph will be a straight line which verifies Ohm's law.
6. Determine the slope of the V-I graph. The reciprocal of the slope gives resistance of the wire.

OBSERVATIONS:

S.No.	Voltage (V)	Current (mA)	Experimental Value R = V/I in Ω	Theoretical Value R = V/I in Ω
1.	1	5	200	220
2.	2	10	200	220
3.	3	16	187.5	220
4.	4	20	200	220
5.	5	24	208.3	220
6.	6	28	214.28	220
7.	7	32	218.75	220

THEORETICAL CALCULATIONS

1. V=IR

$$I=\frac{V}{R}=\frac{1}{220}=4.5454mA$$

$$R=\frac{V}{I}=\frac{1}{4.5454\times10^{-3}}=220\Omega$$

2. $I=\frac{V}{R}=\frac{2}{220}=9.0909mA$

$$R=\frac{V}{I}=\frac{2}{9.0909\times10^{-3}}=220\Omega$$

3. $I=\frac{V}{R}=\frac{3}{220}=13.6363mA$

$$R=\frac{V}{I}=\frac{3}{13.6363\times10^{-3}}=220\Omega$$

4. $I=\frac{V}{R}=\frac{4}{220}=18.1818mA$

$$R=\frac{V}{I}=\frac{4}{18.1818\times10^{-3}}=220\Omega$$

5. $I=\frac{V}{R}=\frac{5}{220}=22.7272mA$

$$R=\frac{V}{I}=\frac{5}{22.7272\times10^{-3}}=220\Omega$$

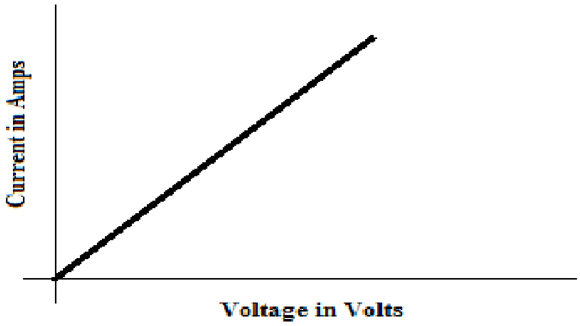
6. $I=\frac{V}{R}=\frac{6}{220}=27.2727mA$

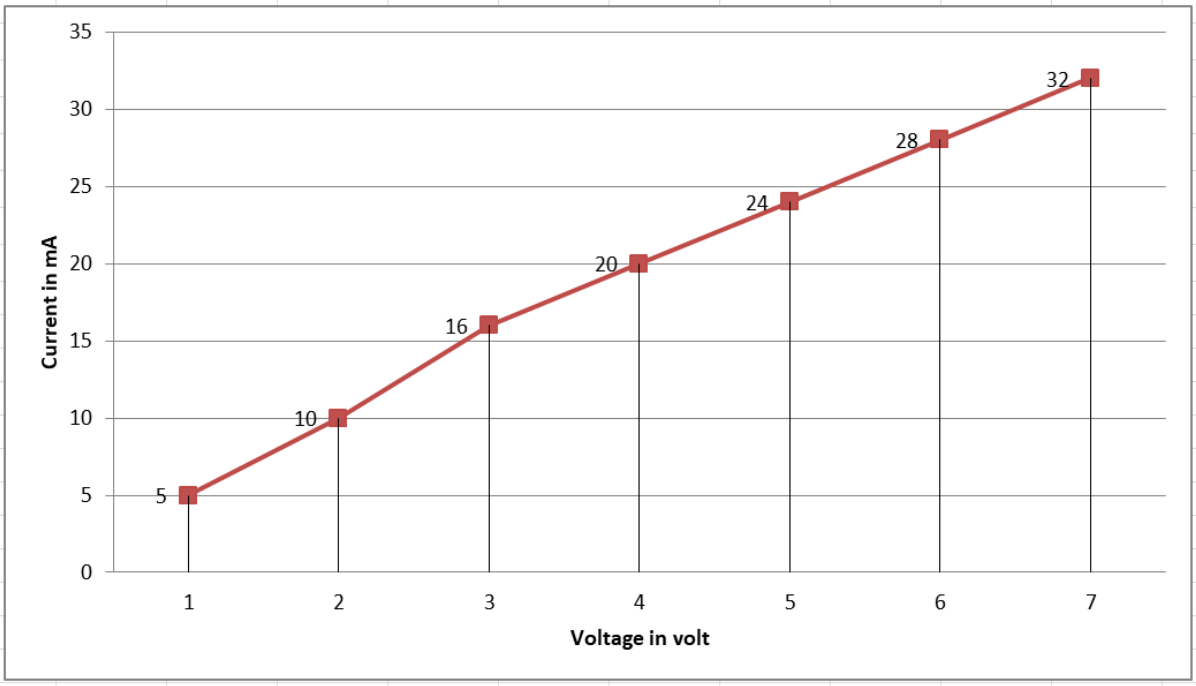
$$R=\frac{V}{I}=\frac{6}{27.2727\times10^{-3}}=220\Omega$$

7. $I=\frac{V}{R}=\frac{7}{220}=31.8181mA$

$$R=\frac{V}{I}=\frac{7}{31.8181\times10^{-3}}=220\Omega$$

MODEL GRAPH:


Current in Amps
Voltage in Volts


35
30
25
20
15
10
5
0
Current in mA
5
10
16
20
24
28
32
1
2
3
4
5
6
7
Voltage in volt

Marks Obtained:

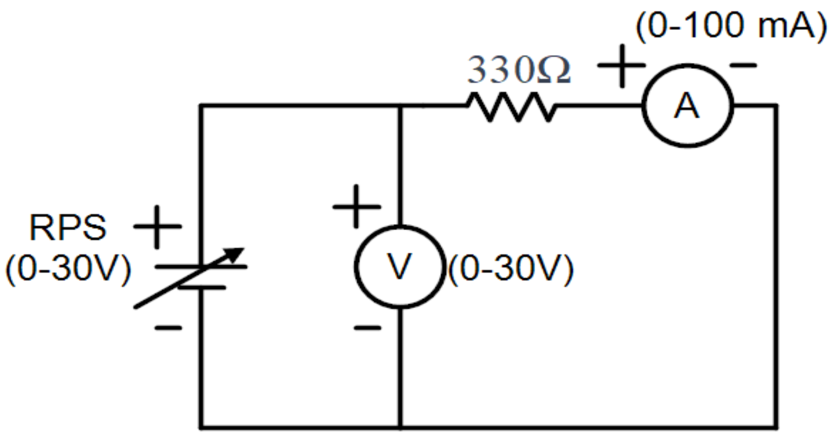
Theoretical Calculations	**20**	
Observation	**20**	
Execution of practice examples	**30**	
Viva	**10**	
Record	**20**	
Total Score	**100**	
Date of experiment		
Date of record submission		**Faculty signature**

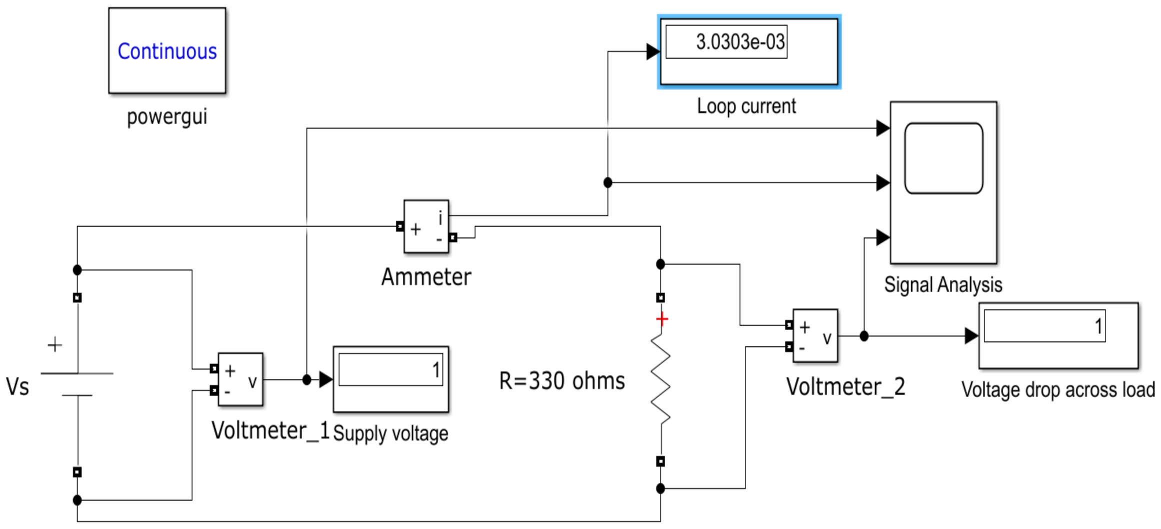
RESULT:

Thus the Ohm's law is verified for the given circuit.

Test case 1:

Conduct a simulation to verify Ohm's law with a relevant circuit using matlab Simulink.





Tabulations:

S.No.	Voltage (V)	Current (mA)	Simulation Value R = V/I in Ω	Theoretical Value R = V/I in Ω
1.	1	3.0303	330	330
2.	2	6.0606	330	330
3.	3	9.0909	330	330
4.	4	12.1212	330	330
5.	5	15.1515	330	330
6.	6	18.1818	330	330
7.	7	21.2121	330	330

THEORETICAL CALCULATIONS

1. V=IR

I=$\frac{V}{R}=\frac{1}{330}=3.0303mA$

$R=\frac{V}{I}=\frac{1}{3.0303\times10^{-3}}=330\Omega$

2. I=$\frac{V}{R}=\frac{2}{330}=6.0606mA$

$R=\frac{V}{I}=\frac{2}{6.0606\times10^{-3}}=330\Omega$

3. I=$\frac{V}{R}=\frac{3}{330}=9.0909mA$

$R=\frac{V}{I}=\frac{3}{9.0909\times10^{-3}}=330\Omega$

4. I=$\frac{V}{R}=\frac{4}{330}=12.1212mA$

$R=\frac{V}{I}=\frac{4}{12.1212\times10^{-3}}=330\Omega$

5. I=$\frac{V}{R}=\frac{5}{330}=15.1515mA$

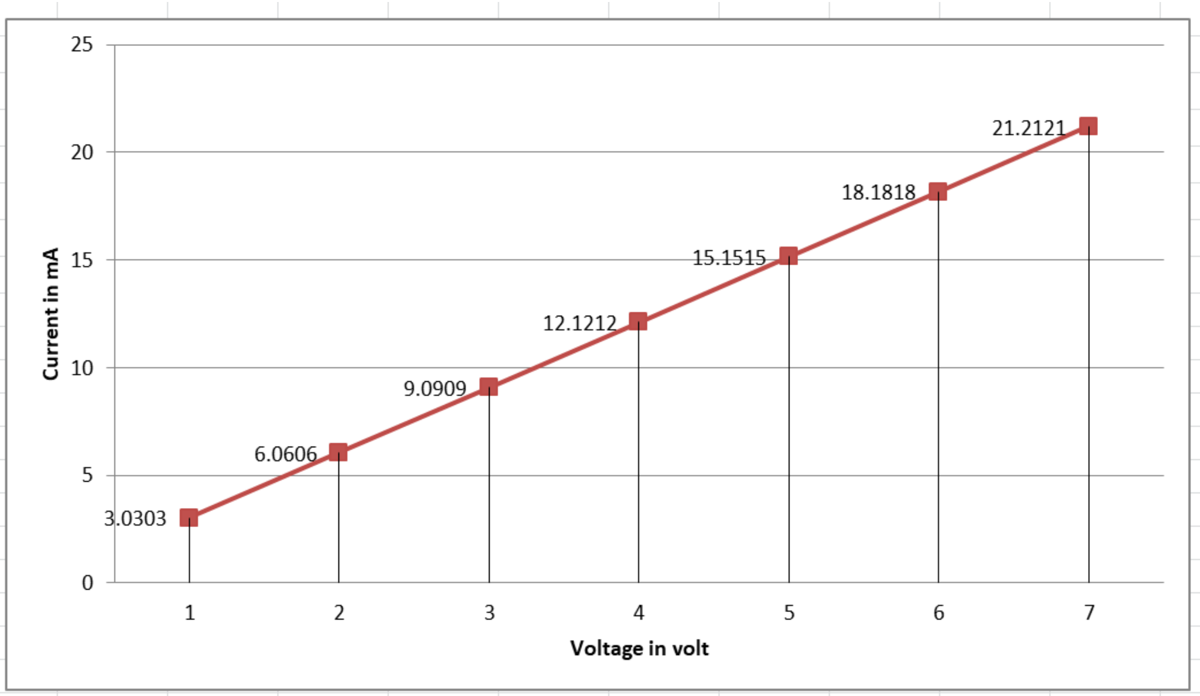
$R=\frac{V}{I}=\frac{5}{15.1515\times10^{-3}}=330\Omega$

6. I=$\frac{V}{R}=\frac{6}{330}=18.1818mA$

$R=\frac{V}{I}=\frac{6}{18.1818\times10^{-3}}=330\Omega$

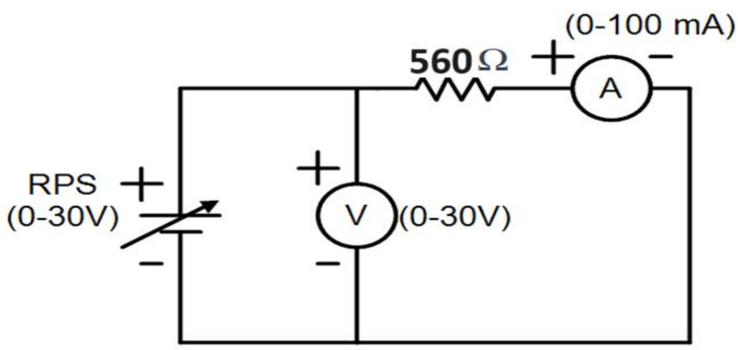
7. I=$\frac{V}{R}=\frac{7}{330}=21.2121mA$

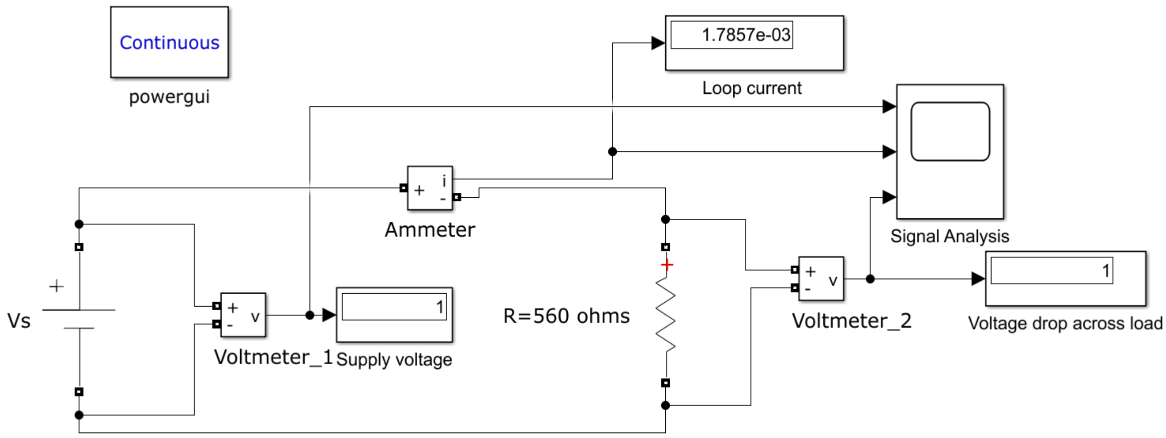
$R=\frac{V}{I}=\frac{7}{21.2121\times10^{-3}}=330\Omega$



Test case 2:

Conduct a simulation to verify Ohm’s law with a relevant circuit using matlab Simulink.





Tabulations:

S.No.	Voltage (V)	Current (mA)	Simulation Value R = V/I in Ω	Theoretical Value R = V/I in Ω
1.	1	1.7857	560	560
2.	2	3.5714	560	560
3.	3	5.3571	560	560
4.	4	7.1429	560	560
5.	5	8.9286	560	560
6.	6	10.7143	560	560
7.	7	12.5	560	560

THEORETICAL CALCULATIONS

1. V=IR

$$I=\frac{V}{R}=\frac{1}{560}=1.7857mA$$

$$R=\frac{V}{I}=\frac{1}{1.7857\times10^{-3}}=560\Omega$$

2. $I=\frac{V}{R}=\frac{2}{560}=3.5714mA$

$$R=\frac{V}{I}=\frac{2}{3.5714\times10^{-3}}=560\Omega$$

3. $I=\frac{V}{R}=\frac{3}{560}=5.3571mA$

$$R=\frac{V}{I}=\frac{3}{5.3571\times10^{-3}}=560\Omega$$

4. $I=\frac{V}{R}=\frac{4}{560}=7.1428mA$

$$R=\frac{V}{I}=\frac{4}{7.1428\times10^{-3}}=560\Omega$$

5. $I=\frac{V}{R}=\frac{5}{560}=8.9286mA$

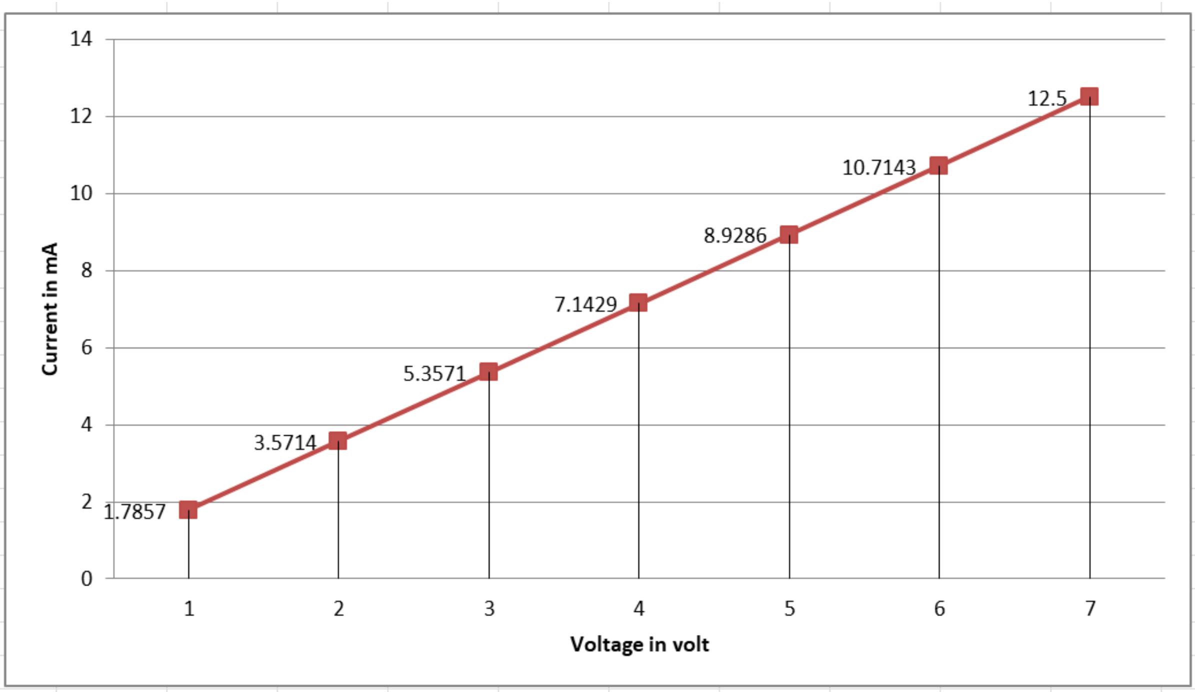
$$R=\frac{V}{I}=\frac{5}{8.9286\times10^{-3}}=560\Omega$$

6. $I=\frac{V}{R}=\frac{6}{560}=10.7143mA$

$$R=\frac{V}{I}=\frac{6}{10.7143\times10^{-3}}=560\Omega$$

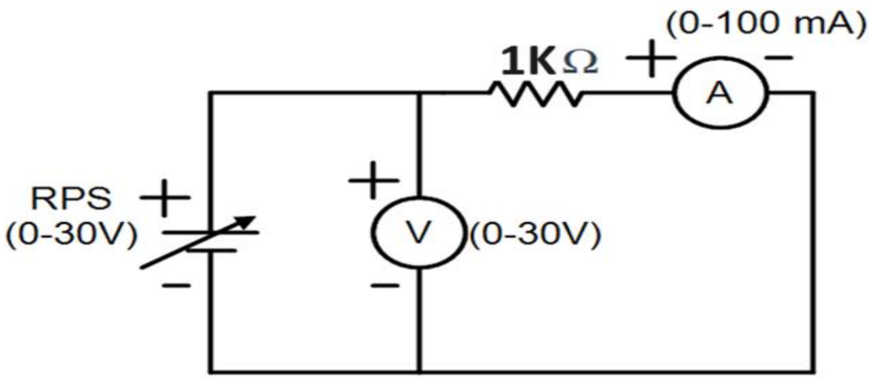
7. $I=\frac{V}{R}=\frac{7}{560}=12.5mA$

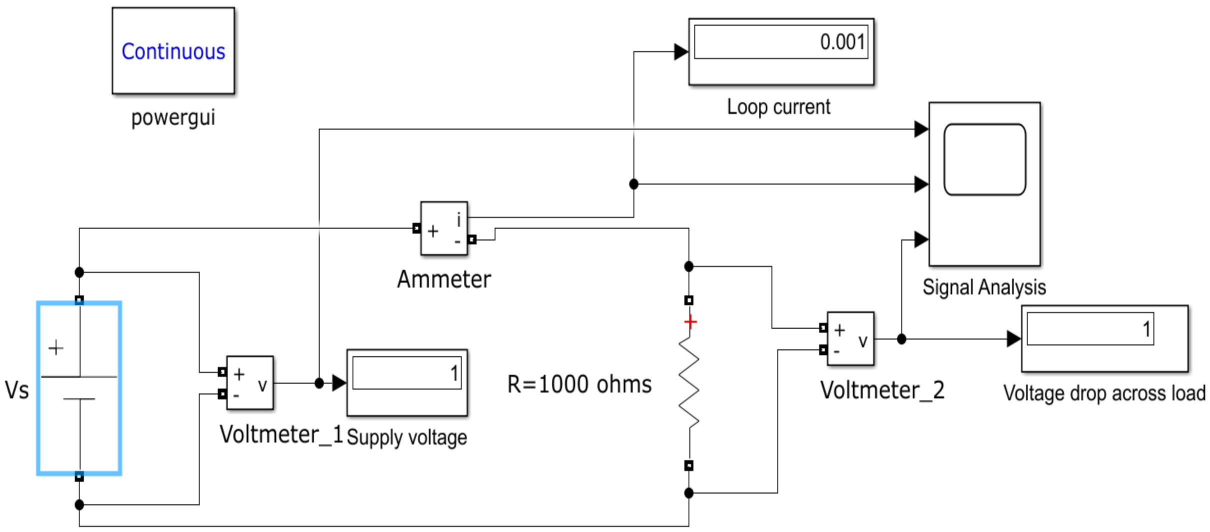
$$R=\frac{V}{I}=\frac{7}{12.5\times10^{-3}}=560\Omega$$



Test case 3:

Conduct a simulation to verify Ohm’s law with a relevant circuit using matlab Simulink.





Tabulations:

S.No.	Voltage (V)	Current (mA)	Simulation Value R = V/I in Ω	Theoretical Value R = V/I in Ω
1.	1	1	1000	1000
2.	2	2	1000	1000
3.	3	3	1000	1000
4.	4	4	1000	1000
5.	5	5	1000	1000
6.	6	6	1000	1000
7.	7	7	1000	1000

THEORETICAL CALCULATIONS

1. V=IR

$$I=\frac{V}{R}=\frac{1}{1000}=1mA$$

$$R=\frac{V}{I}=\frac{1}{1\times10^{-3}}=1000\Omega$$

2. $I=\frac{V}{R}=\frac{2}{1000}=2mA$

$$R=\frac{V}{I}=\frac{2}{2\times10^{-3}}=1000\Omega$$

3. $I=\frac{V}{R}=\frac{3}{1000}=3mA$

$$R=\frac{V}{I}=\frac{3}{3\times10^{-3}}=1000\Omega$$

4. $I=\frac{V}{R}=\frac{4}{1000}=4mA$

$$R=\frac{V}{I}=\frac{4}{4\times10^{-3}}=1000\Omega$$

5. $I=\frac{V}{R}=\frac{5}{1000}=5mA$

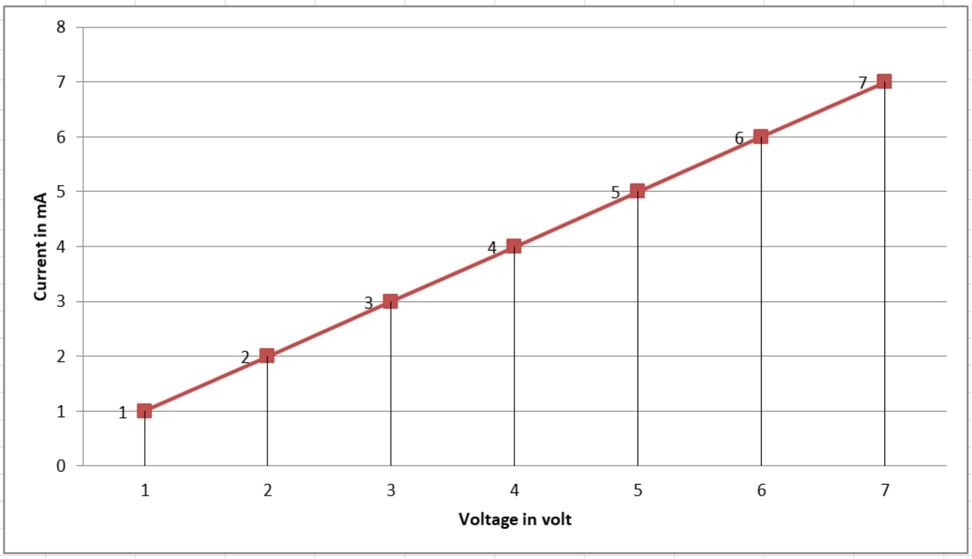
$$R=\frac{V}{I}=\frac{5}{5\times10^{-3}}=1000\Omega$$

6. $I=\frac{V}{R}=\frac{6}{1000}=6mA$

$$R=\frac{V}{I}=\frac{6}{6\times10^{-3}}=1000\Omega$$

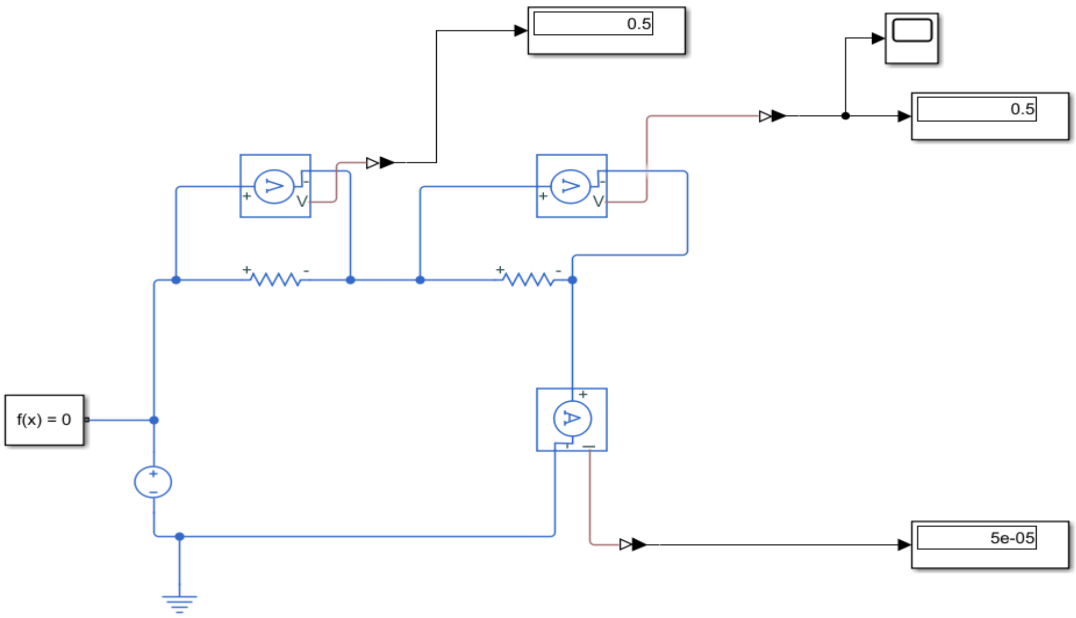
7. $I=\frac{V}{R}=\frac{7}{1000}=7mA$

$$R=\frac{V}{I}=\frac{7}{7\times10^{-3}}=1000\Omega$$



Test case 4:

Conduct a simulation to verify Ohm's law with a relevant circuit using matlab Simscape.



Tabulations:

S.No.	Voltage (V)	Current (mA)	Simulation Value R = V/I in Ω	Theoretical Value R = V/I in Ω
1.	1	0.05	20000	20000
2.	2	0.1	20000	20000
3.	3	0.15	20000	20000

4.	4	0.2	20000	20000
5.	5	0.25	20000	20000
6.	6	0.3	20000	20000
7.	7	0.35	20000	20000

THEORETICAL CALCULATIONS

1. V=IR

I= $\frac{V}{R} = \frac{1}{20000} = 0.05mA$

$R = \frac{V}{I} = \frac{1}{0.05 \times 10^{-3}} = 20000\Omega$

2. I= $\frac{V}{R} = \frac{2}{20000} = 0.1mA$

$R = \frac{V}{I} = \frac{2}{0.1 \times 10^{-3}} = 20000\Omega$

3. I= $\frac{V}{R} = \frac{3}{20000} = 0.15mA$

$R = \frac{V}{I} = \frac{3}{0.15 \times 10^{-3}} = 20000\Omega$

4. I= $\frac{V}{R} = \frac{4}{20000} = 0.2mA$

$R = \frac{V}{I} = \frac{4}{0.2 \times 10^{-3}} = 20000\Omega$

5. I= $\frac{V}{R} = \frac{5}{20000} = 0.25mA$

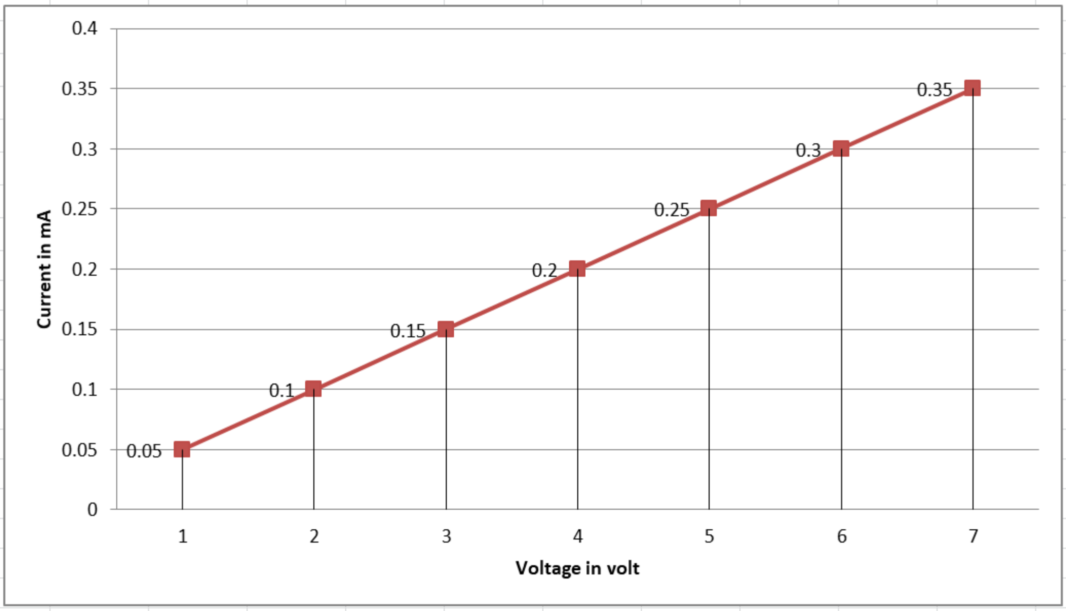
$R = \frac{V}{I} = \frac{5}{0.25 \times 10^{-3}} = 20000\Omega$

6. I= $\frac{V}{R} = \frac{6}{20000} = 0.3mA$

$R = \frac{V}{I} = \frac{6}{0.3 \times 10^{-3}} = 20000\Omega$

7. I= $\frac{V}{R} = \frac{7}{20000} = 0.35mA$

$R = \frac{V}{I} = \frac{7}{0.35 \times 10^{-3}} = 20000\Omega$


Current in mA
Voltage in volt
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1
2
3
4
5
6
7
0.05
0.1
0.15
0.2
0.25
0.3
0.35

Exp. No. 1b **VERIFICATIONS OF KIRCHHOFF'S LAWS**

AIM:

1. To verify Kirchhoff"s voltage law.
2. To verify the Kirchhoff"s current law.

APPARATUS REQUIRED:

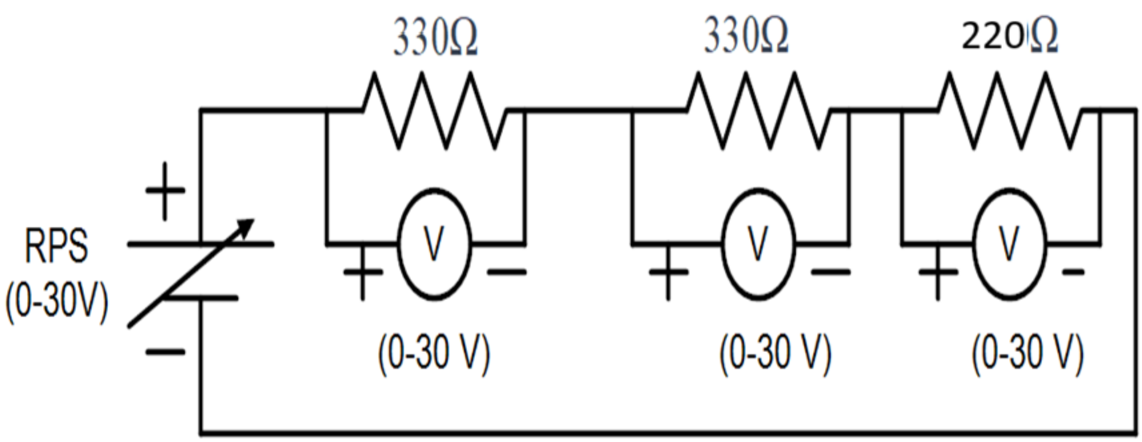
S.No	Name of The Equipment	Type	Range	Qty
1.	RPS	-	(0-15) V	1
2.	Bread board	-	-	1
3.	Ammeter	MC MC	(0-10) mA (0-5) mA	1 2
4.	Voltmeter	MC MC	(0-10)V (0-15) V	1 1
5.	Resistor	-	470Ω , 330Ω, 4kΩ, 4.7kΩ	Each 1
6.	Connecting wires	-	-	As required

THEORY:

KIRCHHOFF'S VOLTAGE LAW (KVL):

In any network the algebraic sum of the voltage drops across the circuit elements of any closed path is equal to the algebraic sum of the emf"s in the path.

CIRCUIT DIAGRAM FOR KVL:



KIRCHHOFF'S CURRENT LAW (KCL):

Kirchhoff's Current law states that the algebraic sum of current entering any node is zero. In other words the sum of current going into a node must be equal to current going out from the node.

PRECAUTIONS:

1. Keep RPS at maximum when switching ON and OFF the power supply.
2. Connections should properly check before switch ON the supply.

PROCEDURE:

1. Connections are given as per the circuit diagram.
2. Apply d.c voltage to the circuit from the given RPS.
3. Tabulate the Voltmeters and Ammeters readings for the corresponding experiment.
4. Increase the voltage step by step to get different readings till the voltage reached up to 15V.
5. Repeat step 3 for different values.
6. Switch OFF the power supply after bringing RPS to the minimum voltage position.

Tabulation for KVL:

Parameter	Experimental Value				Theoretical Value			
Supply voltage	Voltage Across R_1	Voltage Across R_2	Voltage Across R_3	Loop Current(mA)	Voltage Across R_1	Voltage Across R_2	Voltage Across R_3	Loop Current(mA)
20V	7.2	7.3	4.5	21	7.5V	7.5V	5V	22.73

Theoretical Calculation:

$$V = 20V$$

$$R = R_1 + R_2 + R_3$$

$$R = 330 + 330 + 220 = 880\Omega$$

$$I = \frac{V}{R} = \frac{20}{880} = 0.02273A = 22.73mA$$

$$V_1 = IR_1 = 0.02273 \times 330 = 7.5V$$

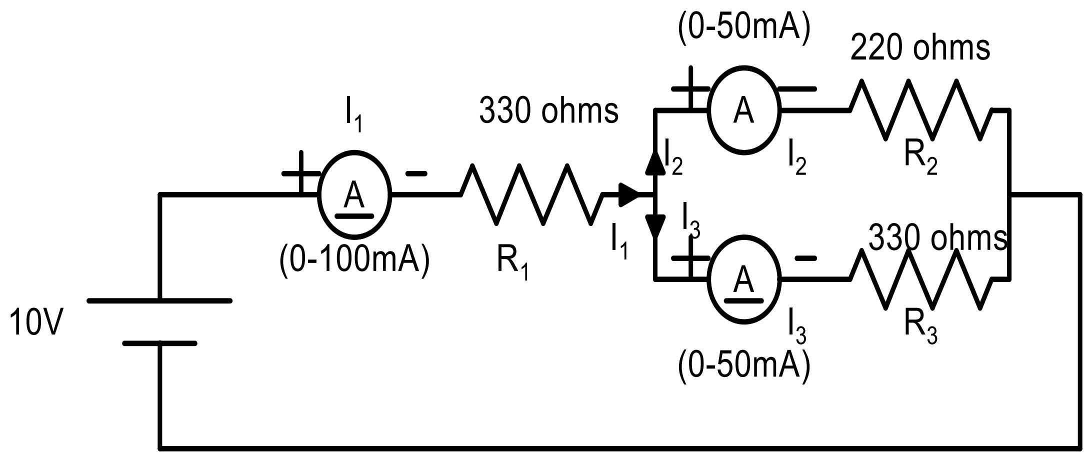
$$V_2 = IR_2 = 0.02273 \times 330 = 7.5V$$

$$V_3 = IR_3 = 0.02273 \times 220 = 5V$$

$$V = V_1 + V_2 + V_3$$

$$V = 7.5 + 7.5 + 5 = 20V$$

1. (b) Verification of Kirchhoff's Current Law



Tabulation for KCL:

Parameter	Experimental Value				Theoretical Value			
Supply voltage	Current I_1 (mA)	Current I_2(mA)	Current I_3(mA)	$I_2 + I_3$ (mA)	Current I_1(mA)	Current I_2(mA)	Current I_3(mA)	$I_2 + I_3$
10V	19.5	11.5	8	19.5	21.64	12.98	8.6575	21.64

Theoretical Calculation:

To Find R_{eq}:

$$R_{eq} = R_1 + R_2 || R_3$$

$$R_{eq} = 330 + 220 || 330$$

$$R_{eq} = 330 + \left(\frac{220 \times 330}{220 + 330} \right) = 462\Omega$$

$$V = 10V$$

$$I = \frac{V}{R} = \frac{10}{462} = 0.02164A = 21.64mA$$

$$V_1 = I_1 R_1 = 0.02164 \times 330 = 7.14V$$

$$V = V_1 + V_2$$

$$10 = 7.14 + V_2$$

$$V_2 = 2.857V$$

$$I_2 = \frac{V_2}{R_2} = \frac{2.857}{220} = 0.01298 = 12.98mA$$

$$I_3 = \frac{V_3}{R_3} = \frac{2.857}{330} = 8.6575mA$$

sum of incoming current = sum of outgoing current

$$I_1 = I_2 + I_3$$

$$I_1 = 12.98 + 8.657 = 21.64mA$$

Marks Obtained:

Theoretical Calculations	**20**	
Observation	**20**	
Execution of practice examples	**30**	
Viva	**10**	
Record	**20**	
Total Score	**100**	
Date of experiment		**Faculty signature**
Date of record submission		

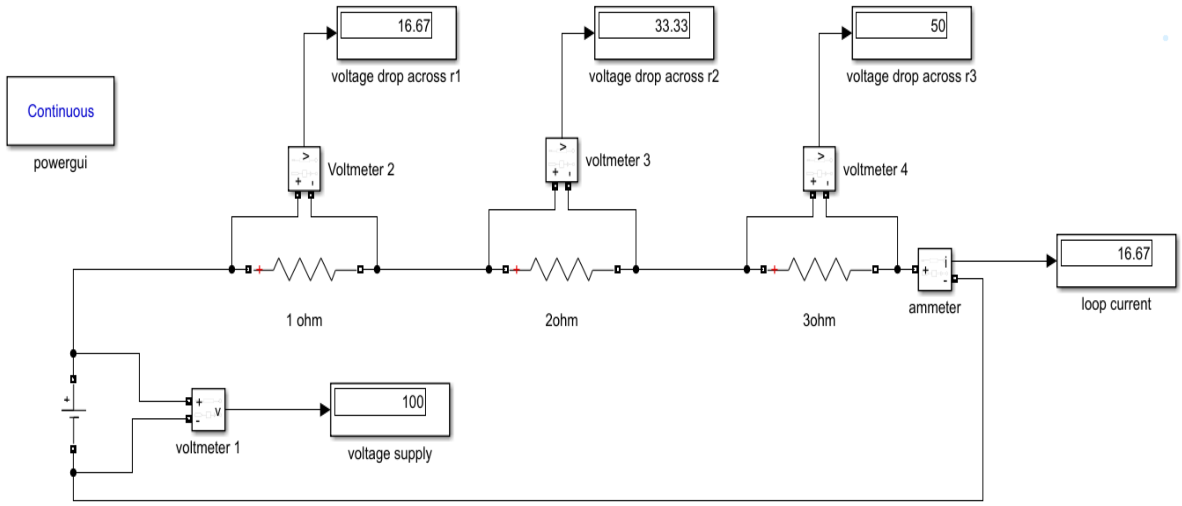
RESULT:

Thus the Kirchhoff's voltage and current law is verified for the given circuit.

Kirchhoffs Voltage law

Test Case 1:

Design a circuit to verify Kirchoff's voltage law for input voltages 100 V which uses three resistors R_1= 1 ohm, R_2= 2 ohm and R_3=3ohm connected in series and this combination is connected across a constant DC source. Also, verify the results by Matlab simulink



Tabulation:

Parameter	Simulation Value				Theoretical Value			
Supply voltage	Voltage Across R_1	Voltage Across R_2	Voltage Across R_3	Loop Current	Voltage Across R_1	Voltage Across R_2	Voltage Across R_3	Loop Current
100V	16.67V	33.33V	50 V	16.67A	16.67V	33.33V	50 V	16.67A

Theoretical Calculation:

Supply voltage V=100V

Total Resistance R= R_1 +R_2 + R_3 = 1+2+3=6Ω

Current $I=\frac{V}{R}=\frac{100}{6}=16.67A$

$V_1=IR_1$ = 16.67x1=16.67V

$V_2=IR_2$ = 16.67x2=33.33V

$V_3=IR_3$ = 16.67x3=50V

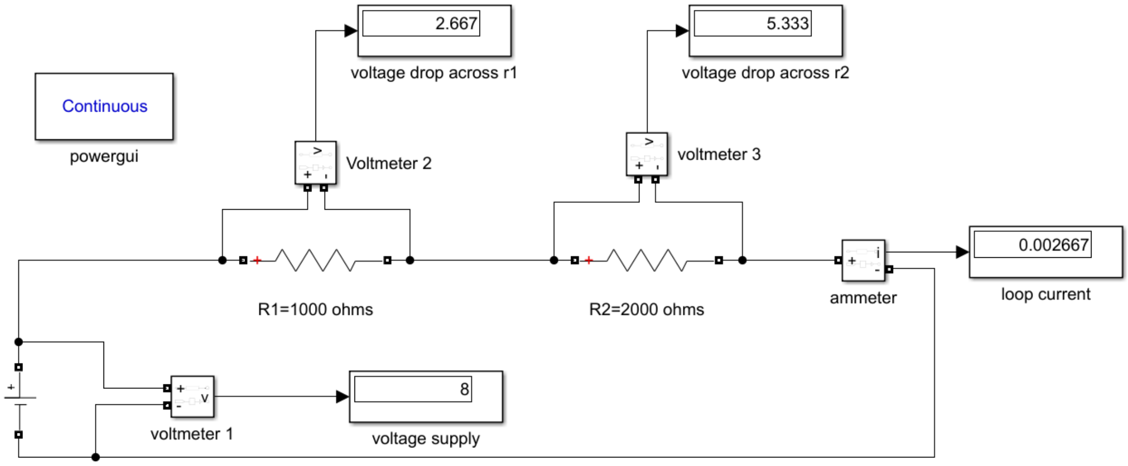
Kirchhoff's Voltage Law (KVL) states:

"The sum of all voltage drops around a closed loop in a circuit is equal to zero."

$V = V_1 + V_2 + V_3 = 16.67+33.33+50 = 100V$

Test Case 2:

Design a circuit to verify Kirchoff's Voltage law for input voltages V=8V. The circuit uses R1= 1kΩ and R2= 2 kΩ. This setup is connected across a constant voltage source. Also, verify the results by Matlab simulink



Tabulation:

Parameter	Simulation Value			Theoretical Value		
Supply voltage	Voltage Across R_1	Voltage Across R_2	Loop Current	Voltage Across R_1	Voltage Across R_2	Loop Current
8V	2.667V	5.333V	2.667mA	2.667V	5.333V	2.667mA

Theoretical Calculation:

Supply voltage V=100V

Total Resistance $R = R_1 + R_2 = 1000+2000=3000\Omega$

$$\text{Current } I = \frac{V}{R} = \frac{8}{3000} = 2.667mA$$

$V_1 = IR_1 = 2.667 \times 10^{-3} \times 1000 = 2.667V$

$V_2 = IR_2 = 2.667 \times 10^{-3} \times 2000 = 5.333V$

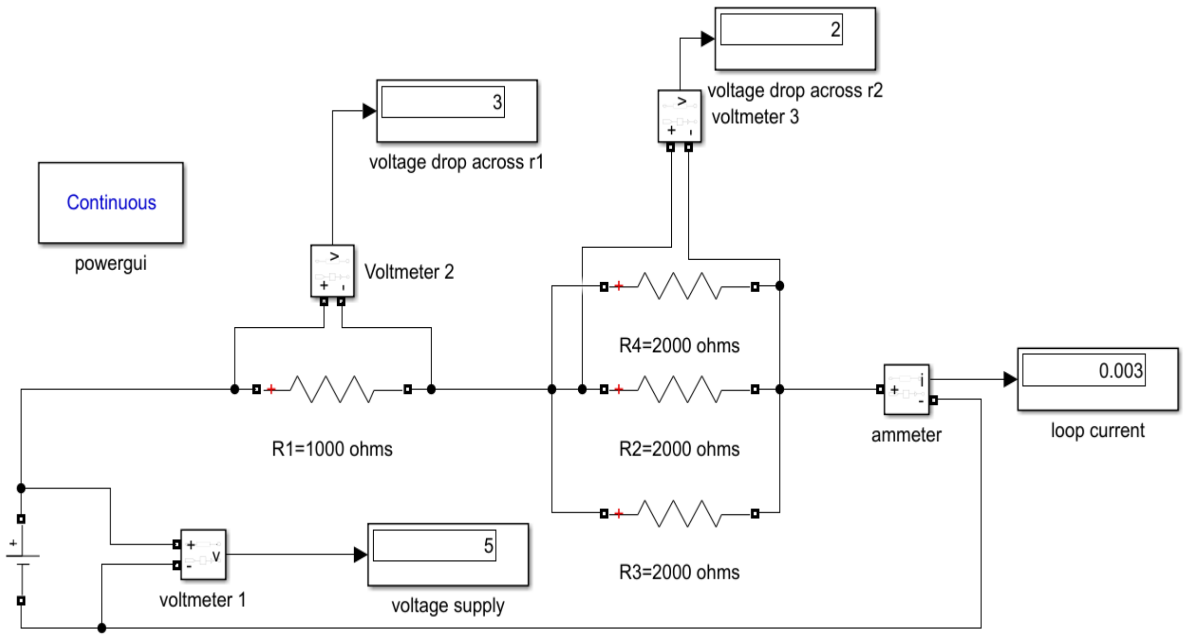
Kirchhoff's Voltage Law (KVL) states:

"The sum of all voltage drops around a closed loop in a circuit is equal to zero."

$V = V_1 + V_2$ = 2.667+5.333 =8V

Test Case 3:

Design a circuit to verify Kirchoff's Voltage law for input voltages V=5V. The circuit uses R1= 1kΩ connected in series and three resistor R2, R3 and R4 are 2 kΩ connected in parallel. This setup is connected across a constant voltage source. Also, verify the results by Matlab simulink



Tabulation:

Parameter	Simulation Value			Theoretical Value		
Supply voltage	Voltage Across R_1	Voltage Across R_2	Loop Current	Voltage Across R_1	Voltage Across R_2	Loop Current
5V	3V	2V	3mA	3V	2V	3mA

Theoretical Calculation:

Supply voltage V=5V

Total Resistance $R = R_1 + R_2 \| R_3 \| R_4$ = 1000+666.667=1666.667Ω

Current $I = \frac{V}{R} = \frac{5}{1666.667}$ =3mA

$V_1 = IR_1 = 3 \times 10^{-3} \times 1000 = 3V$

$V=V_1+V_2$

$5=3+V_2$

$V_2=2V$

$V_2=I_2R_2$

$$i_2=\frac{V_2}{R_2}=\frac{2}{2000}=1mA$$

$$i_3=\frac{V_3}{R_3}=\frac{2}{2000}=1mA$$

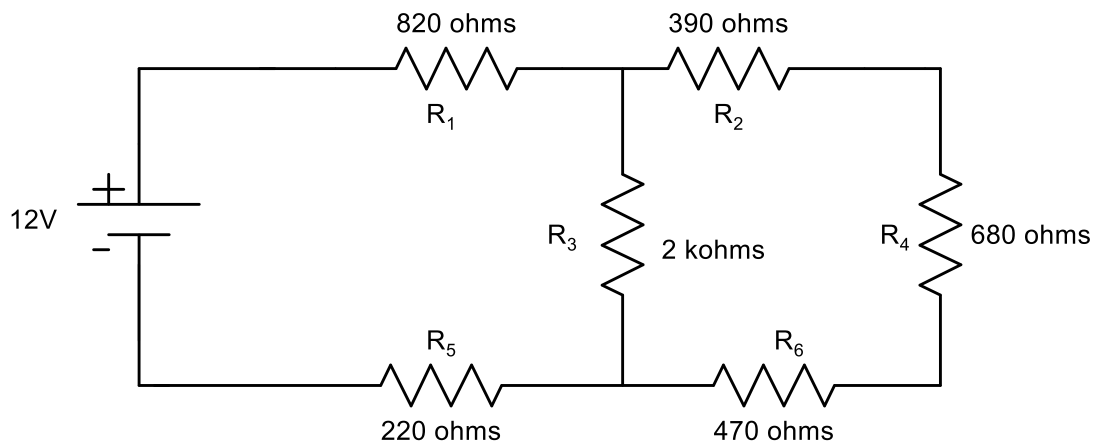
Kirchhoff's Voltage Law (KVL) states:

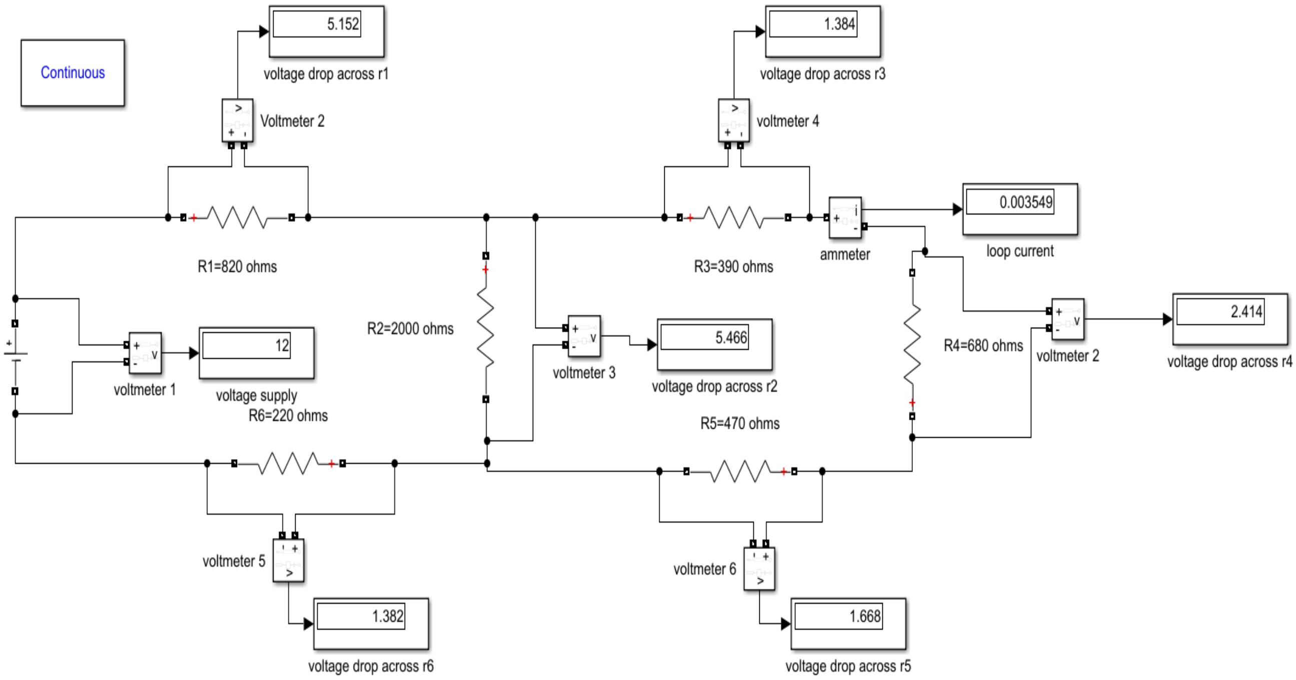
"The sum of all voltage drops around a closed loop in a circuit is equal to zero."

