SIMATS SCHOOL OF ENGINEERING

SAVEETHA INSTITUTE OF MEDICAL AND TECHNICAL SCIENCES

CHENNAI-602105

Lab Manual

EEA01 – BASIC ELECTRICAL AND ELECTRONICS ENGINEERING

LIST OF EXPERIMENTS

1. Verification of Ohm's law & Kirchhoff's law.
2. Verification of 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. **O**.C. and S.C. test on a single phase transformer.
8. Calculation of Secondary turns and Current in a transformer.
9. Load test on Single phase Induction Motor.
10. 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

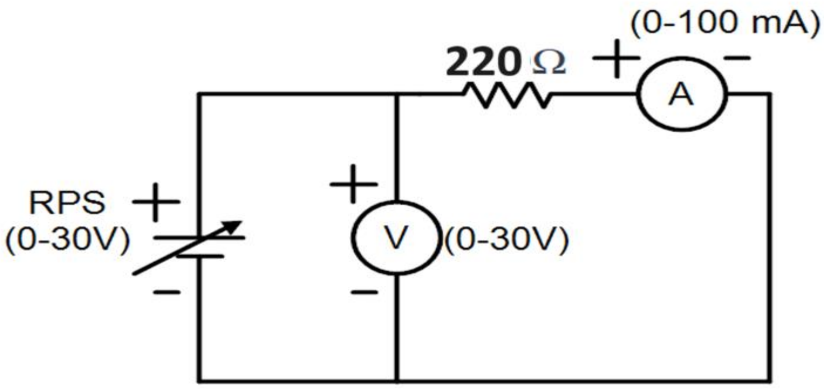
1. (a) Verification of Ohm's law

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	
2.	2	10	200	220
				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=$\frac{V}{R}=\frac{5}{220}=22.7272mA$

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

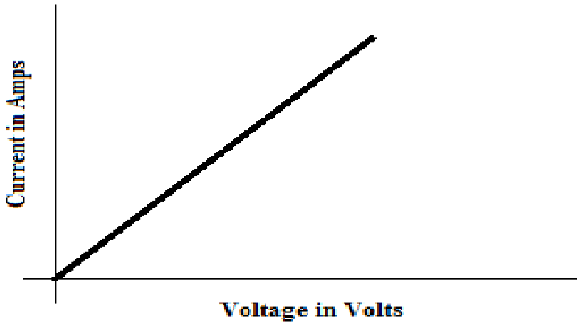
6. I=$\frac{V}{R}=\frac{6}{220}=27.2727mA$

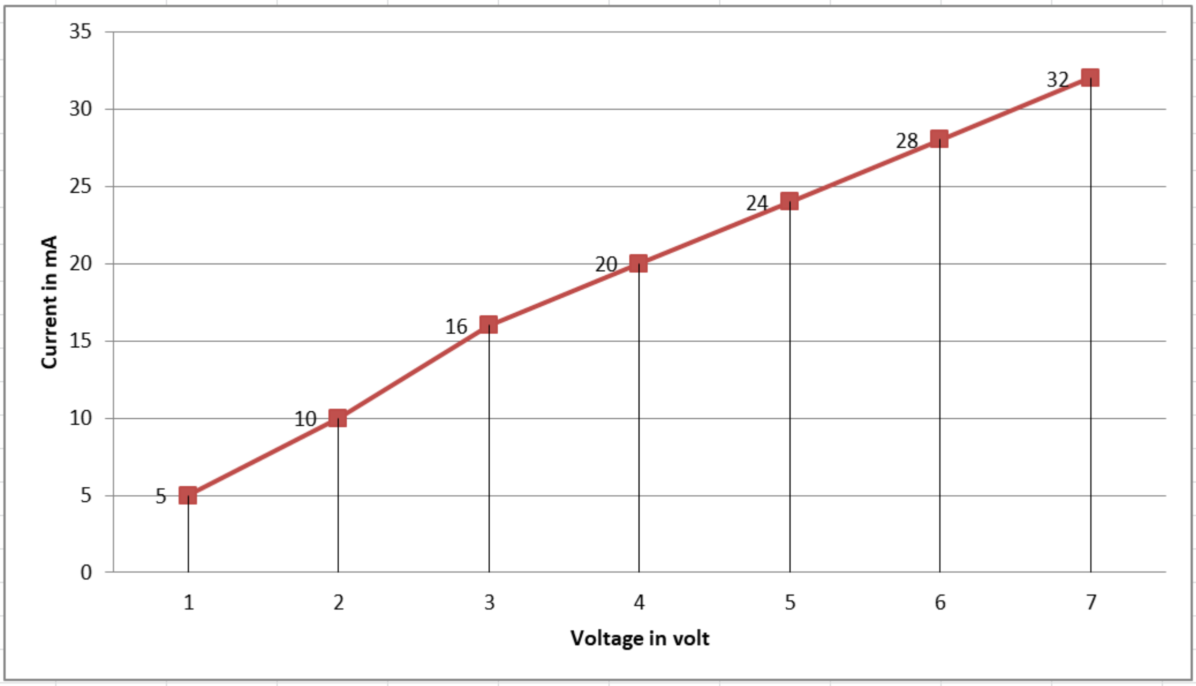
$R=\frac{V}{I}=\frac{6}{27.2727\times10^{-3}}=220\Omega$

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.