$V= V_1 + V_2 = 3+2=5V$

Test Case 4:

In any closed path / mesh, the algebraic sum of EMF and voltage drops is zero. Prove this Kirchoff's Voltage Law simulated for the below circuit.





Tabulation:

Parameter	Simulation Value					Theoretical Value				
Supply voltage	Voltage Across R_1	Voltage Across R_3	Voltage Across R_4	Voltage Across R_5	Voltage Across R_6	Voltage Across R_1	Voltage Across R_3	Voltage Across R_4	Voltage Across R_5	Voltage Across R_6
12V	5.152 V	1.384V	2.414V	1.668V	1.382V	5.152 V	1.384V	2.414V	1.668V	1.382V

Theoretical Calculation:

V=IR

$$\begin{bmatrix} 3040 & -2000 \\ -2000 & 3540 \end{bmatrix}\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 12 \\ 0 \end{bmatrix}$$

$$\Delta = 6761600$$

$$\Delta_1 = \begin{bmatrix} 12 & -2000 \\ 0 & 3540 \end{bmatrix}$$

$$\Delta_1 = 42480$$

$$\Delta_2 = \begin{bmatrix} 3040 & 12 \\ -2000 & 0 \end{bmatrix}$$

$$\Delta_2 = 24000$$

$$i_1 = \frac{\Delta_1}{\Delta} = \frac{42480}{6761600} = 6.2825 \text{ mA}$$

$$i_2 = \frac{\Delta_2}{\Delta} = \frac{24000}{6761600} = 3.5494 \text{ mA}$$

$$\mathrm{V_1 = I_1 R_1} = 6.2825 \times 10^{-3} \times 820 = 5.1516V$$

$$\mathrm{V_2 = \left(I_1 - I_2\right) R_2} = 2.7331 \times 10^{-3} \times 2000 = 5.466V$$

$$\mathrm{V_3 = I_2 R_3} = 3.5494 \times 10^{-3} \times 390 = 1.3843V$$

$$\mathrm{V_4 = I_2 R_4} = 3.5494 \times 10^{-3} \times 680 = 2.4135V$$

$$\mathrm{V_5 = I_2 R_5} = 3.5494 \times 10^{-3} \times 470 = 1.6682V$$

$$\mathrm{V_6 = I_1 R_6} = 6.2825 \times 10^{-3} \times 220 = 1.3822V$$

Kirchhoff's Voltage Law (KVL) states:

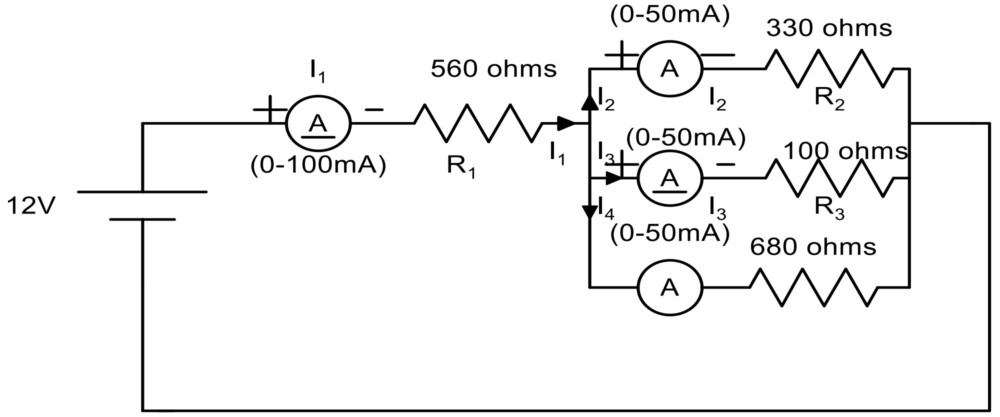
"The sum of all voltage drops around a closed loop in a circuit is equal to zero."

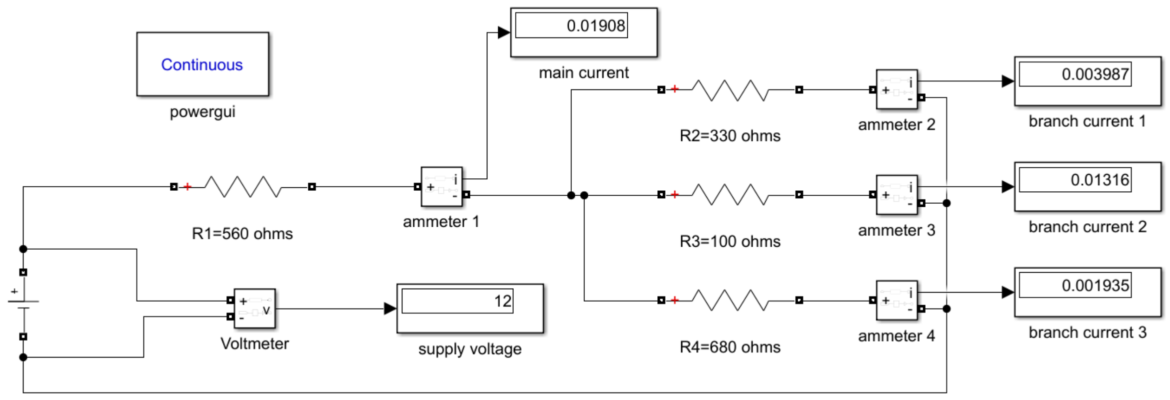
$V = V_1 + V_3 + V_4 + V_5 + V_6 = 5.152 + 1.3843 + 2.4135 + 1.6682 + 1.3822 = 12V$

Kirchhoffs Current law

Test Case 1:

Solve the currents in the circuit shown in Fig. 1. And verify the result using matlab Simulink.





Tabulation for KCL:

Parameter	Simulation Value				Theoretical Value			
Supply voltage	Current I_1 (mA)	Current I_2(mA)	Current I_3(mA)	Current I_4(mA)	Current I_1(mA)	Current I_2(mA)	Current I_3(mA)	Current I_4(mA)
12V	19.08	3.987	13.16	1.935	19.08	3.987	13.16	1.935

Theoretical Calculation:

To find equivalent resistance:

$$\mathrm{R}_{eq} = R_1 + R_2 \,||\, R_3 \,||\, R_4$$
$$\mathrm{R}_{eq} = 560 + 330 \,||\, 100 \,||\, 680$$
$$\mathrm{R}_{eq} = 560 + \frac{330 \times 100}{330 + 100} \,||\, 680$$
$$\mathrm{R}_{eq} = 560 + 76.7442 \,||\, 680$$
$$\mathrm{R}_{eq} = 560 + \frac{76.7442 \times 680}{76.7442 + 680}$$
$$\mathrm{R}_{eq} = 628.96\Omega$$

$$V = I_1 R$$
$$I_1 = \frac{V}{R} = \frac{12}{628.9613} = 19.0791mA$$
$$V_1 = I_1 R_1 = 0.019079 \times 560 = 10.68V$$
$$V = V_1 + V_2$$
$$12 = 10.68 + V_2$$
$$V_2 = 1.3157V$$

$$V_2 = I_2 R_2$$

$$1.3157 = I_2 \times 330$$

$$I_2 = 3.9870mA$$

$$V_3 = I_3 R_3$$

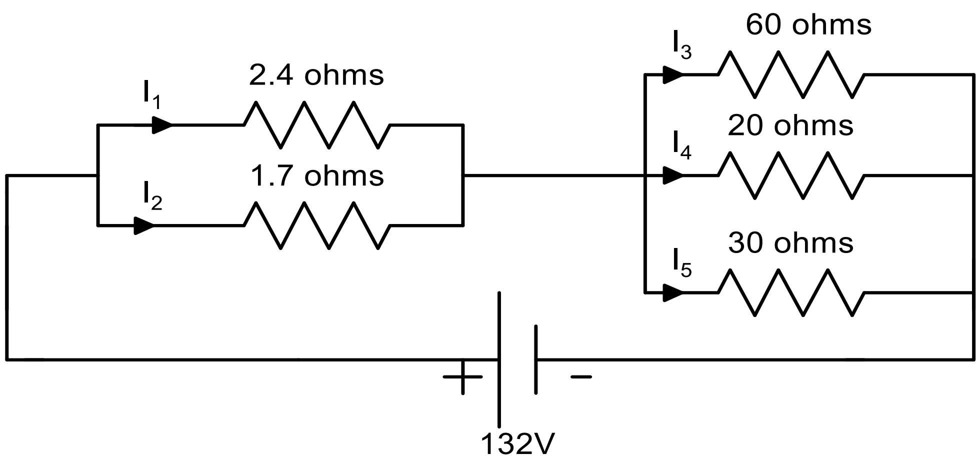
$$I_3 = \frac{V_3}{R_3} = \frac{1.3157}{100} = 13.157mA$$

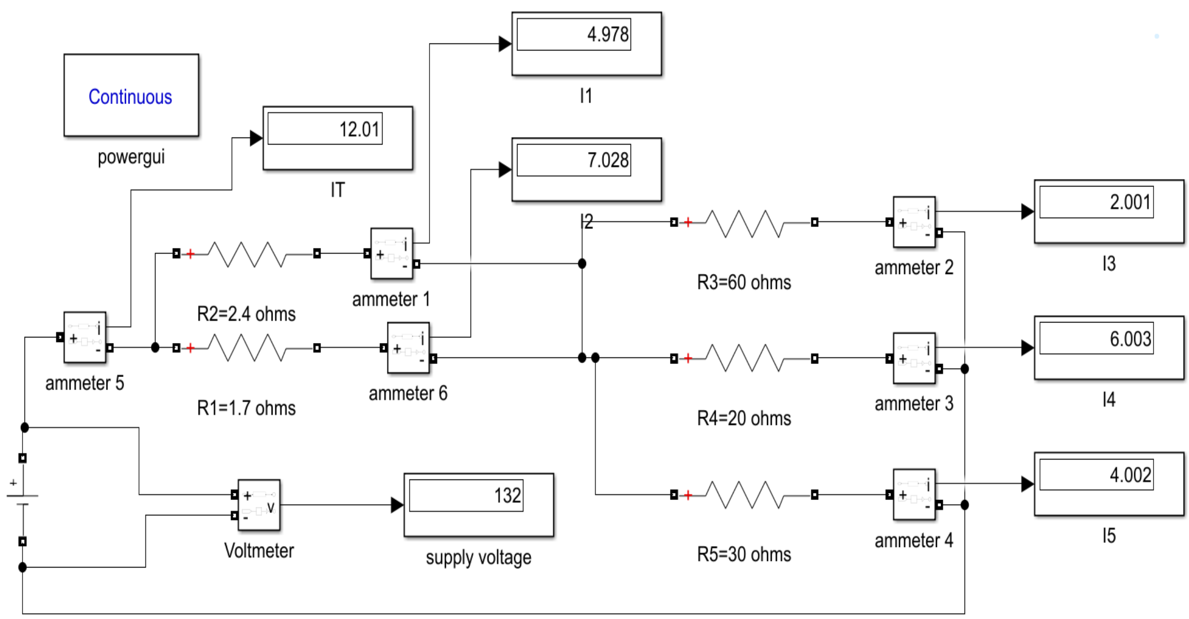
$$V_4 = I_4 R_4$$

$$I_4 = \frac{V_4}{R_4} = \frac{1.3157}{680} = 1.9348mA$$

Test Case 2:

Solve the currents in the circuit shown in Fig. And verify the result using matlab Simulink.





Tabulation for KCL:

Parameter	Simulation Value						Theoretical Value					
Supply voltage	Current I_T (A)	Current I_1(A)	Current I_2(A)	Current I_3(A)	Current I_4(A)	Current I_5(A)	Current I_1(A)	Current I_2(A)	Current I_3(A)	Current I_4(A)	Current I_5(A)	Current I_1(A)
132V	12.01	4.978	7.028	2	6	4	12.01	4.978	7.028	2	6	4

Theoretical Calculation:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{2.4} + \frac{1}{1.7}$$

$$R_T = 0.995\Omega = 1\Omega$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{60} + \frac{1}{20} + \frac{1}{30}$$

$$R_T = 10\Omega$$

$$\mathrm{R}_{eq} = 1 + 10 = 11\Omega$$

$$I_T = \frac{132}{11} = 12A$$

$$V_1 = I_T \times R_1 = 12 \times 1 = 12V$$

$$V = V_1 + V_2$$

$$V_2 = V - V_1 = 132 - 12 = 120V$$

$$I_1 = \frac{V_1}{R_1} = \frac{12}{2.4} = 5A$$

$$I_2 = \frac{V_1}{R_2} = \frac{12}{2.4} = 7A$$

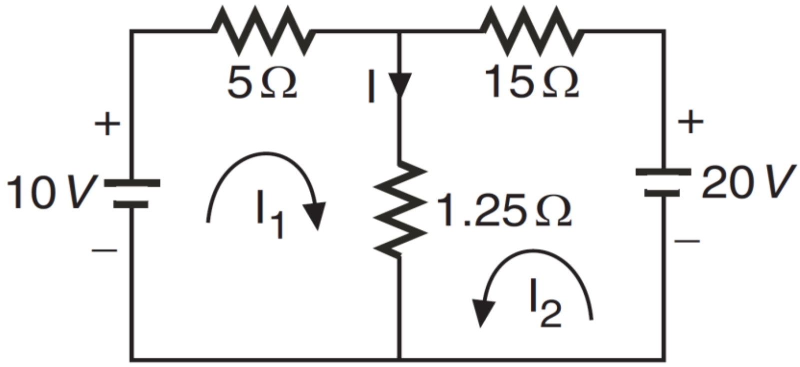
$$I_3 = \frac{V_2}{R_3} = \frac{120}{60} = 2A$$

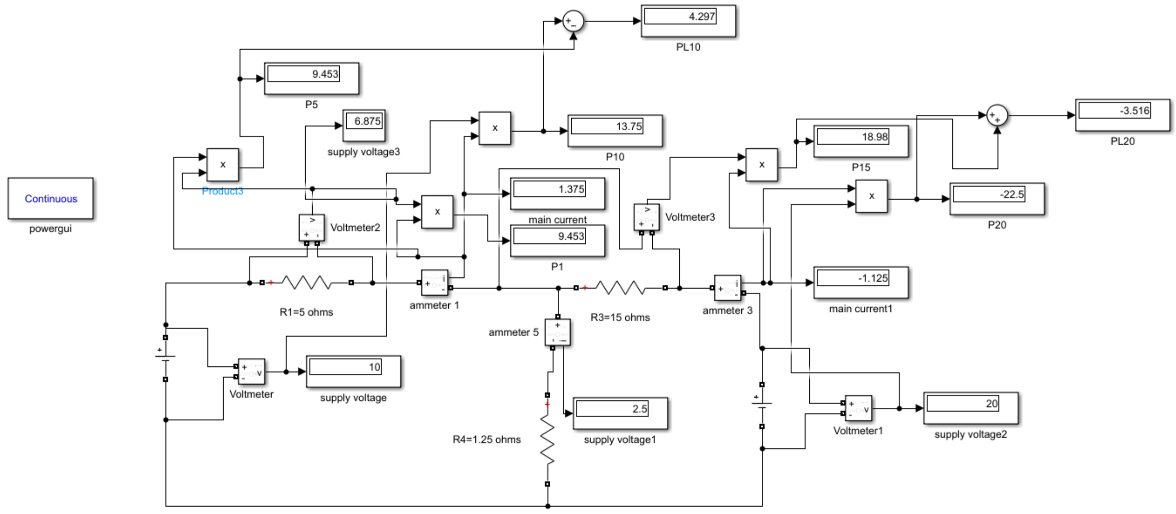
$$I_4 = \frac{V_2}{R_4} = \frac{120}{20} = 6A$$

$$I_5 = \frac{V_2}{R_5} = \frac{120}{30} = 4A$$

Test Case 3:

In the circuit shown in Fig., find the current I by mesh method and the power supplied by each battery to the 1.25 Ω resistor. Verify the result using matlab Simulink.





Tabulation for KCL:

Parameter		Simulation Value					Theoretical Value				
Supply voltage		Current I_T (A)	Current I_1(A)	Current I_2(A)	Power P_{10}	Power P_{20}	Current I_1(A)	Current I_2(A)	Current I_3(A)	Power P_{10}	Power P_{20}
V_1	V_2										
10	20	2.5	1.375	1.125	13.75	22.5	2.5	1.375	1.125	13.75	22.5

Theoretical Calculation:

Let us assume two mesh currents as shown in Fig. 2. Now the current I is given by the sum of I_1 and I_2.

Using the circuit shown in Fig. 1, the mesh basis matrix equation is formed as shown below:

$$\begin{bmatrix} R_{11} & R_{12} \\ R_{21} & R_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} E_{11} \\ E_{22} \end{bmatrix}$$

The elements of resistance matrix and source voltage matrix are formed as shown below:

$R_{11} = 5 + 1.25 = 6.25$	$R_{12} = R_{21} = 1.25$	$E_{11} = 10$
$R_{22} = 15 + 1.25 = 16.25$		$E_{22} = 20$

On substituting the above terms in equation (1), we get,

$$\begin{bmatrix} 6.25 & 1.25 \\ 1.25 & 16.25 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 10 \\ 20 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 6.25 & 1.25 \\ 1.25 & 16.25 \end{vmatrix} = 6.25 \times 16.25 - 1.25 \times 1.25 = 100$$

$$\Delta_1 = \begin{vmatrix} 10 & 1.25 \\ 20 & 16.25 \end{vmatrix} = 10 \times 16.25 - 20 \times 1.25 = 137.5$$

$$\Delta_2 = \begin{vmatrix} 6.25 & 10 \\ 1.25 & 20 \end{vmatrix} = 6.25 \times 20 - 1.25 \times 10 = 112.5$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{137.5}{100} = 1.375\ A$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{112.5}{100} = 1.125\ A$$

$$\therefore \quad I = I_1 + I_2 = 1.375 + 1.125 = 2.5\,A$$

Let P_{10} and P_{20} be the power delivered by 10 *V* and 20 *V* sources.

Now, $P_{10} = 10 \times I_1 = 10 \times 1.375 = 13.75\,W$

$P_{20} = 20 \times I_2 = 20 \times 1.125 = 22.5\,W$

Let P_5 and P_{15} be the power consumed by 5 Ω and 15 Ω resistances, respectively.

Now, $P_5 = I_1^2 \times 5 = 1.375^2 \times 5 = 9.4531\,W$

$P_{15} = I_2^2 \times 15 = 1.125^2 \times 15 = 18.9844\,W$

Let P_{L10} and P_{L20} be the power delivered to load (i.e., to 1.25 Ω resistor) by the 10 *V* and 20 *V* sources, respectively.

Now, $P_{L10} = P_{10} - P_5 = 13.75 - 9.4531 = 4.2969\,W$

$P_{L20} = P_{20} - P_{15} = 22.5 - 18.9844 = 3.5156\,W$

Test Case 4:

Solve the mesh currents in the circuit shown in Fig. 1. And verify the result using matlab Simulink.

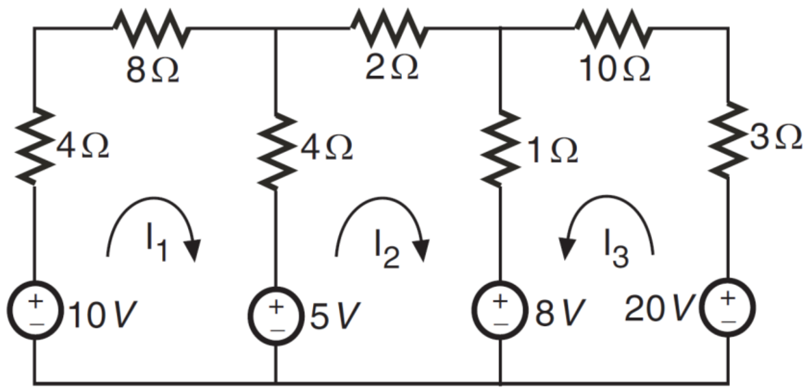
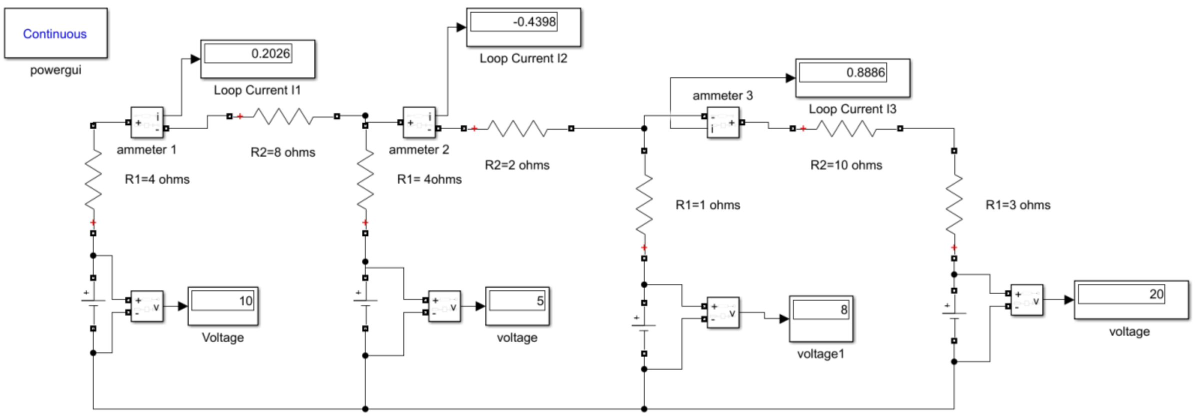


Fig. 1.



Tabulation for KCL:

Parameter	Simulation Value			Theoretical Value		
Supply voltage	Current I_1 (A)	Current I_2(A)	Current I_3(A)	Current I_1(A)	Current I_2(A)	Current I_3(A)
10,5,8,20	0.2026	-0.439	0.8886	0.2026	-0.439	0.8886

Theoretical Calculation:

With reference to Fig.1, the mesh basis matrix equation is formed as shown below:

$$\begin{bmatrix} R_{11} & R_{12} & R_{13} \\ R_{21} & R_{22} & R_{23} \\ R_{31} & R_{32} & R_{33} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} E_{11} \\ E_{22} \\ E_{33} \end{bmatrix}$$

The elements of the resistance matrix and source voltage matrix are formed as shown below:

$R_{11} = 4 + 8 + 4 = 16$	$R_{12} = R_{21} = -4$	$E_{11} = 10 - 5 = 5$
$R_{22} = 4 + 2 + 1 = 7$	$R_{13} = R_{31} = 0$	$E_{22} = 5 - 8 = -3$
$R_{33} = 1 + 10 + 3 = 14$	$R_{23} = R_{32} = 1$	$E_{33} = 20 - 8 = 12$

On substituting the above terms in equation (1), we get,

$$\begin{bmatrix} 16 & -4 & 0 \\ -4 & 7 & 1 \\ 0 & 1 & 14 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 5 \\ -3 \\ 12 \end{bmatrix}$$

In equation (2), the unknowns are I_1, I_2 and I_3. In order to solve I_1, I_2 and I_3, let us define four determinants Δ, Δ_1, Δ_2 and Δ_3 as shown below:

$$\Delta = \begin{vmatrix} 16 & -4 & 0 \\ -4 & 7 & 1 \\ 0 & 1 & 14 \end{vmatrix}; \quad \Delta_1 = \begin{vmatrix} 5 & -4 & 0 \\ -3 & 7 & 1 \\ 12 & 1 & 14 \end{vmatrix}; \quad \Delta_2 = \begin{vmatrix} 16 & 5 & 0 \\ -4 & -3 & 1 \\ 0 & 12 & 14 \end{vmatrix}; \quad \Delta_3 = \begin{vmatrix} 16 & -4 & 5 \\ -4 & 7 & -3 \\ 0 & 1 & 12 \end{vmatrix}$$

The determinants are evaluated by expanding along first row and the mesh currents are solved by Cramer's rule.

$$\Delta = \begin{vmatrix} 16 & -4 & 0 \\ -4 & 7 & 1 \\ 0 & 1 & 14 \end{vmatrix} = 16 \times [7 \times 14 - 1 \times 1] - (-4) \times [-4 \times 14 - 0] + 0$$

$$= 1552 - 224 = 1328$$

$$\Delta_1 = \begin{vmatrix} 5 & -4 & 0 \\ -3 & 7 & 1 \\ 12 & 1 & 14 \end{vmatrix} = 5 \times [7 \times 14 - 1 \times 1] - (-4) \times [-3 \times 14 - 12 \times 1] + 0$$

$$= 485 - 216 = 269$$

$$\Delta_2 = \begin{vmatrix} 16 & 5 & 0 \\ -4 & -3 & 1 \\ 0 & 12 & 14 \end{vmatrix} = 16 \times [-3 \times 14 - 12 \times 1] - 5 \times [-4 \times 14 - 0] + 0$$

$$= -864 + 280 = -584$$

$$\Delta_3 = \begin{vmatrix} 16 & -4 & 5 \\ -4 & 7 & -3 \\ 0 & 1 & 12 \end{vmatrix} = 16 \times [7 \times 12 - 1 \times (-3)] - (-4) \times [-4 \times 12 - 0] + 5 \times [-4 \times 1 - 0]$$

$$= 1392 - 192 - 20 = 1180$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{269}{1328} = 0.2026\ A$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{-584}{1328} = -0.4398\ A$$

$$I_3 = \frac{\Delta_3}{\Delta} = \frac{1180}{1328} = 0.8886\ A$$

Expt. No. 02	Verification of current and voltage division rules

AIM:

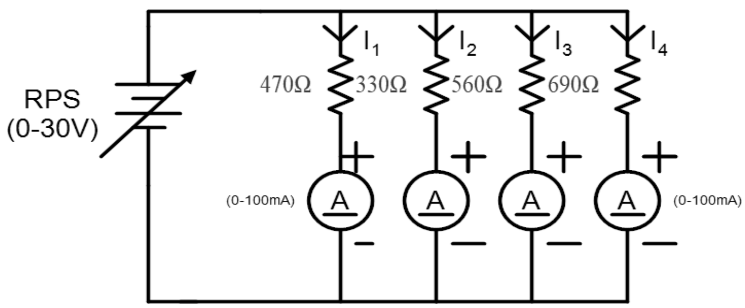
To calculate the individual branch currents and total current drawn from the power supply using current and voltage division rules.

APPARATUS REQUIRED:

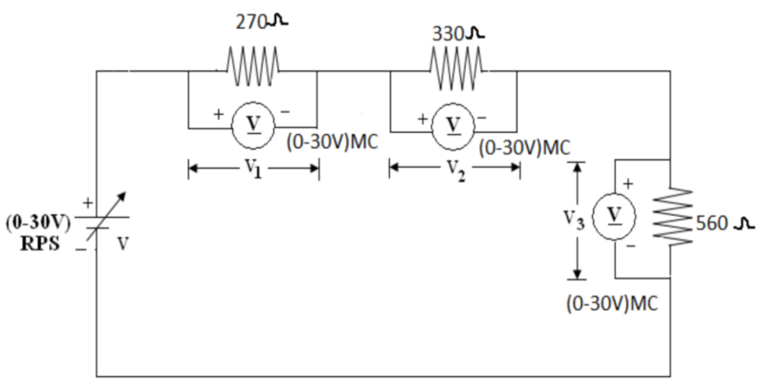
S.No.	Apparatus Name	Range	Quantity
1	DC Regulated Power Supply	(0-30)V	1
2	Ammeter	(0-200)mA	4
3	Resistor	1kΩ, 220Ω	Each two
4	Bread board & Connecting wires	--	Required

CIRCUIT DIAGRAM:

CURRENT DIVISION CIRCUIT DIAGRAM:



Voltage Division Circuit Diagram:



PROCEDURE:

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

OBSERVATIONS:

CURRENT DIVISION RULE:

S. No.	Voltage (V)	Current (mA)			
		I_1	I_2	I_3	I_4
1	1	5	10.64	15.15	8.93
2	2	10	21.28	30.3	17.86
3	3	15	31.91	45.45	26.79
4	4	20	42.55	60.61	35.71
5	5	25	53.19	75.76	44.64

VOLTAGE DIVISION RULE:

S. No.	RPS Voltage (V)	Voltage across Resistors (V)			V1+V2+V3 (V)
		V1	V2	V3	
1	5	1.16	1.42	2.41	5
2	10	2.32	2.84	4.83	10
3	15	3.49	4.26	7.24	15
4	20	4.65	5.68	9.66	20
5	25	5.81	7.1	12.07	25

MODEL CALCULATIONS:

CURRENT DIVISION RULE:

For Voltage (V) = 5V:

Resistor R1 = 470 Ω:
I1 = V / R1= 5V / 470Ω = 10.64 mA
Resistor R2 = 330 Ω:
I2 = V / R2= 5V / 330Ω = 15.15 mA
Resistor R3 = 560 Ω:
I3 = V / R3 = 5V / 560Ω = 8.93 mA
Resistor R4 = 690 Ω:
I4 = V / R4 = 5V / 690Ω = 7.25 mA

For Voltage (V) = 10V:

Resistor R1 = 470 Ω:
I1 = V / R1= 10V / 470Ω = 21.28 mA
Resistor R2 = 330 Ω:
I2 = V / R2= 10V / 330Ω = 30.30 mA
Resistor R3 = 560 Ω:
I3 = V / R3 = 10V / 560Ω = 17.86 mA

Resistor R4 = 690 Ω:
I4 = V / R4 = 10V / 690Ω = 14.49 mA

For Voltage (V) = 15V:

Resistor R1 = 470 Ω:
I1 = V / R1= 15V / 470Ω = 31.91 mA
Resistor R2 = 330 Ω:
I2 = V / R2= 15V / 330Ω = 45.45 mA
Resistor R3 = 560 Ω:
I3 = V / R3 = 15V / 560Ω = 26.79 mA
Resistor R4 = 690 Ω:
I4 = V / R4 = 15V / 690Ω = 21.74 mA

For Voltage (V) = 20V:

Resistor R1 = 470 Ω:
I1 = V / R1= 20V / 470Ω = 42.55 mA
Resistor R2 = 330 Ω:
I2 = V / R2= 20V / 330Ω = 60.61 mA
Resistor R3 = 560 Ω:
I3 = V / R3 = 20V / 560Ω = 35.71 mA
Resistor R4 = 690 Ω:
I4 = V / R4 = 20V / 690Ω = 28.99 mA

For Voltage (V) = 25V:

Resistor R1 = 470 Ω:
I1 = V / R1= 25V / 470Ω = 53.19 mA
Resistor R2 = 330 Ω:
I2 = V / R2= 25V / 330Ω = 75.76 mA
Resistor R3 = 560 Ω:
I3 = V / R3 = 25V / 560Ω = 44.64 mA
Resistor R4 = 690 Ω:
I4 = V / R4 = 25V / 690Ω = 36.23 mA

VOLTAGE DIVISION RULE:

For RPS Voltage (V) = 5V:

Voltage across Resistor R1 (270 Ω):
V1 = 5 * (270 / 1160) = 1.16 V
Voltage across Resistor R2 (330 Ω):
V2 = 5 * (330 / 1160) = 1.42 V
Voltage across Resistor R3 (560 Ω):
V3 = 5 * (560 / 1160) = 2.41 V

Check: V1 + V2 + V3 = 1.16 + 1.42 + 2.41 = 5.00 V

For RPS Voltage (V) = 10V:

Voltage across Resistor R1 (270 Ω):

V1 = 10 * (270 / 1160) = 2.33 V
Voltage across Resistor R2 (330 Ω):
V2 = 10 * (330 / 1160) = 2.84 V
Voltage across Resistor R3 (560 Ω):
V3 = 10 * (560 / 1160) = 4.83 V

Check: V1 + V2 + V3 = 2.33 + 2.84 + 4.83 = 10.00 V

For RPS Voltage (V) = 15V:

Voltage across Resistor R1 (270 Ω):
V1 = 15 * (270 / 1160) = 3.49 V
Voltage across Resistor R2 (330 Ω):
V2 = 15 * (330 / 1160) = 4.27 V
Voltage across Resistor R3 (560 Ω):
V3 = 15 * (560 / 1160) = 7.24 V

Check: V1 + V2 + V3 = 3.49 + 4.27 + 7.24 = 15.00 V

For RPS Voltage (V) = 20V:

Voltage across Resistor R1 (270 Ω):
V1 = 20 * (270 / 1160) = 4.66 V
Voltage across Resistor R2 (330 Ω):
V2 = 20 * (330 / 1160) = 5.69 V
Voltage across Resistor R3 (560 Ω):
V3 = 20 * (560 / 1160) = 9.66 V

Check: V1 + V2 + V3 = 4.66 + 5.69 + 9.66 = 20.00 V

For RPS Voltage (V) = 25V:

Voltage across Resistor R1 (270 Ω):
V1 = 25 * (270 / 1160) = 5.82 V
Voltage across Resistor R2 (330 Ω):
V2 = 25 * (330 / 1160) = 7.11 V
Voltage across Resistor R3 (560 Ω):
V3 = 25 * (560 / 1160) = 12.07 V

Check: V1 + V2 + V3 = 5.82 + 7.11 + 12.07 = 25.00 V

RESULT:

Thus, the individual branch currents and total current drawn from the power supply are calculated using current and voltage division rules.

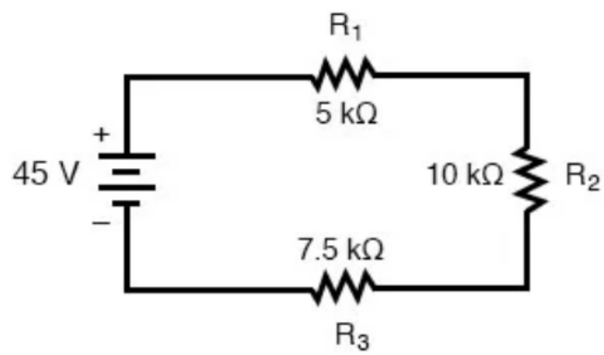
EXP 02: VOLTAGE DIVISION AND CURRENT DIVISION

Case 01:

Analyze the given circuit where a resistor R1=5 kΩ, R2=10kΩ, and R3=7.5 kΩ are connected in a series circuit powered by a 45V DC source.

Instructions:

- Simulate the circuit on MATLAB/Simulink or NI Multisim to verify your calculated values.
- Report the simulated current and voltage drops across each resistor and compare them with your calculated values.



Step 1: Calculate the Total Resistance

Since all the resistors are in series, the total resistance R_{total} is the sum of all the resistances:

$$R_{total} = R_1 + R_2 + R_3 = 5\,k\Omega + 10\,k\Omega + 7.5\,k\Omega = 22.5\,k\Omega$$

Step 2: Calculate the Total Current using Ohm's Law

$$I_{total} = \frac{V_{total}}{R_{total}} = \frac{45V}{22.5\,k\Omega} = 2\,mA$$

Step 3: Apply Voltage Division Rule

- Voltage across R_1:

$$V_{R_1} = I_{total} \times R_1 = 2\,mA \times 5\,k\Omega = 10\,V$$

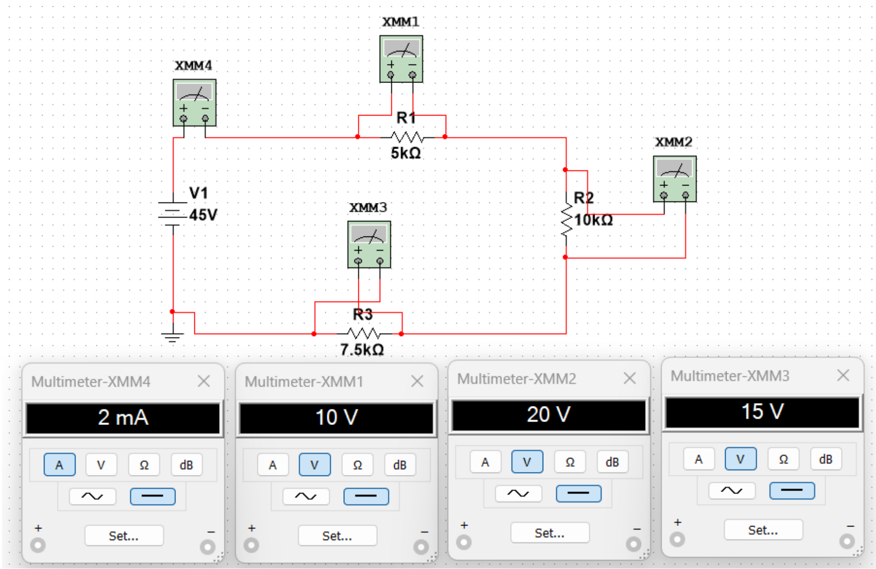
- Voltage across R_2:

$$V_{R_2} = I_{total} \times R_2 = 2\,mA \times 10\,k\Omega = 20\,V$$

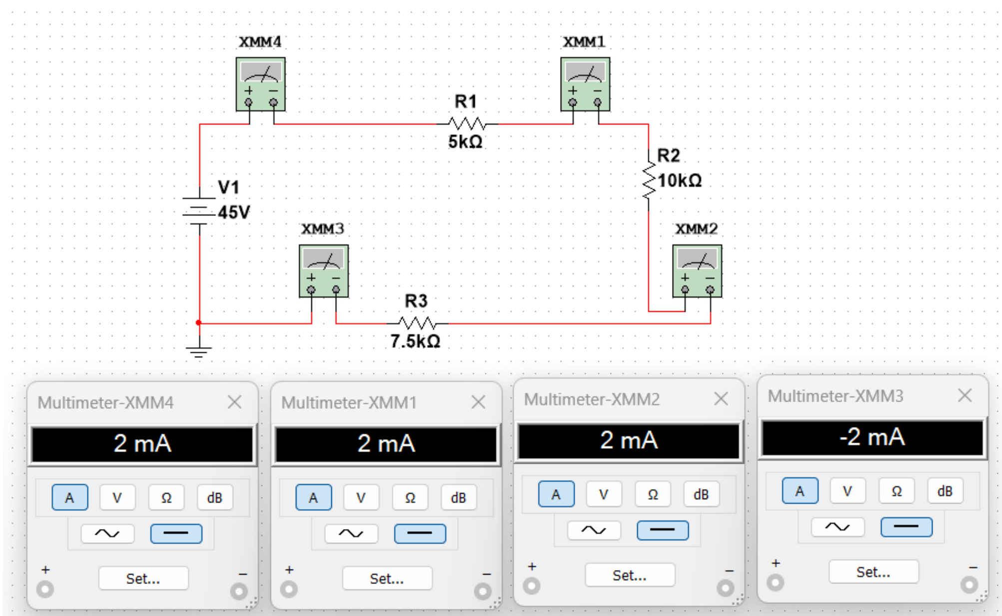
- Voltage across R_3:

$$V_{R_3} = I_{total} \times R_3 = 2\,mA \times 7.5\,k\Omega = 15\,V$$

NI Multisim Simulation Result: Voltage Division



NI Multisim Simulation Result: Current Division



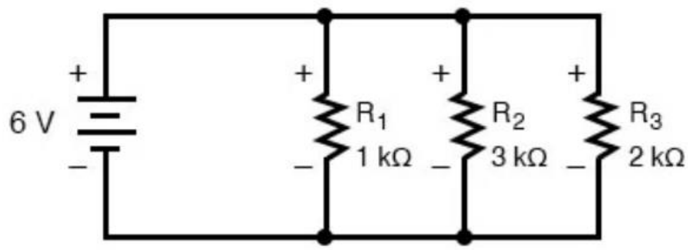
	Simulation Results				Theoretical Values			
Component	R1	R2	R3	Total Voltage/Current	R1	R2	R3	Total Voltage/Current
Voltage (V)	10 V	20 V	15 V	45 V	10 V	20 V	15 V	45 V
Current (mA)	2 mA	2 mA	2 mA	2 mA	2 mA	2 mA	2 mA	2 mA

Case 02:

Analyze the given circuit where resistors R1=1kΩ, R2=3kΩ, and R3=2kΩ are connected in parallel to a 6V DC source.

Instructions:

- Simulate the circuit on MATLAB/Simulink or NI Multisim to verify your calculated values.
- Report the simulated equivalent resistance, currents through each resistor, and total current, then compare them with your calculated values.



Step 1: Apply Voltage Division Rule

In a parallel circuit, the voltage across each resistor is the same as the voltage across the source.

- Voltage across R_1:

$$V_{R_1} = V = 6\,V$$

- Voltage across R_2:

$$V_{R_2} = V = 6\,V$$

- Voltage across R_3:

$$V_{R_3} = V = 6\,V$$

Step 2: Apply Current Division Rule

Next, we calculate the current through each resistor using Ohm's Law:

- Current through R_1:

$$I_{R_1} = \frac{V}{R_1} = \frac{6\,V}{1\,k\Omega} = 6\,mA$$

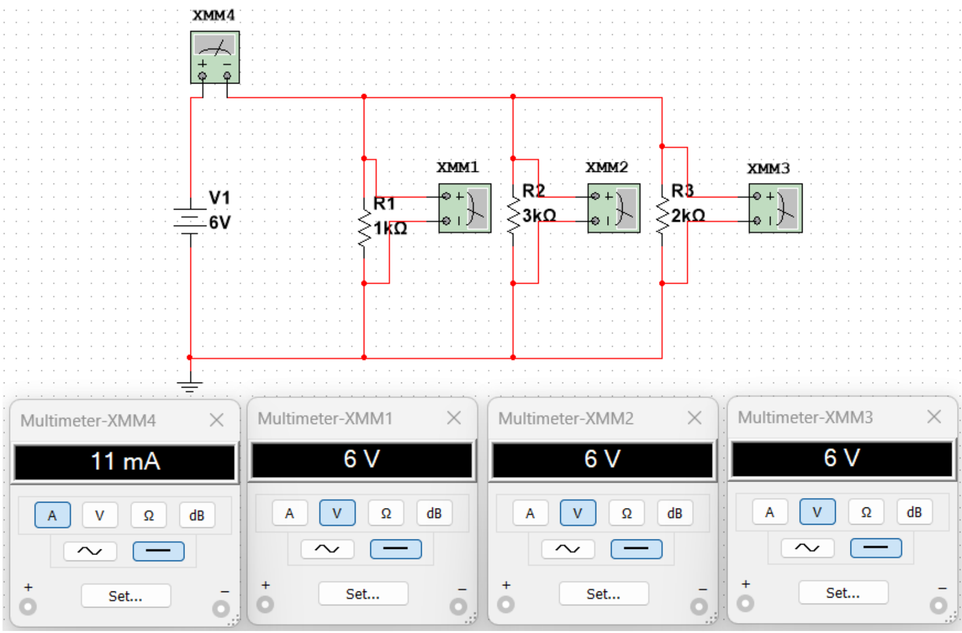
- Current through R_2:

$$I_{R_2} = \frac{V}{R_2} = \frac{6\,V}{3\,k\Omega} = 2\,mA$$

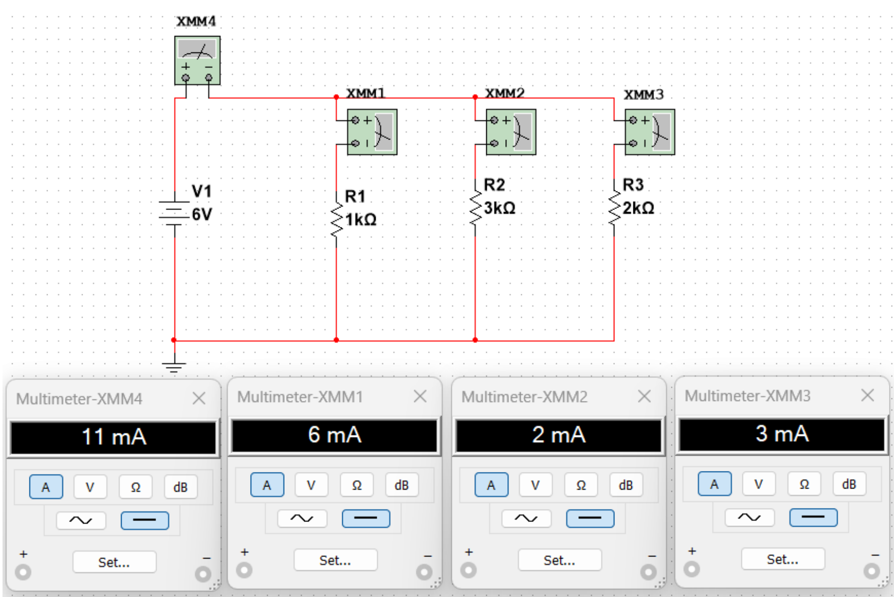
- Current through R_3:

$$I_{R_3} = \frac{V}{R_3} = \frac{6\,V}{2\,k\Omega} = 3\,mA$$

NI Multisim Simulation Result: Voltage Division



NI Multisim Simulation Result: Current Division



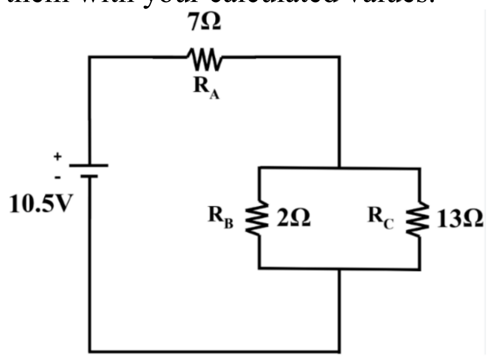
	Simulation Results				Theoretical Calculation Results			
Component	**R1**	**R2**	**R3**	**V_{source}**	**R1**	**R2**	**R3**	**V_{source}**
Voltage (V)	6 V	6 V	6 V	6 V	6 V	6 V	6 V	6 V
Current (mA)	6 mA	2 mA	3 mA	=11 mA	6 mA	2 mA	3 mA	**$I_{total}=I_{R1}+I_{R2}+I_{R3}$ =11 mA**

Case 03:

Analyze the given circuit where resistors R_A=7 Ω, R_B=2 Ω, and R_C=13 Ω are connected as shown in the circuit with a 10.5V DC source.

Instructions:

- Simulate the circuit on MATLAB/Simulink or NI Multisim to verify your calculated values.
- Report the simulated equivalent resistance, currents through each resistor, and total current, then compare them with your calculated values.



Step 1: Calculate Equivalent Resistance

Parallel Combination:

1. R_B and R_C are in parallel:

$$\frac{1}{R_{BC}} = \frac{1}{R_B} + \frac{1}{R_C} = \frac{1}{2\,\Omega} + \frac{1}{13\,\Omega}$$

$$\frac{1}{R_{BC}} = \frac{13+2}{26} = \frac{15}{26}\,\Omega$$

$$R_{BC} = \frac{26}{15}\,\Omega \approx 1.733\,\Omega$$

Total Resistance:

The total resistance of the circuit is the sum of R_A and R_{BC} since they are in series:

$$R_{Total} = R_A + R_{BC} = 7\,\Omega + 1.733\,\Omega = 8.733\,\Omega$$

Step 2: Calculate the Total Current using Ohm's Law

$$I_{Total} = \frac{V}{R_{Total}} = \frac{10.5V}{8.733\,\Omega} \approx 1.202\,A$$

Step 3: Apply Voltage Division Rule

- Voltage across R_A:

$$V_{R_A} = I_{Total} \times R_A = 1.202\,A \times 7\,\Omega = 8.414\,V$$

- Voltage across R_{BC}:

$$V_{R_{BC}} = I_{Total} \times R_{BC} = 1.202\,A \times 1.733\,\Omega \approx 2.086\,V$$

Step 4: Apply Current Division Rule

Now, let's calculate the current through R_B and R_C using the current division rule.

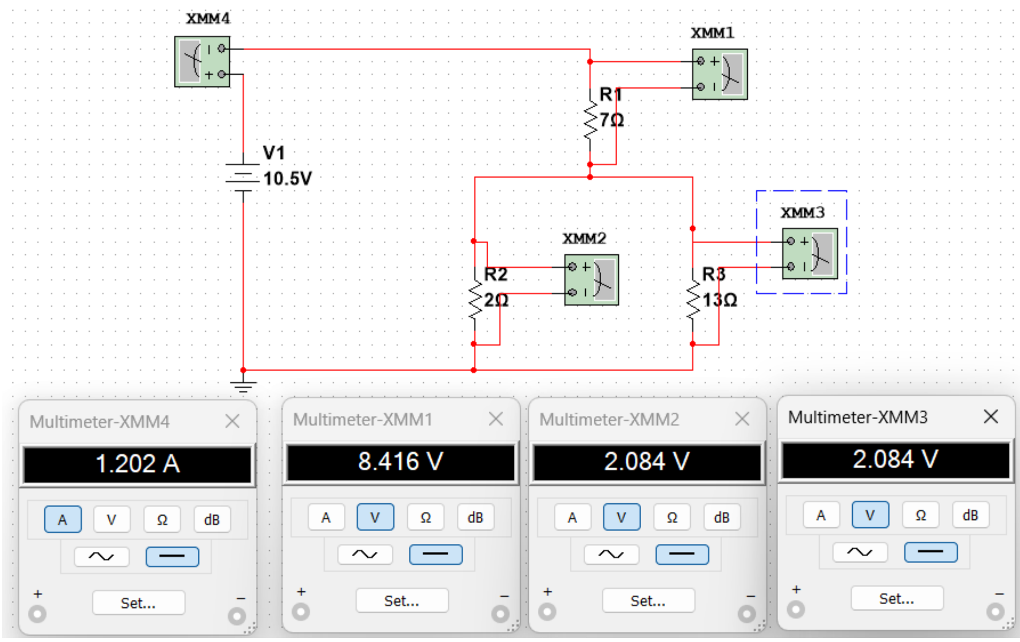
- **Current through R_B:**

$$I_{R_B} = \frac{R_C}{R_B + R_C} \times I_{Total} = \frac{13\,\Omega}{2\,\Omega + 13\,\Omega} \times 1.202\,A \approx 1.040\,A$$

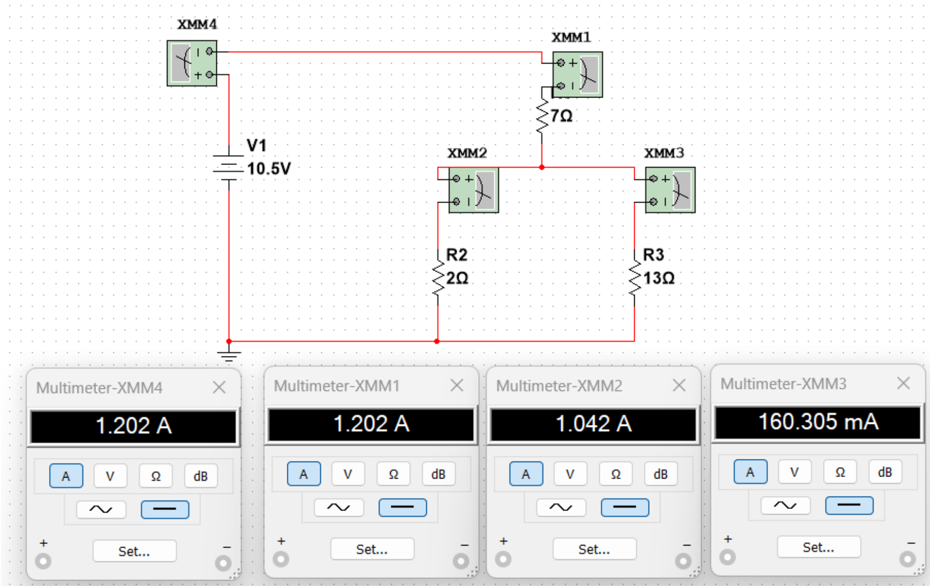
- **Current through R_C:**

$$I_{R_C} = \frac{R_B}{R_B + R_C} \times I_{Total} = \frac{2\,\Omega}{2\,\Omega + 13\,\Omega} \times 1.202\,A \approx 0.162\,A$$

NI Multisim Simulation Result: Voltage Division



NI Multisim Simulation Result: Current Division



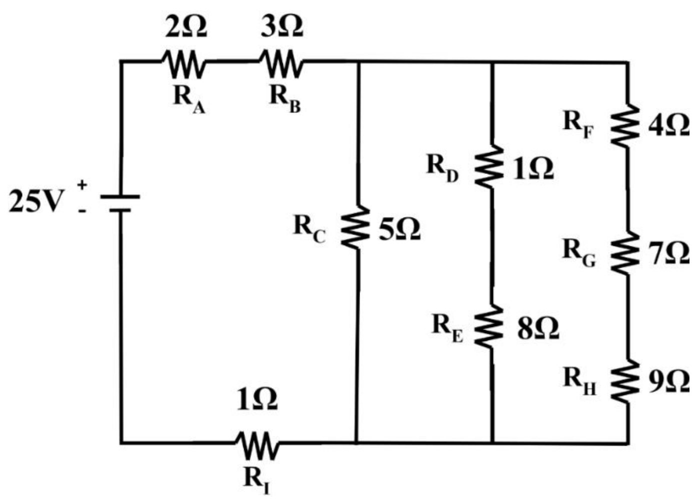
	Simulation Results				Theoretical Calculation Results			
Component	RA	RB	RC	Vsource	RA	RB	RC	Vsource
Voltage (V)	8.414 V	2.086 V	2.086 V	10.5 V	8.414 V	2.086 V	2.086 V	10.5 V
Current (A)	1.202 A	1.040 A	0.162 A	1.202 A	1.202 A	1.040 A	0.162 A	1.202 A

Case 04:

Analyze the complex resistive circuit, resistors R_A=2 Ω, R_B=3 Ω, R_C=5 Ω, R_D=1 Ω, R_E=8 Ω, R_F=4 Ω, R_G=7 Ω, R_H=9 Ω, and R_I=1 Ω are arranged as shown, with a 25V DC power supply.

Instructions:

- Simulate the circuit on MATLAB/Simulink or NI Multisim to verify your calculated values.
- Report the simulated equivalent resistance, currents through each resistor, and total current, then compare them with your calculated values.



Step 1: Calculate Equivalent Resistances

Series Combinations:

1. R_D and R_E are in series:

$$R_{DE} = R_D + R_E = 1\,\Omega + 8\,\Omega = 9\,\Omega$$

2. R_F, R_G, and R_H are in series:

$$R_{FGH} = R_F + R_G + R_H = 4\,\Omega + 7\,\Omega + 9\,\Omega = 20\,\Omega$$

Parallel Combination:

Now, R_C, R_{DE}, and R_{FGH} are in parallel:

$$\frac{1}{R_{Total\_Parallel}} = \frac{1}{R_C} + \frac{1}{R_{DE}} + \frac{1}{R_{FGH}}$$

$$\frac{1}{R_{Total\_Parallel}} = \frac{1}{5\,\Omega} + \frac{1}{9\,\Omega} + \frac{1}{20\,\Omega}$$

$$R_{Total\_Parallel} = \frac{1}{\left(\frac{1}{5} + \frac{1}{9} + \frac{1}{20}\right)} \approx 2.857\,\Omega$$

Total Resistance:

The total resistance of the circuit, which includes R_A, R_B, R_I, and $R_{Total\_Parallel}$, is given by:

$$R_{Total} = R_A + R_B + R_I + R_{Total\_Parallel} = 2\,\Omega + 3\,\Omega + 1\,\Omega + 2.857\,\Omega \approx 8.857\,\Omega$$

Step 2: Calculate the Total Current using Ohm's Law

$$I_{Total} = \frac{V}{R_{Total}} = \frac{25V}{8.857\,\Omega} \approx 2.822\,A$$

Step 3: Apply Voltage Division Rule

- **Voltage across R_A:**

$$V_{R_A} = I_{Total} \times R_A = 2.822\,A \times 2\,\Omega = 5.644\,V$$

- **Voltage across R_B:**

$$V_{R_B} = I_{Total} \times R_B = 2.822\,A \times 3\,\Omega = 8.466\,V$$

- **Voltage across R_I:**

$$V_{R_I} = I_{Total} \times R_I = 2.822\,A \times 1\,\Omega = 2.822\,V$$

- **Voltage across $R_{Total\_Parallel}$ (which will be the same for R_C, R_{DE}, and R_{FGH}):**

$$V_{Parallel} = I_{Total} \times R_{Total\_Parallel} = 2.822\,A \times 2.857\,\Omega \approx 8.068\,V$$

Step 4: Verify Voltage Division

- **Sum of individual voltages:**

$$V_{Total} = V_{R_A} + V_{R_B} + V_{R_I} + V_{Parallel} = 5.644\,V + 8.466\,V + 2.822\,V + 8.068\,V \approx 25\,V$$

This confirms the Voltage Division Rule.

Step 5: Apply Current Division Rule

Now, let's apply the Current Division Rule to the parallel section R_C, R_{DE}, and R_{FGH}.

- **Current through R_C:**

$$I_{R_C} = \frac{V_{Parallel}}{R_C} = \frac{8.068\,V}{5\,\Omega} \approx 1.614\,A$$

- **Current through R_{DE}:**

$$I_{R_{DE}} = \frac{V_{Parallel}}{R_{DE}} = \frac{8.068\,V}{9\,\Omega} \approx 0.896\,A$$

- Current through R_{FGH}:

$$I_{R_{FGH}} = \frac{V_{Parallel}}{R_{FGH}} = \frac{8.068\,V}{20\,\Omega} \approx 0.403\,A$$

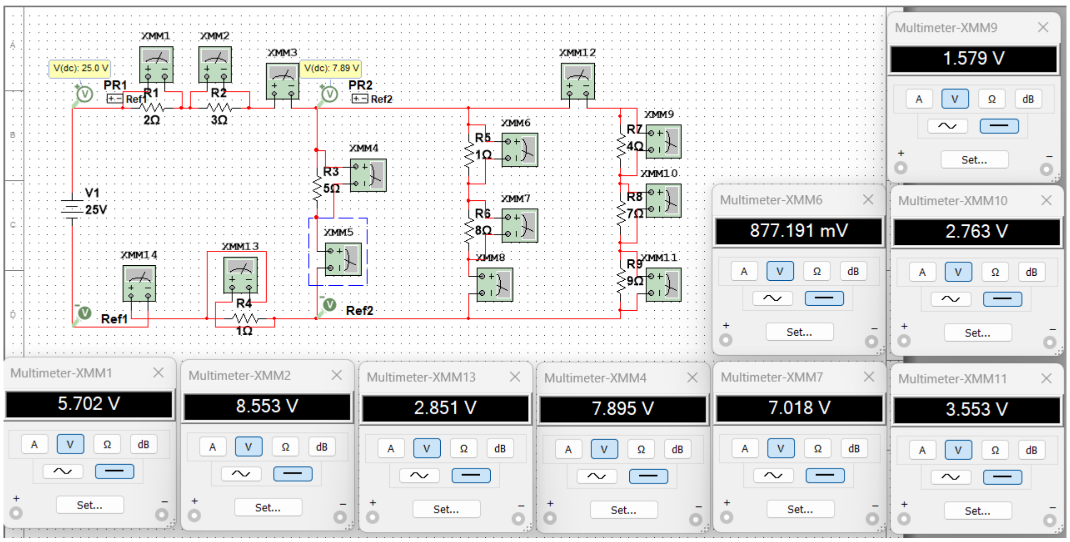
Step 6: Verify Current Division

- Sum of currents through parallel branches:

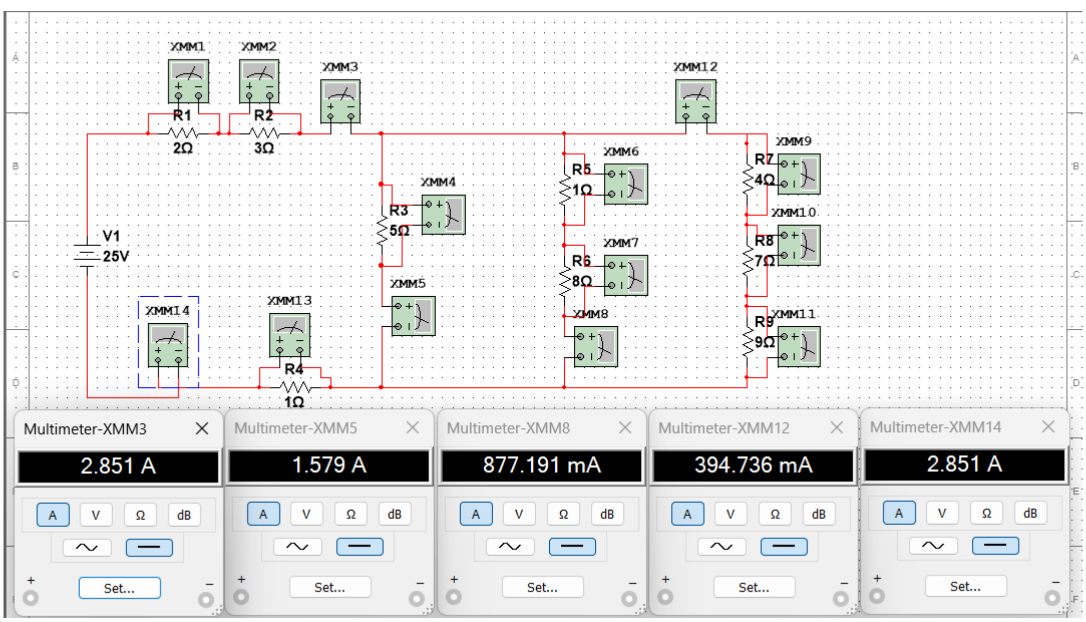
$$I_{Parallel\_Sum} = I_{R_C} + I_{R_{DE}} + I_{R_{FGH}} = 1.614\,A + 0.896\,A + 0.403\,A \approx 2.913\,A$$

This value is slightly higher than the total current calculated earlier (2.822 A) due to rounding in earlier steps. However, this generally verifies the Current Division Rule.

Ni Multisim Simulation Results: KVL



Ni Multisim Simulation Results: KVL



Simulation Results					Theoretical Calculation Results				
RA	RB	RI	RC||RDE||RFGH	Vsource	RA	RB	RC	RC||RDE||RFGH	Vsource
5.702V	8.553V	2.851V	7.895V	25	5.644V	8.466V	2.822V	8.068	25
IRC	IRDE	IRFGH	I Total		IRC	IRDE	IRFGH	I Total	
1.579A	0.8772A	0.395A	2.851A		1.614A	0.896A	0.403A	2.913A	

Expt. No. 03	Verification of star delta transformation Using Resistance Reduction Technique

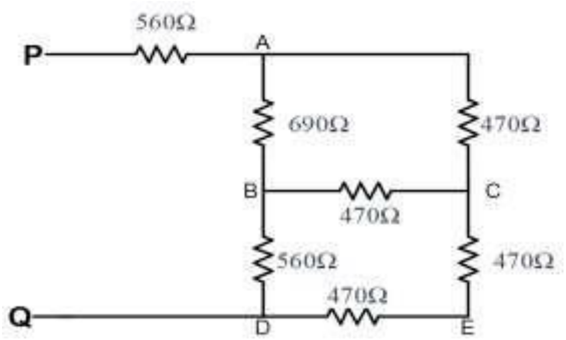
AIM:

To calculate the equivalent circuit resistance using star delta transformation technique.

APPARATUS REQUIRED:

S.No.	Apparatus Name	Range	Quantity
1	Resistor		
2	Bread board & Connecting wires	--	Required

CIRCUIT DIAGRAM:



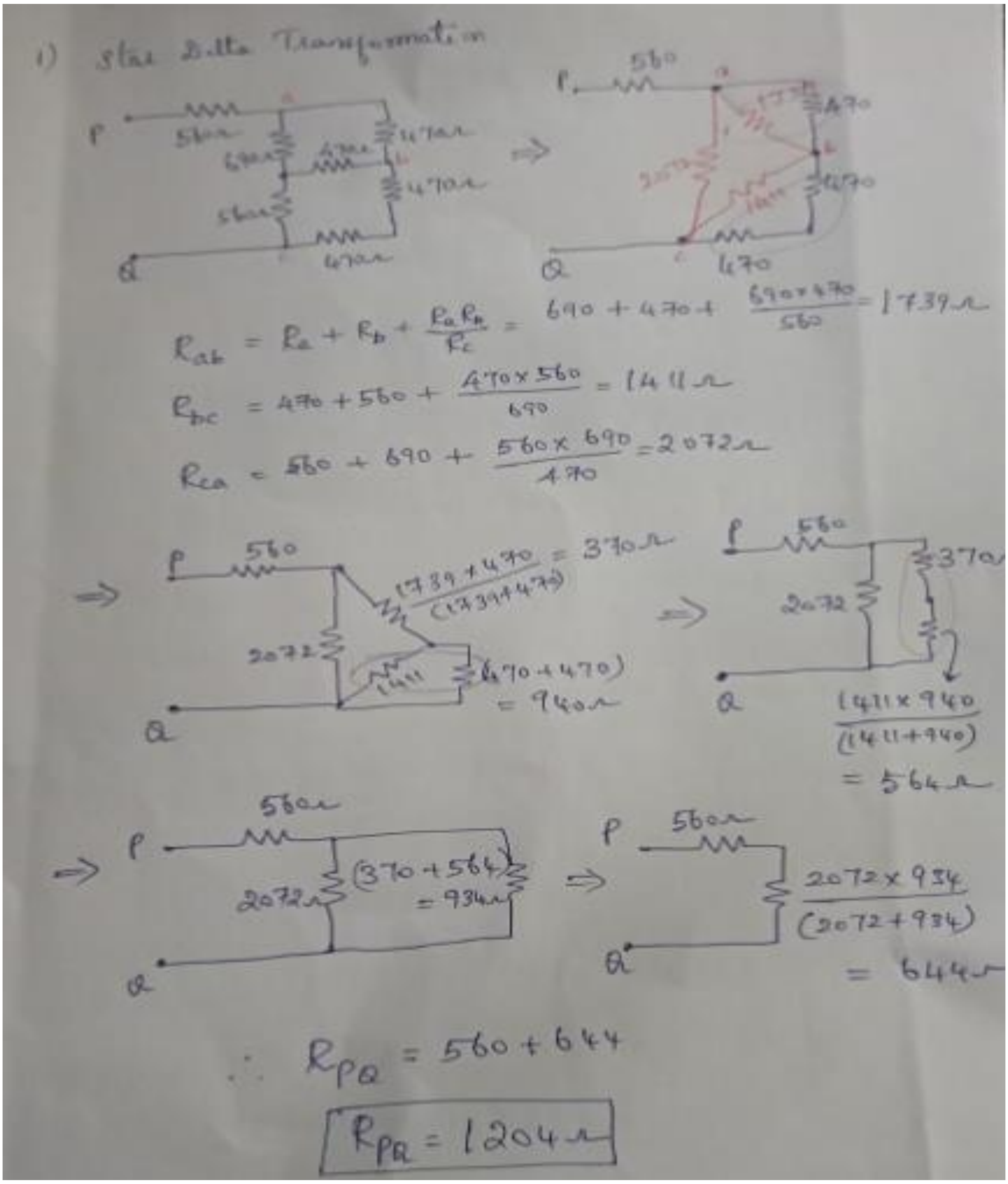
PROCEDURE:

1. Give the connections as per the circuit diagram.
2. Determine the equivalent resistance of the circuit between P and Q using star – deltatransformation technique
3. Verify the same by connecting Multimeter across PQ

OBSERVATIONS:

S.No.	Theoretical value (R_{PQ}) inohm	Measured value(R_{PQ}) in ohm
1	1204	1200

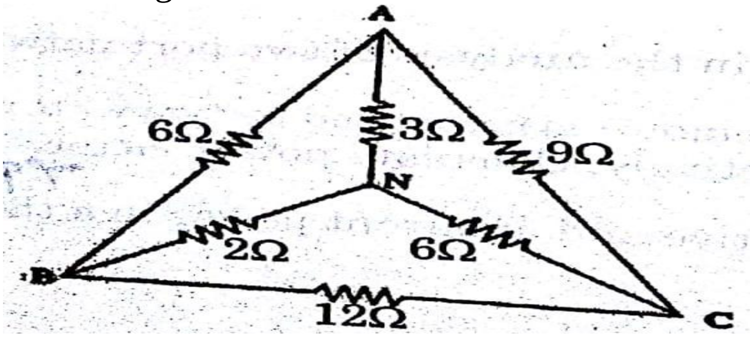
Theoretical Calculations:



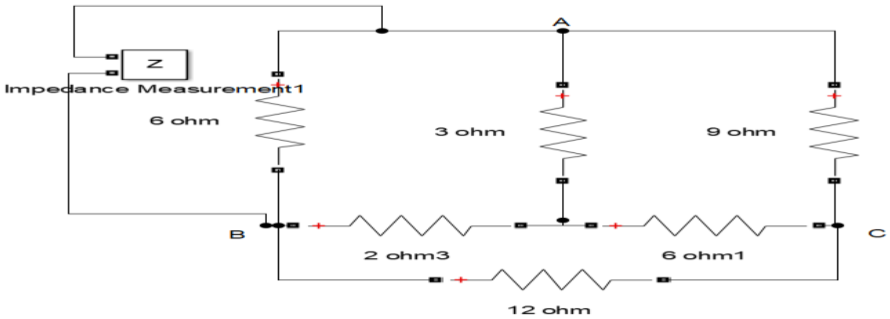
RESULT:

Thus the equivalent circuit resistance is obtained using star delta transformation technique.

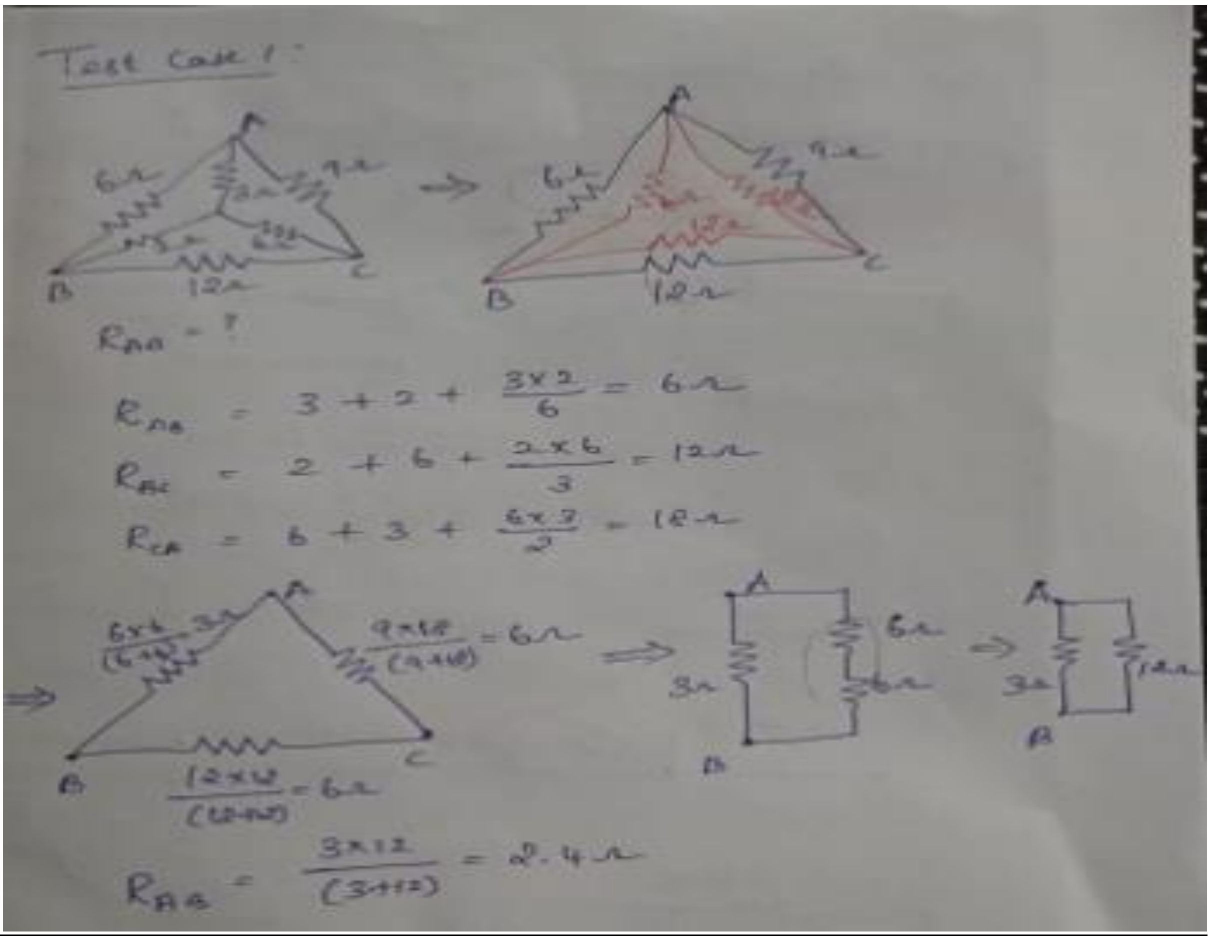
Test Case 1: Design a MATLAB Simulink model to find the effective resistance between A&B using star delta transformation.



Simulink Model:



Theoretical Calculations:

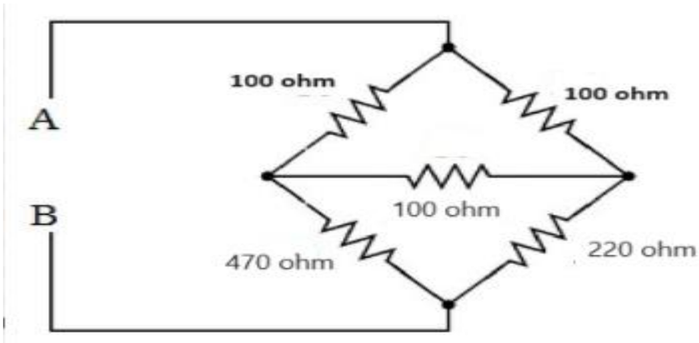


OBSERVATIONS:

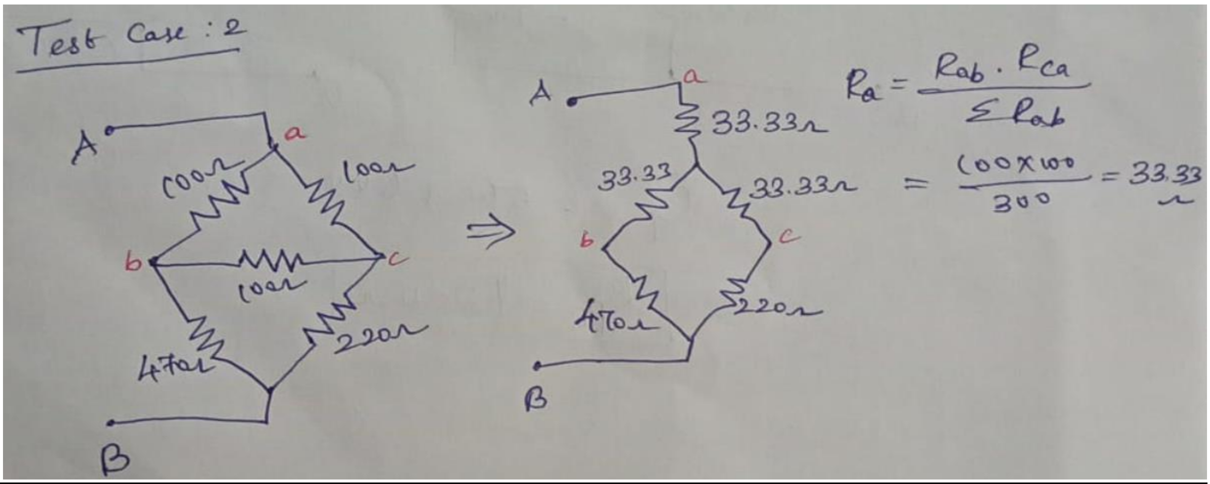
S.No.	Theoretical value (R_{PQ}) in ohm	Measured value in MATLAB (R_{PQ}) in ohm
1	2.4	2

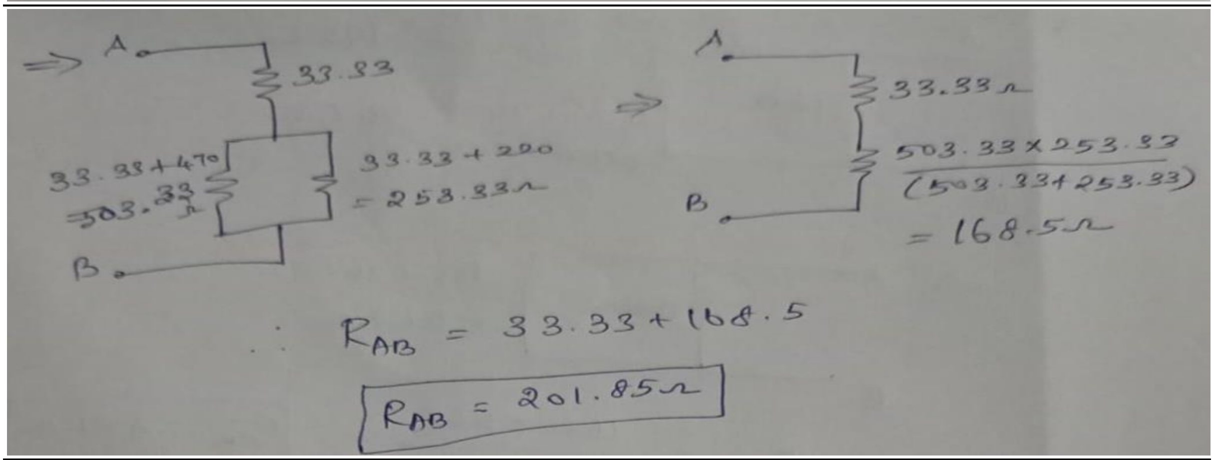
<u>Test Case 2:</u> Design a circuit to verify star delta reduction technique for the bridge circuit shown below. Calculate the effective resistance between the terminals A & B theoretically and practically.

Circuit Diagram



Theoretical Calculations:



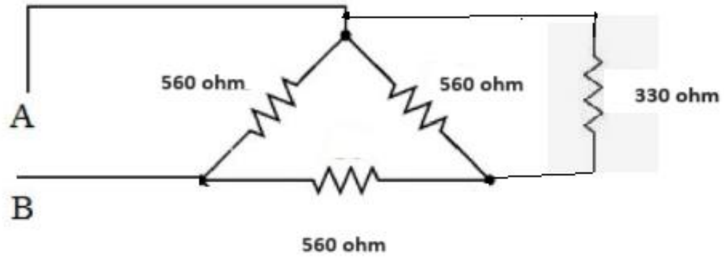


OBSERVATIONS:

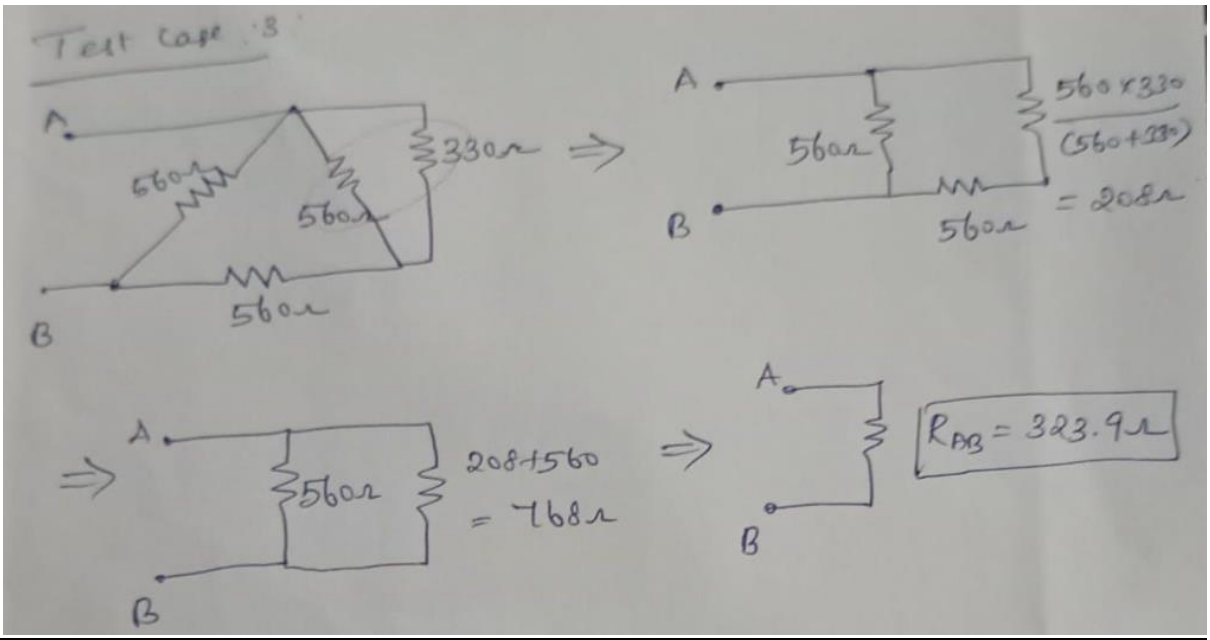
S.No.	Theoretical value (R_{PQ}) inohm	Measured value(R_{PQ}) in ohm
1	201.85	198

<u>Test Case 3: </u>Design a circuit to verify star delta reduction technique for the circuit shown below. Calculate the effective resistance between the terminals A & B theoretically and practically.

Circuit Diagram



Theoretical Calculations:

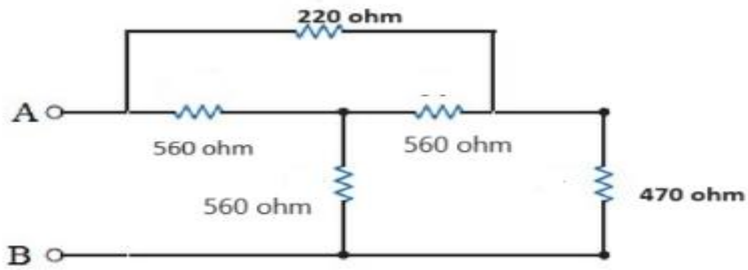


OBSERVATIONS:

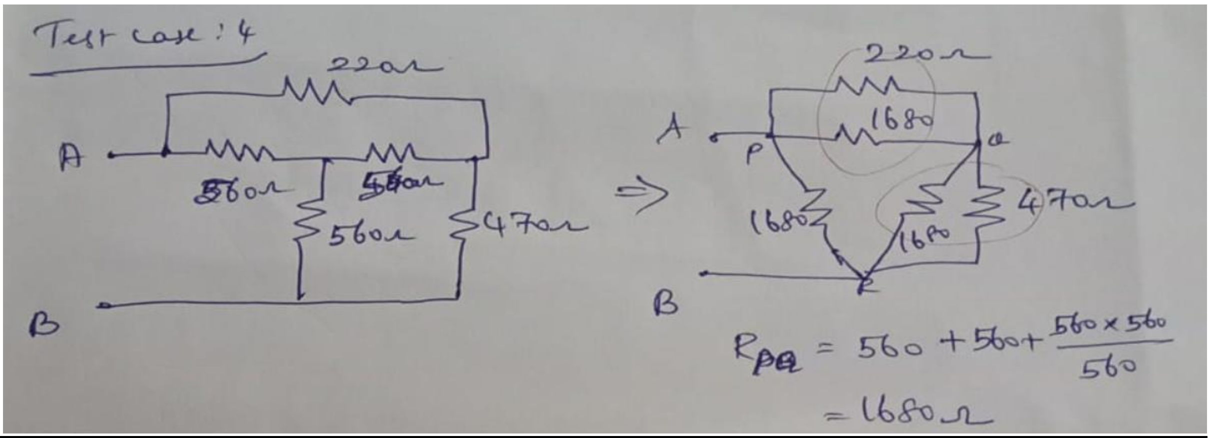
S.No.	Theoretical value (R_{PQ}) inohm	Measured value(R_{PQ}) in ohm
1	323.9	315

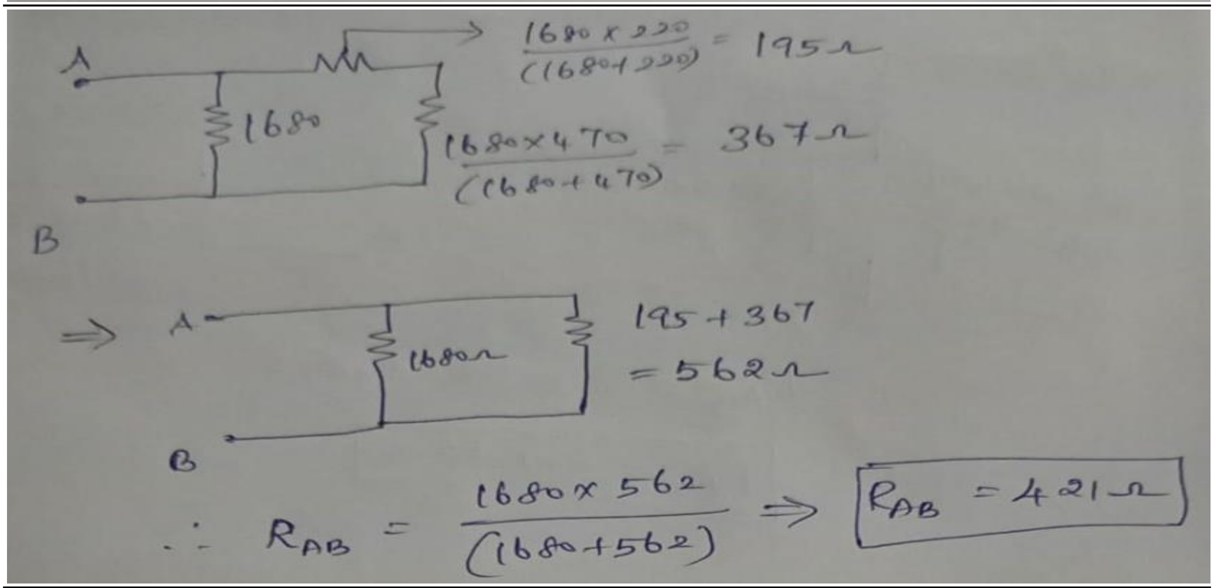
Test Case 4: Design a circuit to verify star delta reduction technique for the circuit shown below. Calculate the effective resistance between the terminals A & B theoretically and practically.

Circuit Diagram



Theoretical Calculations:





OBSERVATIONS:

S.No.	Theoretical value (R_{PQ}) inohm	Measured value(R_{PQ}) in ohm
1	421	412

BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LAB

Expt. No. 04	Verification of Thevenin's and Norton's Theorems

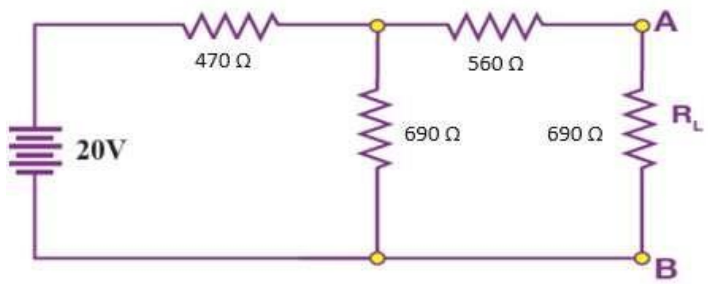
AIM:

To verify the equivalent circuit parameters of Thevenin's and Norton's Theorems theoretically and practically.

APPARATUS REQUIRED:

S.No.	Apparatus Name	Range	Quantity
1	DC Regulated Power Supply	(0-30)V	1
2	Voltmeter	(0-30)V	1
3	Ammeter	(0-200)mA	1
4	Resistor	330Ω, 220Ω, 470 Ω, 560 Ω,100 Ω	As required
5	Multimeter	-	1
6	Bread board & Connecting wires	--	As Required

CIRCUIT DIAGRAM:



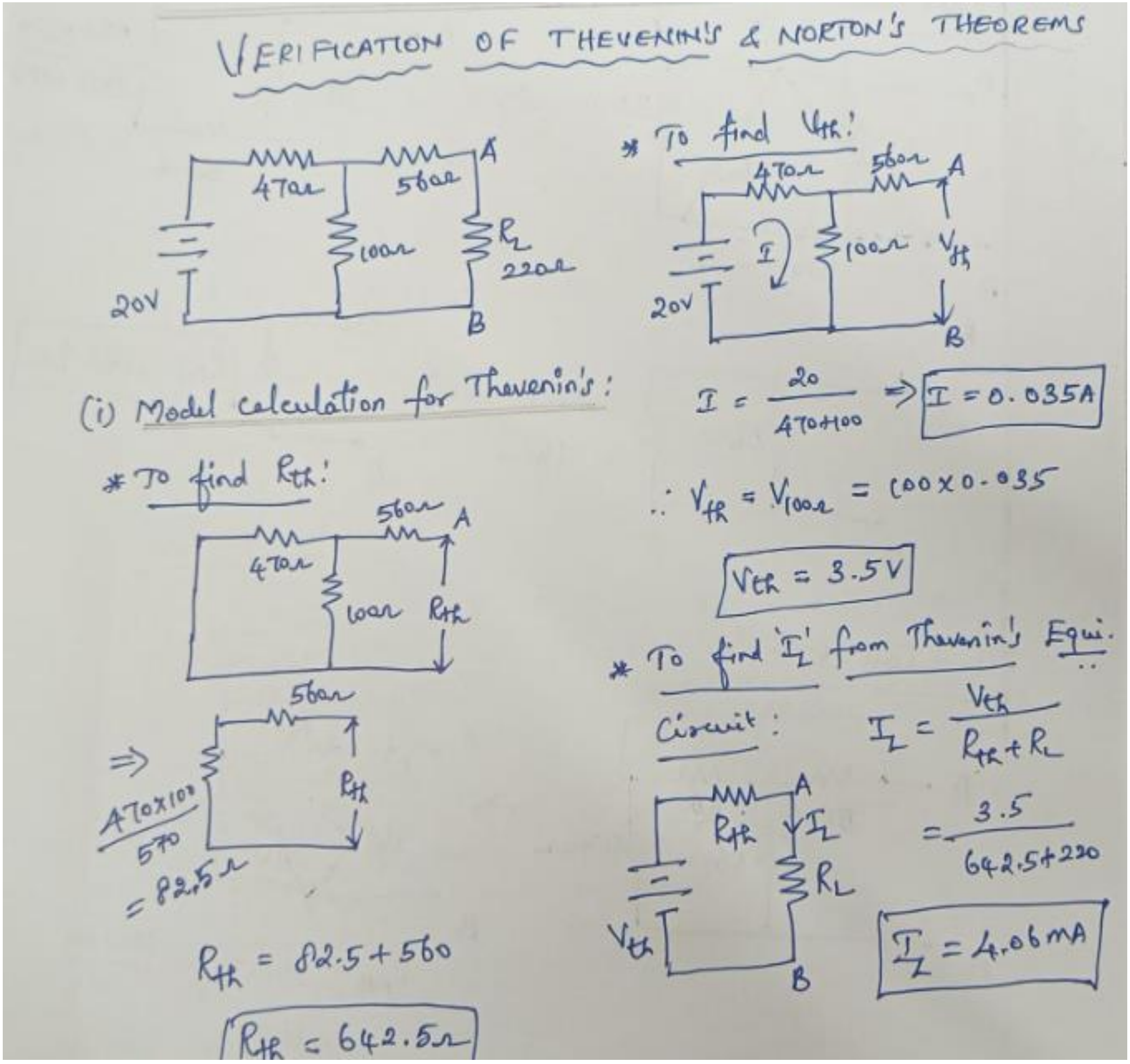
PROCEDURE FOR THEVENIN'S THEOREM:

1. Give the connections as per the circuit diagram.
2. Measure R_{th} using a multimeter by killing sources (O.C the current source and S.C the voltage source) and open circuit R_L.
3. Measure V_{th} across A & B (open circuit R_L)
4. Measure load current I_L through R_L.

$$I_L = \frac{V_{th}}{R_{th} + R_L}$$

5. Draw the Thevenin's Equivalent Circuit.

MODEL CALCULATION: THEVENIN'S THEOREM:



OBSERVATIONS:

S.No.	Supply Voltage (V)	Theoretical values			Measured values		
		$R_{th}(\Omega)$	$V_{th}(V)$	$I_L(mA)$	$R_{th}(\Omega)$	$V_{th}(V)$	$I_L(mA)$
1	20	642.5	3.5	4.06	640	3.5	4.0

PROCEDURE FOR NORTON'S THEOREM:

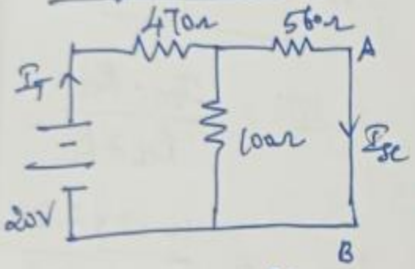
1. Give the connections as per the circuit diagram.
2. Measure Rth using a multimeter by killing sources (O.C the current source and S.C the voltage source) and open circuit R_L.
3. Measure I_N through A & B (Short circuit R_L)
4. Measure load current I_L through R_L.
5. Draw the Norton's Equivalent Circuit.

MODEL CALCULATION: NORTON’S THEOREM:

(ii) Model Calculation for Norton's:

* $R_{th} = 642.5\Omega$ (Same as Thevenin's)

* To find I_{sc} or I_N:



$R_{eq} = 470 + (560 \parallel^{el} 100)$

$\boxed{R_{eq} = 554.85\Omega}$

$$I_T = \frac{V}{R_{eq}} = \frac{20}{554.85}$$

$\boxed{I_T = 0.036A}$

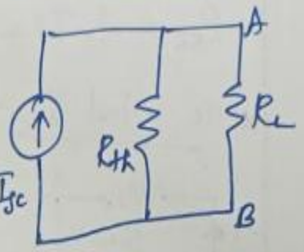
By Current division Rule:

$$I_{sc} = I_{560\Omega} = \frac{I_T}{R_T} \times R_{opp.}$$

$$I_{sc} = \frac{0.036}{(100+560)} \times 100$$

$\boxed{I_{sc} = 5.455\text{ mA}}$

* Norton's Equivalent Circuit



$$I_L = \frac{I_{sc}}{R_{th} + R_L} \times R_{th}$$

$$I_L = \frac{(5.455 \times 10^{-3}) \times 642.5}{(642.5+220)}$$

$\boxed{I_L = 4.063\text{ mA}}$

OBSERVATIONS:

S.No.	Supply Voltage (V)	Theoretical values			Measured values		
		$R_{th}(\Omega)$	I_{SC}(mA)	I_L(mA)	$R_{th}(\Omega)$	I_{SC}(mA)	I_L(mA)
1	20	642.5	5.455	4.063	640	5.5	4.0

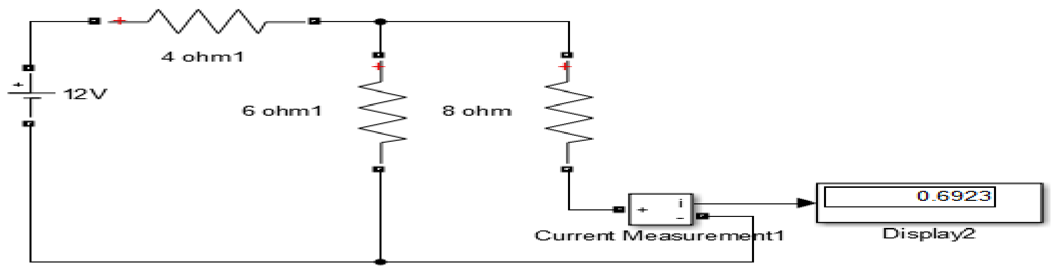
RESULT:

Thus the equivalent circuit parameters are obtained using Thevenin’s and Norton’s Theorem.

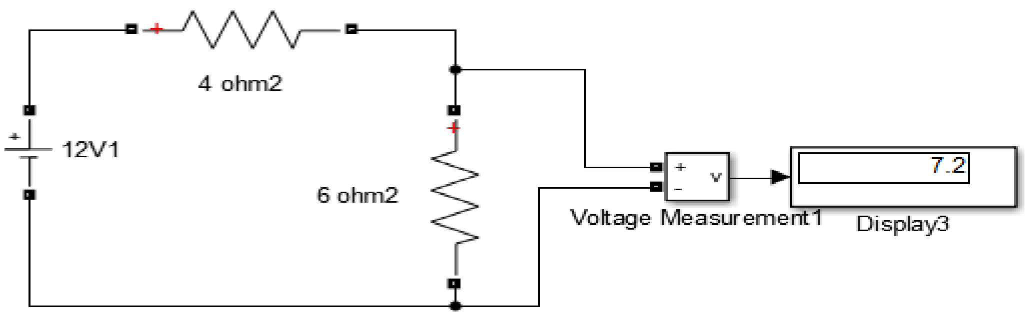
<u>Test Case 1:</u> A 12V voltage source is connected in series with two resistors, R1=4 Ω and R2=6 Ω. The load resistor R_L=8 Ω is connected across the terminals where Thevenin's equivalent is to be found. Verify the results using MATLAB SIMULINK.

MATLAB SIMULINK MODEL(THEVENIN'S):

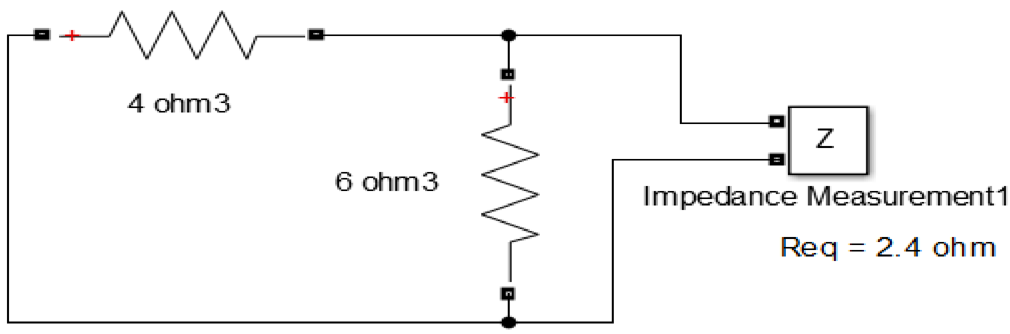
<u>To find I_L:</u>



<u>To find V_{th}:</u>



<u>To find R_{th}:</u>

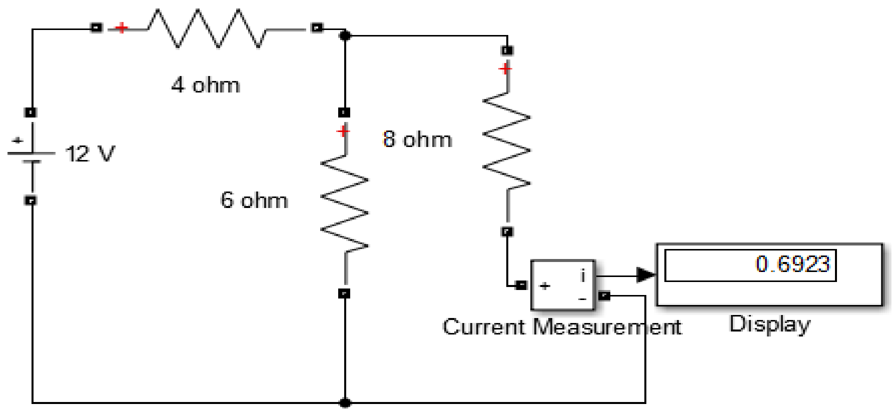


OBSERVATIONS:

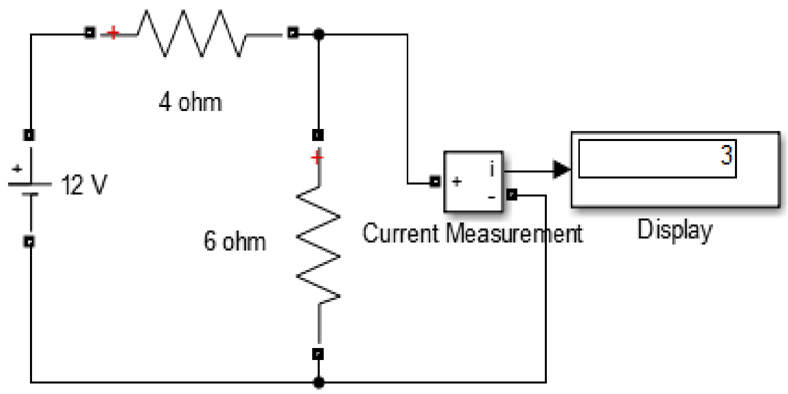
S.No.	Supply Voltage (V)	Theoretical values			Measured values		
		R_{th}(Ω)	V_{th}(V)	I_L(A)	R_{th}(Ω)	V_{th}(V)	I_L(A)
1	12	2.4	7.2	0.72	2.4	7.2	0.6923

MATLAB SIMULINK MODEL (NORTON'S):

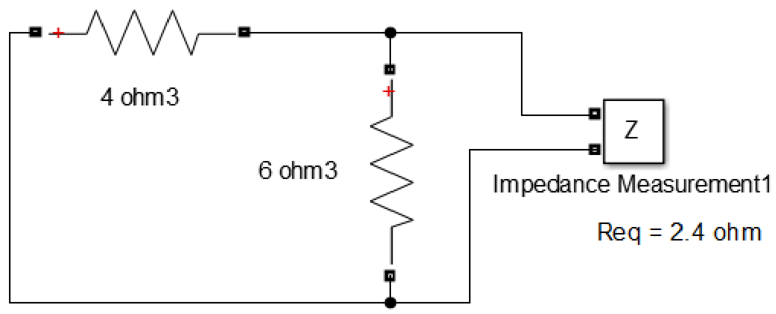
To find I_L:



To find I_{SC}:



To find R_{th}:

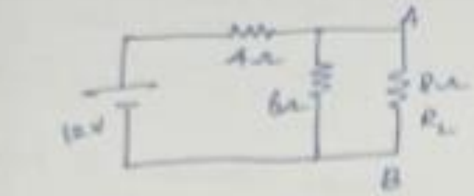


OBSERVATIONS:

S.No.	Supply Voltage (V)	Theoretical values			Measured values		
		$R_{th}(\Omega)$	$I_{SC}(A)$	$I_L(A)$	$R_{th}(\Omega)$	$I_{SC}(A)$	$I_L(A)$
1	12	2.4	1.2	0.692	2.4	3	0.6923

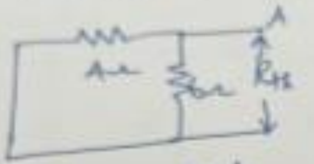
MODEL CALCULATION:

TEST CASE : 1



(i) Model calculation for Thevenin's:

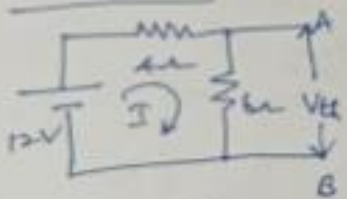
* To find R_{th} : Remove R_L (o.c), s.c the 'V' source



$$R_{th} = \frac{4 \times 6}{4+6}$$

$$\boxed{R_{th} = 2.4\Omega}$$

* To find V_{th} :

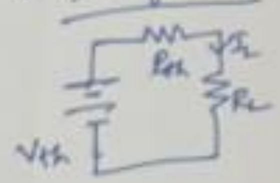


$$I = \frac{12}{4+6} = 1.2A$$

$$\therefore V_{th} = V_{6\Omega} = 6I$$

$$\boxed{V_{th} = 7.2V}$$

* To find I_L :



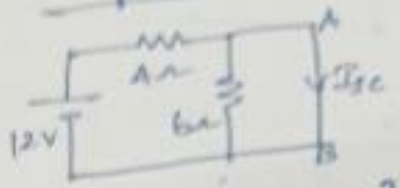
$$I_L = \frac{V_{th}}{R_{th} + R_L} = \frac{7.2}{2.4+8}$$

$$\boxed{I_L = 0.72A}$$

(ii) Model Calculation for Norton's

* $R_{th} = 2.4\Omega$ (same as Thevenin's)

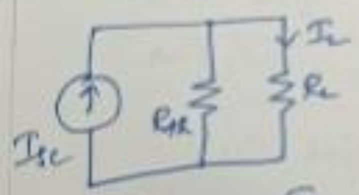
* To find I_{sc}



$$I_{sc} = \frac{12}{4} = 3A.$$

$$\boxed{I_{sc} = 3A}$$

* Norton's Equivalent Circuit to find I_L :

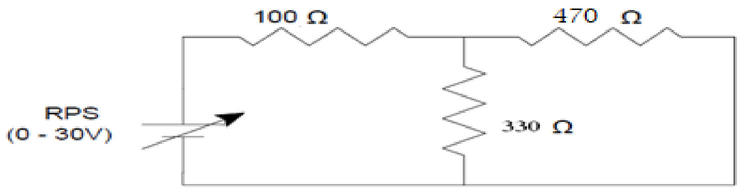


$$I_L = \frac{I_{sc} \cdot R_{th}}{R_{th} + R_L}$$

$$I_L = \frac{3 \times 2.4}{(2.4+8)}$$

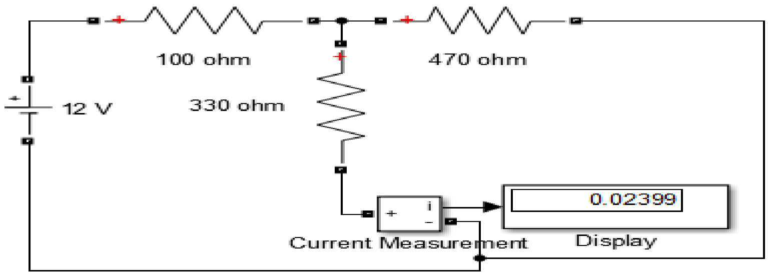
$$\boxed{I_L = 0.692A}$$

<u>Test Case 2:</u> Determine the current flows through 330 Ω resistor by applying Thevenin's & Norton's theorem theoretically and Verify the results using MATLAB SIMULINK. Assume 12V supply.

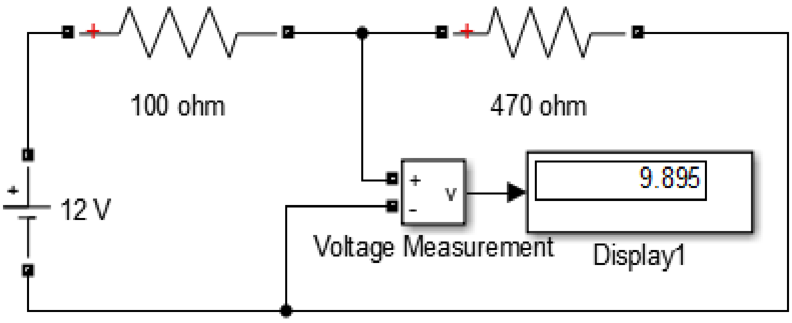


MATLAB SIMULINK MODEL(THEVENIN'S):

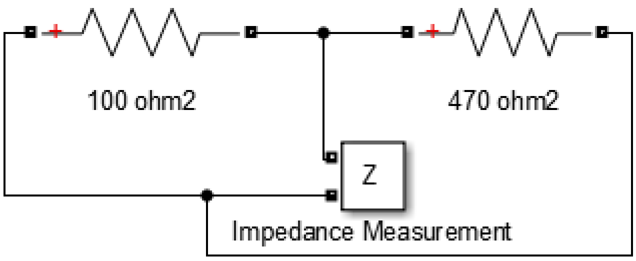
<u>To find I_L:</u>



<u>To find V_{th}:</u>



<u>To find R_{th}:</u>

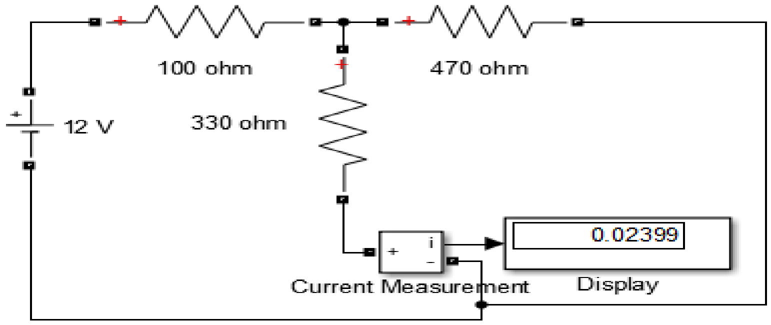


OBSERVATIONS:

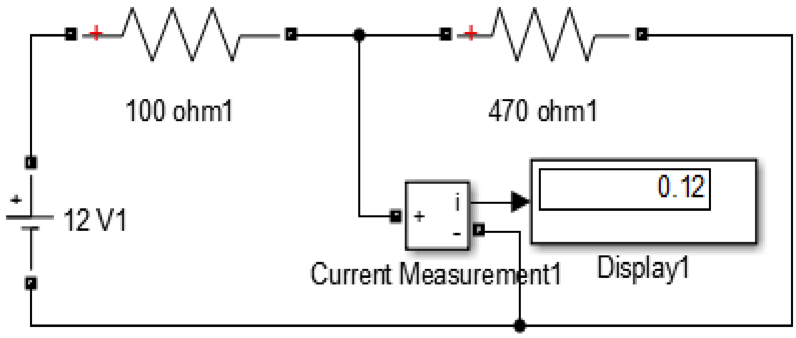
S.No.	Supply Voltage (V)	Theoretical values			Measured values		
		$R_{th}(\Omega)$	$V_{th}(V)$	$I_L(A)$	$R_{th}(\Omega)$	$V_{th}(V)$	$I_L(A)$
1	12	82.46	9.87	0.024	82.46	9.895	0.02399

MATLAB SIMULINK MODEL (NORTON'S):

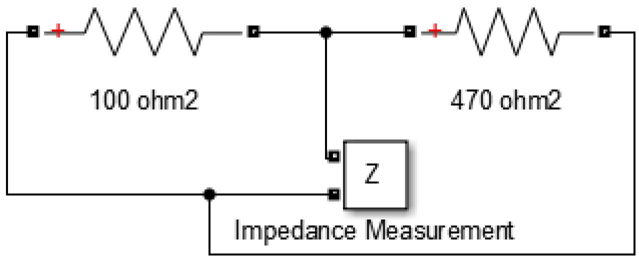
To find I_L:



To find I_{SC}:



To find R_{th}:

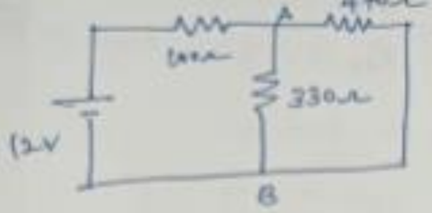


OBSERVATIONS:

S.No.	**Supply Voltage (V)**	**Theoretical values**			**Measured values**		
		$R_{th}(\Omega)$	$I_{SC}(A)$	$I_L(A)$	$R_{th}(\Omega)$	$I_{SC}(A)$	$I_L(A)$
1	12	82.46	0.12	0.024	82.46	0.12	0.02399

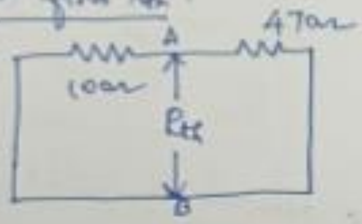
MODEL CALCULATION:

TEST CASE : 2



(i) Model calculation for Thevenin's

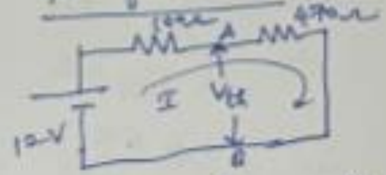
* To find R_{th} :



$$R_{th} = \frac{100 \times 470}{(100+470)}$$

$$\boxed{R_{th} = 82.46\Omega}$$

* To find V_{th} :



$$(100+470)\,I = 12$$

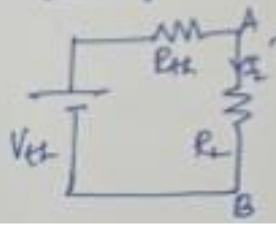
$$\boxed{I = 0.021\,A}$$

$$V_{th} = 12 - 100I = 9.9V$$

(or)

$$\boxed{V_{th} = 470I = 9.87V}$$

* To find I_L :



Thevenin's Equi. ckt

$$I_L = \frac{V_{th}}{R_{th}+R_L}$$

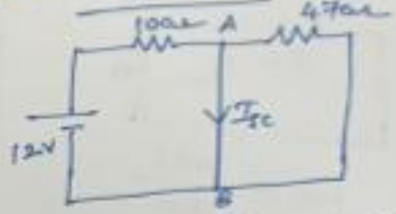
$$I_L = \frac{9.9}{82.46+330}$$

$$\boxed{I_L = 0.024A = 24mA}$$

(ii) model calculation for Norton's

* $R_{th} = 82.46\Omega$ (as like Thevenin's)

* To find I_{sc} :

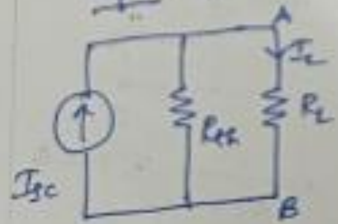


$$I_{sc} = \frac{12}{100} = 0.12A.$$

$$\boxed{I_{sc} = 0.12A}$$

* To find I_L from Norton's

Equi. ckt

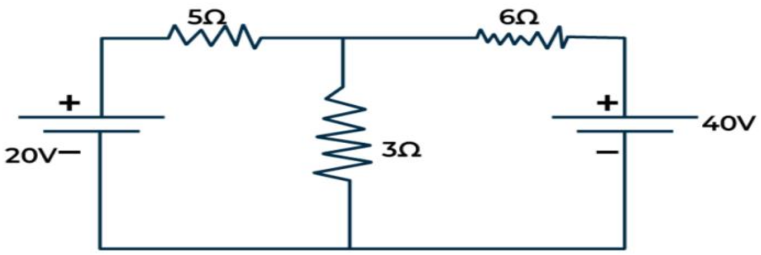


$$I_L = \frac{I_{sc} \cdot R_{th}}{R_{th}+R_L}$$

$$I_L = \frac{0.12 \times 82.46}{(82.46+330)}$$

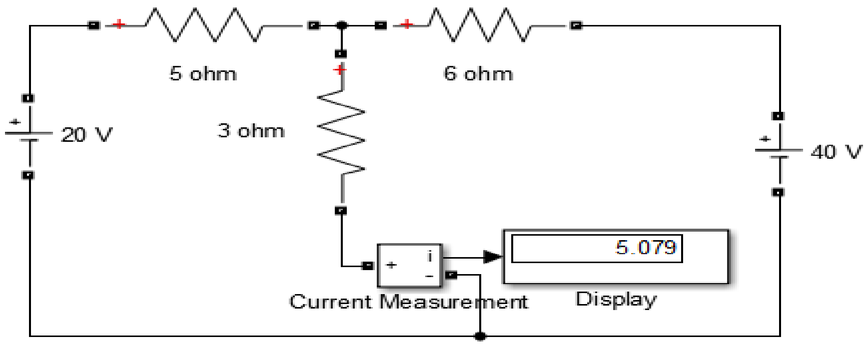
$$\boxed{I_L = 0.024A = 24mA}$$

Test Case 3: **Determine the current flows through 3 Ω resistor by applying Thevenin's & Norton's theorem theoretically and Verify the results using MATLAB SIMULINK. Assume 20V supply.**

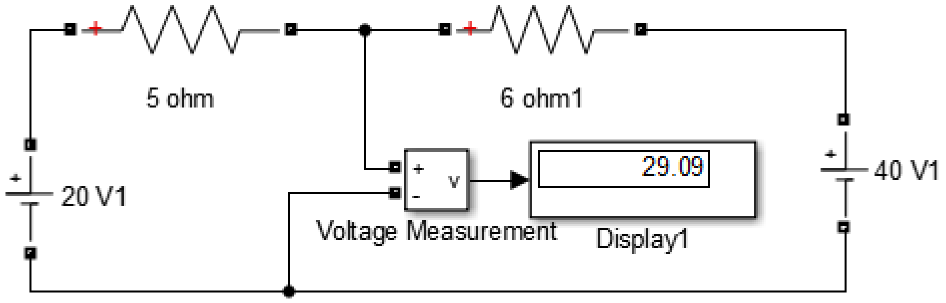


MATLAB SIMULINK MODEL (THEVENIN'S):

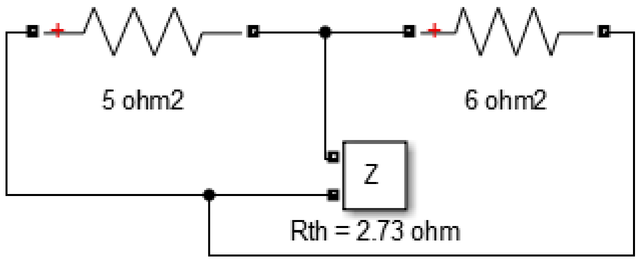
To find I_L:



To find V_{th}:



To find R_{th}:

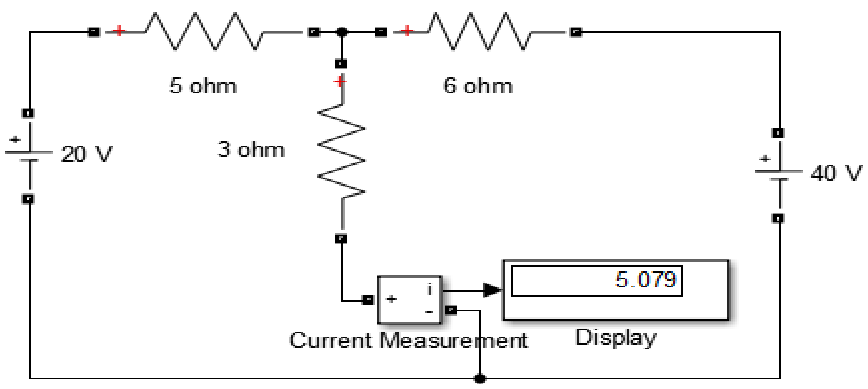


OBSERVATIONS:

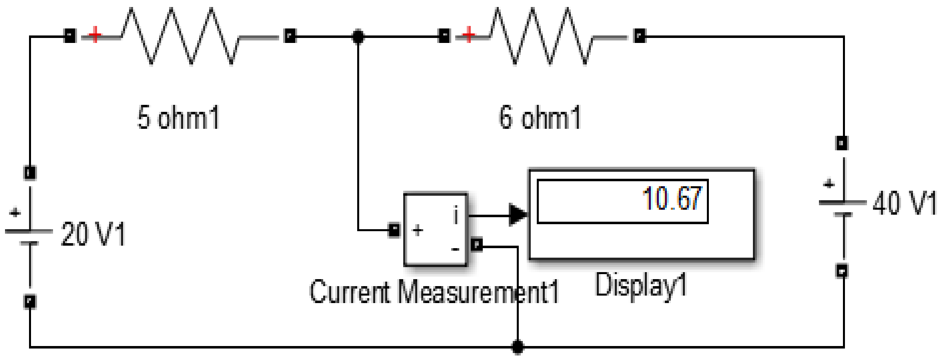
S.No.	Supply Voltage (V)	Theoretical values			Measured values		
		$R_{th}(\Omega)$	$V_{th}(V)$	$I_L(A)$	$R_{th}(\Omega)$	$V_{th}(V)$	$I_L(A)$
1	20V and 40 V	2.73	29.1	1.9	2.73	29.09	5.079

MATLAB SIMULINK MODEL (NORTON'S):

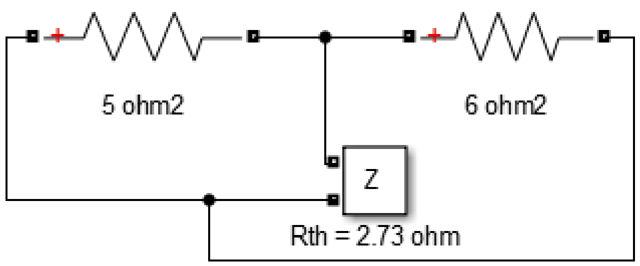
To find I_L:



To find I_{SC}:



To find R_{th}:

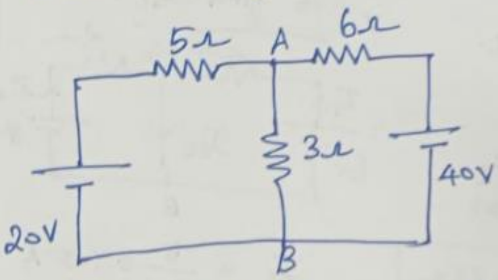


OBSERVATIONS:

S.No.	Supply Voltage (V)	Theoretical values			Measured values		
		$R_{th}(\Omega)$	$I_{SC}(A)$	$I_L(A)$	$R_{th}(\Omega)$	$I_{SC}(A)$	$I_L(A)$
1	20V and 40 V	2.73	10.67	5.08	2.73	10.67	5.079

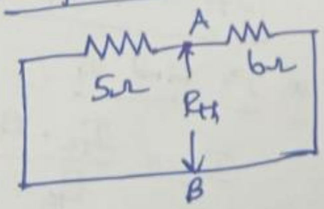
MODEL CALCULATION:

TEST CASE : 3



(i) Model Calculation for Thevenin's:

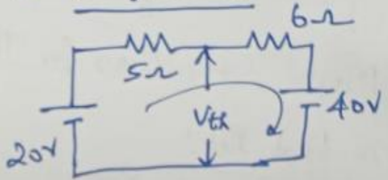
* To find R_{th}:



$$R_{th} = \frac{5 \times 6}{(5+6)}$$

$$\boxed{R_{th} = 2.73\Omega}$$

* To find V_{th}:



$$11 I = 20 - 40$$

$$I = \frac{-20}{11} \Rightarrow \boxed{I = -1.82\,A}$$

$$\therefore V_{th} = 20 - 5I$$

$$\boxed{V_{th} = 29.1\,V}$$

* To find I_L:

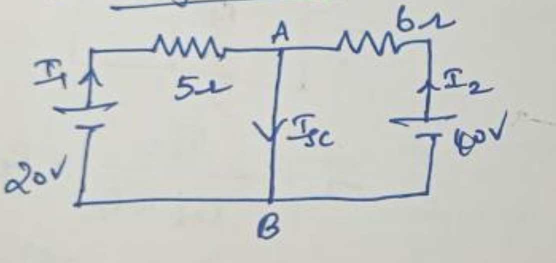
$$I_L = \frac{V_{th}}{R_{th} + R_L} = \frac{29.1}{(2.73+3)}$$

$$\boxed{I_L = 5.08A}$$

(ii) Model Calculation for Norton's:

* $R_{th} = 2.73\Omega$ (as Thevenin's)

* To find I_{sc}:



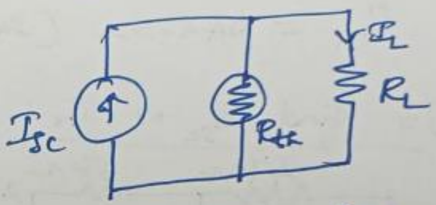
$$I_1 = \frac{20}{5} = 4A$$

$$I_2 = \frac{40}{6} = 6.67A$$

$$\therefore I_{sc} = I_1 + I_2$$

$$\boxed{I_{sc} = 10.67A}$$

* To find I_L:



$$I_L = \frac{I_{sc} \cdot R_{th}}{R_{th} + R_L}$$

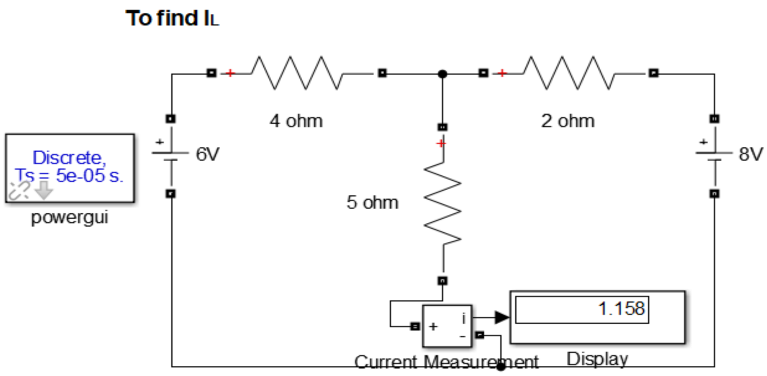
$$= \frac{10.67 \times 2.73}{(2.73+3)}$$

$$\boxed{I_L = 5.08\,A}$$

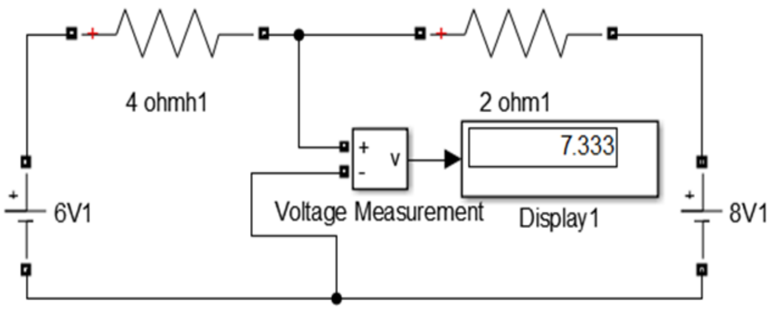
<u>Test Case 4:</u> Determine the current flows through 5Ω resistor by applying Thevenin's & Norton's theorem theoretically and practically.

MATLAB SIMULINK MODEL (THEVENIN'S):

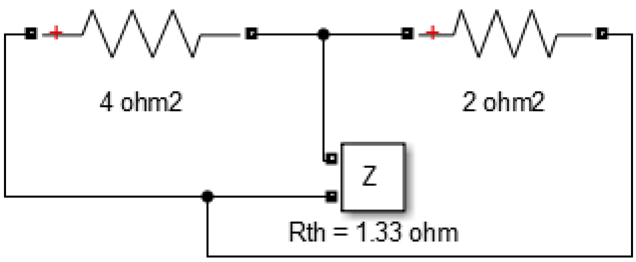
<u>To find I_L:</u>



<u>To find V_{th}:</u>



<u>To find R_{th}:</u>

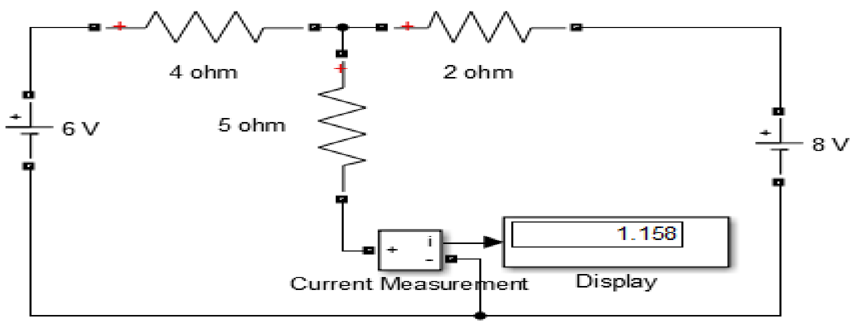


OBSERVATIONS:

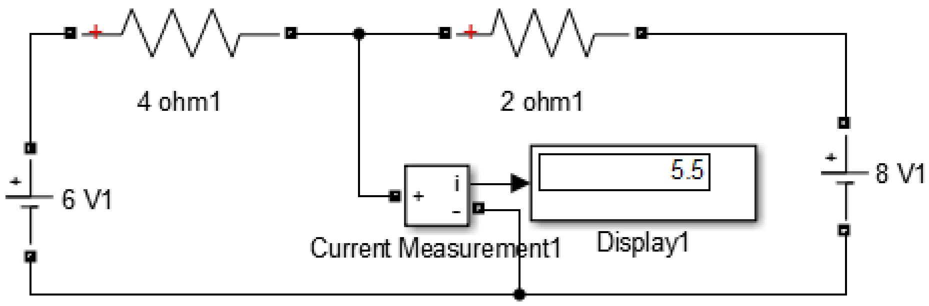
S.No.	Supply Voltage (V)	Theoretical values			Measured values		
		$R_{th}(\Omega)$	$V_{th}(V)$	$I_L(A)$	$R_{th}(\Omega)$	$V_{th}(V)$	$I_L(A)$
1	6V and 8V	1.33	7.32	1.156	1.33	7.333	1.158

MATLAB SIMULINK MODEL (NORTON'S):

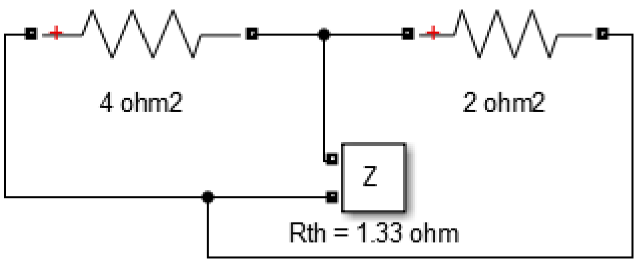
To find I_L:



To find I_{SC}:



To find R_{th}:

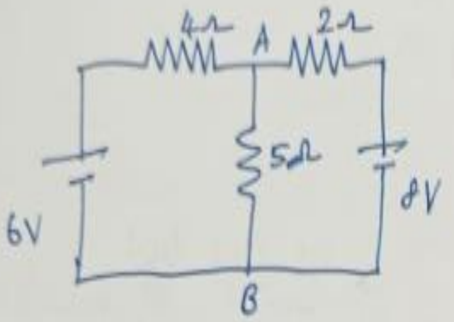


OBSERVATIONS:

S.No.	Supply Voltage (V)	Theoretical values			Measured values		
		$R_{th}(\Omega)$	$I_{SC}(A)$	$I_L(A)$	$R_{th}(\Omega)$	$I_{SC}(A)$	$I_L(A)$
1	6V and 8V	1.33	5.5	1.16	1.33	5.5	1.158

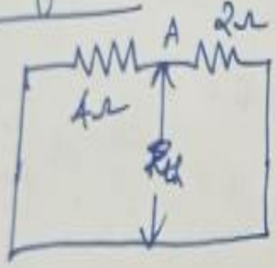
MODEL CALCULATION:

TEST CASE: 4



(i) Model Calculation for Thevenin's:

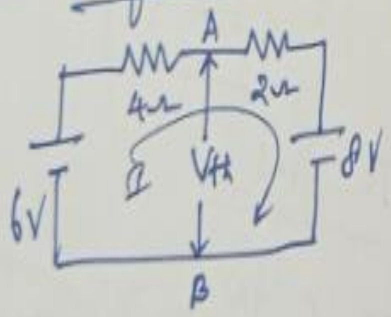
* To find R_{th}:



$$R_{th} = \frac{4\times 2}{(4+2)}$$

$$\boxed{R_{th} = 1.33\Omega}$$

* To find V_{th}:



$$6I = 6-8$$

$$\boxed{I = -0.33\,A}$$

$$V_{th} = 6-4I$$

$$\boxed{V_{th} = 7.32\,V}$$

* To find I_L:

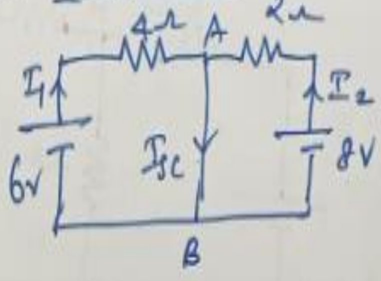
$$I_L = \frac{V_{th}}{R_{th}+R_L} = \frac{7.32}{(1.33+5)}$$

$$\boxed{I_L = 1.156A}$$

(ii) Model Calculation for Norton's

* $R_{th} = 1.33\Omega$ (as Thevenin's)

* To find I_{sc}:



$$I_1 = \frac{6}{4} = 1.5A$$

$$I_2 = \frac{8}{2} = 4A$$

$$\boxed{I_{sc} = I_1 + I_2 = 5.5A}$$

* To find I_L:

$$I_L = \frac{I_{sc}\cdot R_{th}}{R_{th}+R_L}$$

$$= \frac{5.5\times 1.33}{(1.33+5)}$$

$$\boxed{I_L = 1.16A}$$

Expt. No. 05	Verification of Maximum Power Transfer theorem and Superposition theorem

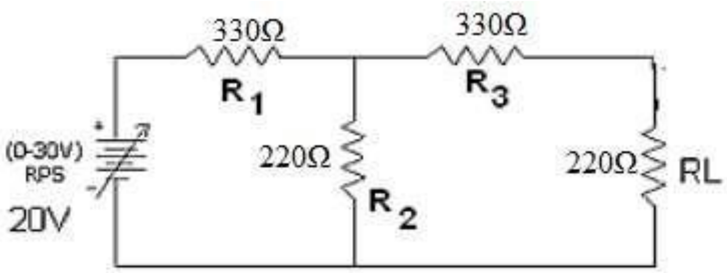
5(a). Verification of Maximum Power Transfer

TheoremAIM:
To verify Maximum Power Transfer Theorem

APPARATUS REQUIRED:

S.No.	Apparatus Name	Range	Quantity
1	DC Regulated Power Supply	(0-30)V	1
2	Voltmeter	(0-30)V	1
3	Ammeter	(0-200)mA	1
4	Resistor	330Ω, 220Ω	Each two
5	Multimeter	-	1
6	Bread board & Connecting wires	--	Required

CIRCUIT DIAGRAM:



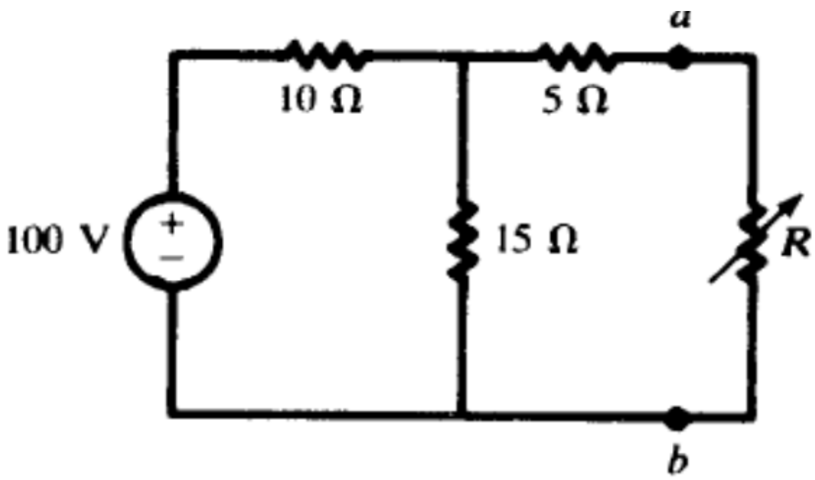
PROCEDURE:

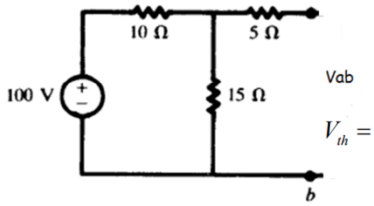
1. Give the connections as per the circuit diagram.
2. Measure R_{th} using a multimeter
3. Measure V_{th} across 220Ω (R_2)
4. Measure load current I_L through R_L
5. Calculate the maximum power transferred to the load

CALCULATION:

Case problems:

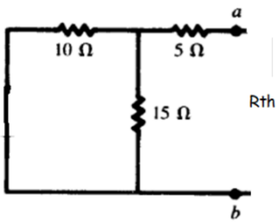
1. Find the value of the adjustable resistance R that dissipates the maximum power across terminals a-b. What is the maximum power that can be delivered to this load?





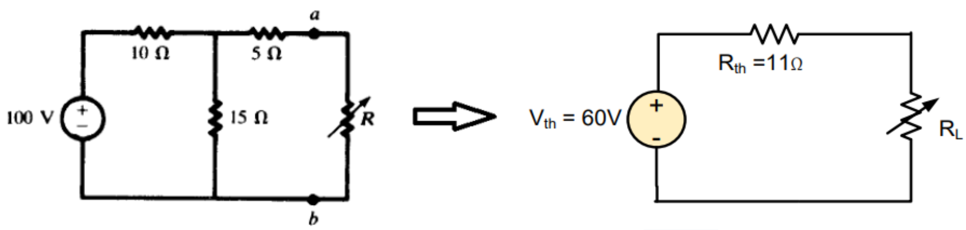
Solution: Obtain Thevenin equivalent of source network

$$V_{th} = V_{ab} = V_{15\Omega} = I_{15\Omega}(15); \quad \mathrm{I}_{15\Omega} = \frac{100}{10+15} = 4A; \quad \boxed{V_{th} = 4(15) = 60V}$$



$$\boxed{R_{th} = \frac{10\times 15}{10+15} + 5 = 11\Omega}$$

Thevenin equivalent is obtained, with V_{th}=60V and R_{th} = 11Ω

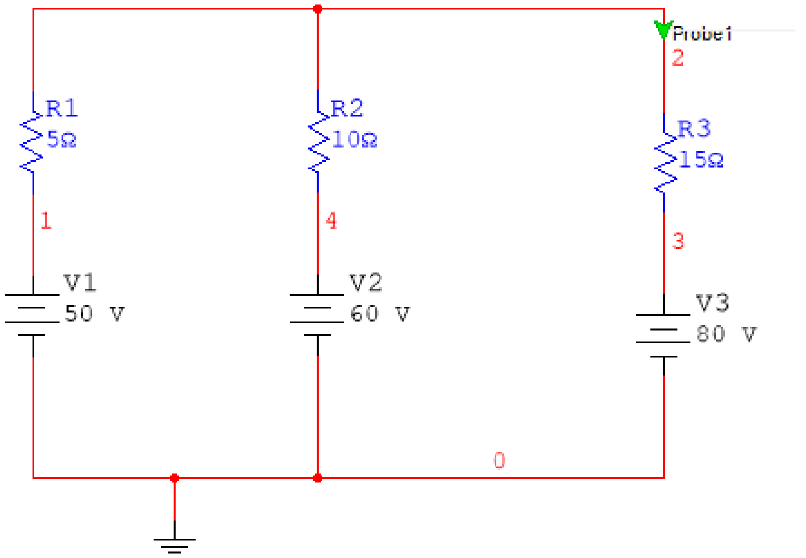


Maximum power transfer occurs for $\boxed{R_L} = R_{th} = \boxed{11\Omega}$

Power delivered to the load is

$$\boxed{P_{\max}} = i^2 R_L = \left(\frac{V_{Th}}{R_{th} + R_L}\right)^2 R_L = \frac{V_{Th}^{\ 2}}{4R_{th}} = \frac{60^2}{4\times 11} = \boxed{81.82W}$$

2. Calculate the Maximum Power Transfer Theorem for given parallel network value R1=5 ohms, R2=10 ohms, R3=15ohms and parallel v1=50V, V2=60V and V3=80V.



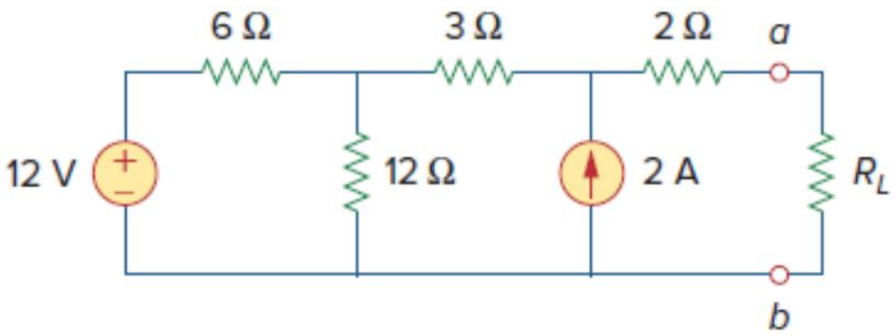
1/R_eq = 1/R1 + 1/R2 + 1/R3
1/R_eq = 1/5 ohms + 1/10 ohms + 1/15 ohms
1/R_eq = 0.2 + 0.1 + 0.0667
1/R_eq = 0.3667
R_eq = 1 / 0.3667
R_eq ≈ 2.7273 ohms

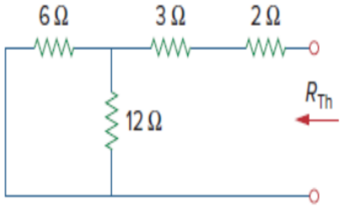
Thevenin voltage (V_{th}):
V_{th} = v1 + v2 + v3
V_{th} = 50V + 60V + 80V
V_{th} = 195V

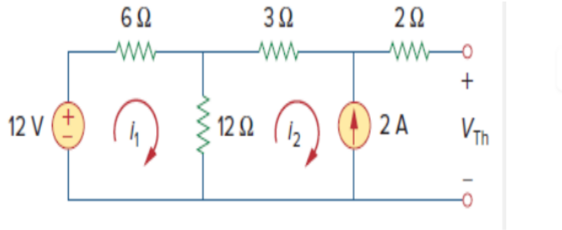
I = V_total / R_eq
I = 190V / 2.7273 ohms
I ≈ 69.6429 A

P_max = (I^2) * R_eq
P_max = $(69.6429\ A)^2$ * 2.7273 ohms
P_max ≈ 13287.2 watts

3. Find the value of RL for maximum power transfer and compute the maximum power delivered







$\boxed{R_{Th}} = 2+3+6\,||\,12 = 5+\frac{6\times 12}{18} = \boxed{9\Omega}$

$-12 + 18i_1 - 12i_2 = 0, \quad i_2 = -2A$

$\Rightarrow i_1 = -2/3.$

KVL around the outer loop: $-12 + 6i_1 + 3i_2 + 2(0) + V_{Th} = 0 \Rightarrow \boxed{V_{Th} = 22V}$

For maximum power transfer,

$R_L = R_{Th} = 9\,\Omega$

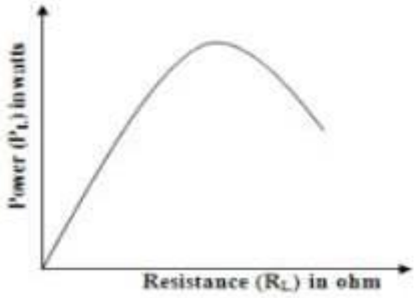
The maximum power is,

$$p_{max} = \frac{V_{Th}^{\ 2}}{4R_L} = \frac{22^2}{4\times 9} = 13.44W$$

OBSERVATIONS:

S.No.	**Supply Voltage (V)**	**Theoretical values**			**Measured values**			**Maximum Power**
		$R_{th}(\Omega)$	$V_{th}(V)$	$I_L(mA)$	$R_{th}(\Omega)$	$V_{th}(V)$	$I_L(mA)$	Pmax = $I_L^2 \cdot R_L$ (watts)
1								
2								
3								
4								

MODEL GRAPH:



RESULT:

Thus the Maximum Power Transfer Theorem is verified.

5(b). Verification of Superposition Theorem

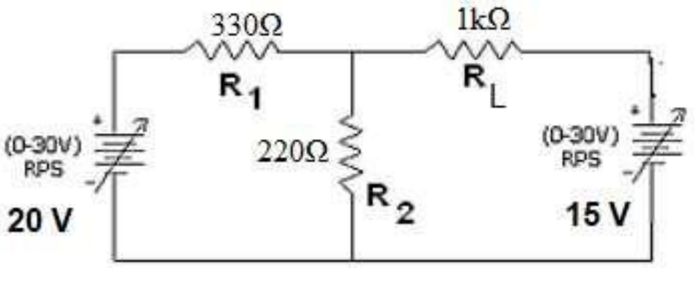
AIM:

To determine the current flow through the load resistor using Superposition Theorem

APPARATUS REQUIRED:

S.No.	Apparatus Name	Range	Quantity
1	DC Regulated Power Supply	(0-30)V	2
2	Voltmeter	(0-30)V	1
3	Ammeter	(0-200)mA	1
4	Resistor	1kΩ, 220Ω, 330 Ω	Each one
5	Multimeter	-	1
6	Bread board & Connecting wires	--	Required

CIRCUIT DIAGRAM:

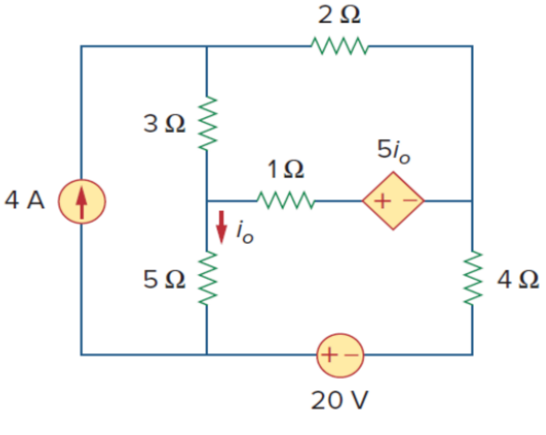


PROCEDURE:

1. Give the connections as per the circuit diagram.
2. Measure current flow through 1kΩ by connecting both the supplies.
3. Short circuit 15 V source.
4. Measure current flow through 1kΩ by connecting 20 V supply.
5. Short circuit 20 V source.
6. Measure current flow through 1kΩ by connecting 15 V supply.
7. Verify the net current through 1kΩ resistor.

Case no.

1. Find i_o in the circuit of Fig using superposition.

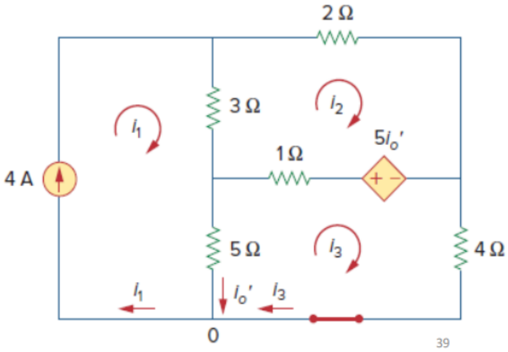


Loop 1: $i_1 = 4A$ (2)

Loop 2: $-3i_1 + 6i_2 - 1i_3 - 5i_o' = 0$ (3)

Loop 3: $-5i_1 - 1i_2 + 10i_3 + 5i_o' = 0$ (4)

Node 0: $i_3 = i_1 - i_0' = 4 - i_0'$ (5)



Substituting (2) and (5) into (3) and (4) gives two simultaneous equations

$3i_2 - 2i'_0 = 8$ (6)

$i_2 - 5i'_0 = 20$ (7)

=> $\boxed{i'_0 = \frac{52}{17}A}$ (8)

To obtain i_0'' we turn off the 4-A current source.

KVL in upper loop: $6i_4 - i_5 - 5i''_0 = 0$ (9)

KVL in lower loop: $-i_4 + 10i_5 - 20 + 5i_0'' = 0$ (10)

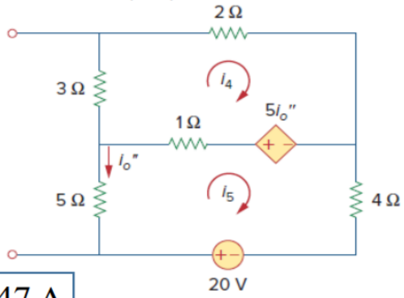
But $i_5 = -i_0''$.

Substituting this in Eqs. (9) and (10) gives

$6i_4 - 4i_0'' = 0$ (11)

$i_4 + 5i_0'' = -20$ (12)

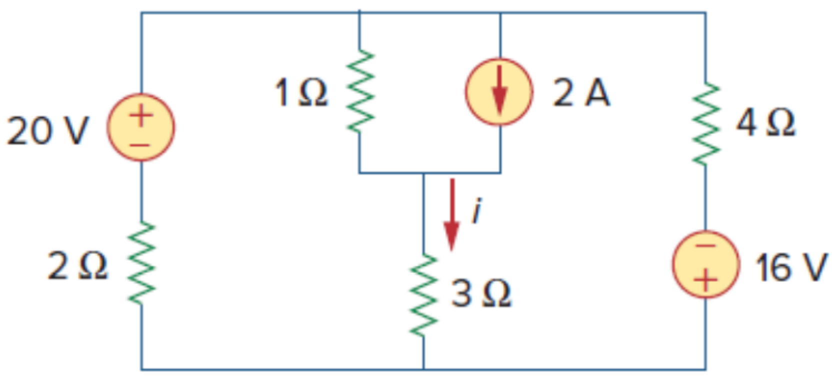
=> $\boxed{i_0'' = -\frac{60}{17}A}$ (13)



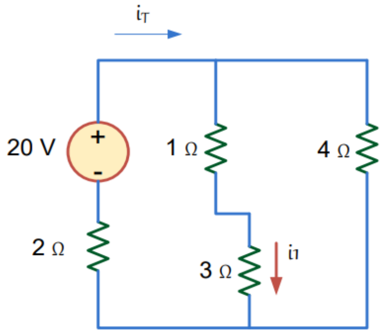
(b)

$\boxed{i_0} = i_0' + i_0'' = (52 – 60)/17 = -8/17 = \boxed{-0.47\text{ A}}$

2. Use superposition to find current flowing through the 3-Ω resistor.



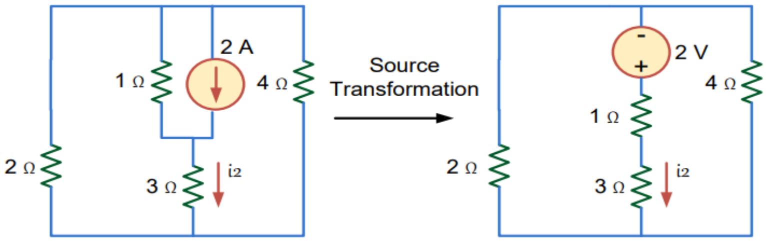
Solution: Since there are three sources, $i = i_1 + i_2 + i_3$



First consider 20V source only

$$R_{eq} = \frac{4\times(3+1)}{4+3+1} + 2 = 4\Omega$$

$$i_T = \frac{20}{4} = 5A; \quad \boxed{i_1} = \frac{5\times 4}{1+3+4} = \boxed{2.5A}(current\,division)$$



$$R_{eq} = \frac{4\times 2}{4+2} + 1 + 3 = 5.33\Omega$$

$$i_T = \frac{2}{5.33} = 0.375A; \quad \boxed{i_2 = i_T = 0.375A}$$

Finally consider 16V source only

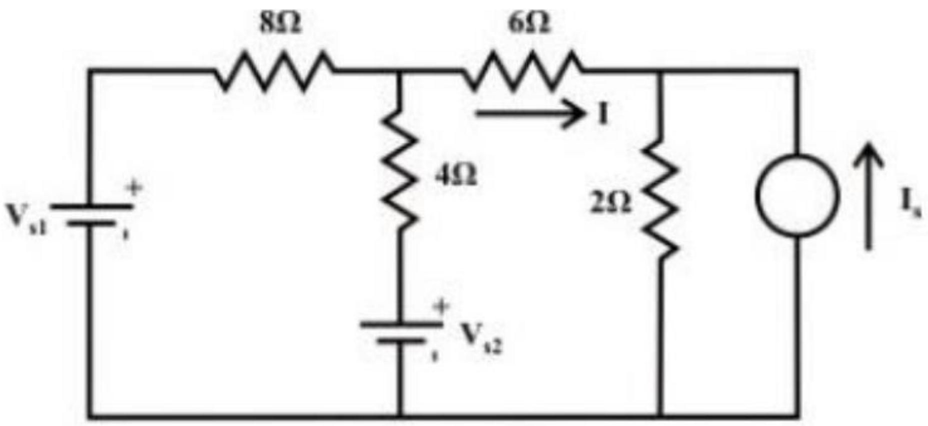
$$R_{eq} = \frac{4\times 2}{4+2} + 1 + 3 = 5.33\Omega$$

$$i_T = \frac{16}{5.33} = 3A; \quad -i_3 = \frac{3\times 2}{2+1+3} = 1A;$$

Current flowing through 3-Ω resistor is

$$\boxed{i} = i_1 + i_2 + i_3 = 2.5 + 0.375 - 1 = \boxed{1.875A}$$

3 For the circuit shown in fig, the value of Vs1 and Is are fixed. When Vs2 = 0, the current I = 4A . Find the value of I when Vs2 = 32 V



Solution: The current flowing through 6Ω resistor due to the voltage and current sources are given by (assuming circuit linearity):

$$I = I'(due\ to\ V_{s1}) + I''(due\ to\ V_{s2}) + I'''(due\ to\ I_s)$$

$$\boxed{I = \alpha V_{s1} + \beta V_{s2} + \eta I_s} \quad (1)$$

where, parameters α, β and η represent constants

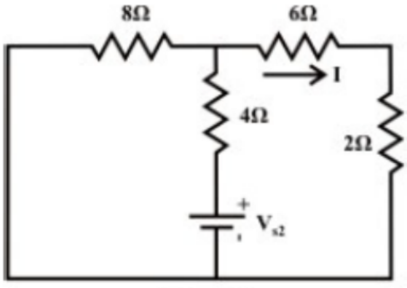
When V_{s2}=0, I = 4 A => $I = I'(due\ to\ V_{s1}) + I'''(due\ to\ I_s) = 4$

=> $\boxed{I = \alpha V_{s1} + \eta I_s = 4}$ (2)

When V_{s2} = 32 V is acting alone: $I_T = \frac{V_{s2}}{R_{eq}} = \frac{32}{(8\,||\,8)+4} = 4A$

$$I_{vs2} = I'' = \frac{I_T \times 8}{8+8}(current\ division) = \frac{4\times 8}{16} = 2A$$

$\boxed{I'' = \beta V_{s2} = 2A}$ (3)



Current flow through 6Ω resistor when V_{s2} = 32 V is

$$\boxed{I = \alpha V_{s1} + \beta V_{s2} + \eta I_s \quad = 4 + 2 = 6A}$$

OBSERVATIONS:

S.No.	Measured Current (mA) through 1kΩ when both supplies are connected	Calculated Current (mA) through 1kΩ		Measured Current (mA) through 1kΩ		Net current (mA)
		V= 20 V	V= 15 V	V= 20 V	V= 15 V	I
1.						

RESULT:

Thus the current flow through the load resistor is determined using Superposition Theorem.

Experiment No.: 7

LOAD TEST ON SINGLE PHASE TRANSFORMER

Aim:

A load test on a single-phase transformer is conducted to evaluate the transformer's performance under full load conditions. The test helps determine the voltage regulation, efficiency, and overall behaviour of the transformer when it is delivering power to a load.

Apparatus required:

S. No.	Apparatus required	Range	Quantity
1	Single-phase transformer	1ϕ, (0-260)V	1
2	Voltmeter	(0-150)V (0-300) V MI type	1 Each
3	Ammeter	(0-10)A (0-5) A MI type	1 Each
4	Wattmeter	(300V, 5A) (150V, 5A) UPF	1 Each
5	Supply source (AC power source)		
6	Variable resistive load or a load bank	5KW, 230V	1
7	Connecting wires	As required	

Procedure:

1. **Setup:**
   a. Connect the primary winding of the transformer to the AC power source.
   b. Connect the secondary winding to a variable resistive load or load bank.
   c. Connect the voltmeter across the secondary winding to measure the secondary voltage.
   d. Connect the ammeter in series with the load to measure the load current.
   e. Connect the wattmeter to measure the power consumed by the load.
2. **Adjust the Load:**
   a. Start with no load on the secondary side and gradually increase the load by adjusting the variable resistor or load bank.

b. Increase the load until the rated current flows through the secondary winding.

3. **Record Readings:**
   - For each load setting, record the following:
     - Primary voltage (V_1)
     - Primary current (I_1)
     - Secondary voltage (V_2)
     - Secondary current (I_2)
     - Power consumed by the load (W)

4. **Calculate Voltage Regulation:**
   - Voltage regulation is a measure of how much the secondary voltage drops from no-load to full-load conditions. It can be calculated using the formula:

$$\boxed{\text{Voltage Regulation } (\%) = \frac{V_{\text{no load}} - V_{\text{full load}}}{V_{\text{full load}}} \times 100}$$

V_{noload} is the secondary voltage with no load, and V_{fullload} is the secondary voltage with full load.

5. Calculate Efficiency:

- Efficiency (η) of the transformer can be calculated using the formula:

$$\eta = \frac{P_{\text{output}}}{P_{\text{input}}} \times 100$$

- $P_{\text{output}} = V_{\text{load}} \times I_{\text{load}}$
- $P_{\text{input}} = P_{\text{output}} + P_{\text{losses}}$ where P_{losses} includes both copper and iron losses.

6. Analyse the Results:

- Use the data collected to analyse the transformer's performance. Look for any significant drops in voltage or unexpected losses which could indicate issues with the transformer.

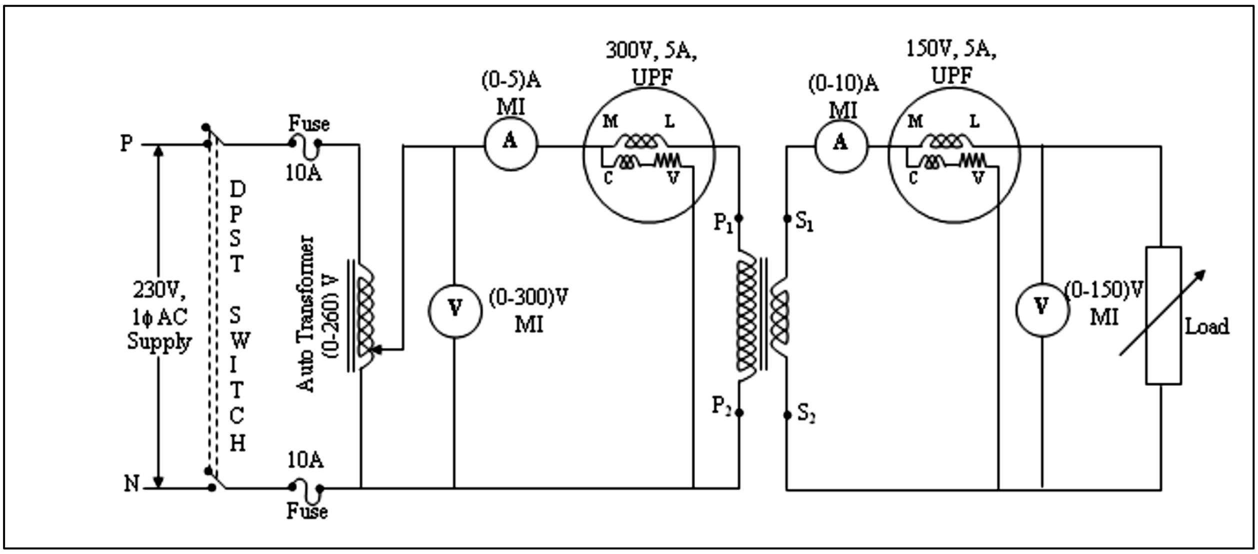
Precautions:

Ensure that the transformer and the equipment used for testing are properly rated for the test conditions.

a. Be cautious while handling electrical equipment and ensure all connections are secure to avoid short circuits or shocks.

b. Gradually increase the load to prevent sudden surges that could damage the transformer.

Circuit Diagram



Fuse Rating:

- Primary Fuse: 125% of 27.17 A ≈ 34 A (choose a 35 A fuse)
- Secondary Fuse: 125% of 54.35 A ≈ 68 A (choose a 70 A fuse)

Name late details:

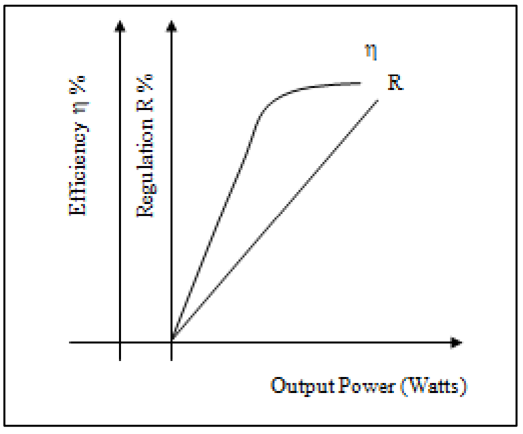
Parameter	Details
Manufacturer	
Serial Number	
Rated Power (kVA or VA)	
Primary Voltage (V)	
Secondary Voltage (V)	
Frequency (Hz)	
Phase	
Cooling Type	
Impedance (%)	
Insulation Class	
Temperature Rise (°C)	
Weight (kg or lbs)	
Date of Manufacture	

Connection Type	
Full Load Current (Primary)	
Full Load Current (Secondary)	
Efficiency (%)	
Standards Compliance	

Tabulation:

S.No.	Load Current (I_2)	Secondary Voltage (V_2)	Primary Voltage (V_1)	Primary Current (I_1)	Power Input (W_{input})	Power Output (W_{output})	Efficiency (η)	Voltage Regulation (%)
1	0.2 A	230 V	230 V	0.21 A	48 W	46 W	95.83 %	-
2	0.4 A	228 V	230 V	0.42 A	95 W	91 W	95.79 %	0.87 %
3	0.6 A	226 V	230 V	0.63 A	142 W	136 W	95.77 %	1.77 %
4	0.8 A	224 V	230 V	0.84 A	189 W	182 W	95.77 %	2.68 %
5	1.0 A	222 V	230 V	1.05 A	236 W	227 W	95.76 %	3.60 %

Model Graph



1. **Voltage Regulation vs. Load Current**
2. **Efficiency vs. Load Current**

1. Voltage Regulation vs. Load Current

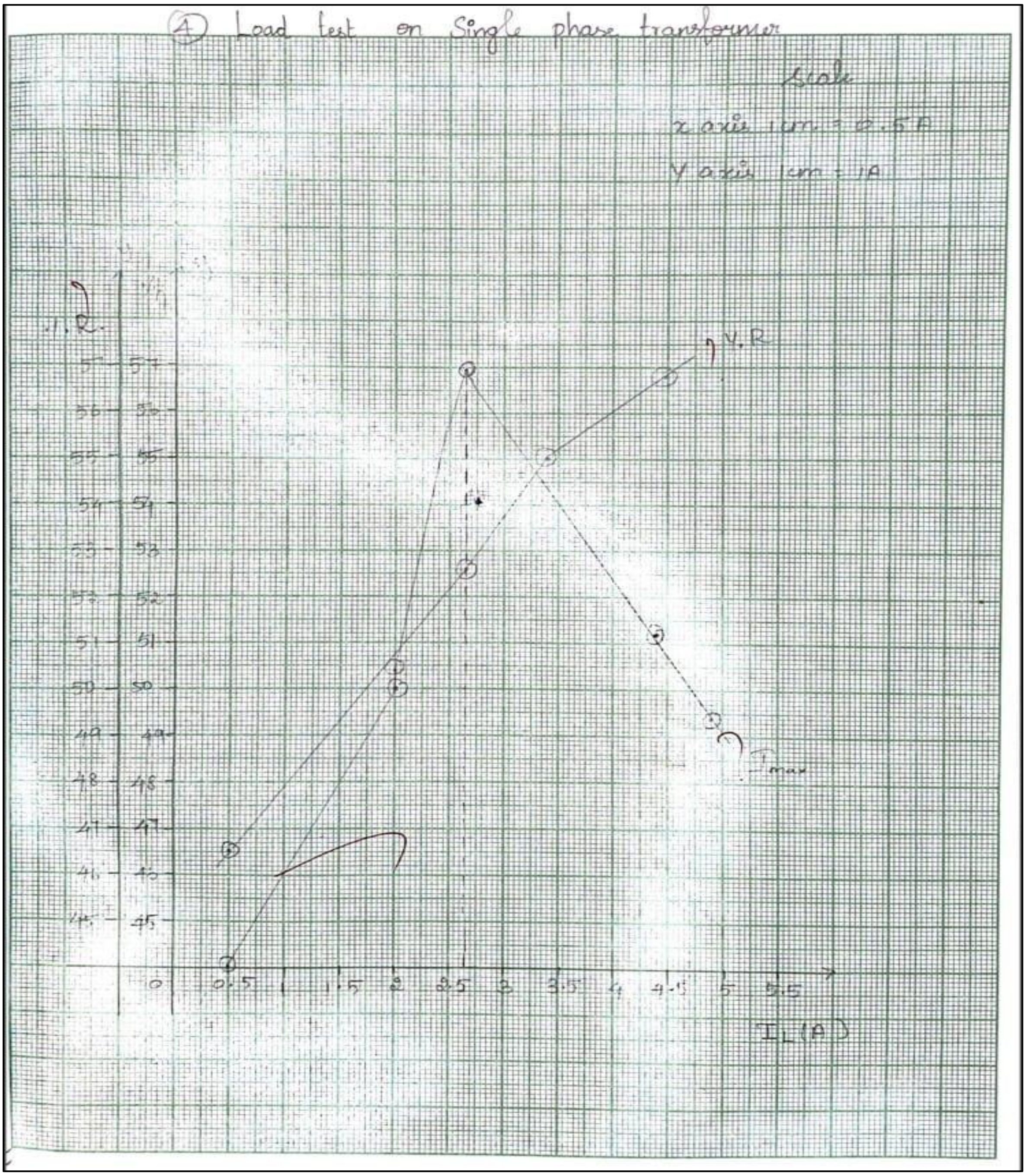
This graph shows how the voltage regulation of the transformer varies with the load current.

- **X-Axis:** Load Current (I_2) in Amperes
- **Y-Axis:** Voltage Regulation (%)

2. Efficiency vs. Load Current

This graph shows how the efficiency of the transformer varies with the load current.

- **X-Axis:** Load Current (I_2) in Amperes
- **Y-Axis:** Efficiency (%)



Test Case 1: Basic Load Test Simulation

This program simulates a basic load test on a single-phase transformer by applying a resistive load to the secondary side and measuring the voltage and current.

% Transformer Parameters

V1 = 230; % Primary Voltage (V)

```
V2 = 115;       % Secondary Voltage (V)
P_rated = 5000; % Rated Power (VA)
R_load = [5, 10, 20, 50]; % Load Resistance Values (Ohms)
% Simulation
for i = 1:length(R_load)
    I2 = V2 / R_load(i);        % Load Current (A)
    V2_load = V2 - I2 * (V2/V1);% Secondary Voltage under Load (V)
    I1 = P_rated / V1;          % Primary Current (A)
    disp(['Load Resistance: ', num2str(R_load(i)), ' Ohms']);
    disp(['Secondary Voltage: ', num2str(V2_load), ' V']);
    disp(['Secondary Current: ', num2str(I2), ' A']);
    disp(['Primary Current: ', num2str(I1), ' A']);
    disp('------------------------------------');
end
```

Output:

```
Load Resistance: 5 Ohms
Secondary Voltage: 103.5 V
Secondary Current: 23 A
Primary Current: 21.7391 A
------------------------------
Load Resistance: 10 Ohms
Secondary Voltage: 109.25 V
Secondary Current: 11.5 A
Primary Current: 21.7391 A
------------------------------
Load Resistance: 20 Ohms
Secondary Voltage: 112.125 V
Secondary Current: 5.75 A
Primary Current: 21.7391 A
------------------------------
Load Resistance: 50 Ohms
Secondary Voltage: 113.85 V
Secondary Current: 2.3 A
Primary Current: 21.7391 A
------------------------------
```

Test Case 2: Efficiency Calculation

This program calculates the efficiency of the transformer based on the input and output power.

```
% Transformer Parameters
V1 = 230;       % Primary Voltage (V)
```

```
V2 = 115;       % Secondary Voltage (V)
P_rated = 5000; % Rated Power (VA)
R_load = 20;    % Load Resistance (Ohms)
P_loss = 100;   % Estimated Total Losses (Copper + Iron) in Watts
% Load Test
I2 = V2 / R_load; % Secondary Current (A)
P_out = V2 * I2;  % Output Power (W)
P_in = P_out + P_loss; % Input Power (W)
% Efficiency Calculation
efficiency = (P_out / P_in) * 100;
% Display Results
disp(['Load Resistance: ', num2str(R_load), ' Ohms']);
disp(['Secondary Current: ', num2str(I2), ' A']);
disp(['Output Power: ', num2str(P_out), ' W']);
disp(['Input Power: ', num2str(P_in), ' W']);
disp(['Efficiency: ', num2str(efficiency), ' %']);
```

Output:

```
Load Resistance: 20 Ohms
Secondary Current: 5.75 A
Output Power: 661.25 W
Input Power: 761.25 W
Efficiency: 86.8637 %
```

Test Case 3: Voltage Regulation Calculation

This program calculates the voltage regulation of the transformer based on the no-load and full-load conditions.

```
% Transformer Parameters
V_no_load = 115;  % No Load Secondary Voltage (V)
V_full_load = 110;% Full Load Secondary Voltage (V)
% Voltage Regulation Calculation
voltage_regulation = ((V_no_load - V_full_load) / V_full_load) * 100;
% Display Result
disp(['Voltage Regulation: ', num2str(voltage_regulation), ' %']);
```

Output:

```
Load Resistance: 20 Ohms
Secondary Current: 5.75 A
Output Power: 661.25 W
Input Power: 761.25 W
Efficiency: 86.8637 %
Voltage Regulation: 4.5455 %
```

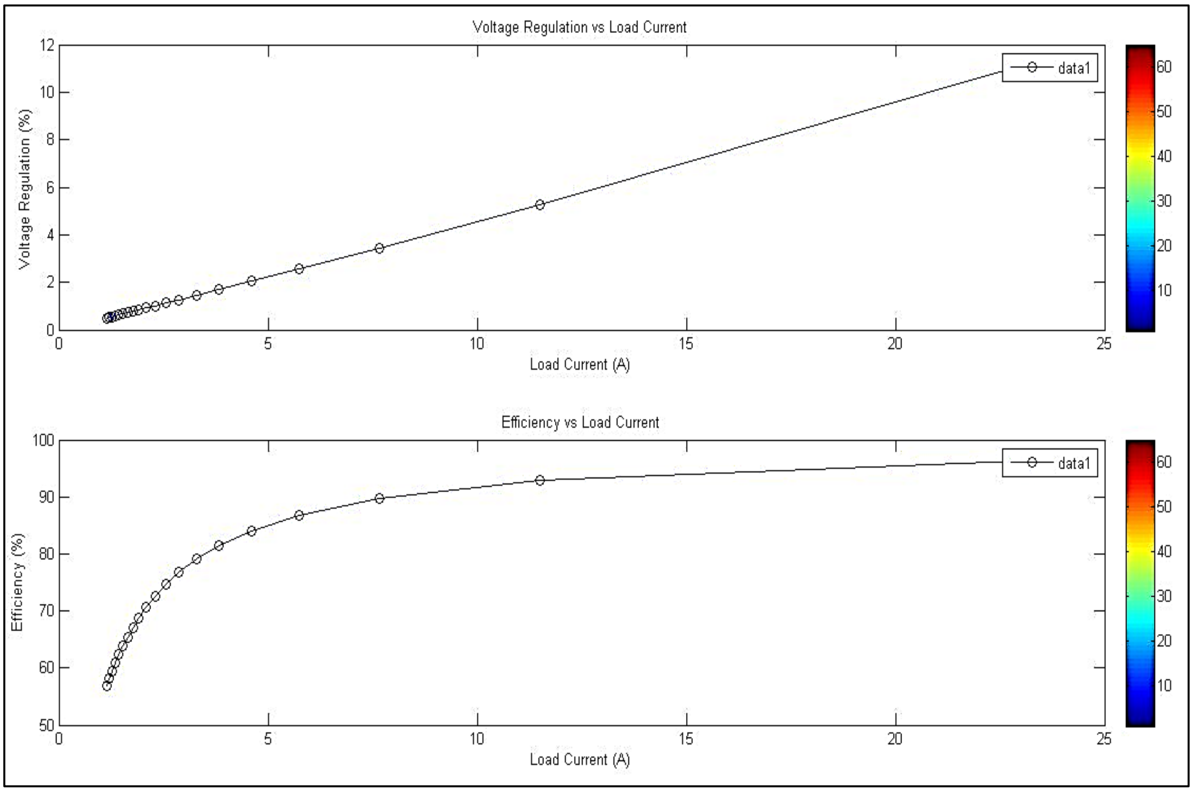
Test Case 4: Plotting Voltage Regulation and Efficiency vs. Load Current

This program plots the voltage regulation and efficiency against the load current.

```
% Transformer Parameters
V1 = 230;       % Primary Voltage (V)
V2 = 115;       % Secondary Voltage (V)
P_rated = 5000; % Rated Power (VA)
R_load = linspace(5, 100, 20); % Load Resistance Values (Ohms)
P_loss = 100;   % Estimated Total Losses (Copper + Iron) in Watts
% Initialize Arrays
I2_array = zeros(1, length(R_load));
efficiency_array = zeros(1, length(R_load));
voltage_regulation_array = zeros(1, length(R_load));
% Simulation Loop
for i = 1:length(R_load)
    I2 = V2 / R_load(i);          % Secondary Current (A)
    P_out = V2 * I2;              % Output Power (W)
    P_in = P_out + P_loss;        % Input Power (W)
    efficiency_array(i) = (P_out / P_in) * 100;
    V2_full_load = V2 - I2 * (V2/V1); % Full Load Voltage
    voltage_regulation_array(i) = ((V2 - V2_full_load) / V2_full_load) * 100;
    I2_array(i) = I2;
end
% Plotting
figure;
subplot(2, 1, 1);
plot(I2_array, voltage_regulation_array, '-o');
xlabel('Load Current (A)');
ylabel('Voltage Regulation (%)');
```

```
title('Voltage Regulation vs Load Current');
subplot(2, 1, 2);
plot(I2_array, efficiency_array, '-o');
xlabel('Load Current (A)');
ylabel('Efficiency (%)');
title('Efficiency vs Load Current');
```

Output:



RESULT:

Thus the load test on single phase transformer is conducted.

Expt. No. 8	OC and SC test on single phase transformer

AIM:

To conduct load test on single phase transformer and to find efficiency and percentage regulation.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-10)A (0-5) A	MI MI	1 1
2	Voltmeter	(0-150)V (0-300) V	MI MI	1 1
3	Wattmeter	(300V, 5A) (150V, 5A)	Upf Upf	1 1
4	Auto Transformer	1Ø, (0-260)V	-	1
5	Resistive Load	5KW, 230V	-	1
6	Connecting Wires	2.5sq.mm	Copper	Few

PRECAUTIONS:

1. Auto Transformer should be in minimum position.
2. The AC supply is given and removed from the transformer under no load condition.

NAME PLATE DETAILS:

- KVA Rating : 1KVA
- Rated H.V side Voltage : 230V
- Rated H.V side Current : 43A
- Rated L.V side Voltage : 115V
- Rated L.V side Current : 8.6A

FUSE RATING CALCULATIONS:

The required fuse ratings for O.C. are 20 % of rated current on L.V side

= (20/100) x Rated current on L.V. Side

= $\frac{20}{100} \times 4.3 = 0.86A \simeq 2Amps.$

The required fuse ratings for S.C. are 120 % of rated current on H.V side

= (120/100) x Rated current on H.V. Side

= $\frac{120}{100} \times 8.6 = 10.32A \simeq 20Amps.$

Experiment No.: 9

CACULATION OF SECONDARY TURNS AND CURRENT IN A TRANSFORMER

Aim:

To evaluate secondary turns and current in a transformer. The test helps determine the voltage regulation,efficiency, and overall behaviour of the transformer when it is delivering power to a load.

Apparatus required:

S. No.	Apparatus required	Range	Quantity
1	Single-phase transformer	1ϕ, (0-260)V	1
2	Voltmeter	(0-150)V (0-300) V MI type	1 Each
3	Ammeter	(0-10)A (0-5) A MI type	1 Each
4	Wattmeter	(300V, 5A) (150V, 5A) UPF	1 Each
5	Supply source (AC power source)		
6	Variable resistive load or a load bank	5KW, 230V	1
7	Connecting wires	As required	

Procedure:

Step 1: Understand the Transformer Basics

A transformer operates on the principle of electromagnetic induction and consists of:

- **Primary Winding**: Connected to the input voltage source.
- **Secondary Winding**: Connected to the load.
- **Turn Ratio**: The ratio of the number of turns in the primary winding (Np) to the number of turns in the secondary winding (Ns).

Step 2: Gather Required Parameters

Before performing calculations, you need to gather the following parameters:

1. **Primary Voltage (Vp)**: The voltage applied to the primary winding.
2. **Primary Turns (Np)**: The number of turns in the primary winding.
3. **Primary Current (Ip)**: The current flowing through the primary winding.
4. **Desired Secondary Voltage (Vs)**: The voltage you want across the secondary winding.

Step 3: Calculate Secondary Turns (Ns)

Use the turn ratio equation:

$Ns=(Vs/Vp)\times Np$

- **Input**: Vs, Vp, and Np.
- **Output**: Calculate Ns.

Step 4: Calculate Secondary Current (Is)

Use the current relationship:

$Is=(Np/Ns)\times Ip$

- **Input**: Ip and the calculated Ns.
- **Output**: Calculate Is.

Step 5: Perform Example Calculations

Example:

- Given:
    - $Vp=230$ V (primary voltage)
    - $Np=100$ turns (primary turns)
    - $Ip=5$ A (primary current)
    - $Vs=115$ V (desired secondary voltage)

Calculations:

1. Calculate Ns:

   $Ns=(Vs/Vp)\times Np=115/230\times 100=50$ turns

2. Calculate Is:

   $Is=(Np/Ns)\times Ip=100/50\times 5=10$ A

Step 6: Review Results

- **Total Secondary Turns (Ns)**: 50 turns
- **Secondary Current (Is)**: 10 A

Conclusion

By following these steps, you can effectively calculate the secondary turns and current in a transformer. This procedure can be adapted for any set of input values, making it a versatile method for transformer analysis

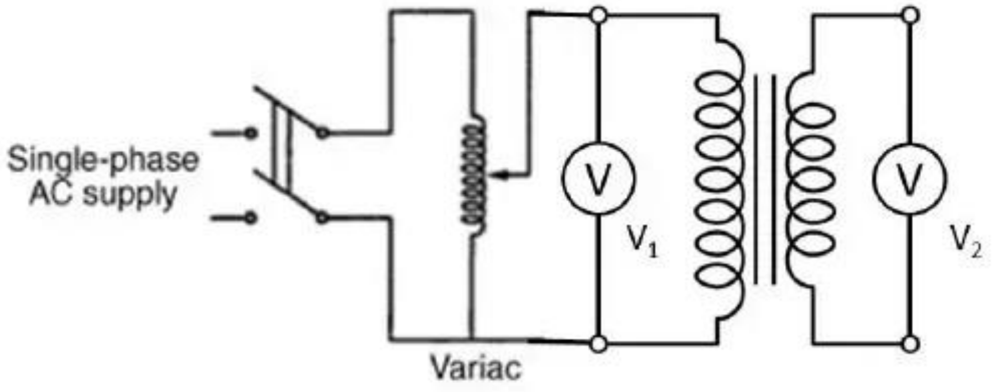
Precautions:

Ensure that the transformer and the equipment used for testing are properly rated for the test conditions.

a. Be cautious while handling electrical equipment and ensure all connections are secure to avoid short circuits or shocks.

b. Gradually increase the load to prevent sudden surges that could damage the transformer.

Circuit Diagram



Fuse Rating:

- Primary Fuse: 125% of 27.17 A ≈ 34 A (choose a 35 A fuse)
- Secondary Fuse: 125% of 54.35 A ≈ 68 A (choose a 70 A fuse)

Name late details:

Parameter	**Details**
Manufacturer	
Serial Number	
Rated Power (kVA or VA)	
Primary Voltage (V)	
Secondary Voltage (V)	
Frequency (Hz)	
Phase	
Cooling Type	
Impedance (%)	
Insulation Class	
Temperature Rise (°C)	
Weight (kg or lbs)	
Date of Manufacture	

Connection Type	
Full Load Current (Primary)	
Full Load Current (Secondary)	
Efficiency (%)	
Standards Compliance	

Tabulation:

S.No.	Load Current(I_2)	Secondary Voltage (V_2)	Primary Voltage (V_1)	Primary Current(I_1)	Power Input (W_{input})	Power Output (W_{output})
1	0.2 A	230 V	230 V	0.21 A	48 W	46 W
2	0.4 A	228 V	230 V	0.42 A	95 W	91 W
3	0.6 A	226 V	230 V	0.63 A	142 W	136 W
4	0.8 A	224 V	230 V	0.84 A	189 W	182 W
5	1.0 A	222 V	230 V	1.05 A	236 W	227 W

Test Case 1: Basic Test Simulation

Given Parameters

- **Primary Turns (NpN_pNp)**: 200 turns
- **Primary Voltage (VpV_pVp)**: 400 V
- **Primary Current (IpI_pIp)**: 2 A
- **Desired Secondary Voltage (VsV_sVs)**: 200 V

Calculations

1. Calculate the Turns Ratio

N=VsVp=200400=0.5N =VpVs=400200=0.5

2. Calculate the Secondary Turns (Ns)

Using the turns ratio:

Ns=Np×VsVp=200×0.5=100 turnsN_s = 200 \times 0.5 = 100 \text{ turns}Ns=Np×VpVs =200×0.5=100 turns

3. Calculate the Secondary Current (Is)

Using the current relationship:

Is=Ip×NsNp=2×100200=1 AI_s = I_p = 1}Is=Ip×NpNs=2×200100=1 A

Summary of Results

Parameter	Symbol	Value
Primary Turns	NpN_pNp	200 turns
Primary Voltage	VpV_pVp	400 V
Primary Current	IpI_pIp	2 A
Desired Secondary Voltage	VsV_sVs	200 V
Turns Ratio	NNN	0.5
Secondary Turns	NsN_sNs	100 turns
Secondary Current	IsI_sIs	1 A

Test case 1. Calculate the Turns Ratio

% MATLAB Script for Transformer Calculations

```
% Given Parameters
Np = 200;          % Primary turns
Vp = 400;          % Primary voltage in volts
Ip = 2;            % Primary current in amperes
Vs = 200;          % Desired secondary voltage in volts
% Calculate Turns Ratio
turns_ratio = Vs / Vp;
% Calculate Secondary Turns (Ns)
Ns = Np * turns_ratio;
% Calculate Secondary Current (Is)
Is = Ip * (Ns / Np);
% Display Results
fprintf('Given Parameters:\n');
fprintf('Primary Turns (Np): %d turns\n', Np);
fprintf('Primary Voltage (Vp): %.2f V\n', Vp);
fprintf('Primary Current (Ip): %.2f A\n', Ip);
fprintf('Desired Secondary Voltage (Vs): %.2f V\n', Vs);
fprintf('\nCalculations:\n');
fprintf('Turns Ratio (N): %.2f\n', turns_ratio);
fprintf('Secondary Turns (Ns): %.2f turns\n', Ns);
fprintf('Secondary Current (Is): %.2f A\n', Is);
```

Output:
Given Parameters:
Primary Turns (Np): 200 turns
Primary Voltage (Vp): 400.00 V
Primary Current (Ip): 2.00 A
Desired Secondary Voltage (Vs): 200.00 V
Calculations:
Turns Ratio (N): 0.50
Secondary Turns (Ns): 100.00 turns
Secondary Current (Is): 1.00 A

Test Case 2: Calculate the Secondary Turns

```
% MATLAB Script to Calculate Secondary Turns in a Transformer
% Given Parameters
Np = 200;          % Primary turns
Vp = 400;          % Primary voltage in volts
Vs = 200;          % Desired secondary voltage in volts
% Calculate Turns Ratio
turns_ratio = Vs / Vp;
% Calculate Secondary Turns (Ns)
Ns = Np * turns_ratio;
% Display Results
fprintf('Given Parameters:\n');
fprintf('Primary Turns (Np): %d turns\n', Np);
```

```
fprintf('Primary Voltage (Vp): %.2f V\n', Vp);
fprintf('Desired Secondary Voltage (Vs): %.2f V\n', Vs);
fprintf('\nCalculation:\n');
fprintf('Secondary Turns (Ns): %.2f turns\n', Ns);
```

Output:
Given Parameters:
Primary Turns (Np): 200 turns
Primary Voltage (Vp): 400.00 V
Desired Secondary Voltage (Vs): 200.00 V
Calculation:
Secondary Turns (Ns): 100.00 turns

Test Case 3: Calculate the Secondary Current

```
% MATLAB Script to Calculate Secondary Current in a Transformer

% Given Parameters

Np = 200;          % Primary turns

Vp = 400;          % Primary voltage in volts

Ip = 2;            % Primary current in amperes

Vs = 200;          % Desired secondary voltage in volts

% Calculate Turns Ratio

turns_ratio = Vs / Vp;

% Calculate Secondary Turns (Ns)

Ns = Np * turns_ratio;

% Calculate Secondary Current (Is)

Is = Ip * (Ns / Np);


% Display Results

fprintf('Given Parameters:\n');

fprintf('Primary Turns (Np): %d turns\n', Np);

fprintf('Primary Voltage (Vp): %.2f V\n', Vp);

fprintf('Primary Current (Ip): %.2f A\n', Ip);

fprintf('Desired Secondary Voltage (Vs): %.2f V\n', Vs);

fprintf('\nCalculations:\n');

fprintf('Turns Ratio (N): %.2f\n', turns_ratio);

fprintf('Secondary Turns (Ns): %.2f turns\n', Ns);

fprintf('Secondary Current (Is): %.2f A\n', Is);
```

Output:

Given Parameters:

Primary Turns (Np): 200 turns

Primary Voltage (Vp): 400.00 V

Primary Current (Ip): 2.00 A

Desired Secondary Voltage (Vs): 200.00 V

Calculations:

Turns Ratio (N): 0.50

Secondary Turns (Ns): 100.00 turns

Secondary Current (Is): 1.00 A

Test Case 4: Calculate the Secondary Current:

```
% MATLAB Script to Calculate Secondary Current in a Transformer
% Given Parameters
Np = 200;          % Number of primary turns
Vs = 200;          % Secondary voltage in volts
Vp = 400;          % Primary voltage in volts
Ip = 2;            % Primary current in amperes
% Calculate Turns Ratio
turns_ratio = Vs / Vp;

% Calculate Secondary Turns (Ns)
Ns = Np * turns_ratio;
% Calculate Secondary Current (Is) using the turns ratio
Is = Ip * (Np / Ns);
% Display Results
fprintf('Given Parameters:\n');
fprintf('Primary Turns (Np): %d turns\n', Np);
fprintf('Primary Voltage (Vp): %.2f V\n', Vp);
fprintf('Primary Current (Ip): %.2f A\n', Ip);
fprintf('Secondary Voltage (Vs): %.2f V\n', Vs);
fprintf('\nCalculations:\n');
fprintf('Turns Ratio (N): %.2f\n', turns_ratio);
fprintf('Secondary Turns (Ns): %.2f turns\n', Ns);
fprintf('Secondary Current (Is): %.2f A\n', Is);
```

Output:

Given Parameters:

Primary Turns (Np): 200 turns

Primary Voltage (Vp): 400.00 V

Primary Current (Ip): 2.00 A

Secondary Voltage (Vs): 200.00 V

Calculations:

Turns Ratio (N): 0.50

Secondary Turns (Ns): 100.00 turns

Secondary Current (Is): 4.00 A

Result :

Parameter	Symbol	Value
Primary Turns	Np	200 turns
Primary Voltage	Vp	400 V
Primary Current	Ip	2 A
Desired Secondary Voltage	Vs	200 V
Turns Ratio	N	0.5
Secondary Turns	Ns	100 turns
Secondary Current	Is	1 A

RESULT:

Thus the calculation of secondary turns and current in a transformer is done.

11.LOAD TEST ON SINGLE PHASE INDUCTION MOTOR

AIM:

To conduct load test on the given single phase induction motor and to plot its performance characteristics.

(i) Electrical characteristics – speed, torque, slip, power factor and efficiency vs. output power

APPARATUS REQUIRED:

S.NO	APPARATUS	SPECIFICATIONS	QUANTITY
1	VOLTMETER	(0-300V) MI	1
2	AMMETER	(0-10A) MI	1
3	WATTMETER	(300V,10A,UPF)	1
4	TACHOMETER	(0-10000 RPM)	1

FORMULAE:

1. circumference of the brake drum = 2ΠR (m)
   R = Radius of the brake drum

2. Input power W (watts)
   W = wattmeter readings

3. Torque (T) = 9.81* R * (S_1 ~ S_2) (N-m)
   S_1, S2 = spring balance readings (Kg)

4. Output power = $\frac{2\pi NT}{60}$ (watts)

   N- Speed in rpm

5. % Efficiency (η) = $\frac{output\ power}{input\ power} x100$

6. Power factor, COS Φ= $\frac{W}{VI}$

7. % Slip, S = $\frac{Ns - N}{Ns} \times 100$

   N_S = synchronous speed = $\frac{120f}{P}$ (rpm)

   P = no. of poles
   F=frequency of supply (Hz)

PRECAUTIONS:

1. The auto transformer is kept at minimum voltage position.
2. The motor is started at no load condition.

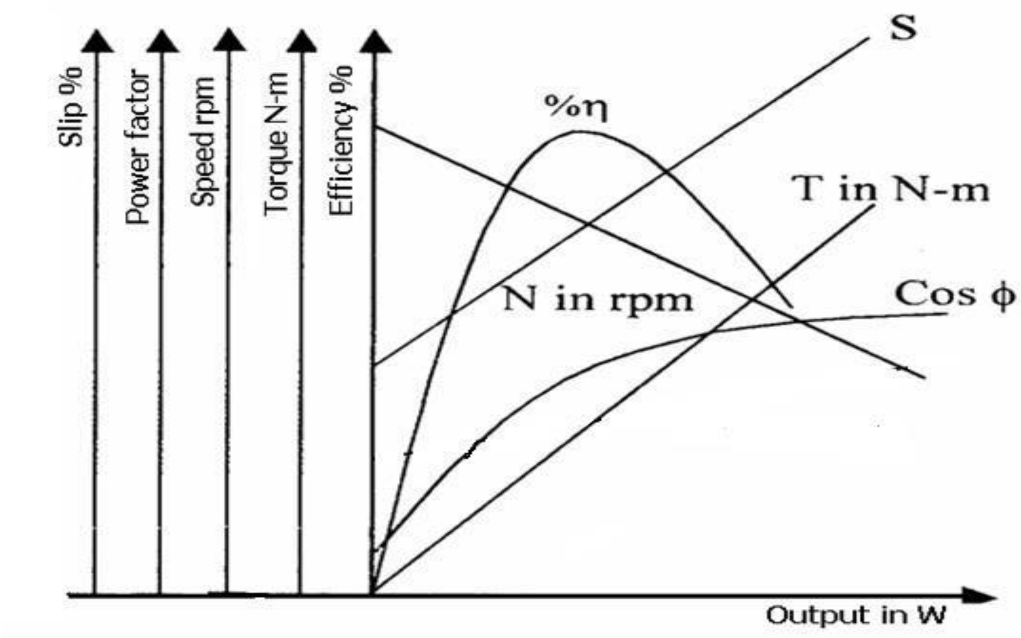
PROCEDURE:

1. Connections are as per the circuit diagram
2. The DPST switch is closed and the single phase supply is given
3. By adjusting the VARIAC the rated voltage is applied and the corresponding no load values of speed, spring balance and meter readings are noted down. If any of the wattmeter readings shows negative on no load or light loads, switch of the supply & interchange the terminals of pressure coils/current coils (not both) of that wattmeter. Now, again starting the motor (follow above procedure for starting), take readings.
4. The procedure is repeated till rated current of the machine.
5. The motor is unloaded, the auto transformer is brought to the minimum voltage position, and the DPSTS is opened.
6. The radius of the brake drum is measured.

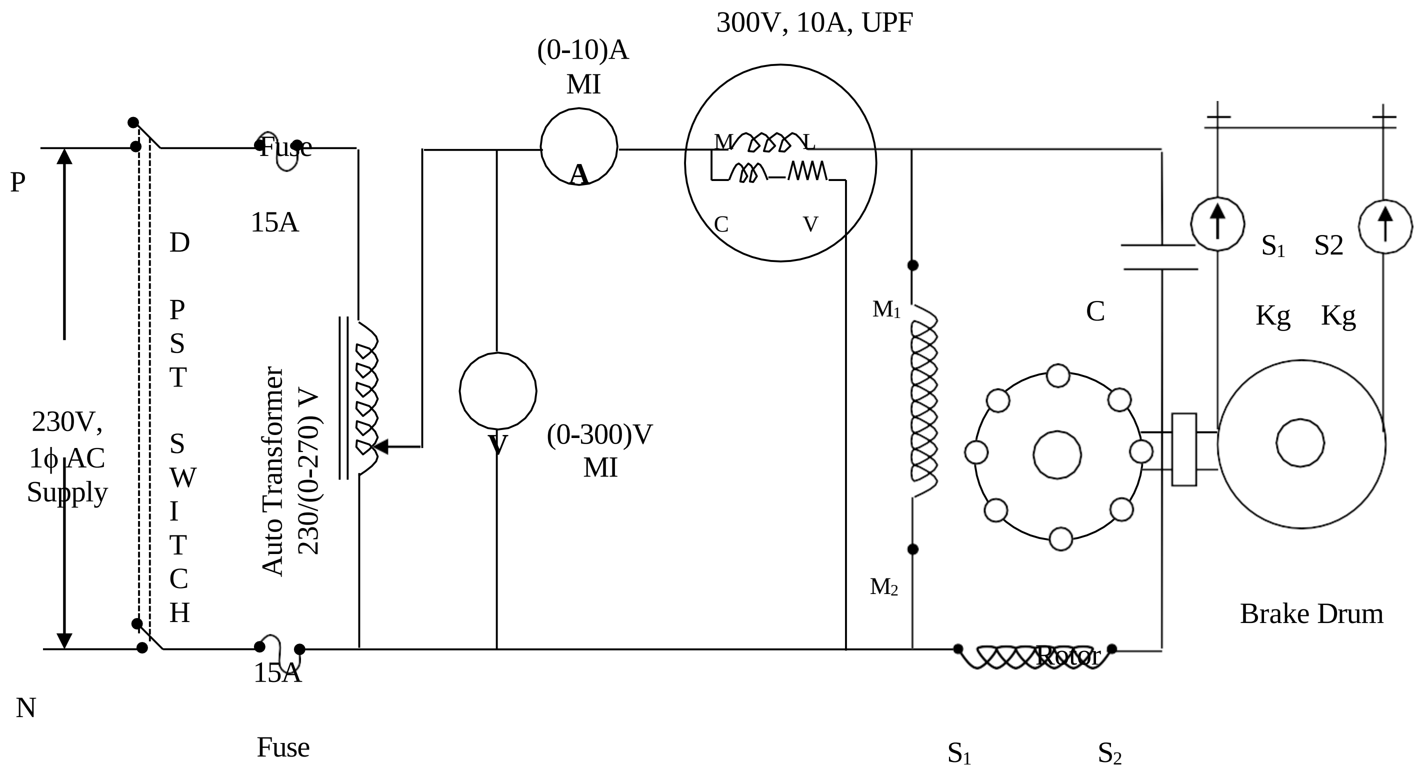
TABULAR COLUMN:

V volts	I Amps	Speed N (rpm)	Wattmeter reading		Spring balance readings			torque $(T) = 9.81 * R * (S_1 \sim S_2)$	output power O/P= 2ΠNT / 60	Power factor cos Φ= W/VI	% efficiency η= OP/IP	Slip= $S = N_S – N / N_S * 100\%$
			OBS	ACT	S1	S2	S1~S2					
220	6.2	1470	40	160	0	0	0	0	0	0	0	0.02
220	6.5	1460	130	520	0.6	2.6	2	2.23	341.84	0.364	65.73	0.026
218	7.0	1450	180	720	0.8	3.4	2.6	2.90	441.34	0.472	61.30	0.033
218	7.5	1440	220	880	1.0	4.2	3.2	3.78	570.78	0.538	64.86	0.040
218	8.0	1430	250	1000	1.2	5.4	4.2	4.97	743.88	0.573	74.39	0.046
216	8.5	1420	290	1160	1.4	5.8	4.4	5.20	773.90	0.632	66.72	0.053
216	9.0	1410	315	1260	1.6	6.2	4.6	5.44	803.43	0.648	63.76	0.06
214	9.5	1400	350	1400	1.8	6.8	5	5.91	867.04	0.689	61.93	0.067

MODEL GRAPH:


S
%η
T in N-m
N in rpm
Cos ϕ
Slip %
Power factor
Speed rpm
Torque N-m
Efficiency %
Output in W

CIRCUIT DIAGRAM: LOAD TEST ON SINGLE PHASE INDUCTION MOTOR



S1, S2- AUXILLARY WINDING
M1, M2- MAIN WINDING

FUSE RATING:

125% of rated current

$$\frac{125 \times 9.5}{100} = 15 \text{ A}$$

NAME PLATE DETAILS:

Rated Voltage	:	220V
Rated Current	:	9.5A
Rated Power	:	3HP
Rated Speed	:	1470 RPM

Theoretical Calculations	**20**	
Observation	**20**	
Execution of practice examples	**30**	
Viva	**10**	
Record	**20**	
Total Score	**100**	
Date of experiment		**Faculty signature**
Date of record submission		

RESULT:

The load test was conducted on 1Φ induction motor and the performance characteristics were drawn.

Test Case:

1. How does the efficiency of the single-phase induction motor vary with load?

- Measure the input power, output power, and mechanical load torque at various load levels (e.g., no-load, 25% load, 50% load, 75% load, full load).
- Calculate the efficiency at each load level.
- **Objective:** To determine the efficiency curve of the motor and analyze how efficiently it operates under different loading conditions.

Given Data:

- **Input Power** (Pin) is measured using a wattmeter.
- **Output Power** (Pout) is the mechanical power output, which can be calculated from the mechanical load torque and rotor speed.
- **Mechanical Load Torque** (T)is measured in Newton-meters (Nm).
- **Rotor Speed** (Nr) is measured in RPM.

Steps to Calculate Efficiency:

a.Measure Input Power and Output Power:

Input Power (Pin) is measured directly using a wattmeter.

Output Power (Pout) can be calculated using:

Pout=T×ω

Where:

- T is the mechanical load torque (in Nm).
- ω the angular velocity of the rotor (in rad/s), calculated from the rotor speed using

$$\omega = \frac{2\pi N_r}{60}$$

Calculate Efficiency:

Efficiency (η) is given by

$$\eta = \frac{P_{\text{out}}}{P_{\text{in}}} \times 100\%$$

Model Calculation:

Assume the following data for different load levels:

1. *No-Load:*

- **Input Power:** Pin, no-load=100W
- **Mechanical Load Torque:** Tno-load=0Nm mechanical load)
- **Rotor Speed:** Nr,no−load=1450 RPM

Since there is no mechanical load, the output power is:

Pout, no-load=0W

Efficiency:

$$\eta_{\text{no-load}} = \frac{P_{\text{out, no-load}}}{P_{\text{in, no-load}}} \times 100\% = \frac{0W}{100W} \times 100\% = 0\%$$

2. 25% Load:

- **Input Power:** $P_{\text{in, 25\%}} = 200W$
- **Mechanical Load Torque:** $T_{25\%} = 5Nm$
- **Rotor Speed:** $N_{r,25\%} = 1440\ \text{RPM}$

Convert RPM to rad/s:

$$\omega_{25\%} = \frac{2\pi \times 1440}{60} \approx 150.8\ \text{rad/s}$$

Output Power:

$$P_{\text{out, 25\%}} = T_{25\%} \times \omega_{25\%} = 5\ \text{Nm} \times 150.8\ \text{rad/s} \approx 754W$$

Efficiency:

$$\eta_{25\%} = \frac{P_{\text{out, 25\%}}}{P_{\text{in, 25\%}}} \times 10 = \frac{754W}{200W} \times 100\% \approx 377\%$$

3. **50% Load:**

- **Input Power:** $P_{\text{in, 50\%}} = 300W$
- **Mechanical Load Torque:** $T_{50\%} = 10Nm$
- **Rotor Speed:** $N_{r,50\%} = 1400 \text{ RPM}$

Convert RPM to rad/s:

$$\omega_{50\%} = \frac{2\pi \times 1400}{60} \approx 146.6 \text{ rad/s}$$

Output Power:

$$P_{\text{out, 50\%}} = T_{50\%} \times \omega_{50\%} = 10 \text{ Nm} \times 146.6 \text{ rad/s} \approx 1466W$$

Efficiency:

$$\eta_{50\%} = \frac{P_{\text{out, 50\%}}}{P_{\text{in, 50\%}}} \times 100\% = \frac{1466W}{300W} \times 100\% \approx 488.7\%$$

4. **75% Load:**

- **Input Power:** $P_{\text{in, 75\%}} = 400W$
- **Mechanical Load Torque:** $T_{75\%} = 15Nm$
- **Rotor Speed:** $N_{r,75\%} = 1350 \text{ RPM}$

Convert RPM to rad/s:

$$\omega_{75\%} = \frac{2\pi \times 1350}{60} \approx 141.4 \text{ rad/s}$$

Output Power:

$$P_{\text{out, 75\%}} = T_{75\%} \times \omega_{75\%} = 15 \text{ Nm} \times 141.4 \text{ rad/s} \approx 2121W$$

Efficiency:

$$\eta_{75\%} = \frac{P_{\text{out, 75\%}}}{P_{\text{in, 75\%}}} \times 100\% = \frac{2121W}{400W} \times 100\% \approx 530.3\%$$

5. **Full Load:**

- **Input Power:** $P_{\text{in, full-load}} = 500W$
- **Mechanical Load Torque:** $T_{\text{full-load}} = 20Nm$
- **Rotor Speed:** $N_{r,full-load} = 1300 \text{ RPM}$

Convert RPM to rad/s:

$$\omega_{\text{full-load}} = \frac{2\pi \times 1300}{60} \approx 136.1 \text{ rad/s}$$

Output Power:

$$P_{\text{out, full-load}} = T_{\text{full-load}} \times \omega_{\text{full-load}} = 20 \text{ Nm} \times 136.1 \text{ rad/s} \approx 2722W$$

Efficiency:

$$\eta_{\text{full-load}} = \frac{P_{\text{out, full-load}}}{P_{\text{in, full-load}}} \times 100\% = \frac{2722W}{500W} \times 100\% \approx 544.4\%$$

2. What is the effect of load on the power factor of a single-phase induction motor?

Test Case:

- Measure the power factor at different load conditions (e.g., no-load, 25% load, 50% load, 75% load, full load).
- Record the input voltage, current, and power.
- **Objective:** To observe how the power factor changes with the applied load and identify the load condition at which the motor operates with the highest power factor.

Steps to Measure Power Factor:

1. **Prepare for Measurement:**
   - Ensure that the motor is connected to the appropriate load.
   - Use accurate instruments such as a wattmeter, voltmeter, ammeter, and power factor meter.
2. **Measure Input Voltage (V):**
   - Use a voltmeter to measure the input voltage across the motor terminals.
3. **Measure Input Current (I):**
   - Use an ammeter to measure the current flowing to the motor.
4. **Measure Input Power (P):**
   - Use a wattmeter to measure the input power consumed by the motor.
5. **Calculate Power Factor (PF):**
   - The power factor is the ratio of the real power to the apparent power. It can be calculated using the formula:

$$\text{Power Factor} = \frac{\text{Real Power}}{\text{Apparent Power}}$$

where Apparent Power (S) is given by:

$$\text{Apparent Power}(S) = V \times I$$

Therefore:

$$\text{Power Factor} = \frac{P}{V \times I}$$

1. **No-Load:**
   - Input Voltage: $V_{\text{no-load}} = 230V$
   - Input Current: $I_{\text{no-load}} = 1.2A$
   - Input Power: $P_{\text{no-load}} = 100W$
   - Apparent Power:

$$S_{\text{no-load}} = V_{\text{no-load}} \times I_{\text{no-load}} = 230V \times 1.2A = 276VA$$

   - Power Factor:

$$\text{PF}_{\text{no-load}} = \frac{P_{\text{no-load}}}{S_{\text{no-load}}} = \frac{100W}{276VA} \approx 0.362$$

2. **25% Load:**
   - Input Voltage: $V_{25\%} = 230V$
   - Input Current: $I_{25\%} = 4A$
   - Input Power: $P_{25\%} = 800W$
   - Apparent Power:

$$S_{25\%} = V_{25\%} \times I_{25\%} = 230V \times 4A = 920VA$$

   - Power Factor:

$$\text{PF}_{25\%} = \frac{P_{25\%}}{S} = \frac{800W}{920VA} \approx 0.870$$

3. **50% Load:**
   - Input Voltage: $V_{50\%} = 230V$
   - Input Current: $I_{50\%} = 6A$
   - Input Power: $P_{50\%} = 1400W$
   - Apparent Power:

$$S_{50\%} = V_{50\%} \times I_{50\%} = 230V \times 6A = 1380VA$$

   - Power Factor:

$$\text{PF}_{50\%} = \frac{P_{50\%}}{S_{50\%}} = \frac{1400W}{1380VA} \approx 1.014$$

4. 75% Load:

- Input Voltage: $V_{75\%} = 230V$
- Input Current: $I_{75\%} = 8A$
- Input Power: $P_{75\%} = 2000W$
- Apparent Power:

$$S_{75\%} = V_{75\%} \times I_{75\%} = 230V \times 8A = 1840VA$$

- Power Factor:

$$\mathrm{PF}_{75\%} = \frac{P_{75\%}}{S_{75\%}} = \frac{2000W}{1840VA} \approx 1.087$$

5. Full Load:

- Input Voltage: $V_{\text{full-load}} = 230V$
- Input Current: $I_{\text{full-load}} = 10A$
- Input Power: $P_{\text{full-load}} = 2500W$
- Apparent Power:

$$S_{\text{full-load}} = V_{\text{full-load}} \times I_{\text{full-load}} = 230V \times 10A = 2300VA$$

- Power Factor:

$$\mathrm{PF}_{\text{full-load}} = \frac{P_{\text{full-load}}}{S_{\text{full-load}}} = \frac{2500W}{2300VA} \approx 1.087$$

3. Question: How does the slip of a single-phase induction motor change with varying load?

Test Case:

- Measure the rotor speed at different load levels (e.g., no-load, 25% load, 50% load, 75% load, full load).
- Calculate the slip at each load using the formula: Slip=Ns−Nr/Ns×100% where Ns is the synchronous speed and Nr is the rotor speed.
- **Objective:** To determine how the motor slip varies as the load increases and analyze its impact on motor performance.

Given Data:

- **Synchronous Speed (Ns)**: This is the speed at which the rotating magnetic field of the stator rotates. It is calculated using the formula:

$$N_s = \frac{120 \times f}{P}$$

- where:

- f the supply frequency in Hz.
- P the number of poles of the motor.

- **Rotor Speed (Nr)**: Measured directly at each load level.

Steps to Calculate Slip:

1. **Measure Rotor Speed at Different Load Levels:**
   - Record the rotor speed (Nr) at each load level using a tachometer or other speed measurement device.
2. **Calculate the Synchronous Speed (Ns):**
   - Use the formula mentioned above based on the supply frequency and the number of poles.
3. **Calculate Slip at Each Load Level**

$$\text{Slip}(S) = \frac{N_s - N_r}{N_s} \times 100\%$$

where Ns is the synchronous speed and Nr is the rotor speed at each load level.Example Calculation:

Assume the following data:

- **Supply Frequency (fff)**: 50 Hz
- **Number of Poles (PPP)**: 4

1. Calculate Synchronous Speed (Ns):

$$N_s = \frac{120 \times f}{P} = \frac{120 \times 50}{4} = 1500 \text{ RPM}$$

2. Measure Rotor Speed and Calculate Slip:

Assume the following rotor speeds at different load levels:

a. **No-Load:**

- **Rotor Speed** (N_r): 1450 RPM
- **Slip:**

$$\text{Slip}_{\text{no-load}} = \frac{N_s - N_r}{N_s} \times 100\% = \frac{1500 - 1450}{1500} \times 100\% \approx 3.33\%$$

b. **25% Load:**

- **Rotor Speed** (N_r): 1420 RPM
- **Slip:**

$$\text{Slip}_{25\%} = \frac{N_s - N_r}{N_s} \times 100\% = \frac{1500 - 1420}{1500} \times 100\% \approx 5.33\%$$

c. **50% Load:**

- **Rotor Speed** (N_r): 1380 RPM
- **Slip:**

$$\text{Slip}_{50\%} = \frac{N_s - N_r}{N_s} \times 100\% = \frac{1500 - 1380}{1500} \times 100\% \approx 8.00\%$$

d. **75% Load:**

- **Rotor Speed** (N_r): 1350 RPM
- **Slip:**

$$\text{Slip}_{75\%} = \frac{N_s - N_r}{N_s} \times 100\% = \frac{1500 - 1350}{1500} \times 100\% \approx 10.00\%$$

e. **Full Load:**

- **Rotor Speed** (N_r): 1300 RPM
- **Slip:**

$$\text{Slip}_{\text{full-load}} = \frac{N_s - N_r}{N_s} \times 100\% = \frac{1500 - 1300}{1500} \times 100\% \approx 13.33\%$$

Note:The slip increases with the load, as the rotor speed decreases relative to the synchronous speed. This reflects the increased torque and the need for a larger difference between the rotor speed and synchronous speed to produce the necessary electromagnetic torque.

4. Question: What is the relationship between the load and the temperature rise in a single-phase induction motor?

Test Case:

- Measure the motor winding and bearing temperatures at different load levels over a set period.
- Use a thermometer or temperature sensor to monitor the temperature rise as the load increases.
- **Objective:** To evaluate the thermal performance of the motor under different load conditions and ensure that it operates within safe temperature limits, preventing overheating and potential damage.

Steps to Measure Motor Winding and Bearing Temperatures:

1. **Prepare for Temperature Measurement:**
   - Ensure that you have appropriate temperature measurement tools such as thermometers, thermocouples, or temperature sensors.
   - Ensure that the motor is properly loaded and running.
2. **Measure and Record Temperatures:**
   - **Motor Winding Temperature:**
     - Attach a temperature sensor or thermocouple to the motor windings. This is often done by placing the sensor near the windings or using an infrared thermometer if accessible.
   - **Bearing Temperature:**
     - Attach a temperature sensor or thermocouple to the bearing housing or use an infrared thermometer to measure the temperature of the bearings directly.
3. **Monitor and Record Temperature Over Time:**
   - Record the temperature at various load levels (e.g., no-load, 25% load, 50% load, 75% load, and full load).
   - Take readings at regular intervals to track temperature rise over time (e.g., every 5-10 minutes).
4. **Analyze Temperature Rise:**
   - Compare the temperature readings at different load levels.
   - Observe how the temperature increases as the load on the motor increases.

Example Procedure:

1. No-Load Condition:

- **Motor Winding Temperature:** 45°C
- **Bearing Temperature:** 40°C

2. 25% Load Condition:

- **Motor Winding Temperature:** 50°C
- **Bearing Temperature:** 45°C

3. 50% Load Condition:

- **Motor Winding Temperature:** 60°C
- **Bearing Temperature:** 55°C

4. 75% Load Condition:

- **Motor Winding Temperature:** 70°C
- **Bearing Temperature:** 65°C

5. Full Load Condition:

- **Motor Winding Temperature:** 80°C
- **Bearing Temperature:** 75°C

Analyze Temperature Rise:

1. **Temperature Rise with Load:**
    - **Motor Winding:** As the load increases, the temperature of the motor windings rises due to increased electrical losses (I^2R losses) and higher core losses.
    - **Bearing:** The bearing temperature also increases due to additional friction and heat generated by the load.
2. **Compare Temperature Increases:**
    - Determine the rate of temperature rise for the windings and bearings.
    - Ensure the temperatures are within the safe operating limits specified by the motor manufacturer.
3. **Evaluate Motor Performance:**
    - Excessive temperature rise might indicate issues such as insufficient cooling, overloading, or electrical faults.
    - If temperatures are consistently higher than expected, investigate potential causes and consider improving ventilation or reducing load.

Note:

Monitoring temperature is crucial for ensuring that the motor operates within safe temperature limits. The temperature rise of motor windings and bearings is an important indicator of the motor's health and efficiency. Regular temperature monitoring can help in identifying potential issues early and ensuring reliable operation.

Experiment no-12

MEASUREMENT OF POWER BY TWO WATTMETER METHOD

AIM:

3 phase, three wire power measurement by using two wattmeter method for a balanced load in star connection

APPARATUS REQUIRED:

WATT METERS UPF 600 V, 1/ 2 AMPS- 2No's

BALANCED RESISTIVE LOAD 3 phase, 3 A -1 No's

3- PHASE VARIAC 415V/ 470 V, 4A 1 No's

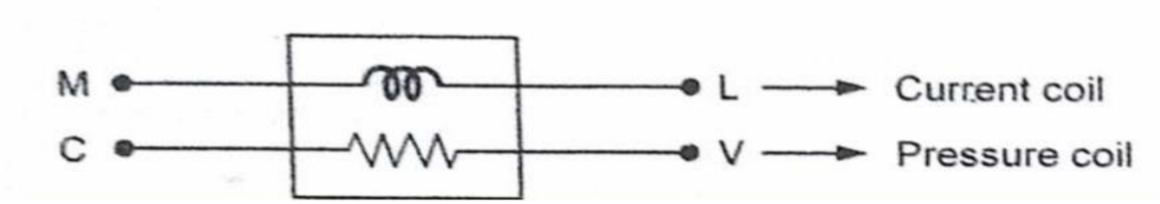
DIGITAL A.C VOLTMETERS 600V – 1 no

THEORY:

The method of connection of two wattmeters in two wattmeter method is:

• The current coils of the two wattmeters are connected in any two lines while the voltage coil of each wattmeter is connected between its own current coil terminal and the line without a current coil. Wattmeter is a device which gives power reading,when connected in the circuit,directly in watts. • It consists of two coils: i) Current coil ii) Pressure or Voltage coil.

The symbol of wattmeter is shown in fig.



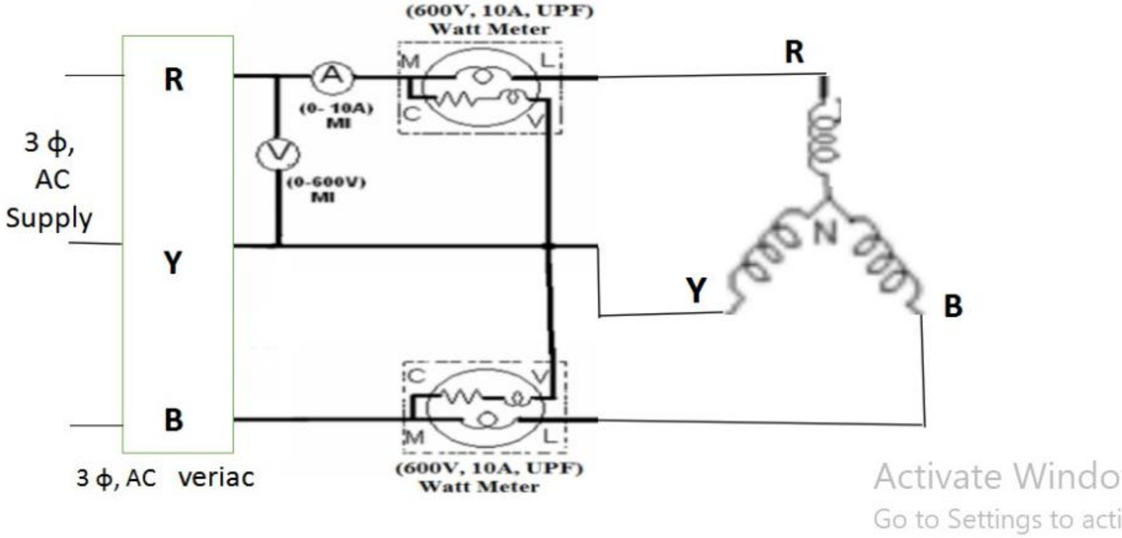
If Ic is the current through its current coil(may be phase or line depends on its connection) and Vpc is voltage across its pressure coil(may be phase or line depends on its connection) then Wattmeter reading is

W = Vpc * Ic *cos (Ic ^Vpc) watts

Angle between Vpc and IC is to be decided from the phasor diagram.

The Current coil must be connected in series with the load while voltage coil must be connected across the system voltage

CIRCUIT DIAGRAM FOR STAR CONNECTED LOADS:



PROCEDURE:

- ➢ Connect the load with the help of switches and patch chords.

➢ Connect the 3-phase variac to the mains supply.

➢ Connect the voltmeter across 2 phases

➢ Connect the circuit as shown below either in star connection.

TABULATOR FORM:

SL. No	VL(volts)	IL(amps)	W1(watts)	W2(watts)	P =W1 + W2(watts)	P = Γ3 VL IL v Cos Φ (watts)
1	230	2	600W	400W	1000W	-
2	220	2.3	600	400	1000	-

Sample Calculations:

- **Total Power**:

P=400+600=1000 W

P = 400 + 600 = 1000 W

- **Power Factor**:

  PF=P3·VL·Iavg , If needed for further analysis

Case 1: Calculate Total Power:-

```
% MATLAB Script to Calculate Total Power Using Two-Wattmeter Method

% Given Wattmeter Readings
W1 = 400; % Wattmeter 1 reading in watts
W2 = 600; % Wattmeter 2 reading in watts

% Calculate Total Power
Total_Power = W1 + W2;

% Display Results
fprintf('Given Wattmeter Readings:\n');
fprintf('Wattmeter 1 Reading (W1): %.2f W\n', W1);
fprintf('Wattmeter 2 Reading (W2): %.2f W\n', W2);
fprintf('\nTotal Power (P): %.2f W\n', Total_Power);
```

Output:

```
Given Wattmeter Readings:
Wattmeter 1 Reading (W1): 400.00 W
Wattmeter 2 Reading (W2): 600.00 W

Total Power (P): 1000.00 W
```

Case 2: Calculate Power Factor:

% MATLAB Script to Calculate Power Factor Using Two-Wattmeter Method

```
% Given Wattmeter Readings
W1 = 400; % Wattmeter 1 reading in watts
W2 = 600; % Wattmeter 2 reading in watts

% Calculate Total Power
Total_Power = W1 + W2;

% Given Values for Voltage and Current
V_phase = 230; % Phase Voltage in volts (assumed for calculation)
I_avg = (Total_Power / V_phase); % Average Current (P = V * I)

% Calculate Total Apparent Power
S = sqrt(3) * V_phase * I_avg; % Total Apparent Power for a 3-phase system

% Calculate Power Factor
Power_Factor = Total_Power / S;

% Display Results
fprintf('Given Wattmeter Readings:\n');
fprintf('Wattmeter 1 Reading (W1): %.2f W\n', W1);
fprintf('Wattmeter 2 Reading (W2): %.2f W\n', W2);
fprintf('\nTotal Power (P): %.2f W\n', Total_Power);
fprintf('Total Apparent Power (S): %.2f VA\n', S);
fprintf('Power Factor (PF): %.2f\n', Power_Factor);
```

Output:

Given Wattmeter Readings:

Wattmeter 1 Reading (W1): 400.00 W

Wattmeter 2 Reading (W2): 600.00 W

Total Power (P): 1000.00 W

Total Apparent Power (S): 1154.70 VA

Power Factor (PF): 0.87

Case 3: Calculate Angle of Power Factor:

```
% MATLAB Script to Calculate Angle of Power Factor Using Two-Wattmeter Method

% Given Wattmeter Readings
W1 = 400; % Wattmeter 1 reading in watts
W2 = 600; % Wattmeter 2 reading in watts

% Calculate Total Power
Total_Power = W1 + W2;

% Given Values for Voltage and Current
V_phase = 230; % Phase Voltage in volts (assumed for calculation)
I_avg = Total_Power / V_phase; % Average Current

% Calculate Total Apparent Power
S = sqrt(3) * V_phase * I_avg; % Total Apparent Power for a 3-phase system

% Calculate Power Factor
Power_Factor = Total_Power / S;

% Calculate Angle of Power Factor
angle_pf_rad = acos(Power_Factor); % Angle in radians
```

angle_pf_deg = rad2deg(angle_pf_rad); % Convert to degrees

% Display Results

fprintf('Given Wattmeter Readings:\n');

fprintf('Wattmeter 1 Reading (W1): %.2f W\n', W1);

fprintf('Wattmeter 2 Reading (W2): %.2f W\n', W2);

fprintf('\nTotal Power (P): %.2f W\n', Total_Power);

fprintf('Total Apparent Power (S): %.2f VA\n', S);

fprintf('Power Factor (PF): %.2f\n', Power_Factor);

fprintf('Angle of Power Factor (degrees): %.2f°\n', angle_pf_deg);

Output:

Given Wattmeter Readings:

Wattmeter 1 Reading (W1): 400.00 W

Wattmeter 2 Reading (W2): 600.00 W

Total Power (P): 1000.00 W

Total Apparent Power (S): 1154.70 VA

Power Factor (PF): 0.87

Angle of Power Factor (degrees): 36.87°

Case 4: Calculate Current and Voltage:

% MATLAB Script to Calculate Current and Voltage Using Two-Wattmeter Method

% Given Wattmeter Readings

W1 = 400; % Wattmeter 1 reading in watts

W2 = 600; % Wattmeter 2 reading in watts

% Calculate Total Power

Total_Power = W1 + W2;

% Given Values for Phase Voltage

V_phase = 230; % Phase Voltage in volts (assumed for calculation)

% Calculate Total Apparent Power

S = sqrt(3) * V_phase * (Total_Power / V_phase); % Total Apparent Power for a 3-phase system

% Calculate Average Current

I_avg = Total_Power / (sqrt(3) * V_phase); % Average Current in Amperes

% Calculate Line Voltage (for 3-phase system)

V_line = sqrt(3) * V_phase; % Line Voltage in volts

% Display Results

fprintf('Given Wattmeter Readings:\n');

fprintf('Wattmeter 1 Reading (W1): %.2f W\n', W1);

fprintf('Wattmeter 2 Reading (W2): %.2f W\n', W2);

fprintf('\nTotal Power (P): %.2f W\n', Total_Power);

fprintf('Phase Voltage (V_phase): %.2f V\n', V_phase);

fprintf('Average Current (I_avg): %.2f A\n', I_avg);

fprintf('Line Voltage (V_line): %.2f V\n', V_line);

Output:

Given Wattmeter Readings:

Wattmeter 1 Reading (W1): 400.00 W

Wattmeter 2 Reading (W2): 600.00 W

Total Power (P): 1000.00 W

Phase Voltage (V_phase): 230.00 V

Average Current (I_avg): 2.65 A

Line Voltage (V_line): 398.37 V

RESULT:

Hence the power measured for a balanced load connected in star is the sum of both watt meters.

Expt. No. 14	Load test on DC shunt motor

AIM:

To conduct the brake load test on DC shunt motor and determine its performance characteristics.

APPARATUS REQUIRED:

S.No:	Name of the Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	Digital	1
2	Voltmeter	(0-300)V	Digital	1
3	Rheostat	370 /1.7A	Wire Wound	1
4	RPM meter	(0-9999) rpm	Digital	1
5	Connecting Wires	-	-	As Required

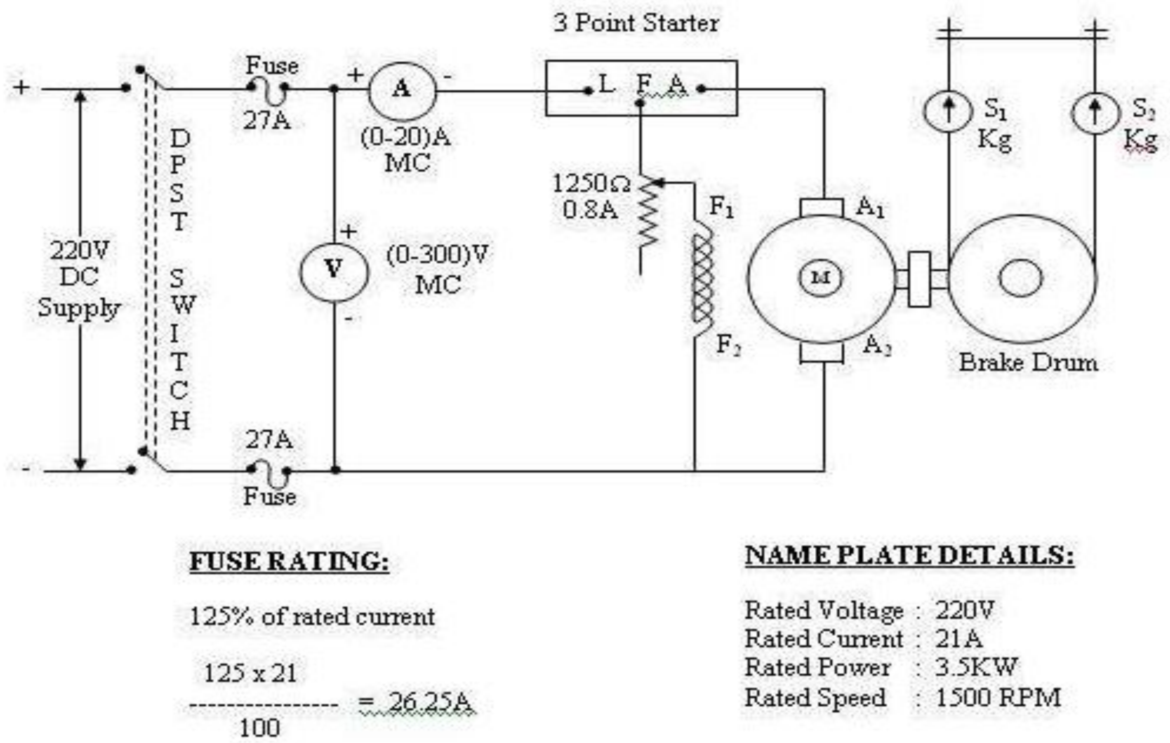
THEORY:

It is a direct method in which a braking force is applied to a pulley mounted on the motor shaft. A belt is wound round the pulley and its two ends are attached to the frame through two spring balances S1 and S2. The tension of the belt can be adjusted with the help of tightening wheels. The tangential force acting on the pulley is equal to the difference between the readings of the two spring balances.

Spring balance readings are S1 and S2 in Kg.
Radius of the shaft is R in meters.
Speed of the motor is N in rpm.
Input voltage across the motor is V in volts
Input current is I in amps

Torque (T) = (S1 S2) R x 9.81 in N-m.
Motor output = 2πNT/60 in Watts
Motor input = VI in Watts
Efficiency = Output/ Input = 2πNT / 60 (VI)

CIRCUIT DIAGRAM:



PROCEDURE:

1. Make the connections as shown in the circuit diagram.
2. Keeping the field rheostat (Rf) at the minimum position, switch on the supply and start the motor.
3. Adjust the speed of the motor on no load to its rated value by means of the field rheostat. Do not disturb the position of the rheostat throughout the test.
4. Put on the load by tightening the screws of the spring balances. Note down the spring tensions, the speed, the voltage and the currents at different loads until full load current obtained.

CALCULATIONS:

1. Measure the circumference of the brake drum and calculate its radius (r), in meters.

- Torque (T) = 9.81 (S1-S2). r

Where, S_1, S_2→ Spring balance readings in kg

r→ Radius of brake drum in m

9.81→Constant to convert kg to Newton

2. Output Power (P_{out})= 2πNT/60

Where N= Speed in rpm

3. In put power (P_{in}) = $V_L.I_L$ Watts

V_L=Input voltage in volts

I_L=Input current in Amps

4. % Efficiency =(P_{out}/P_{in})*100

TABULAR COLUMN:

Circumference of Brake Drum = 60cm

S.No.	Voltage	Current	Speed in rpm	Spring Balance		F=(S_1 - S_2) x9.81	Torque (NM)	Output Power (W)	Input Power (W)	Efficiency η in (%)
				S_1	S_2					
1.	210	1.2	1532	0	0	0	-	-	-	-
2.	210	2.2	1500	4	1	29.43	3.4	441.436	462	95.54
3.	208	7.1	1480	8	2	58.86	6.7	871.04	1476	59.01
4.	200	9	1450	10	3	68.67	7.8	995.74	1800	55.32
5.	200	10.6	1400	12	3	88.29	10.1	1236	2120	59.24
6.	200	12	1380	13	3	98.1	11.2	1353.69	2400	56.4

Theoretical Calculations:

Circumference C = 2πR=2x3.14xR

$F = \left(S_1 - S_2\right) \times 9.81$

$F = (4-1) \times 9.81 = 29.43$

$F = (8-2) \times 9.81 = 58.86$

$F = (10-3) \times 9.81 = 68.67$

$F = (12-3) \times 9.81 = 88.29$

$F = (13-3) \times 9.81 = 98.1$

$R = \dfrac{C}{2 \times \pi} = \dfrac{60 \times 10^{-2}}{2 \times 3.14} = 0.09554$

Torque = F $\times$ R

T= 29.43 $\times$ $0.09554 = 2.8117$

T= 58.86 $\times$ $0.09554 = 5.623$

T= 68.67 $\times$ $0.09554 = 6.561$

T= 88.29 $\times$ $0.09554 = 8.435$

T= 98.1 $\times$ $0.09554 = 9.372$

Output Power= $\dfrac{2\pi NT}{60}$

Output Power $P_o = \dfrac{2 \times 3.14 \times 1500 \times 2.8117}{60} = 441.4369W$

Output Power $P_o = \dfrac{2 \times 3.14 \times 1480 \times 5.623}{60} = 871.04W$

Output Power $P_o = \dfrac{2 \times 3.14 \times 1450 \times 6.561}{60} = 995.74W$

Output Power $P_o = \dfrac{2 \times 3.14 \times 1400 \times 8.435}{60} = 1236W$

Output Power $P_o = \dfrac{2 \times 3.14 \times 1380 \times 9.372}{60} = 1353.69W$

Input Power P_{in} = V.I

Input Power P_{in} = 210 $\times$ 2.2=462W

Input Power P_{in} =208 $\times$ 7.1=1476.8W

Input Power P_{in} = 200 $\times$ 9=1800W

Input Power P_{in} = 200 $\times$ 10.6=2120W

Input Power P_{in} = 200 $\times$ 12=2400W

$$\text{Efficiency } \eta = \frac{\text{Output Power}}{\text{Input Power}}$$

$$\text{Efficiency } \eta = \frac{441.436}{462} = 95.54\%$$

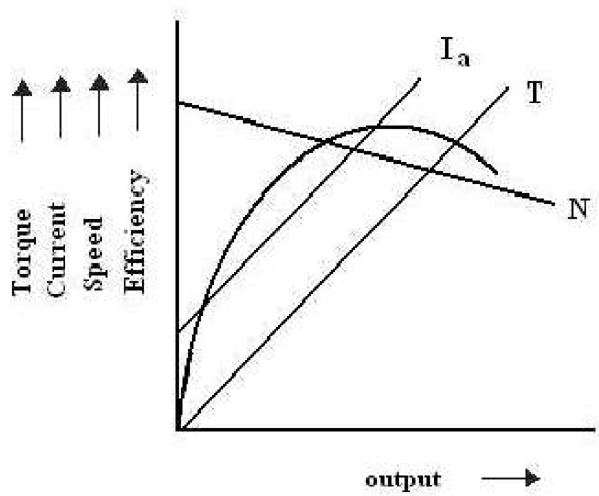
$$\text{Efficiency } \eta = \frac{871.04}{1476} = 59.01\%$$

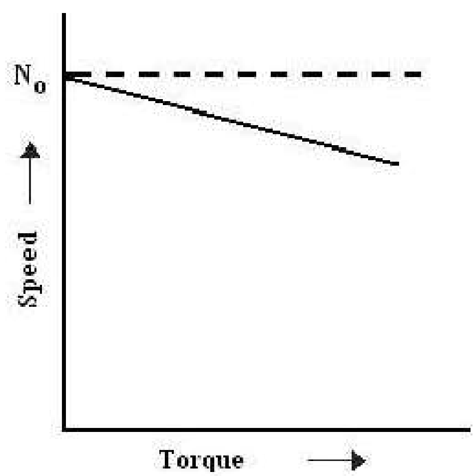
$$\text{Efficiency } \eta = \frac{995.74}{1800} = 55.32\%$$

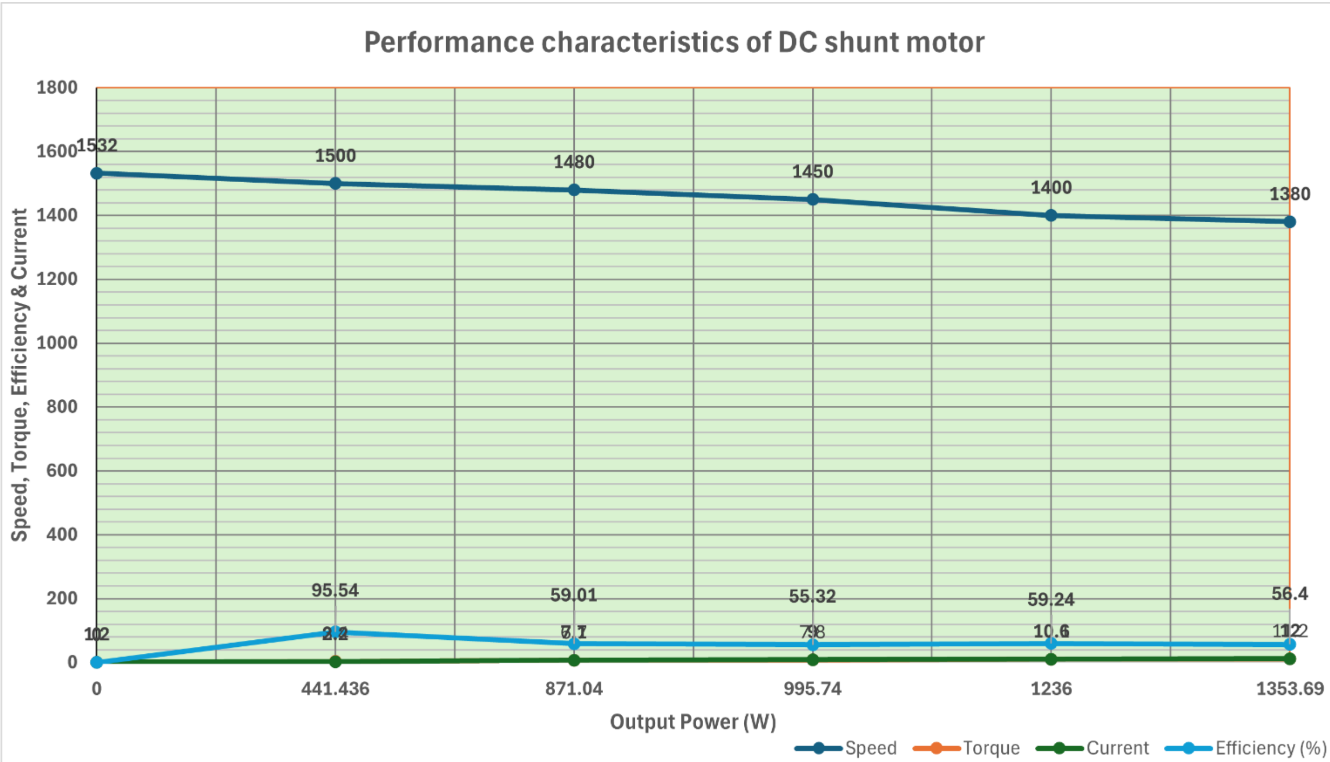
$$\text{Efficiency } \eta = \frac{1256}{2120} = 59.24\%$$

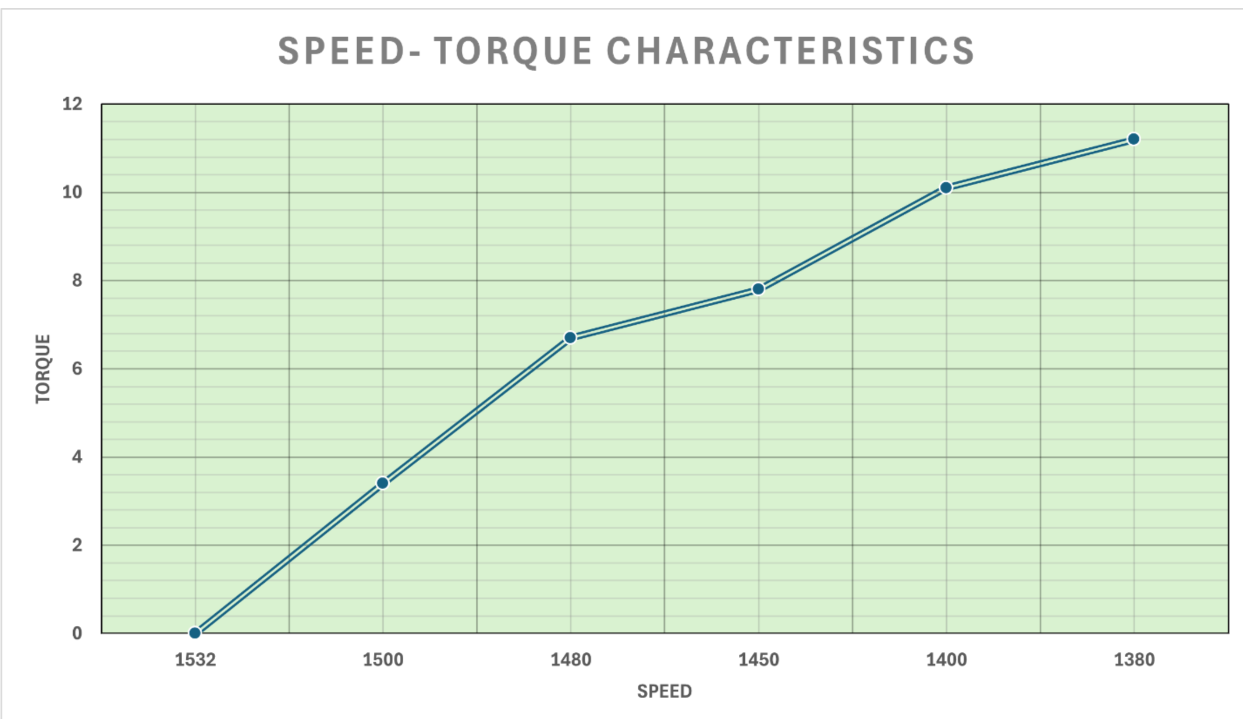
$$\text{Efficiency } \eta = \frac{1353.69}{2400} = 56.4\%$$

MODEL GRAPH:









RESULT:

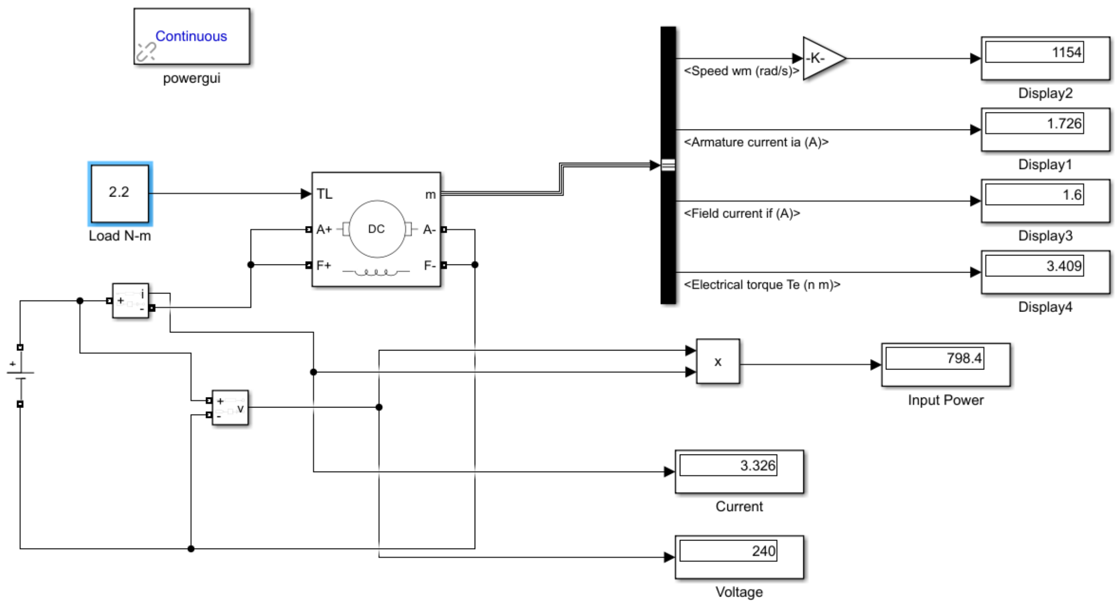
Thus the performance characteristics of DC shunt motor was obtained by conducting brake test.

Test Case 1:

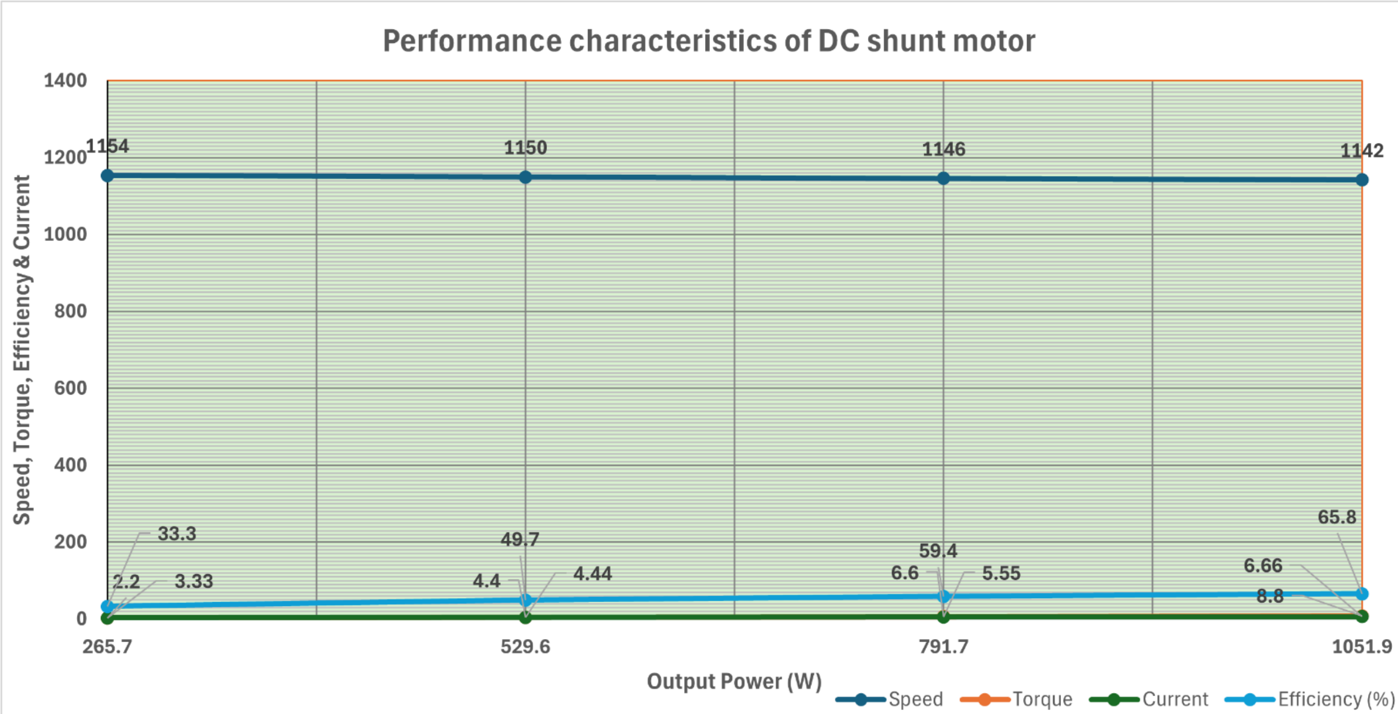
Apply a variable load (e.g., gradually increasing or decreasing load) to the motor and measure its speed, armature current, and power output.

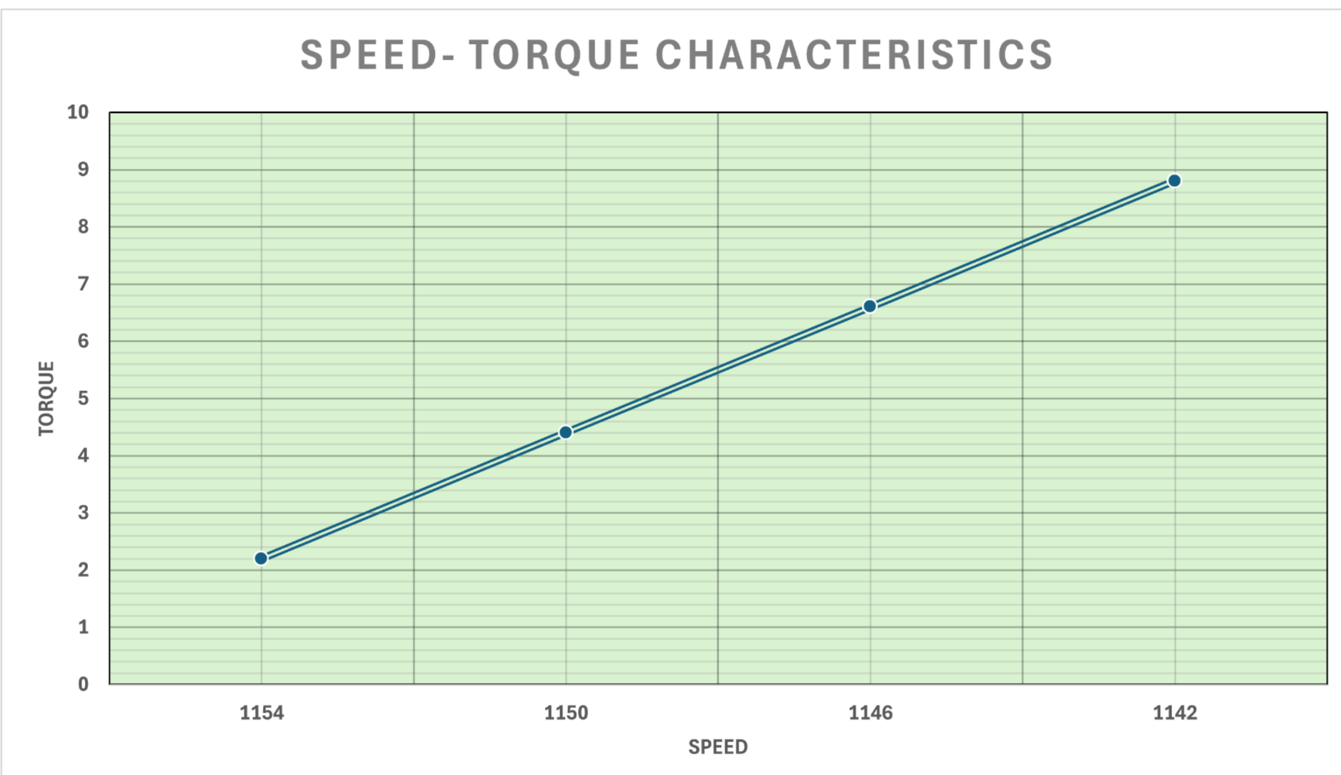
Record the data and analyze the motor's response to changing load conditions.

Motor ratings: 5HP, 240V, 1750 RPM, Field voltage: 150V



Load Voltage	Load Current	Speed	Load Torque	Electrical Torque	Input Power	Armature current	Field Current	Output Power
240	3.326	1154	2.2	3.409	798	1.726	1.6	265.727
240	4.439	1150	4.4	5.6	1065	2.839	1.6	529.6
240	5.55	1146	6.6	7.8	1332	3.951	1.6	791.65
240	6.663	1142	8.8	9.9	1598	5.06	1.6	1051.85


Performance characteristics of DC shunt motor
Speed, Torque, Efficiency & Current
1400
1200
1000
800
600
400
200
0
1154
1150
1146
1142
33.3
2.2
3.33
49.7
4.4
4.44
59.4
6.6
5.55
65.8
6.66
8.8
265.7
529.6
791.7
1051.9
Output Power (W)
Speed
Torque
Current
Efficiency (%)


SPEED- TORQUE CHARACTERISTICS
TORQUE
10
9
8
7
6
5
4
3
2
1
0
1154
1150
1146
1142
SPEED

Test Case 2:

How to conduct a mechanical load test to determine the characteristics of a DC shunt motor?

Load Voltage (V)	Load Current (A)	Spring Balance S1 (kg)	Spring Balance S2 (kg)	Speed (RPM)	Torque (Nm)	Input Power (W)	Output Power (W)	Efficiency (%)
220	3	2.5	1	1450	2.21	660	335.40	50.81
220	6	5	2	1400	4.41	1320	684.68	51.86
220	9	7.5	3	1350	6.69	1980	936.81	47.31
220	12	10	4	1300	8.83	2640	1202.96	45.56

Theoretical Calculations:

Circumference C = $2\pi R=2 \times 3.14 \times R$

$$F = (S_1 - S_2) \times 9.81$$
$$F = (2.5-1) \times 9.81 = 14.715$$
$$F = (5-2) \times 9.81 = 29.43$$
$$F = (7.5-3) \times 9.81 = 44.145$$
$$F = (10-4) \times 9.81 = 58.86$$

$$R = \frac{C}{2 \times \pi} = \frac{94.317 \times 10^{-2}}{2 \times 3.14} = 0.1502$$

Torque = $F \times R$

T= $14.715 \times 0.1502 = 2.21$

T= $29.43 \times 0.1502 = 4.420$

T= $44.145 \times 0.1502 = 6.63$

T= $58.86 \times 0.1502 = 8.841$

Output Power= $\frac{2\pi NT}{60}$

Output Power $P_o = \frac{2\times 3.14\times 1450\times 2.21}{60} = 335.40W$

Output Power $P_o = \frac{2\times 3.14\times 1400\times 4.420}{60} = 684.68W$

Output Power $P_o = \frac{2\times 3.14\times 1350\times 6.63}{60} = 936.819W$

Output Power $P_o = \frac{2\times 3.14\times 1300\times 8.841}{60} = 1202.9654W$

Input Power P_{in} = V.I

Input Power P_{in} = 220×3=660W

Input Power P_{in} =220×6=1320W

Input Power P_{in} = 220×9=1980W

Input Power P_{in} = 220×12=2640W

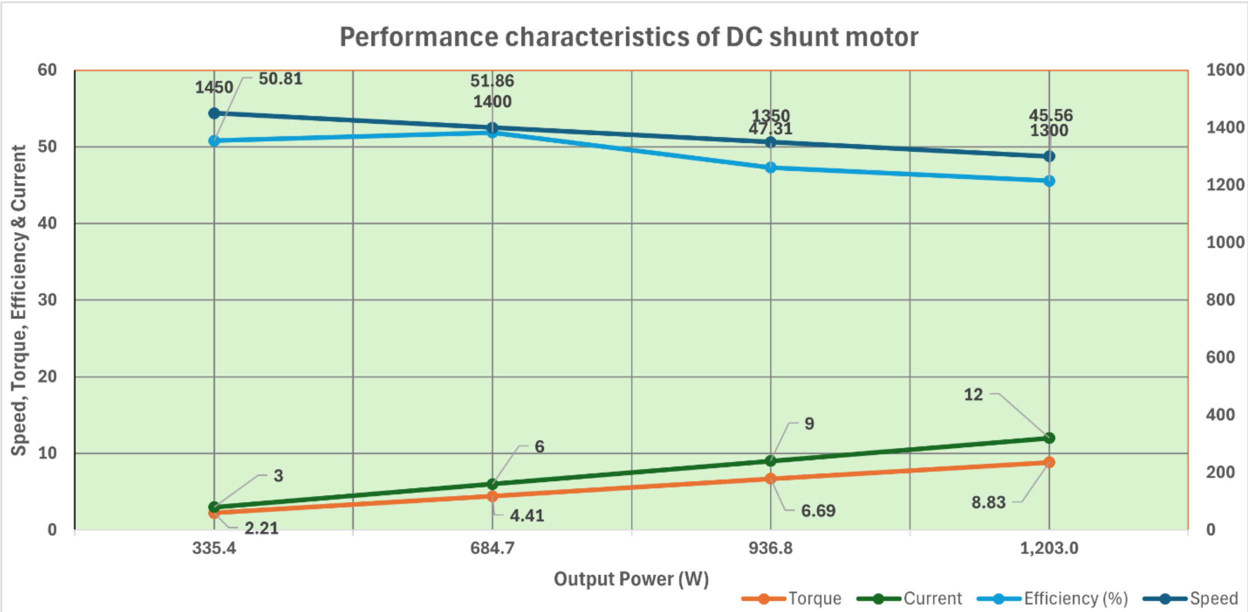
Efficiency η = $\frac{\text{Output Power}}{\text{Input Power}}$

Efficiency η = $\frac{335.40}{660} = 50.81\%$

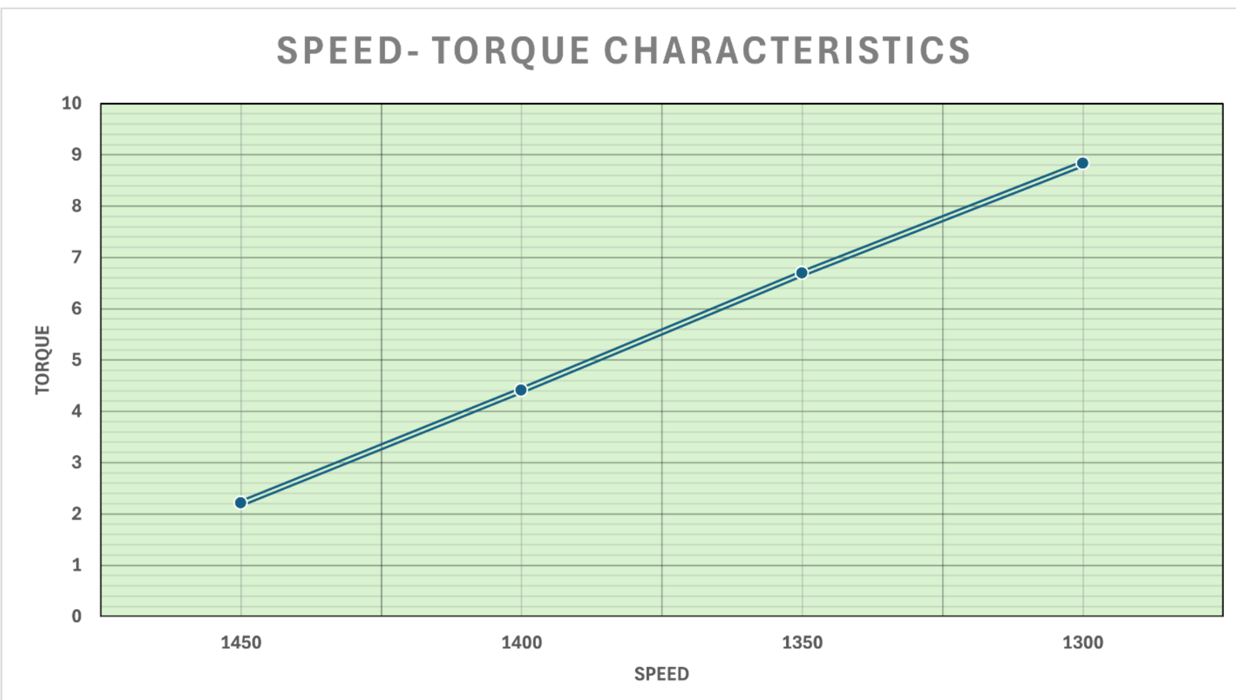
Efficiency η = $\frac{684.68}{1320} = 51.86\%$

Efficiency η = $\frac{936.819}{1980} = 47.31\%$

Efficiency η = $\frac{1202.965}{2640} = 45.56\%$



Performance characteristics of DC shunt motor
Speed, Torque, Efficiency & Current
Output Power (W)
335.4
684.7
936.8
1,203.0
1450
50.81
51.86
1400
1350
47.31
45.56
1300
12
9
6
3
2.21
4.41
6.69
8.83
Torque
Current
Efficiency (%)
Speed



SPEED- TORQUE CHARACTERISTICS
TORQUE
SPEED
1450
1400
1350
1300

Test Case 3:

Conduct the load test on DC shunt motor and obtain its performance characteristics.

Load Condition	Load Voltage (V)	Load Current (A)	Spring Balance S1 (kg)	Spring Balance S2 (kg)	Speed (RPM)	Torque (Nm)
No Load	220	0.5	0	0	1500	0
25% Load	220	3	2.5	1	1450	2.21
50% Load	220	6	5	2	1400	4.41
75% Load	220	9	7.5	3	1350	6.69
Full Load	220	12	10	4	1300	8.83

Theoretical Calculations:

Circumference C = 2πR=2x3.14xR

$$F = (S_1 - S_2) \times 9.81$$
$$F = (2.5-1) \times 9.81 = 14.715$$
$$F = (5-2) \times 9.81 = 29.43$$
$$F = (7.5-3) \times 9.81 = 44.145$$
$$F = (10-4) \times 9.81 = 58.86$$

$$R = \frac{C}{2 \times \pi} = \frac{94.317 \times 10^{-2}}{2 \times 3.14} = 0.1502$$

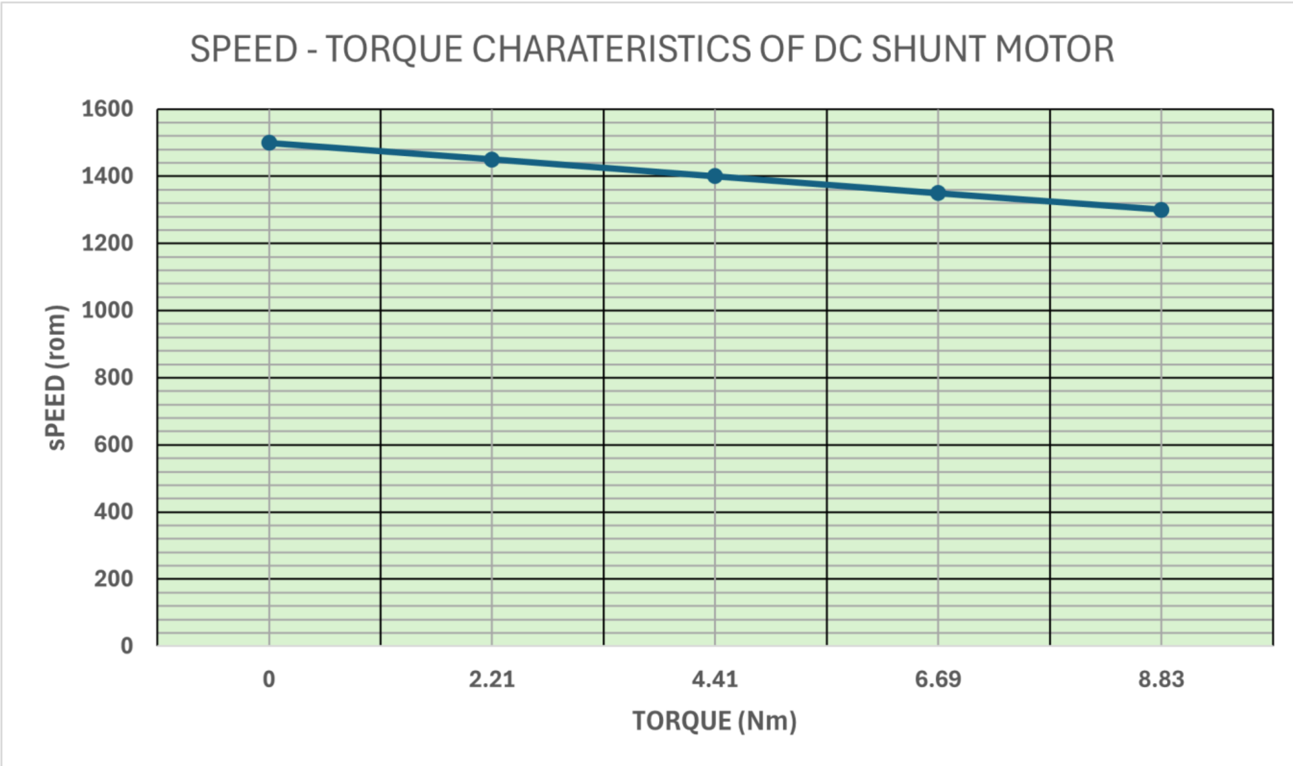
Torque = $F \times R$

T= $14.715 \times 0.1502 = 2.21$

T= $29.43 \times 0.1502 = 4.420$

T= $44.145 \times 0.1502 = 6.63$

T= $58.86 \times 0.1502 = 8.841$

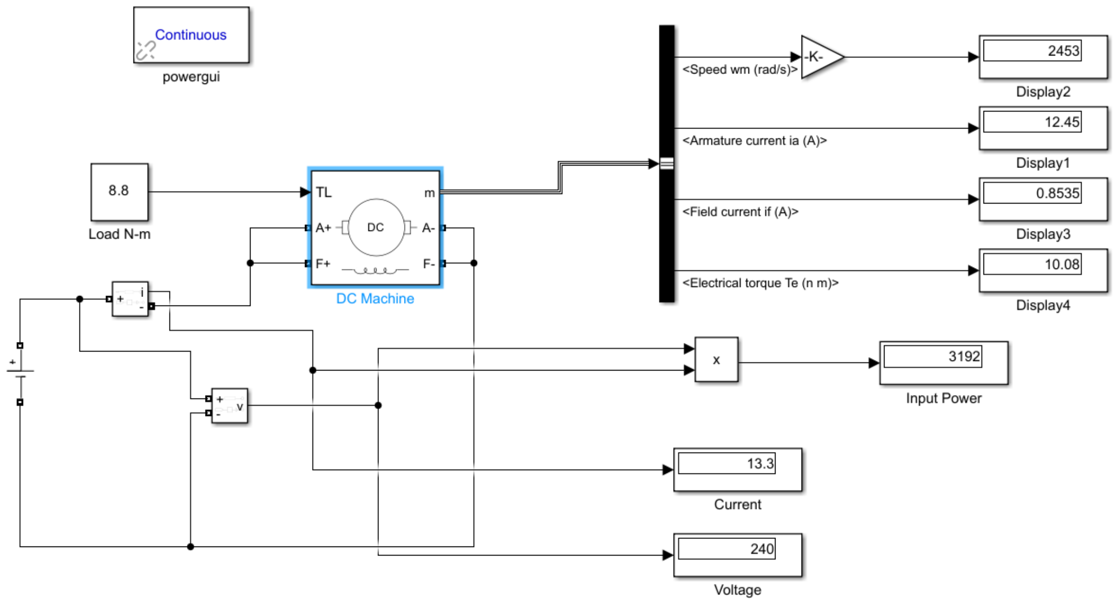


Test Case 4:

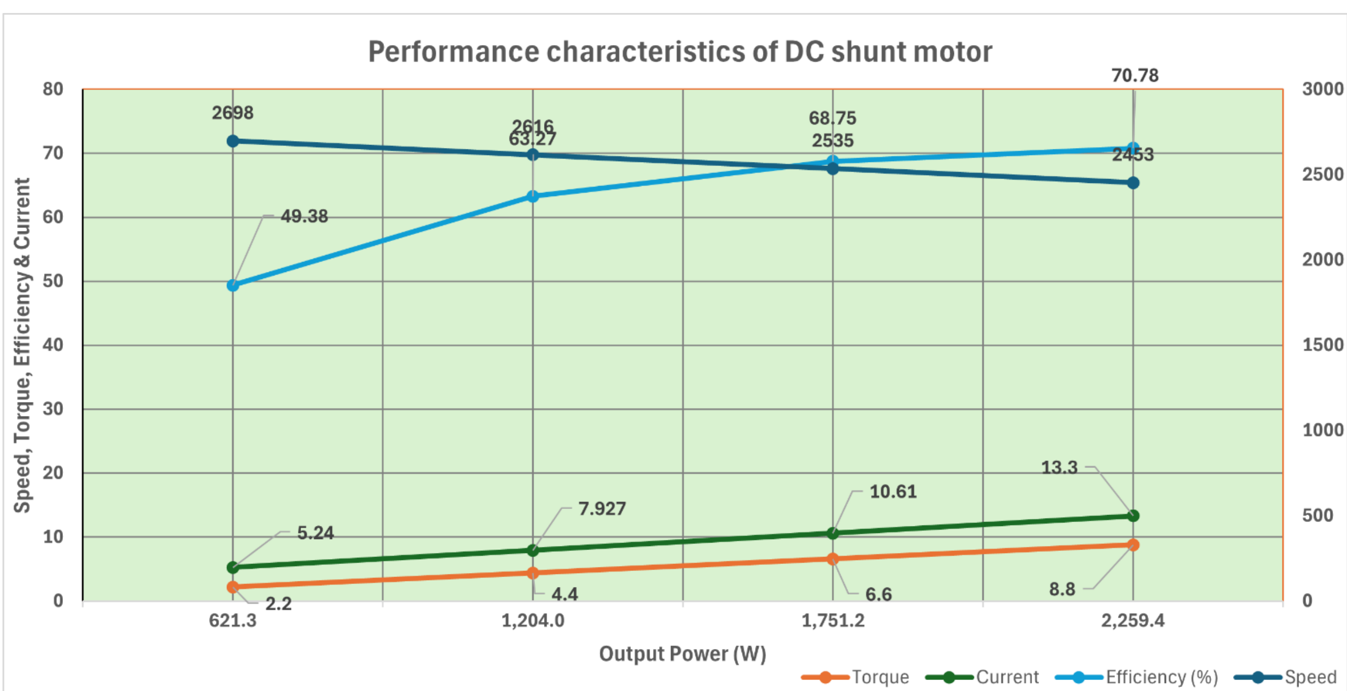
In this lab exam, you are tasked with conducting a load test on a DC shunt motor to analyze its performance characteristics. The motor's specifications are as follows:
Motor ratings: 5HP, 240V, 1750 RPM, Field voltage: 300V

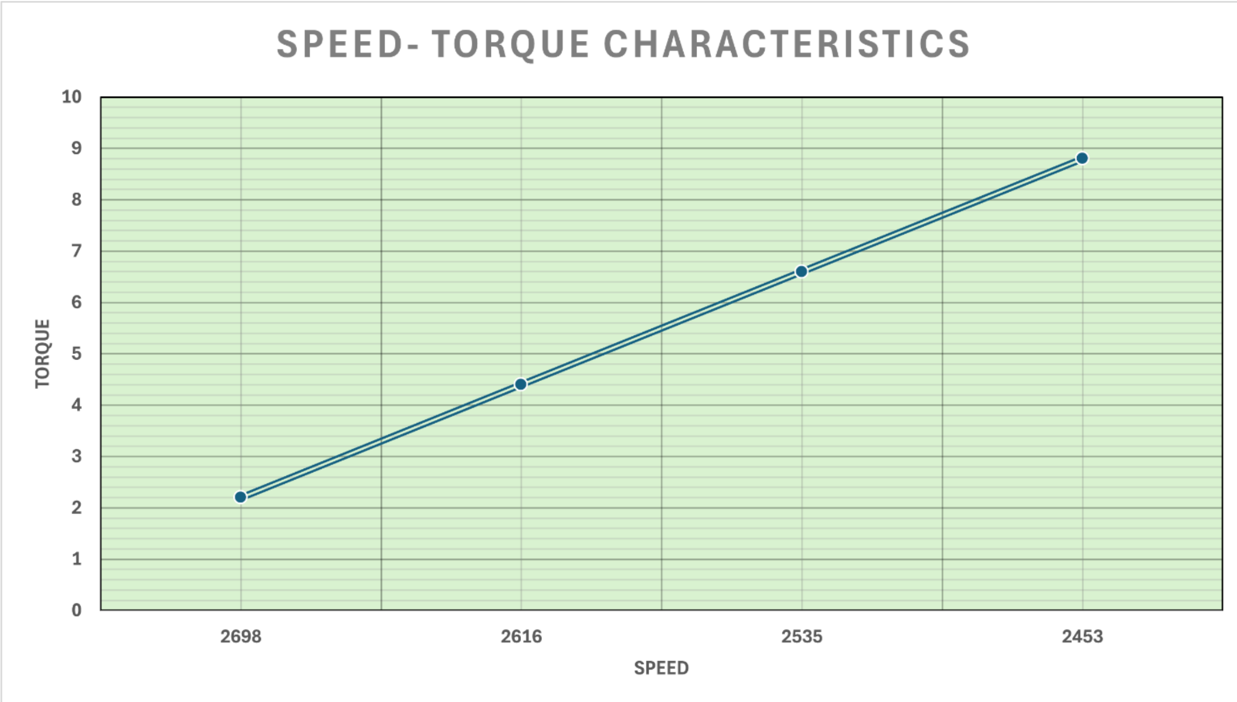
Perform the following:

Load Test:
i) Gradually apply load to the motor using a mechanical brake or other load arrangement.
ii) Record the load torque (T_load) and the corresponding speed (N_load) for various load levels.
iii) Ensure that the load applied does not exceed the motor's rated torque.
a) Determine the motor's output power at rated conditions (P_rated).
b) Calculate the efficiency (η) of the motor for each load level using the formula η = (P_out / P_in) *100, where P_{in} is the electrical input power.



Load Voltage	Load Current	Speed	Load Torque	Electrical Torque	Input Power	Armature current	Field Current	Output Power
240	5.24	2698	2.2	3.551	1258	4.38	0.8535	621.25
240	7.927	2616	4.4	5.727	1903	7.07	0.8535	1204
240	10.61	2535	6.6	7.901	2547	9.761	0.8535	1751.17
240	13.3	2453	8.8	10.08	3192	12.45	0.8535	2259.37





Output Power= $\frac{2\pi NT}{60}$

Output Power $P_o = \frac{2\times3.14\times2698\times2.2}{60} = 621.25W$

Output Power $P_o = \frac{2\times3.14\times2616\times4.4}{60} = 1204W$

Output Power $P_o = \frac{2\times3.14\times2535\times6.6}{60} = 1751.17W$

Output Power $P_o = \frac{2\times3.14\times2453\times8.8}{60} = 2259.37W$

Input Power P_{in} = V.I

Input Power P_{in} = 240×5.24=1258W

Input Power P_{in} =240×7.927=1903W

Input Power P_{in} = 240×10.61=2547W

Input Power P_{in} = 240×13.3=3192W

Expt. No. 15(a)	Staircase Wiring

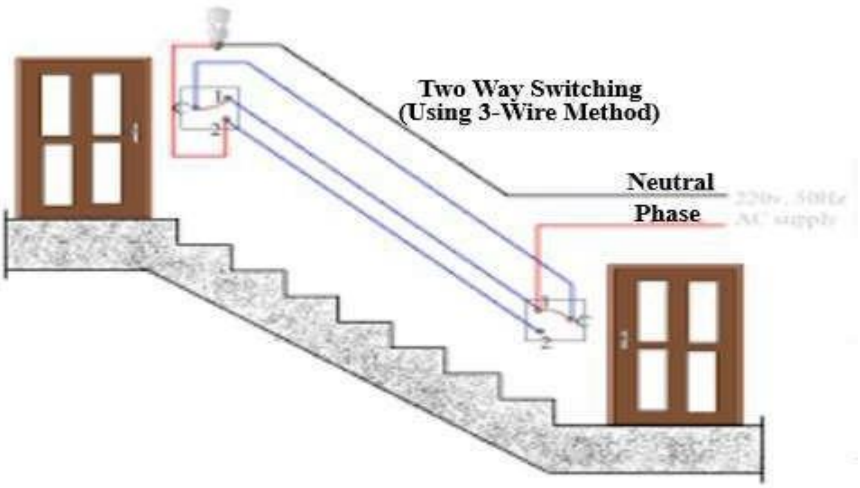
AIM:
To control the status of the given lamp using two-way switches.

APPARATUS REQUIRED:

S.NO	APPARATUS	RANGE / TYPE	QUANTITY
1	Incandescent Lamp	60W/40W	1
2	SPDT (Single Pole Double Throw-Double Way Switch)	5A, 230V	2
3	Lamp holder	Pendant type	1
4	Line Tester	500V / Taparia 813	1
5	3 Pin Plug	5A, 230V	1
6	Wire Stripper Cum Cutter	Pye 950	1
7	Connecting Wires	12A / 1 sq.mm Area/ 0.7 Thickness	As Per Requirement

THEORY:

Staircase wiring is a common multi-way switching or two-way light switching connection; one light two switches wiring. One lamp is controlled by two switches from two different positions that is to operate the load from separate positions such as above or below the staircase, from inside or outside of a room, or as a two-way bed switch. The main purpose of two-way switching connection is to connect and control AC appliances and equipments from two separate locations. It is mostly used in staircase wiring where a light bulb can be control (Switch ON / Switch OFF) from different places, no matter you are in the upper or lower portion of stair; it does not depend on the switches position as well. You just have to press theswitch button to OFF/ON to perform the switching operation. It is also used in rooms having large area which has two entry and exit gates. It is used to control any electrical (AC or DC) appliance or equipment like fan, light bulbs etc from two different places.

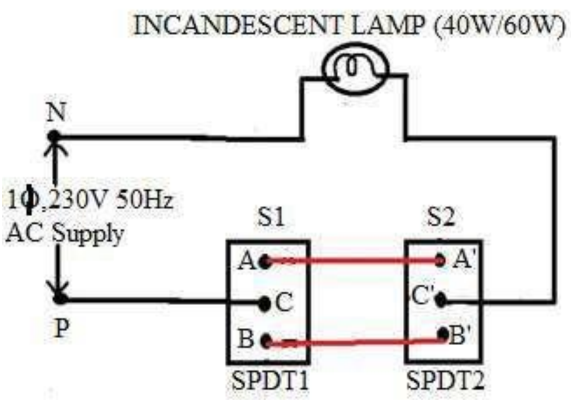


PROCEDURE:

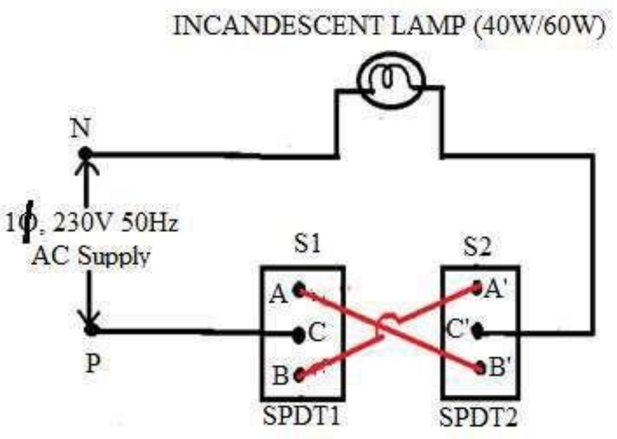
1. A piece of wire is connected to the phase side and other end to the middle point of SPDT switch1.
2. Another point of lamp holder is connected to neutral line.
3. Upper point of SPDT switch 1 is connected to the upper point of SPDT switch 2.Lower point of SPDT switch 1 is connected to the lower point of switch 2.
4. Circuit is tested that all combination of switch connection.

CIRCUIT DIAGRAM:

DIRECT CONNECTION:



INDIRECT CONNECTION:



TABULATION:

DIRECT CONNECTION:

S.NO	S1	S2	LAMP STATUS
1	CA	C'A'	ON
2	CB	C'B'	ON
3	CA	C'B'	OFF
4	CB	C'A'	OFF

INDIRECT CONNECTION:

S.NO	S1	S2	LAMP STATUS
1	CA	C'A'	OFF
2	CB	C'B'	OFF
3	CA	C'B'	ON
4	CB	C'A'	ON

RESULT:

Thus the status of the given lamp was controlled and tested under direct and indirect connection using two way switches.

Expt. No. 15(b)	Fluorescent tube wiring

AIM:

To prepare wiring for a fluorescent tube light with switch control.

APPARATUS REQUIRED:

Sl No.	Apparatus	Range	Quantity
1.	Tube light with fitting	-	1
2.	Joint clips	-	As required
3.	Switch	-	1
4.	Wires	-	As required
5.	Screws	-	As required
6.	Switch board	-	1

THEORY:

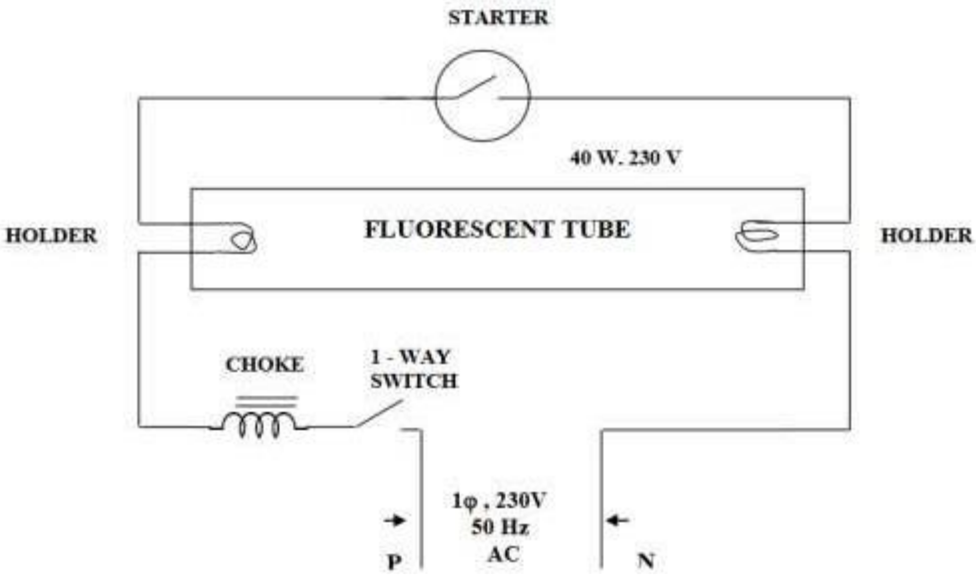
Working of the Fluorescent Tube Light:

The fluorescent lamp circuit consists of a choke, a starter, a fluorescent tube and a frame. The length of the commonly used fluorescent tube is 100 cm; its power rating is 40 W and 230V. The tube is filled with argon and a drop of mercury. When the supply is switched on, the current heats the filaments and initiates emission of electrons. After one or two seconds, the starter circuit opens and makes the choke to induce a momentary high voltage surge across the two filaments. Ionization takes place through argon and produces bright light.

PROCEDURE:

1. Mark the switch and tube light location points and draw lines for wiring on the wooden board.
2. Place wires along the lines and fix them with the help of clips.
3. Fix the switch and tube light fitting in the marked positions.
4. Complete the wiring as per the wiring diagram.
5. Test the working of the tube light by giving electric supply to theCircuit.

CIRCUIT DIAGRAM - TUBE LIGHT



INFERENCE:

When SW is switched on:

CONDITION	OBSERVATION
With Starter	

If the starter is removed with the tube light on, ____________________

RESULT:

Thus the wiring for the tube light is completed and tested.

Case (1-a) Conduct a suitable experiment to verify the below conditions.

S.NO	S1	S2	LAMP STATUS
1	CA	C'A'	ON
2	CB	C'B'	ON
3	CA	C'B'	OFF
4	CB	C'A'	OFF

Answer:

AIM:
To control the status of the given lamp using two-way switches.

APPARATUS REQUIRED:

S.NO	APPARATUS	RANGE / TYPE	QUANTITY
1	Incandescent Lamp	60W/40W	1
2	SPDT (Single Pole Double Throw-Double Way Switch)	5A, 230V	2
3	Lamp holder	Pendant type	1
4	Line Tester	500V / Taparia 813	1
5	3 Pin Plug	5A, 230V	1
6	Wire Stripper Cum Cutter	Pye 950	1
7	Connecting Wires	12A / 1 sq.mm Area/ 0.7 Thickness	As Per Requirement

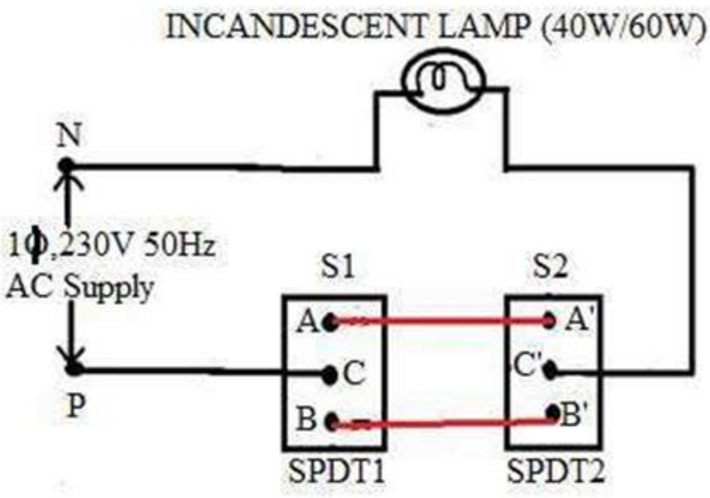
THEORY:

Staircase wiring is a common multi-way switching or two-way light switching connection; one light two switches wiring. One lamp is controlled by two switches from two different positions that is to operate the load from separate positions such as above or below the staircase, from inside or outside of a room, or as a two-way bed switch. The main purpose of two-way switching connection is to connect and control AC appliances and equipments from two separate locations. It is mostly used in staircase wiring where a light bulb can be control (Switch ON / Switch OFF) from different places, no matter you are in the upper or lower portion of stair; it does not depend on the switches position as well. You just have to press theswitch button to OFF/ON to perform the switching operation. It is also used in rooms having large area which has two entry and exit gates. It is used to control any electrical (AC or DC) appliance or equipment like fan, light bulbs etc from two different places.

PROCEDURE:

1. A piece of wire is connected to the phase side and other end to the middle point of SPDT switch1.
2. Another point of lamp holder is connected to neutral line.
3. Upper point of SPDT switch 1 is connected to the upper point of SPDT switch 2.Lower point of SPDT switch 1 is connected to the lower point of switch 2.
4. Circuit is tested that all combination of switch connection.

CIRCUIT DIAGRAM:



TABULATION:

S.NO	S1	S2	LAMP STATUS
1	CA	C'A'	ON
2	CB	C'B'	ON
3	CA	C'B'	OFF
4	CB	C'A'	OFF

RESULT:

Thus the lamp was controlled for the given conditions by constructing a circuit using two way switches.

Case (1-b) Conduct an experiment to verify the connection of fluorescent lamp to its ballast and power supply.

Answer:

AIM:

To prepare wiring for a fluorescent tube light with switch control.

APPARATUS REQUIRED:

Sl No.	Apparatus	Range	Quantity
1.	Tube light with fitting	-	1
2.	Joint clips	-	As required
3.	Switch	-	1
4.	Wires	-	As required
5.	Screws	-	As required
6.	Switch board	-	1

THEORY:

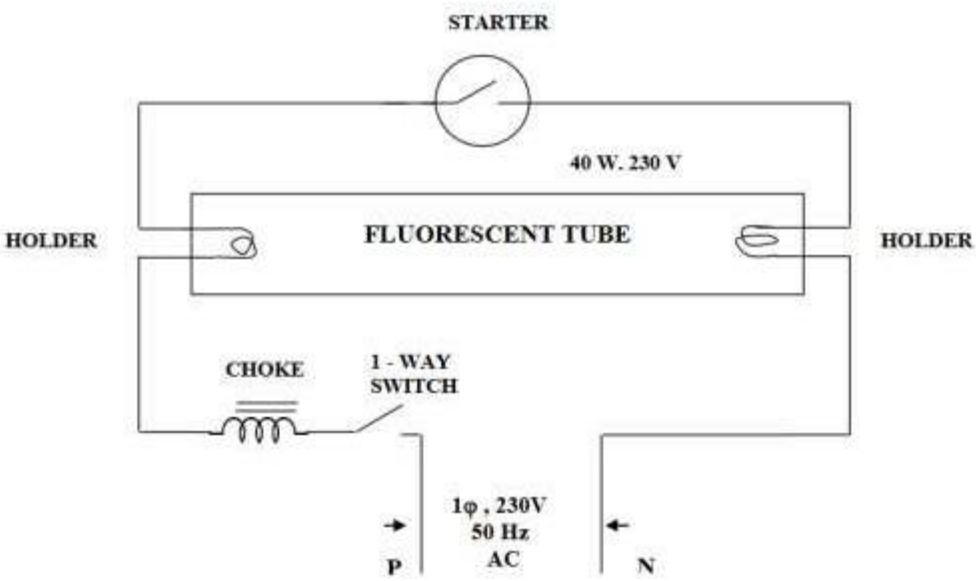
Working of the Fluorescent Tube Light:

The fluorescent lamp circuit consists of a choke, a starter, a fluorescent tube and a frame. The length of the commonly used fluorescent tube is 100 cm; its power rating is 40 W and 230V. The tube is filled with argon and a drop of mercury. When the supply is switched on, the current heats the filaments and initiates emission of electrons. After one or two seconds, the starter circuit opens and makes the choke to induce a momentary high voltage surge across the two filaments. Ionization takes place through argon and produces bright light.

PROCEDURE:

1. Mark the switch and tube light location points and draw lines for wiring on thewooden board.
2. Place wires along the lines and fix them with the help of clips.
3. Fix the switch and tube light fitting in the marked positions.
4. Complete the wiring as per the wiring diagram.
5. Test the working of the tube light by giving electric supply to theCircuit.

CIRCUIT DIAGRAM - TUBE LIGHT



INFERENCE:

When SW is switched on:

CONDITION	OBSERVATION
With Starter	

If the starter is removed with the tube light on, ______________________________

RESULT:

Thus the wiring for the tube light is completed and tested.

Case (2-a) Conduct a suitable experiment to verify the below conditions.

S.NO	S1	S2	LAMP STATUS
1	CA	C'A'	OFF
2	CB	C'B'	OFF
3	CA	C'B'	ON
4	CB	C'A'	ON

Answer:

AIM:

To control the status of the given lamp using two-way switches.

APPARATUS REQUIRED:

S.NO	APPARATUS	RANGE / TYPE	QUANTITY
1	Incandescent Lamp	60W/40W	1
2	SPDT (Single Pole Double Throw-Double Way Switch)	5A, 230V	2
3	Lamp holder	Pendant type	1
4	Line Tester	500V / Taparia 813	1
5	3 Pin Plug	5A, 230V	1
6	Wire Stripper Cum Cutter	Pye 950	1
7	Connecting Wires	12A / 1 sq.mm Area/ 0.7 Thickness	As Per Requirement

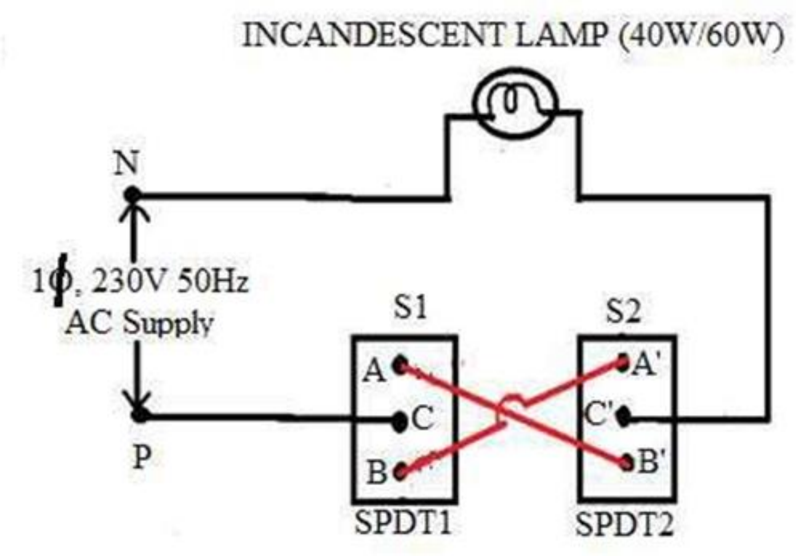
THEORY:

Staircase wiring is a common multi-way switching or two-way light switching connection; one light two switches wiring. One lamp is controlled by two switches from two different positions that is to operate the load from separate positions such as above or below the staircase, from inside or outside of a room, or as a two-way bed switch. The main purpose of two-way switching connection is to connect and control AC appliances and equipments from two separate locations. It is mostly used in staircase wiring where a light bulb can be control (Switch ON / Switch OFF) from different places, no matter you are in the upper or lower portion of stair; it does not depend on the switches position as well. You just have to press theswitch button to OFF/ON to perform the switching operation. It is also used in rooms having large area which has two entry and exit gates. It is used to control any electrical (AC or DC) appliance or equipment like fan, light bulbs etc from two different places.

PROCEDURE:

1. A piece of wire is connected to the phase side and other end to the middle point of SPDT switch1.
2. Another point of lamp holder is connected to neutral line.
3. Upper point of SPDT switch 1 is connected to the upper point of SPDT switch 2.Lower point of SPDT switch 1 is connected to the lower point of switch 2.
4. Circuit is tested that all combination of switch connection.

CIRCUIT DIAGRAM:



TABULATION:

S.NO	S1	S2	LAMP STATUS
1	CA	C'A'	OFF
2	CB	C'B'	OFF
3	CA	C'B'	ON
4	CB	C'A'	ON

RESULT:

Thus the lamp was controlled for the given conditions by constructing a circuit using two way switches.

Case (2-b) Conduct an experiment to verify the step by step process for installing a fluorescent lamp into a fixture.
Answer:

AIM:

To prepare wiring for a fluorescent tube light with switch control.

APPARATUS REQUIRED:

Sl No.	Apparatus	Range	Quantity
1.	Tube light with fitting	-	1
2.	Joint clips	-	As required
3.	Switch	-	1
4.	Wires	-	As required
5.	Screws	-	As required
6.	Switch board	-	1

THEORY:

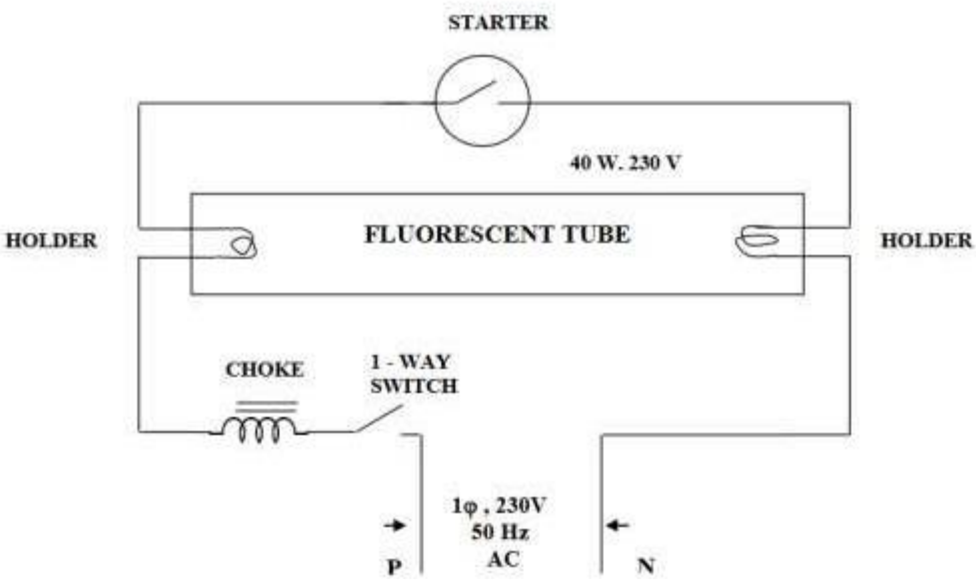
Working of the Fluorescent Tube Light:

The fluorescent lamp circuit consists of a choke, a starter, a fluorescent tube and a frame. The length of the commonly used fluorescent tube is 100 cm; its power rating is 40 W and 230V. The tube is filled with argon and a drop of mercury. When the supply is switched on, the current heats the filaments and initiates emission of electrons. After one or two seconds, the starter circuit opens and makes the choke to induce a momentary high voltage surge across the two filaments. Ionization takes place through argon and produces bright light.

PROCEDURE:

1. Mark the switch and tube light location points and draw lines for wiring on thewooden board.
2. Place wires along the lines and fix them with the help of clips.
3. Fix the switch and tube light fitting in the marked positions.
4. Complete the wiring as per the wiring diagram.
5. Test the working of the tube light by giving electric supply to theCircuit.

CIRCUIT DIAGRAM - TUBE LIGHT



INFERENCE:

When SW is switched on:

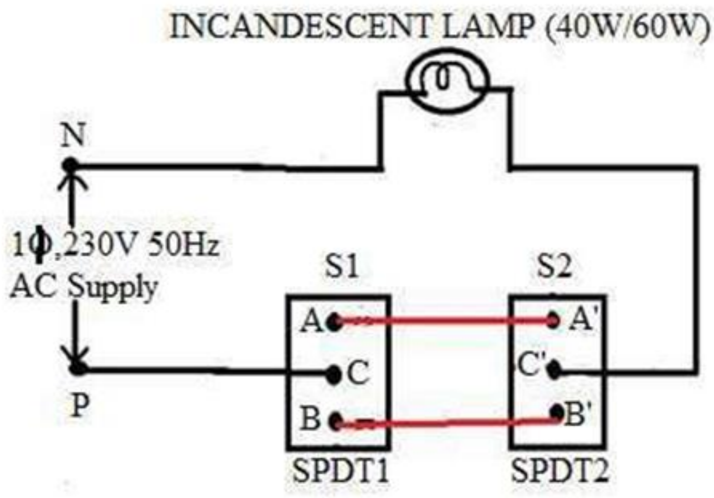
CONDITION	OBSERVATION
With Starter	

If the starter is removed with the tube light on, ______________________________

RESULT:

Thus the wiring for the tube light is completed and tested.

Case (3-a) Conduct a suitable experiment to verify the output conditions for the diagram given below.



Answer:

AIM:
To control the status of the given lamp using two-way switches.

APPARATUS REQUIRED:

S.NO	APPARATUS	RANGE / TYPE	QUANTITY
1	Incandescent Lamp	60W/40W	1
2	SPDT (Single Pole Double Throw-Double Way Switch)	5A, 230V	2
3	Lamp holder	Pendant type	1
4	Line Tester	500V / Taparia 813	1
5	3 Pin Plug	5A, 230V	1
6	Wire Stripper Cum Cutter	Pye 950	1
7	Connecting Wires	12A / 1 sq.mm Area/ 0.7 Thickness	As Per Requirement

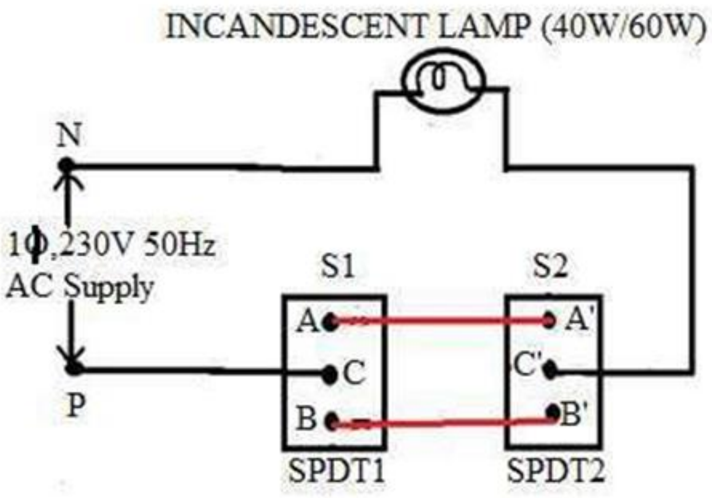
THEORY:

Staircase wiring is a common multi-way switching or two-way light switching connection; one light two switches wiring. One lamp is controlled by two switches from two different positions that is to operate the load from separate positions such as above or below the staircase, from inside or outside of a room, or as a two-way bed switch. The main purpose of two-way switching connection is to connect and control AC appliances and equipments from two separate locations. It is mostly used in staircase wiring where a light bulb can be control (Switch ON / Switch OFF) from different places, no matter you are in the upper or lower portion of stair; it does not depend on the switches position as well. You just have to press theswitch button to OFF/ON to perform the switching operation. It is also used in rooms having large area which has two entry and exit gates. It is used to control any electrical (AC or DC) appliance or equipment like fan, light bulbs etc from two different places.

PROCEDURE:

1. A piece of wire is connected to the phase side and other end to the middle point of SPDT switch1.
2. Another point of lamp holder is connected to neutral line.
3. Upper point of SPDT switch 1 is connected to the upper point of SPDT switch 2.Lower point of SPDT switch 1 is connected to the lower point of switch 2.
4. Circuit is tested that all combination of switch connection.

CIRCUIT DIAGRAM:



TABULATION:

S.NO	S1	S2	LAMP STATUS
1	CA	C'A'	ON
2	CB	C'B'	ON
3	CA	C'B'	OFF
4	CB	C'A'	OFF

RESULT:

Thus the lamp conditions were verified for the given circuit using two way switches.

Case (3-b) Conduct an experiment to test whether a fluorescent lamp is functioning correctly.
Answer:

AIM:

To prepare wiring for a fluorescent tube light with switch control.

APPARATUS REQUIRED:

Sl No.	Apparatus	Range	Quantity
1.	Tube light with fitting	-	1
2.	Joint clips	-	As required
3.	Switch	-	1
4.	Wires	-	As required
5.	Screws	-	As required
6.	Switch board	-	1

THEORY:

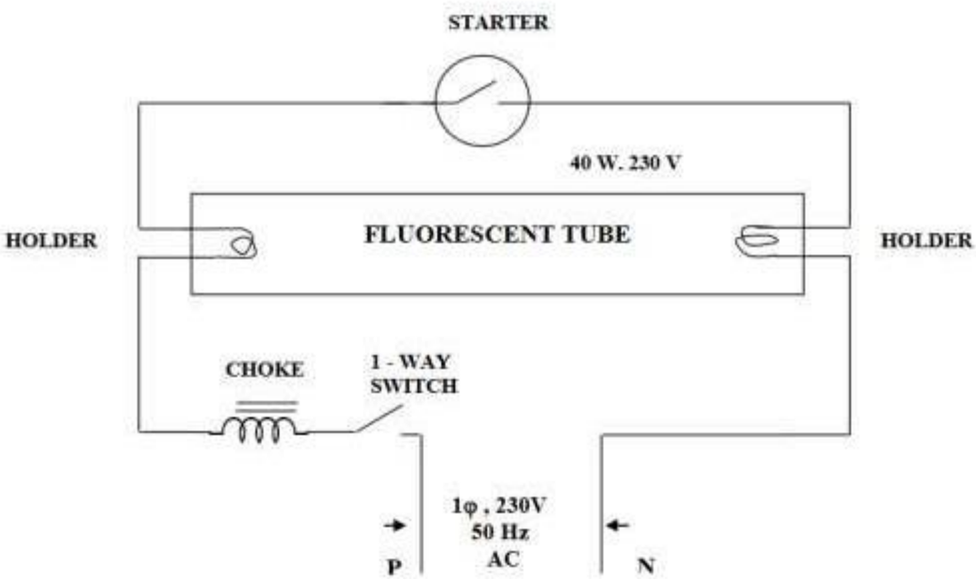
Working of the Fluorescent Tube Light:

The fluorescent lamp circuit consists of a choke, a starter, a fluorescent tube and a frame. The length of the commonly used fluorescent tube is 100 cm; its power rating is 40 W and 230V. The tube is filled with argon and a drop of mercury. When the supply is switched on, the current heats the filaments and initiates emission of electrons. After one or two seconds, the starter circuit opens and makes the choke to induce a momentary high voltage surge across the two filaments. Ionization takes place through argon and produces bright light.

PROCEDURE:

1. Mark the switch and tube light location points and draw lines for wiring on thewooden board.
2. Place wires along the lines and fix them with the help of clips.
3. Fix the switch and tube light fitting in the marked positions.
4. Complete the wiring as per the wiring diagram.
5. Test the working of the tube light by giving electric supply to theCircuit.

CIRCUIT DIAGRAM - TUBE LIGHT



INFERENCE:

When SW is switched on:

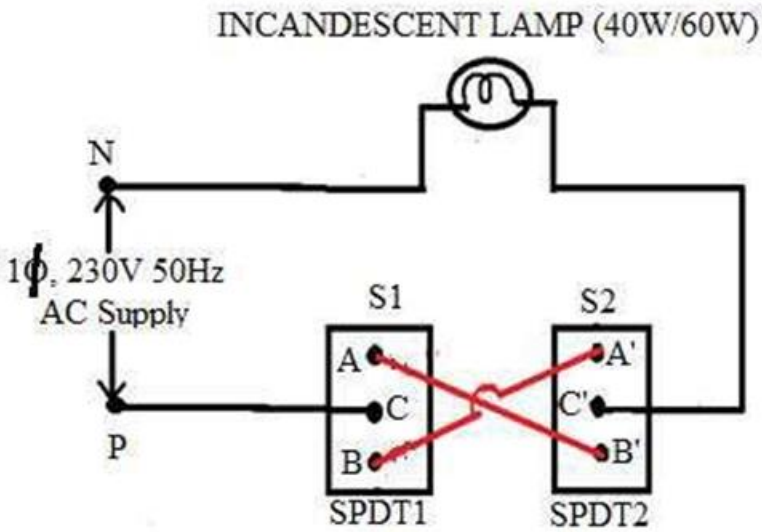
CONDITION	OBSERVATION
With Starter	

If the starter is removed with the tube light on, ______________________________

RESULT:

Thus the wiring for the tube light is completed and tested.

Case (4-a) Conduct a suitable experiment to verify the output conditions for the diagram given below.



Answer:

AIM:
To control the status of the given lamp using two-way switches.

APPARATUS REQUIRED:

S.NO	APPARATUS	RANGE / TYPE	QUANTITY
1	Incandescent Lamp	60W/40W	1
2	SPDT (Single Pole Double Throw-Double Way Switch)	5A, 230V	2
3	Lamp holder	Pendant type	1
4	Line Tester	500V / Taparia 813	1
5	3 Pin Plug	5A, 230V	1
6	Wire Stripper Cum Cutter	Pye 950	1
7	Connecting Wires	12A / 1 sq.mm Area/ 0.7 Thickness	As Per Requirement

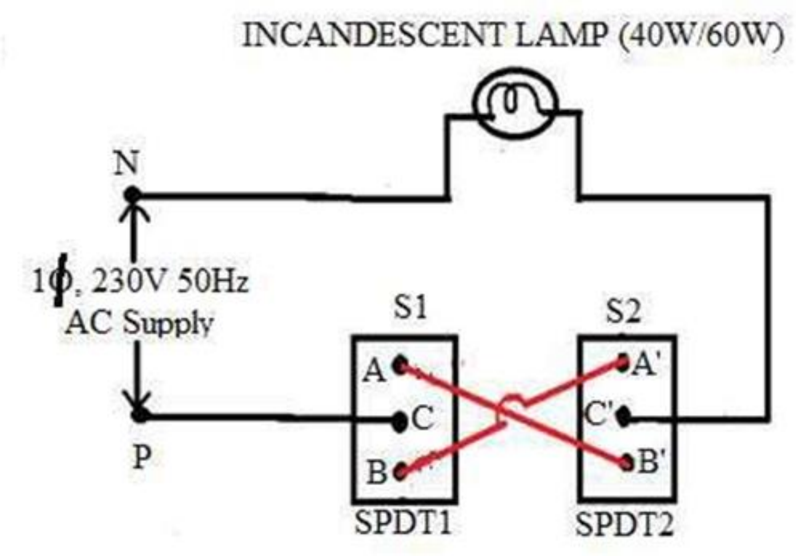
THEORY:

Staircase wiring is a common multi-way switching or two-way light switching connection; one light two switches wiring. One lamp is controlled by two switches from two different positions that is to operate the load from separate positions such as above or below the staircase, from inside or outside of a room, or as a two-way bed switch. The main purpose of two-way switching connection is to connect and control AC appliances and equipments from two separate locations. It is mostly used in staircase wiring where a light bulb can be control (Switch ON / Switch OFF) from different places, no matter you are in the upper or lower portion of stair; it does not depend on the switches position as well. You just have to press theswitch button to OFF/ON to perform the switching operation. It is also used in rooms having large area which has two entry and exit gates. It is used to control any electrical (AC or DC) appliance or equipment like fan, light bulbs etc from two different places.

PROCEDURE:

1. A piece of wire is connected to the phase side and other end to the middle point of SPDT switch1.
2. Another point of lamp holder is connected to neutral line.
3. Upper point of SPDT switch 1 is connected to the upper point of SPDT switch 2.Lower point of SPDT switch 1 is connected to the lower point of switch 2.
4. Circuit is tested that all combination of switch connection.

CIRCUIT DIAGRAM:



TABULATION:

S.NO	S1	S2	LAMP STATUS
1	CA	C'A'	OFF
2	CB	C'B'	OFF
3	CA	C'B'	ON
4	CB	C'A'	ON

RESULT:

Thus the lamp conditions were verified for the given circuit using two way switches.

Case (4-b) Conduct an experiment to configure the lamp and ballast to ensure its stable operation.
Answer:

AIM:

To prepare wiring for a fluorescent tube light with switch control.

APPARATUS REQUIRED:

Sl No.	Apparatus	Range	Quantity
1.	Tube light with fitting	-	1
2.	Joint clips	-	As required
3.	Switch	-	1
4.	Wires	-	As required
5.	Screws	-	As required
6.	Switch board	-	1

THEORY:

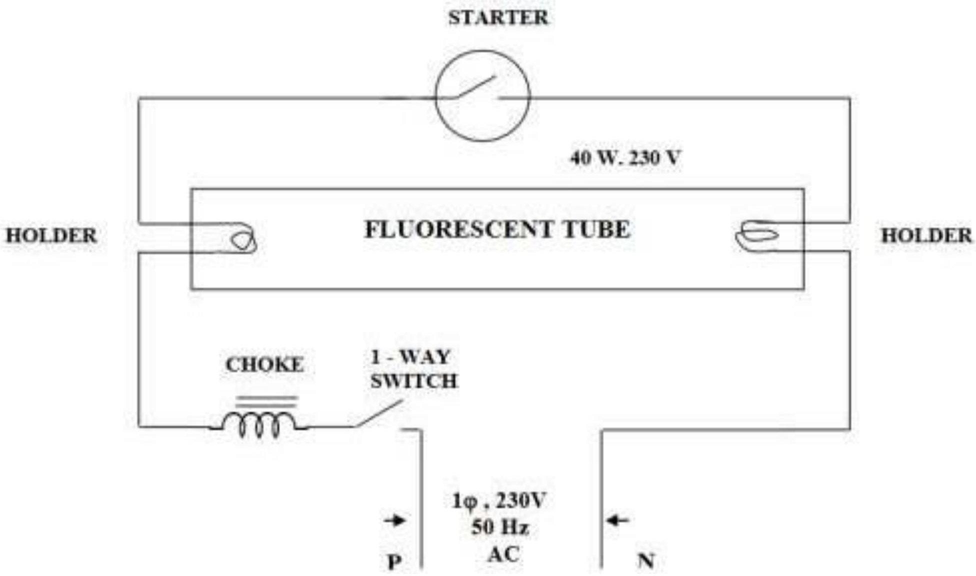
Working of the Fluorescent Tube Light:

The fluorescent lamp circuit consists of a choke, a starter, a fluorescent tube and a frame. The length of the commonly used fluorescent tube is 100 cm; its power rating is 40 W and 230V. The tube is filled with argon and a drop of mercury. When the supply is switched on, the current heats the filaments and initiates emission of electrons. After one or two seconds, the starter circuit opens and makes the choke to induce a momentary high voltage surge across the two filaments. Ionization takes place through argon and produces bright light.

PROCEDURE:

1. Mark the switch and tube light location points and draw lines for wiring on thewooden board.
2. Place wires along the lines and fix them with the help of clips.
3. Fix the switch and tube light fitting in the marked positions.
4. Complete the wiring as per the wiring diagram.
5. Test the working of the tube light by giving electric supply to the Circuit.

CIRCUIT DIAGRAM - TUBE LIGHT



INFERENCE:

When SW is switched on:

CONDITION	OBSERVATION
With Starter	

If the starter is removed with the tube light on, ____________________

RESULT:

Thus the wiring for the tube light is completed and tested.

Exp: 15 FIND STABILITY OF A SYSTEM USING ROUTH HURWITZ CRITERION

Aim:
To determine the stability of the closed-loop system using Routh Hurwitz Criterion for the given polynomial characteristics equations.

(i) $(s)=s^4+2s^3+3s^2+4s+5$ and
(ii) $(s)=s^5+7s^4+6s^3+42s^2+8s+56$

Tools Used:

(i) SCILAB software

(ii) PC

Program code:

```
clear;
clc;
xdel(winsid());
mode(0);
s=%s;
H=s^4+2*s^3+3*s^2+4*s+5;
//H=s^5+7*s^4+6*s^3+42*s^2+8*s+56;
disp(H,'The given characteristics equation 1-G(s)H(s)=');
c=coeff(H);
len=length(c);
r=routh_t(H);
disp(r,"Rouths table=");
x=0;
for i=1:len
if(r(i,1)<0)
x=x+1;
end
end
if(x>=1)
printf("From Rouths table, it is clear that the system is unstable.")
else
printf("From Rouths table, it is clear that the system is stable.")
end
```

Simulation output:

```
Scilab 6.0.2 Console

 The given characteristics equation 1-G(s)H(s)=

              2     3    4
   5 +4s +3s  +2s  +s

 Rouths table=

   1.   3.   5.
   2.   4.   0.
   1.   5.   0.
  -6.   0.   0.
   5.   0.   0.
From Rouths table, it is clear that the system is unstable.
-->
```

```
Scilab 6.0.2 Console

 The given characteristics equation 1-G(s)H(s)=

                2     3     4    5
   56 +8s +42s  +6s  +7s  +s

 Rouths table=

   1.          6.    8.
   7.          42.   56.
   28.         84.   0.
   21.         56.   0.
   9.3333333   0.    0.
   56.         0.    0.
From Rouths table, it is clear that the system is stable.
-->
```

Marks Obtained:

Theoretical Calculations	**20**	
Observation	**20**	
Execution of practice examples	**30**	
Viva	**10**	
Record	**20**	
Total Score	**100**	
Date of experiment		
Date of record submission		**Faculty signature**

RESULT:

Thus the stability of a system using routh hurwitz criterion is verified.

Aim: To Study the Function of Three Phase Induction Motor Drive Systemin E-Mobility.

Requirements:

1. 750W Three Phase Induction Motor	1 Nos.
2. Panel with DC Voltmeter, DC Ammeter & AC Meter	1 Nos.
3. 750W Variable Frequency AC Drive (VFD)	1 Nos.
4. Battery Emulator/DC Drive	1 Nos.
5. Human Machine Interface (HMI)	1 Nos.
6. 12 V Alternator with 12V Batteries for Electrical Loading	1 Nos.

Theory:

Three-phase AC induction motors play a very important role in industry due to its low price and simplicity. The induction motor is used to convert three-phase AC power into mechanical power. When the load on an induction motor increases the percentage of slip is increase, which leads to decrease the speed of induction motor while constant speed in industryis very important. The speed of induction motor is controlled by variable frequency drive (VFD) automatically through controller. It is simple and efficient method to control the speed because speed depends upon voltage, pole and frequency. Poles are fix inbuilt in the motor so we cannotchange it and speed control through VFD is simple and energy efficient method. This technique implemented on hardware. So this technique is robust and simpler to implement.

Synchronous Speed:

When Alternating current (AC) is applied to the stator of a three phase motor, a rotating magnetic field is setup. This rotating magnetic field moves with a speed called synchronous speed. The Synchronous speed can be calculated as follows: 120 times the frequency (F), divided by the number of poles (P):

$$N_S = \frac{120F}{P}$$

The synchronous speed decreases as the number of poles increases. Thetable below shows the synchronous speed associated with various numbers of poles at supply frequencies of 50Hz and 60Hz:

No. of Poles	Synchronous Speed @ 50Hz	Synchronous Speed @ 60Hz
2	3000	3600
4	1500	1800
6	1000	1200
8	750	900
12	500	600

Rated Speed: The speed of operation of an AC motor when fully loaded at rated voltage is called the rated speed. It is usually given in RPM an electric motor nameplate. The rated speed is the speed of the rotor.**Slip**: The speed of the rotor magnetic field in an induction motor lags slightly behind the synchronous speed of the changing stator magnetic field. This difference in speed between rotor and stator fields is called slipand is measured in %.The slip of an AC motor is a key factor and is necessary to produce torque. The greater the load (torque), the greater slip will be

The formula for calculating motor slip is given by:

$$Slip = \frac{N_S - N}{N_S}$$

$Where:$

$N_s = Synchronous - speed$

$N = Rotor - speed$

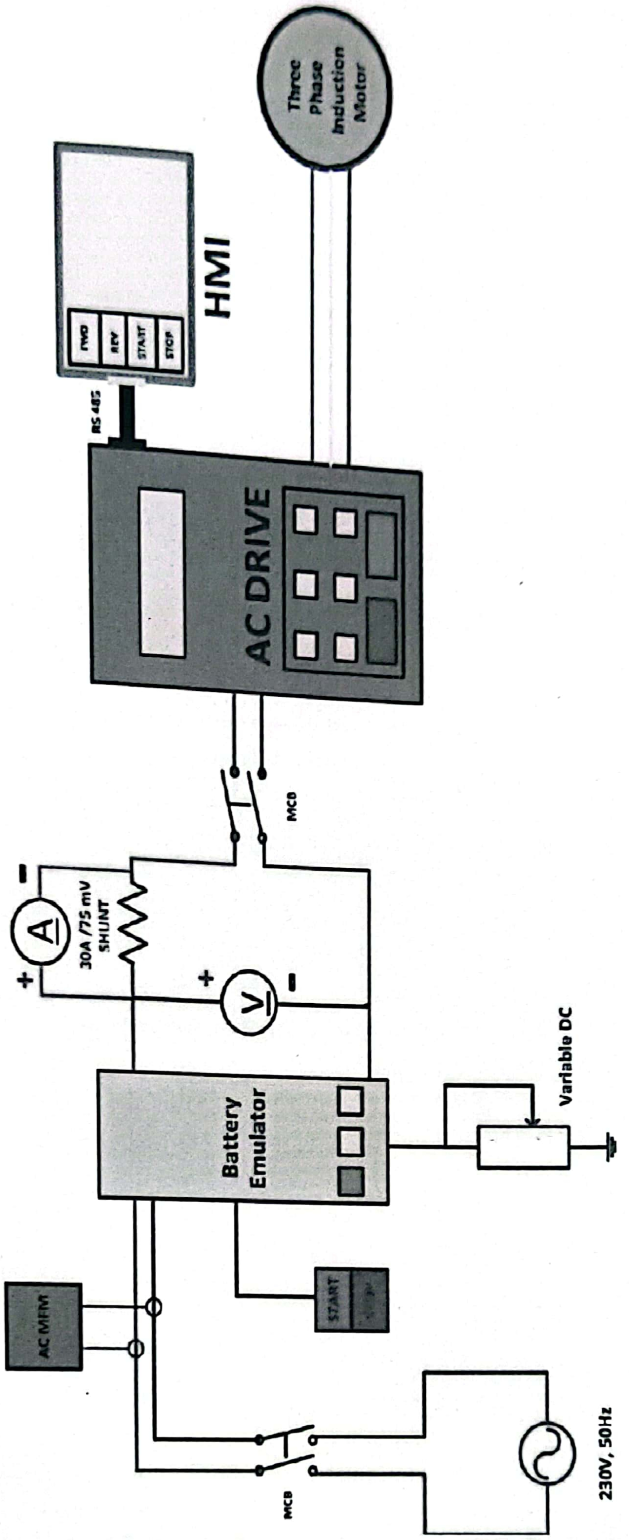
Note that rotor speed is the same as the rated speed of the AC motor as given on the motor nameplate.

The two main features of variable frequency drive are **adjustable speeds and soft start/stop** capabilities. These two features make VFD's a powerful controller to control the AC motors in industrial terms, **AC drive is also called as variable frequency drive (VFD), variable speed drive (VSD), or adjustable speed drive (ASD), Adjustable frequency drive (AFD), variable voltage variable frequency drive (VVVFD).**

Though there are different types of VFDs (or AC drives), all of them are works on same principle that converting fixed incoming voltage and frequency into variable voltage and frequency output. The **frequency** of the drive determines the how fast motor should **run** while the combinationof **voltage (V) and frequency (F)** decides the amount of **torque** that the motor to generate.

Procedure:

Three Phase AC Induction Motor Based Model Connection Diagram



1. Give AC Supply to Meter(s), Battery Emulator/DC Drive & HMI etc.
2. Fully Rotate Potentiometer of DC Control connected with Battery Emulator.
3. Select Forward/Reverse Mode Using HMI.
4. Vary the Frequency Using VFD.

5. Connect 12V Battery in Excitation Panel **of Alternator** according to Connection Diagram & Make sure to Switch on the Toggle switch
6. Calculate different values given on the below Table to Understand the working Characteristics of VFD & Three Phase Induction Motor Drive System.

Cautions:

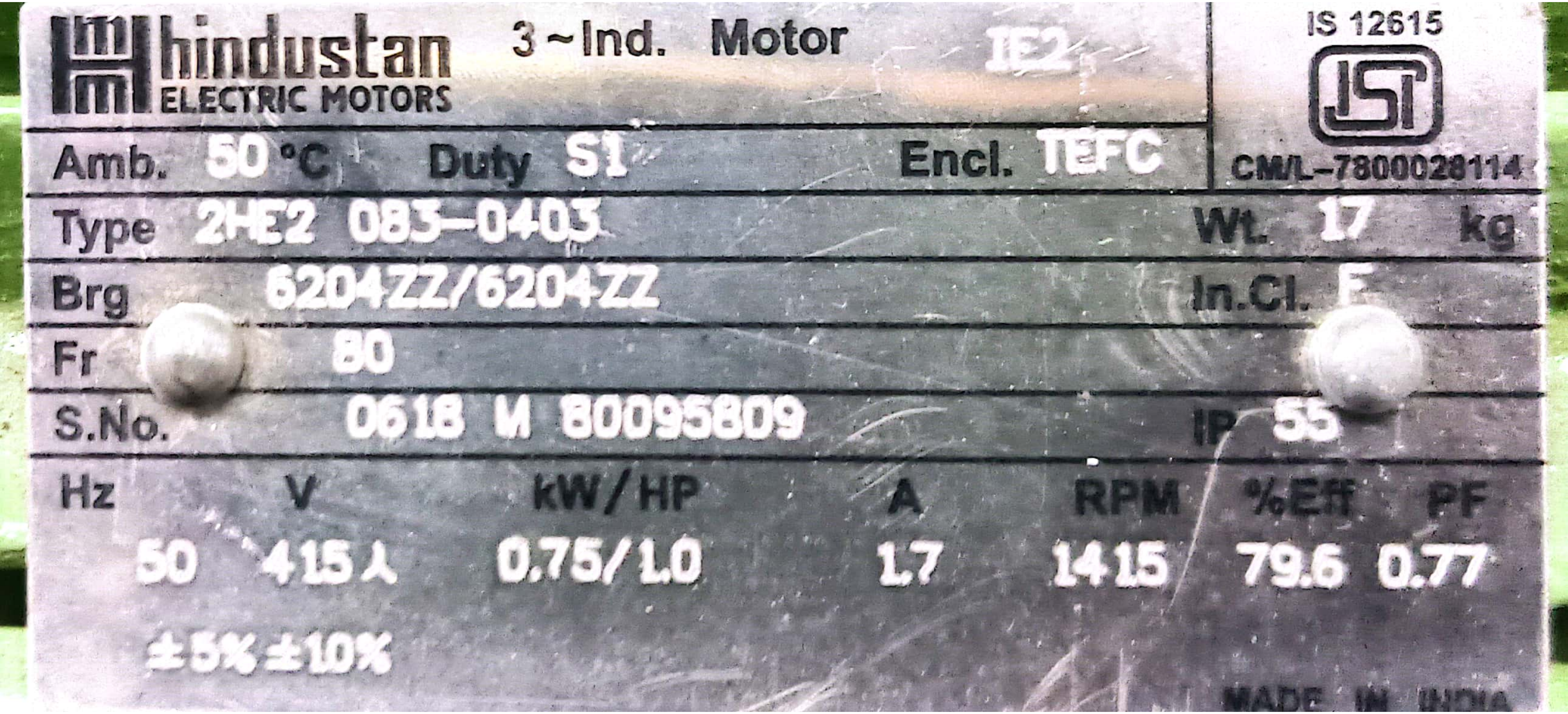
1. Do not connect overvoltage supply.
2. Check proper connection before testing.
3. Do not overload the Motor.

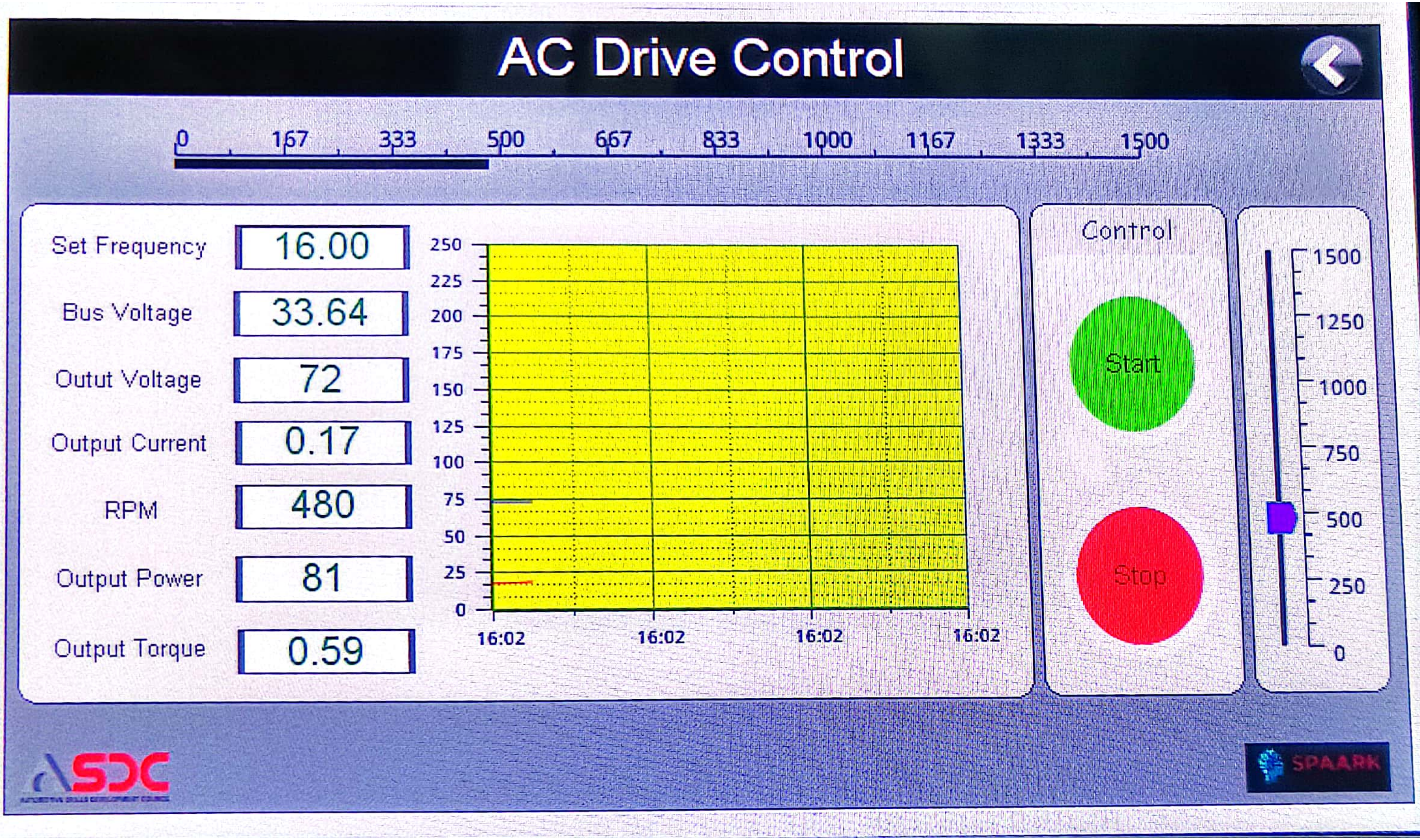
Calculations:

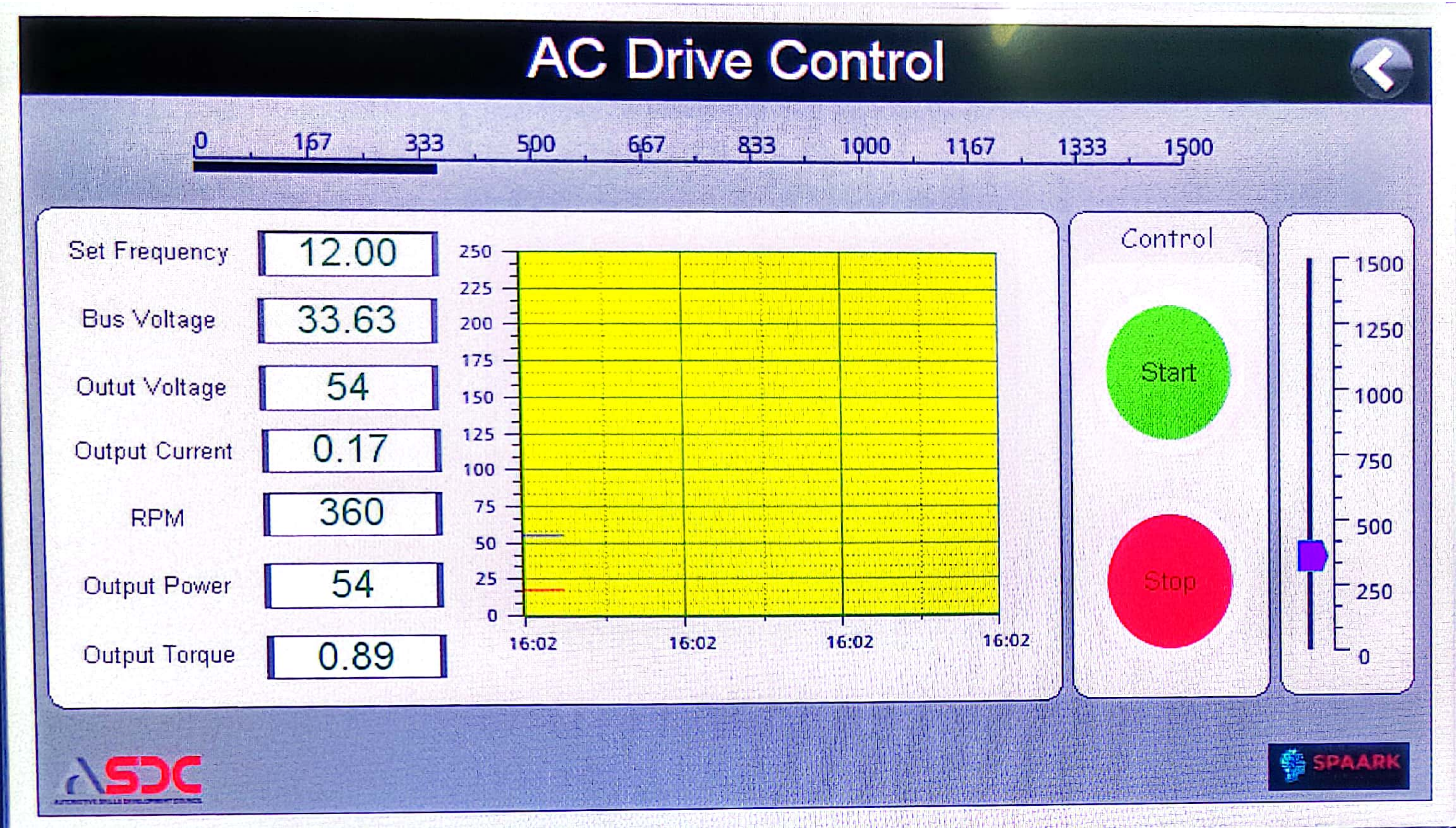
S. No.	Frequency (f)	Output Voltage (V)	Ratio = V/f	RPM Calculated (Ns=120f/P)	Tachometer (Rotor) RPM	Slip
1						
2						
3						

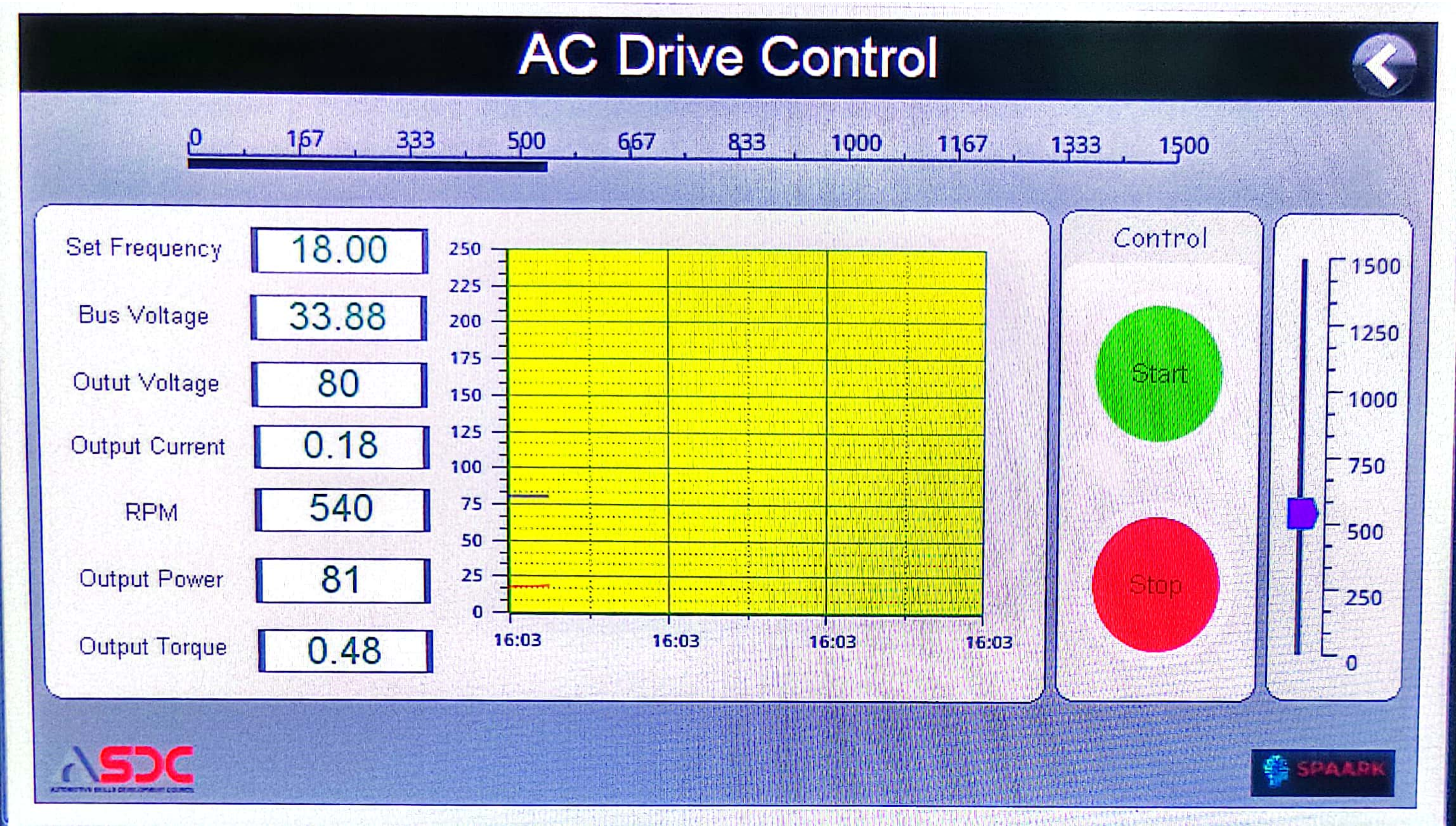
Load/ Charging current Across Alternator 0 V	Load/ Charging current Across Alternator 12 V Battery 1 No	Load/ Charging current Across Alternator 12 V Batteries 2 Nos in parallel

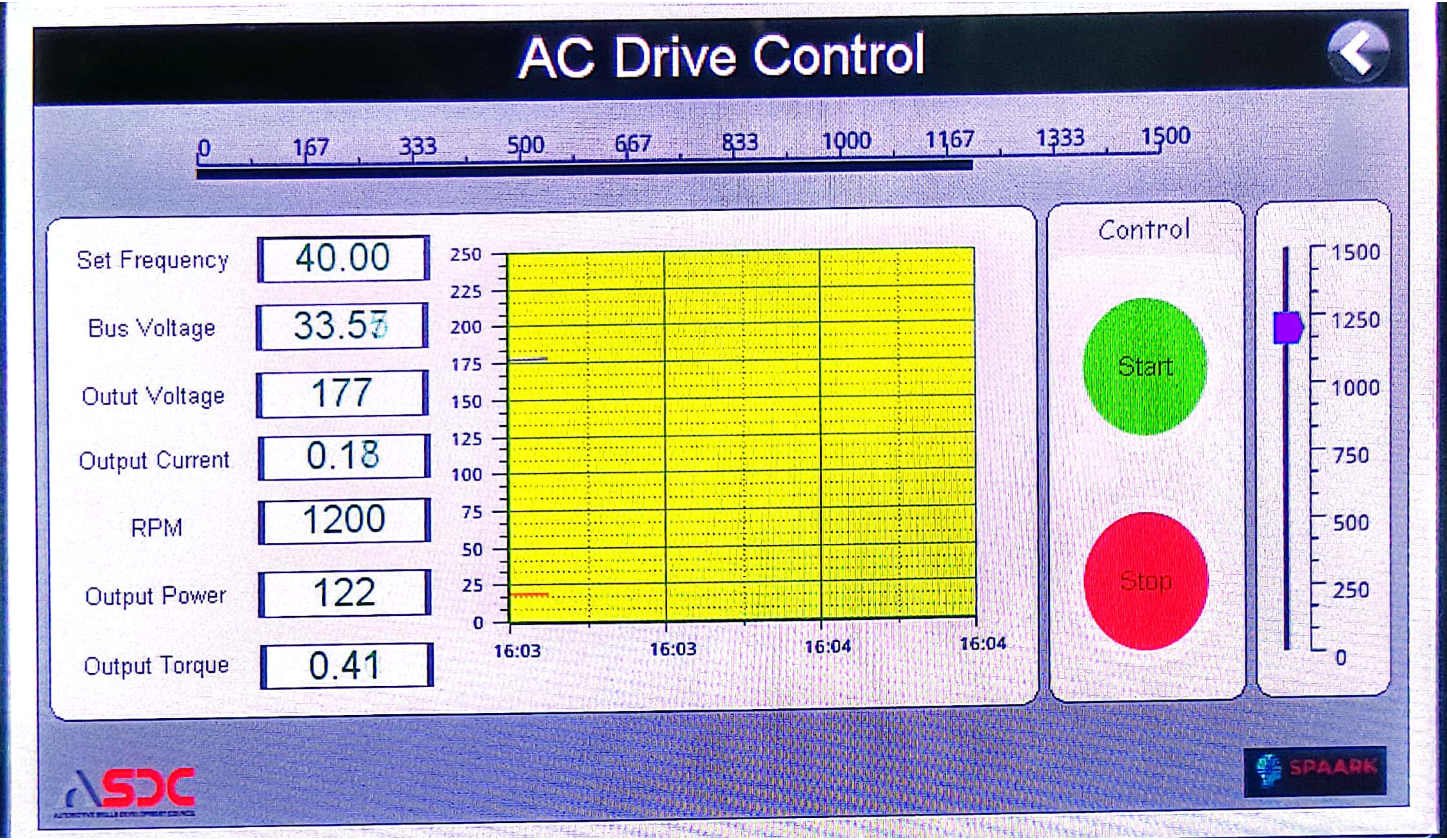
Result: Thus, the test on Three Phase Induction Motor Drive System inE-Mobility is Performed Successfully.

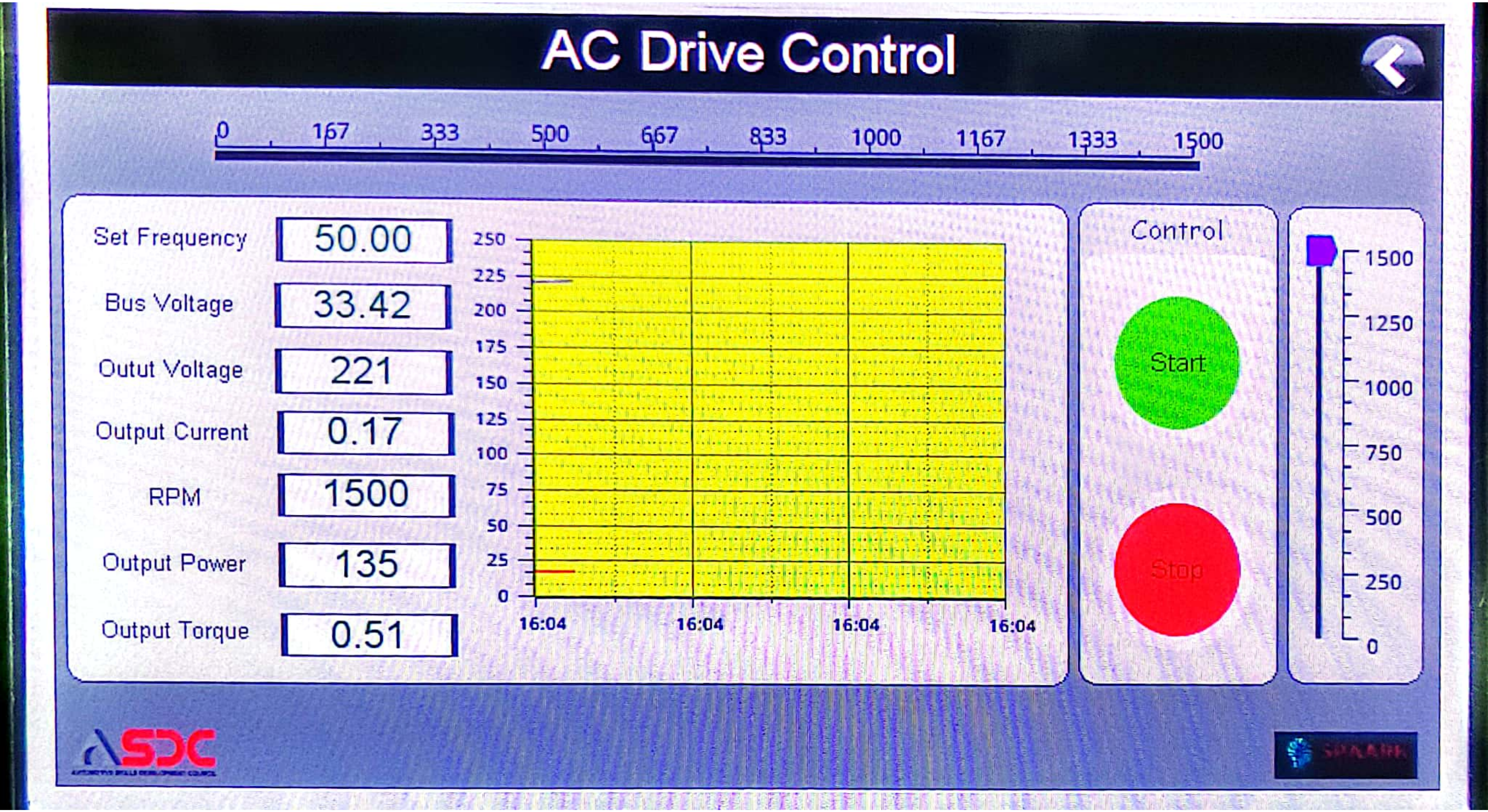

hindustan
ELECTRIC MOTORS
3 ~ Ind. Motor
IE2
IS 12615
ISI
CM/L-7800028114
Amb. 50 °C
Duty S1
Encl. TEFC
Type 2HE2 083-0403
Wt. 17 kg
Brg 6204ZZ/6204ZZ
In.Cl. F
Fr 80
S.No. 0618 M 80095809
IP 55
Hz
V
kW/HP
A
RPM
%Eff
PF
50
415 人
0.75/1.0
1.7
1415
79.6
0.77
±5% ±10%
MADE IN INDIA


AC Drive Control
0 167 333 500 667 833 1000 1167 1333 1500
Set Frequency 16.00
Bus Voltage 33.64
Outut Voltage 72
Output Current 0.17
RPM 480
Output Power 81
Output Torque 0.59
250 225 200 175 150 125 100 75 50 25 0
16:02 16:02 16:02 16:02
Control
Start
Stop
1500 1250 1000 750 500 250 0
ASDC
SPAARK


AC Drive Control
0
167
333
500
667
833
1000
1167
1333
1500
Set Frequency
12.00
Bus Voltage
33.63
Outut Voltage
54
Output Current
0.17
RPM
360
Output Power
54
Output Torque
0.89
250
225
200
175
150
125
100
75
50
25
0
16:02
16:02
16:02
16:02
Control
Start
Stop
1500
1250
1000
750
500
250
0
SPAARK


AC Drive Control
0
167
333
500
667
833
1000
1167
1333
1500
Set Frequency
18.00
Bus Voltage
33.88
Outut Voltage
80
Output Current
0.18
RPM
540
Output Power
81
Output Torque
0.48
250
225
200
175
150
125
100
75
50
25
0
16:03
16:03
16:03
16:03
Control
Start
Stop
1500
1250
1000
750
500
250
0
SPAARK


AC Drive Control
0 167 333 500 667 833 1000 1167 1333 1500
Set Frequency
40.00
Bus Voltage
33.57
Outut Voltage
177
Output Current
0.18
RPM
1200
Output Power
122
Output Torque
0.41
250 225 200 175 150 125 100 75 50 25 0
16:03 16:03 16:04 16:04
Control
Start
Stop
1500 1250 1000 750 500 250 0
SPAARK


AC Drive Control
0 167 333 500 667 833 1000 1167 1333 1500
Set Frequency 50.00
Bus Voltage 33.42
Outut Voltage 221
Output Current 0.17
RPM 1500
Output Power 135
Output Torque 0.51
250 225 200 175 150 125 100 75 50 25 0
16:04 16:04 16:04 16:04
Control
Start
Stop
1500 1250 1000 750 500 250 0
ASDC

EX NO:17	Generation of Common Discrete Time Signals
DATE:	

Aim

Generate and plot the Unit Impulse Signal, Unit Step Signal,Unit Ramp Signal, Sinusoidal Signal,Exponential Signal: For each signal Write the SCILAB code to generate the signal.Plot the signal and label the axes appropriately.

using SCILAB:

Unit Impulse Signal, Unit Step Signal,Unit Ramp Signal, Sinusoidal Signal,Exponential Signal: **For each signal** Write the SCILAB code to generate the signal.Plot the signal and label the axes appropriately.

Software Required

1. Scilab 6.1.0

Procedure:

Start the scilab Program
Open scinotes ,type the program and save the program in current directory
Compile and run the program
If any error occur in the program,correct the error and run the program
For the output ,see the console window
Stop the program

Theory:

Discrete-time signals are a fundamental concept in digital signal processing and communication. They represent variations in amplitude over discrete points in time. Here, I'll provide a brief overview of some common discrete-time signals and their characteristics:

Unit Step Signal (u[n]): The unit step signal is a basic discrete-time signal that takes the value 1 for non-negative time indices (n >= 0) and 0 otherwise. It is often used to model the onset of events or changes in a system.

Impulse Signal (δ[n]): The impulse signal is also known as the discrete-time delta function. It has a value of 1 at n = 0 and is zero for all other time indices. It's a fundamental signal in signal processing and is used to represent discrete-time impulses or impulses in discrete-time systems.

Exponential Signal: An exponential discrete-time signal is defined as x[n] = A * α^n, where A is the amplitude and α is the exponential factor. Depending on whether α is greater or less than 1, the signal can grow or decay exponentially with time.

Sinusoidal Signal: A sinusoidal discrete-time signal has the form x[n] = A * cos(ωn + φ), where A is the amplitude, ω is the angular frequency, n is the time index, and φ is the phase shift. Sinusoidal signals exhibit periodic behavior and are a fundamental representation of oscillations.

Ramp Signal: A ramp signal is a linearly increasing or decreasing signal with time. It's given by x[n] = a * n, where 'a' is the slope of the ramp. The ramp signal is commonly used to model linear changes or trends.

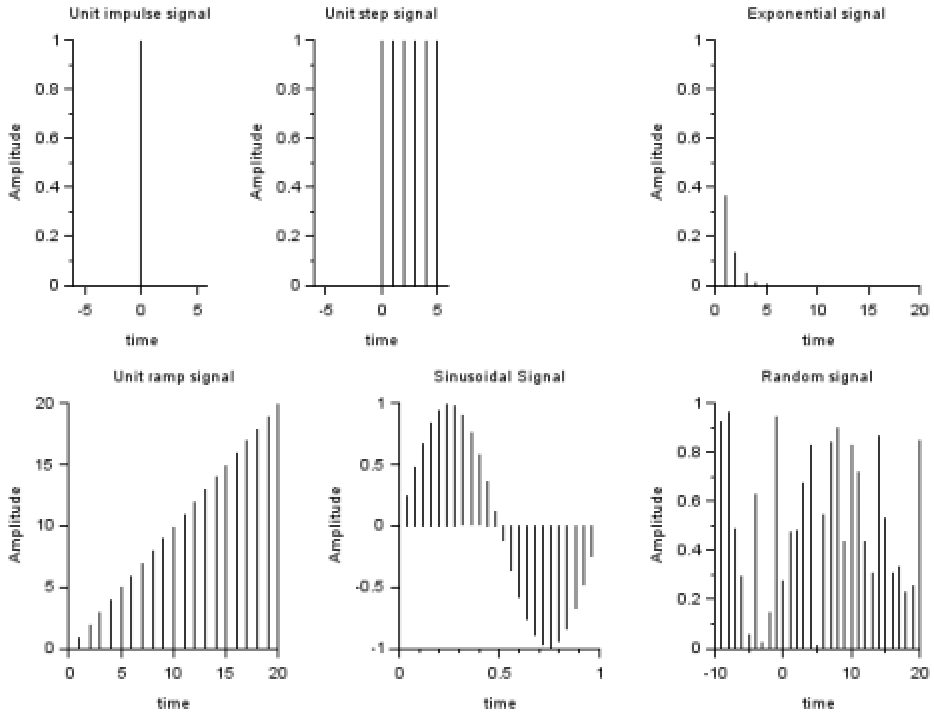
Random Signal: A random signal represents random variations or noise in a system. It's often generated using a random number generator. In digital communication, noise can introduce errors in the received signal, impacting the quality of communication.

Program:

```
//UNIT IMPULSE SIGNAL
    clear all;
     close ;
     N =5; //SET LIMIT
      t1 = -5:5;
     x1 =[ zeros (1 , N ) ,ones (1 ,1) ,zeros (1 , N ) ];
     subplot (2 ,4 ,1) ;
     plot2d3 ( t1 , x1 )
     xlabel ( ’ tim e ’ ) ;
     ylabel ( ’ Ampli tude ’ ) ;
     title ( ’ Uni t im p ul s e s i g n a l ’ ) ;
     //UNIT STEP SIGNAL
     t2 = -5:5;
     x2 =[ zeros (1 , N ) ,ones (1 , N +1) ];
     subplot (2 ,4 ,2) ;
      plot2d3 ( t2 , x2 )
      xlabel ( ’ tim e ’ ) ;
      ylabel ( ’ Ampli tude ’ ) ;
     title ( ’ Uni t s t e p s i g n a l ’ ) ;
      //EXPONENTIAL SIGNAL
      t3 =0:1:20;
```

```
x3 =exp( - t3 ) ;
subplot (2 ,3 ,3) ;
 plot2d3 ( t3 , x3 ) ;
 xlabel ( ’ tim e ’ ) ;
 ylabel ( ’ Ampli tude ’ ) ;
 title ( ’ E x p o n e n t i a l s i g n a l ’ ) ;

 //UNIT RAMP SIGNAL 4
t4 =0:20;
 x4 = t4 ;
 subplot (2 ,3 ,4) ;
 plot2d3 ( t4 , x4 ) ;
 xlabel ( ’ tim e ’ ) ;
 ylabel ( ’ Ampli tude ’ ) ;
 title ( ’ Uni t ramp s i g n a l ’ ) ;
 //SINUSOIDAL SIGNAL
 t5 =0:0.04:1;
 x5 =sin (2* %pi * t5 ) ;
 subplot (2 ,3 ,5) ;
 plot2d3 ( t5 , x5 ) ;
 title ( ’ S i n u s o i d a l S i g n a l ’ )
xlabel ( ’ tim e ’ ) ;
 ylabel ( ’ Ampli tude ’ ) ;
 //RANDOM SIGNAL
 t6 = -10:1:20;
 x6 = rand (1 ,31) ;
 subplot (2 ,3 ,6) ;
 plot2d3 ( t6 , x6 ) ;
 xlabel ( ’ tim e ’ ) ;
 ylabel ( ’ Ampli tude ’ ) ;
 title ( ’ Random s i g n a l ’ ) ;
```
Output:



Result:

The following discrete-time signals were successfully generated and plotted using SCILAB:For each signal, the plots were labeled appropriately, with the x-axis representing time (n) and the y-axis representing the signal values.

EX NO: 18	**DIT-FFT and DIF-FFT Algorithm**
DATE:	

(i) Given a sequence x[n]=[1,-1,-1,-1,1,1,1,-1] compute the DFT using the DIT-FFT algorithm. The sequence exhibits real and symmetric properties. How does symmetry affect the twiddle factor calculations in the DIT-FFT algorithm?

Aim

(i) To Compute the DFT of given Sequence x[n]=[1,-1,-1,-1,1,1,1,-1] using DIT-FFT Algorithm.

Software Required

Scilab 6.1.0

Procedure:

Start the scilab Program
Open scinotes ,type the program and save the program in current directory
Compile and run the program
If any error occur in the program,correct the error and run the program
For the output ,see the console window
Stop the program

Theory:

The Decimation-in-Time Fast Fourier Transform (DIT-FFT) algorithm is an efficient method to compute the Discrete Fourier Transform (DFT) of a sequence. The FFT algorithm reduces the computational complexity of the DFT from

The DFT of a sequence $x[n]$ of length N is given by:

$$X[k] = \sum_{n=0}^{N-1} x[n] \cdot e^{-j\frac{2\pi kn}{N}}, \quad k = 0, 1, 2, \ldots, N-1$$

DIT-FFT Algorithm

The DIT-FFT algorithm is a divide-and-conquer approach that breaks down the DFT computation into smaller parts, recursively decimating the sequence into smaller subsequences. The key idea behind DIT-FFT is to separate the original sequence into even-indexed and odd-indexed terms, recursively applying the FFT on these smaller sequences.

Program

```
clear;
clc ;
close ;
x = [1,-1,-1,-1,1,1,1,-1];
//FFT Computation
X = fft (x , -1);
disp(X,'X(z) = ');
```

Output

```
    column 1 to 5
 0  - 1.4142136 + 3.4142136i    2. - 2.i    1.4142136 - 0.5857864i    4.
    column 6 to 8
 1.4142136 + 0.5857864i    2. + 2.i  - 1.4142136 - 3.4142136i
```

Result: Thus the DFT of the sequence x[n]=[1,-1,-1,-1,1,1,1,-1] using the DIT-FFT algorithm results in the expected frequency components, confirming the correct implementation of the algorithm.

(ii) Given a sequence x[n]=[1,2,3,4,4,3,2,1] compute the DFT using the DIF-FFT algorithm. The sequence exhibits real and symmetric properties. How does symmetry affect the twiddle factor calculations in the DIF-FFT algorithm?

Aim

To compute the DFT of the sequence x[n]=[1,2,3,4,4,3,2,1] using the Decimation-in-Frequency (DIF) FFT algorithm, we will utilize the symmetry of the sequence to optimize the twiddle factor calculations.

Software Required

Scilab 6.1.0

Procedure:

Start the scilab Program
Open scinotes ,type the program and save the program in current directory
Compile and run the program
If any error occur in the program,correct the error and run the program
For the output ,see the console window
Stop the program

Theory:

DIF-FFT Algorithm

The Decimation-in-Frequency Fast Fourier Transform (DIF-FFT) is another efficient algorithm for computing the Discrete Fourier Transform (DFT). Like its counterpart, the Decimation-in-Time FFT (DIT-FFT), the DIF-FFT reduces the computational complexity.

The DFT of a sequence $x[n]$ of length N is defined as:

$$X[k] = \sum_{n=0}^{N-1} x[n] \cdot e^{-j\frac{2\pi kn}{N}}, \quad k = 0, 1, 2, \ldots, N-1$$

The DIF-FFT algorithm, like the DIT-FFT, is a divide-and-conquer approach. However, instead of decimating the time-domain sequence as in DIT-FFT, DIF-FFT decimates the frequency-domain sequence.

Program:

```
clear;
clc ;
close ;
x = [1,2,3,4,4,3,2,1];
//FFT Computation
X = fft (x , -1);
disp(X,'X(z) = ');
```

Output:

```
X(z) =
       column 1 to 5
   20.  - 5.8284271 - 2.4142136i    0  - 0.1715729 - 0.4142136i    0
       column 6 to 8
  - 0.1715729 + 0.4142136i    0  - 5.8284271 + 2.4142136i
```

Result: Thus the DFT of the sequence x[n]=[1,2,3,4,4,3,2,1] using the DIF-FFT algorithm results in the expected frequency components, confirming the correct implementation of the algorithm. Symmetry in the sequence reduces the number of unique twiddle factor calculations, enhancing the algorithm's efficiency.

EXNO:19	Analog Butterworth Filter
DATE:	

(i)Design a Butterworth filter to process audio signals that attenuates frequencies above 0.2 * pi and maintains a flat frequency response in the passband. Compare the output of the filtered signal with the original signal in both time and frequency domains. Plot both to verify the attenuation of high frequencies.

Aim

To design a Butterworth filter for processing audio signals that attenuates frequencies above 0.2π0.2\pi0.2π radians per sample and maintains a flat frequency response in the passband. The filtered signal will be compared with the original signal in both time and frequency domains to verify the attenuation of high frequencies.Software Required

Scilab 6.1.0

Procedure:

Start the scilab Program
Open scinotes ,type the program and save the program in current directory
Compile and run the program
If any error occur in the program,correct the error and run the program
For the output ,see the console window
Stop the program

Theory:

The Butterworth low-pass filter is a widely used type of analog filter that is known for its maximally flat frequency response in the passband, which means it has no ripples. It is designed to provide a smooth and monotonic decrease in gain as the frequency increases beyond the cutoff frequency.

Program:

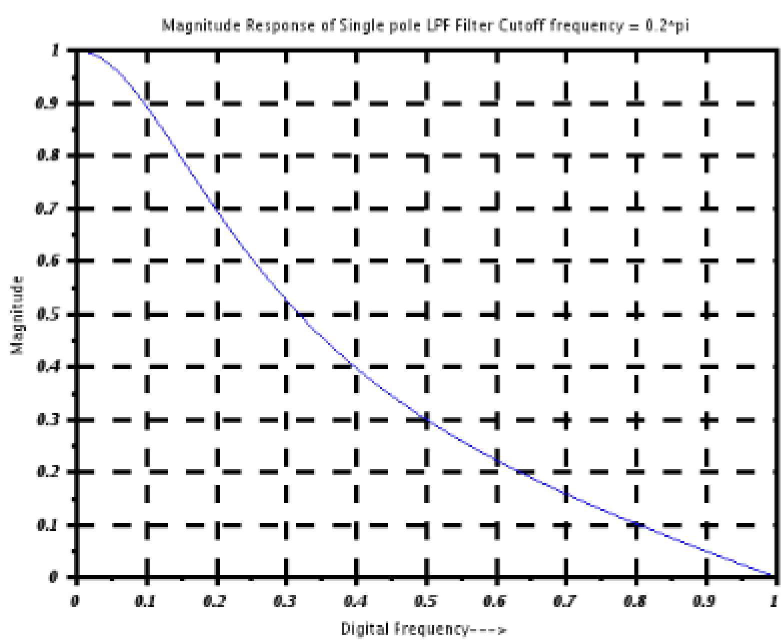
//First Order Butterworth Low Pass Filter

```
clear;
clc;
close;
s = poly(0,'s');
Omegac = 0.2*%pi;
H = Omegac/(s+Omegac);
T =1;//Sampling period T = 1 Second
```

```
z = poly(0,'z');
Hz = horner(H,(2/T)*((z-1)/(z+1)))
HW  =frmag(Hz(2),Hz(3),512);
W = 0:%pi/511:%pi;
plot(W/%pi,HW)
a=gca();
a.thickness = 3;
a.foreground = 1;
a.font_style = 9;
xgrid(1)
xtitle('Magnitude Response of Single pole LPF Filter Cutoff frequency =
0.2*pi','Digital Frequency--->','Magnitude');
Disp("Hz",Hz);
```

Output:

```
Hz  =
    0.6283185 + 0.6283185z
    ----------------------
  - 1.3716815 + 2.6283185z
```



Result:

The Butterworth filter successfully attenuated frequencies above 0.2π0.2\pi0.2π, confirming its design. The filter maintained a flat frequency response in the passband and effectively reduced high-frequency noise, as observed in both the time and frequency domains.

(ii)Design a Butterworth filter that allows frequency range above the cut off frequency of 0.2*pi for a digital audio processing application.

Aim

The aim of this experiment is to design a Butterworth high-pass filter for a digital audio processing application, allowing frequencies above the cutoff frequency of 0.2×π0.2 \times \pi0.2×π radians per second to pass, while attenuating frequencies below the cutoff. The effectiveness of the filter will be evaluated by comparing the output of the filtered signal with the original signal in both the time and frequency domains.Software Required

Scilab 6.1.0

Procedure:

Start the scilab Program
Open scinotes ,type the program and save the program in current directory
Compile and run the program
If any error occur in the program,correct the error and run the program
For the output ,see the console window
Stop the program

Theory:

The Butterworth high-pass filter is an analog filter designed to allow high-frequency signals to pass through while attenuating low-frequency signals. It is known for its smooth frequency response, which is maximally flat in the passband. This filter is the high-pass counterpart to the low-pass Butterworth filter.

Program

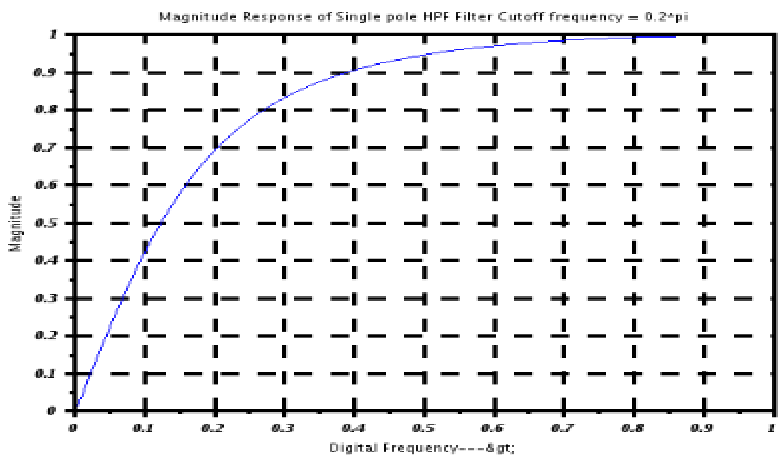
//First Order Butterworth Filter

```
//High Pass Filter Using Digital Filter Transformation
clear;
clc;
close;
s = poly(0,'s');
Omegac = 0.2*%pi;
H = Omegac/(s+Omegac);
T =1;//Sampling period T = 1 Second
z = poly(0,'z');
Hz_LPF = horner(H,(2/T)*((z-1)/(z+1)));
alpha = -(cos((Omegac+Omegac)/2))/(cos((Omegac-Omegac)/2));
HZ_HPF=horner(Hz_LPF,-(z+alpha)/(1+alpha*z))
HW  =frmag(HZ_HPF(2),HZ_HPF(3),512);
W = 0:%pi/511:%pi;
```

```
plot(W/%pi,HW)
a=gca();
a.thickness = 3;
a.foreground = 1;
a.font_style = 9;
xgrid(1)
xtitle('Magnitude Response of Single pole HPF Filter Cutoff frequency =
0.2*pi','Digital Frequency---&gt;','Magnitude');
disp("HZ_HPF",HZ_HPF);
```

Output:

```
HZ_HPF  =
 - 0.7484757 + 0.7484757z
   ----------------------
    - 0.4969514 + z
```



Result:

The Butterworth high-pass filter was successfully designed with a cutoff frequency of 0.2×π0.2 \times \pi0.2×π. In the time domain, (iii)For a signal processing application design a Butterworth filter to isolate a specific frequency range from an audio signal between 0.4 pi and 0.6 pi.

Aim

To design a Butterworth band-pass filter for a signal processing application to isolate a specific frequency range between 0.4π and 0.6π radians per second from an audio signal.

Software Required

Scilab 6.1.0

Procedure:

Start the scilab Program
Open scinotes ,type the program and save the program in current directory
Compile and run the program
If any error occur in the program,correct the error and run the program
For the output ,see the console window
Stop the program

Theory:

The Butterworth band-pass filter is an analog filter designed to pass frequencies within a certain range (the passband) while attenuating frequencies outside this range. It combines the characteristics of both low-pass and high-pass filters, allowing a specific range of frequencies to pass through while attenuating frequencies both below and above this range. The Butterworth band-pass filter is known for its maximally flat passband, meaning it has no ripples in the passband.

Program:

```
clear;
clc;
close;
omegaP = 0.2*%pi;
omegaL =  (2/5)*%pi;
omegaU =  (3/5)*%pi;
z=poly(0,'z');
H_LPF = (0.245)*(1+(z^-1))/(1-0.509*(z^-1))
alpha = (cos((omegaU+omegaL)/2)/cos((omegaU-omegaL)/2));
k = (cos((omegaU - omegaL)/2)/sin((omegaU - omegaL)/2))*tan(omegaP/2);
NUM =-((z^2)-((2*alpha*k/(k+1))*z)+((k-1)/(k+1)));
DEN = (1-((2*alpha*k/(k+1))*z)+(((k-1)/(k+1))*(z^2)));
HZ_BPF=horner(H_LPF,NUM/DEN)
disp(HZ_BPF,'Digital BPF IIR Filter H(Z)= ')
HW  =frmag(HZ_BPF(2),HZ_BPF(3),512);
```

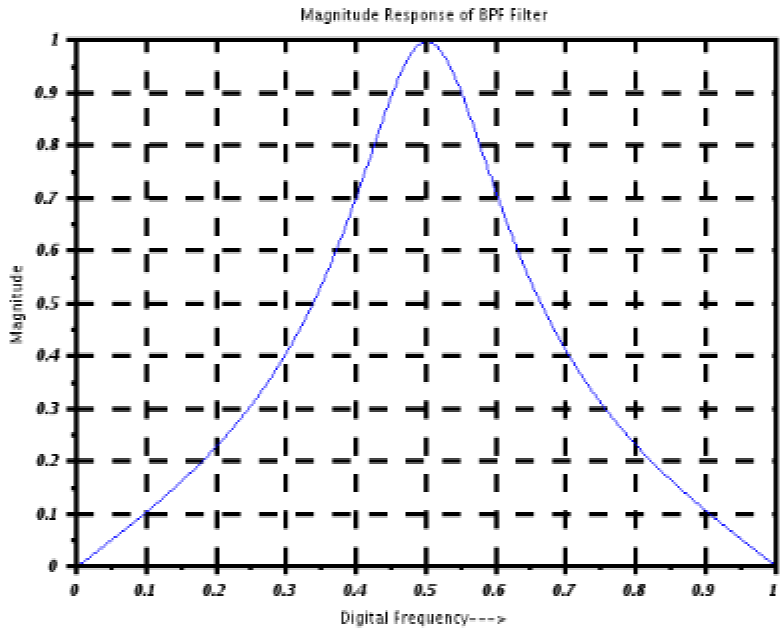
```
W = 0:%pi/511:%pi;
plot(W/%pi,HW)
a=gca();
a.thickness = 3;
a.foreground = 1;
a.font_style = 9;
xgrid(1)
xtitle('Magnitude Response of BPF Filter', 'Digital Frequency--->','Magnitude');
Disp("HZ_BPF",HZ_BPF);
```

Output:

```
H_LPF  =
   0.245 + 0.245z
   --------------
   - 0.509 + z

 HZ_BPF  =
                          2           3           4
   0.245 - 1.577D-17z - 0.245z + 1.577D-17z + 1.360D-17z
   -----------------------------------------------------
                        2           3           4
   - 0.509 + 1.299D-16z - z + 6.438D-17z + 5.551D-17z

Digital BPF IIR Filter H(Z)=
                          2           3           4
   0.245 - 1.577D-17z - 0.245z + 1.577D-17z + 1.360D-17z
   -----------------------------------------------------
                        2           3           4
   - 0.509 + 1.299D-16z - z + 6.438D-17z + 5.551D-17z
```



Result:

Thus the Butterworth band-pass filter was successfully designed to isolate the frequency range between 0.4π and 0.6π inn the time domain,

(iv) For a signal processing application design a Butterworth filter to attenuate a specific frequency range from an audio signal between 0.4 pi and 0.6 pi.

Aim

The aim of this experiment is to design a Butterworth band-stop filter for a signal processing application to attenuate a specific frequency range between 0.4π and 0.6π radians per second from an audio signal. using Sci lab

Software Required

Scilab 6.1.0

Procedure:

Start the scilab Program
Open scinotes ,type the program and save the program in current directory
Compile and run the program
If any error occur in the program,correct the error and run the program
For the output ,see the console window
Stop the program

Theory:

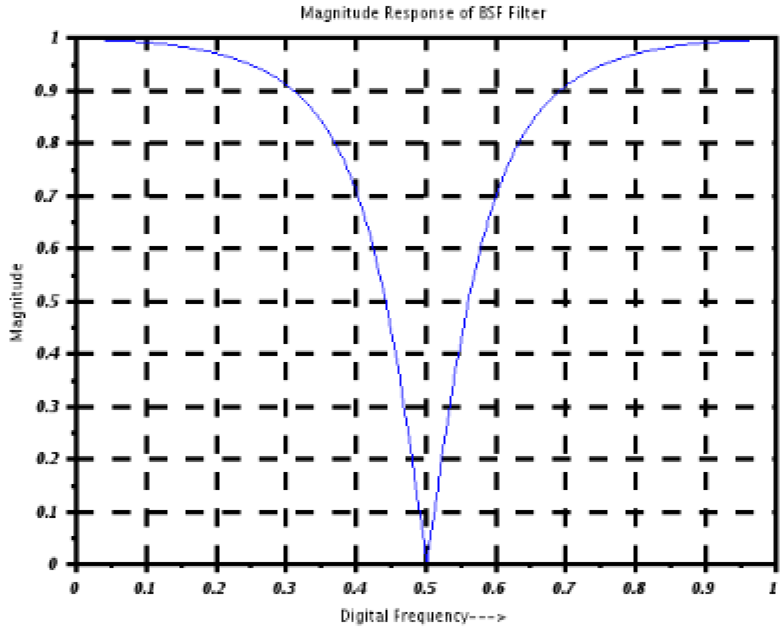
The Butterworth band-reject filter, also known as a band-stop or band-elimination filter, is an analog filter designed to attenuate frequencies within a specific range while allowing frequencies outside this range to pass with minimal attenuation. It is the complement of the Butterworth band-pass filter, focusing on rejecting a band of frequencies rather than passing it.

Program:

```
clear;
clc;
close;
omegaP = 0.2*%pi;
omegaL =  (2/5)*%pi;
omegaU =  (3/5)*%pi;
z=poly(0,'z');
H_LPF = (0.245)*(1+(z^-1))/(1-0.509*(z^-1))
alpha = (cos((omegaU+omegaL)/2)/cos((omegaU-omegaL)/2));
k = tan((omegaU - omegaL)/2)*tan(omegaP/2);
NUM =((z^2)-((2*alpha/(1+k))*z)+((1-k)/(1+k)));
DEN = (1-((2*alpha/(1+k))*z)+(((1-k)/(1+k))*(z^2)));
HZ_BSF=horner(H_LPF,NUM/DEN)
HW  =frmag(HZ_BSF(2),HZ_BSF(3),512);
W = 0:%pi/511:%pi;
plot(W/%pi,HW)
a=gca();
a.thickness = 3;
a.foreground = 1;
a.font_style = 9;
xgrid(1)
xtitle('Magnitude Response of BSF Filter','Digital Frequency--->','Magnitude');
Disp("HZ_BSF",HZ_BSF);
```

Output:

```
HZ_BPF  =
                               2
  0.7534875 - 9.702D-17z + 0.7534875z
  -----------------------------------
                           2
     0.5100505 - 9.722D-17z + z
```



Result:

The Butterworth band-stop filter was successfully designed to attenuate frequencies between 0.4π and 0.6π. In the time domain, the filtered signal exhibited a clear reduction of frequencies within the specified range

EX NO: 20	**Generations of Standard Signals using DSP Processor**
DATE:	

Aim: Verify the generations of signals using DSP Processor

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Euipments:

Operating System – Windows XP

DSP processor: TMS320C54x or similar.

Assembly language: TMS320C54x Assembly Language.

Kit: DSK- DSK5716 kit, USB probe, 5V DC supply

Program:

Sine Wave Generation:

assembly

```
; Sine wave generation
;
; Registers used:
;   AR0: angle register
;   AR1: sine value register
;
      MOV    AR0, #0        ; initialize angle to 0
LOOP_SINE:
      MOV    AR1, #0        ; initialize sine value to 0
      LDP    AR1, SINETAB(AR0) ; load sine value from lookup table
```

```
    ST      AR1, *DST       ; store sine value in destination
    ADD     AR0, #10        ; increment angle by 10 degrees
    CMP     AR0, #360       ; check if angle exceeds 360 degrees
    JL      LOOP_SINE       ; loop if angle is less than 360 degrees
```

Square Wave Generation:

```
assembly
; Square wave generation
;
; Registers used:
;   AR0: counter register
;   AR1: output register
;
    MOV     AR0, #0         ; initialize counter to 0
LOOP_SQUARE:
    MOV     AR1, #0xFF      ; set output high (square wave)
    ST      AR1, *DST       ; store output in destination
    ADD     AR0, #10        ; increment counter by 10
    CMP     AR0, #100       ; check if counter exceeds 100
    JL      LOOP_SQUARE     ; loop if counter is less than 100
    MOV     AR1, #0x00      ; set output low (square wave)
    ST      AR1, *DST       ; store output in destination
    SUB     AR0, #100       ; decrement counter by 100
    JL      LOOP_SQUARE     ; loop if counter is less than 0
```

Triangular Wave Generation:

assembly

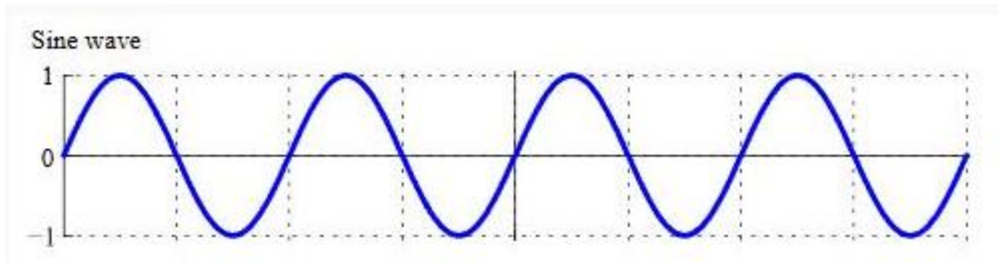
```
; Triangular wave generation
;
; Registers used:
;   AR0: counter register
;   AR1: output register
;
        MOV     AR0, #0         ; initialize counter to 0
LOOP_TRIANGLE:
        MOV     AR1, AR0        ; output increases linearly with counter
        ST      AR1, *DST       ; store output in destination
        ADD     AR0, #10        ; increment counter by 10
        CMP     AR0, #100       ; check if counter exceeds 100
        JL      LOOP_TRIANGLE   ; loop if counter is less than 100
        SUB     AR0, #100       ; decrement counter by 100
        NEG     AR1             ; output decreases linearly with counter
        ST      AR1, *DST       ; store output in destination
        JL      LOOP_TRIANGLE   ; loop if counter is less than 0
```

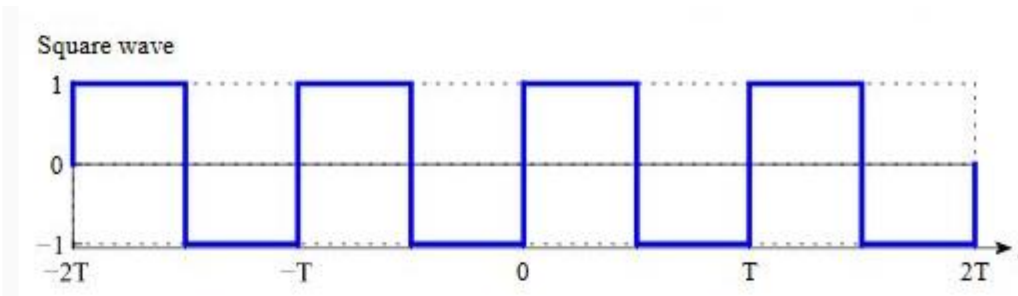
Common Code:

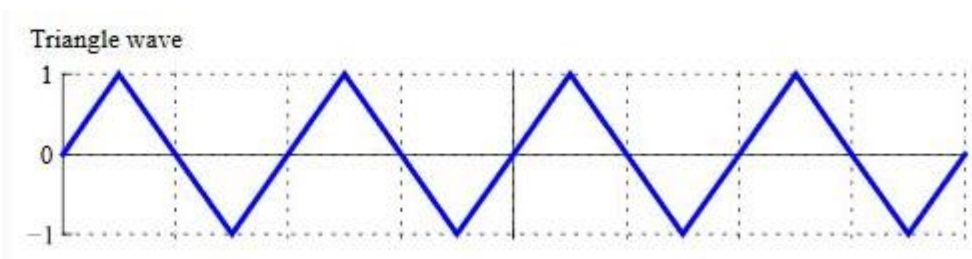
assembly

```
; Common code for all waveforms
;
; Registers used:
;   DST: destination address
;
        MOV     DST, #0x0000    ; initialize
```

Output:







Result:

Using assembly programming on a DSP processor, various signals (sinusoidal, square, and triangular) were generated effectively. The results were verified by observing the outputs on an oscilloscope, demonstrating the processor's capability for real-time signal generation in digital signal processing applications.