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:

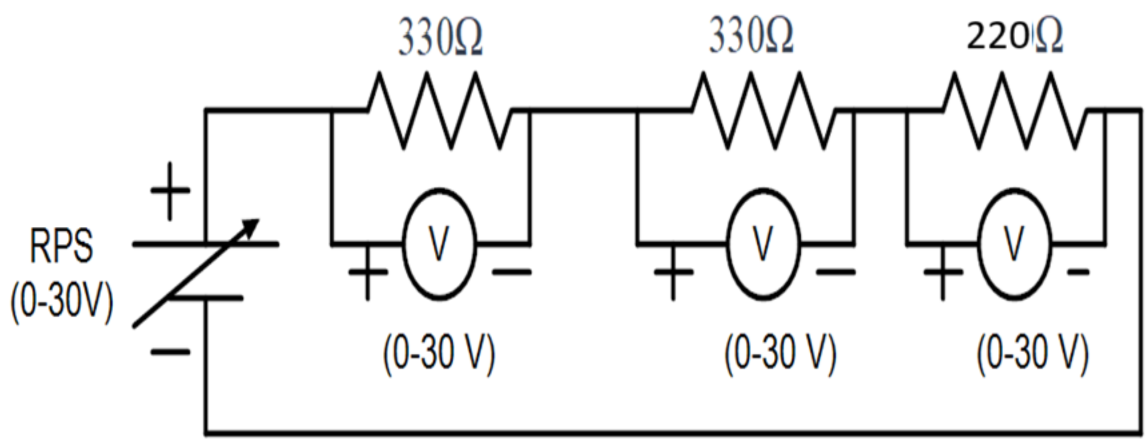
S.No	Name of The Equipment	Type	Range	Qty
1.	RPS	-	(0-15) V	1
2.	Bread board	-	-	1
3.	Ammeter	MC MC	(0-10) mA (0-5) mA	1 2
4.	Voltmeter	MC MC	(0-10)V (0-15) V	1 1
5.	Resistor	-	470Ω , 330Ω, 4kΩ, 4.7kΩ	Each 1
6.	Connecting wires	-	-	As required

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.

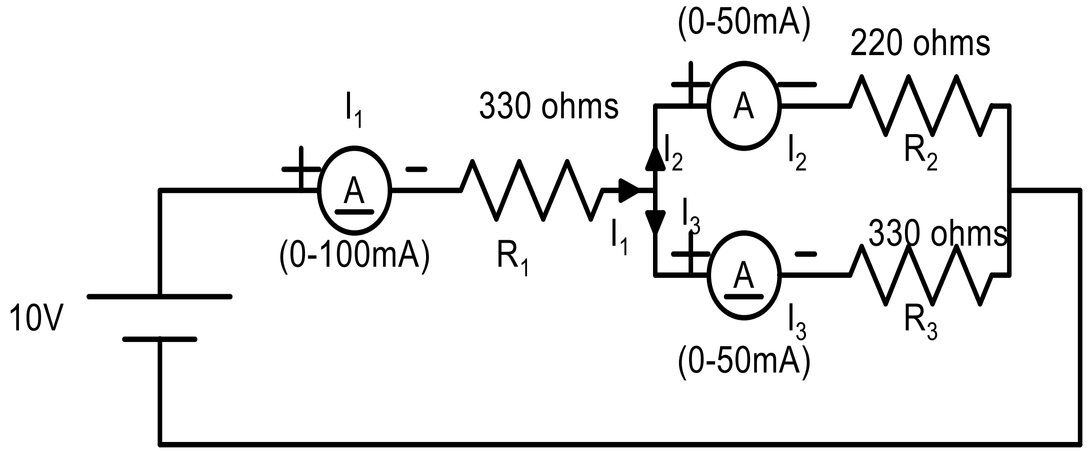
Tabulation for KVL:

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		
Date of record submission		**Faculty signature**

RESULT:

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

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

AIM:

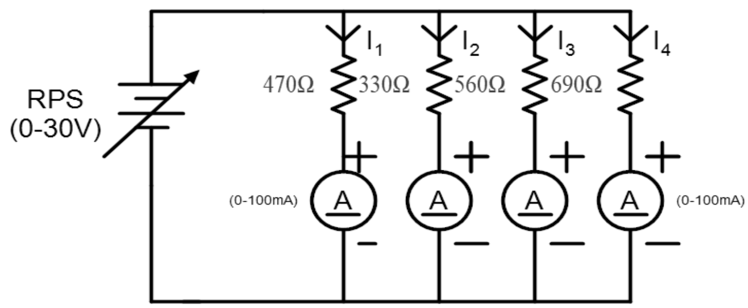
To calculate the individual branch currents and total current drawn from the power supply using current and voltage division rules.

APPARATUS REQUIRED:

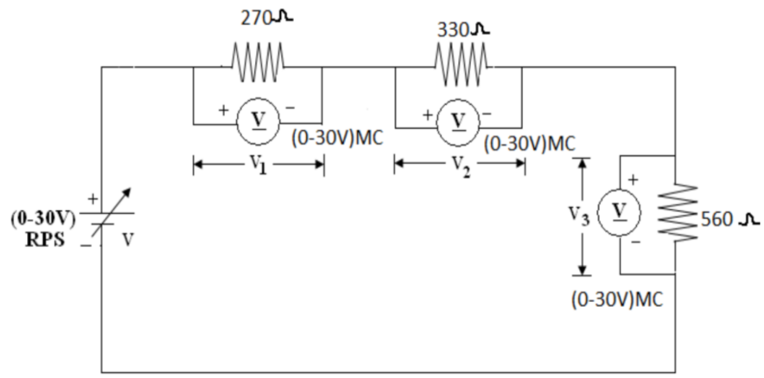
S.No.	Apparatus Name	Range	Quantity
1	DC Regulated Power Supply	(0-30)V	1
2	Ammeter	(0-200)mA	4
3	Resistor	1kΩ, 220Ω	Each two
4	Bread board & Connecting wires	--	Required

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.

Expt. No. 03	Verification of star delta transformation

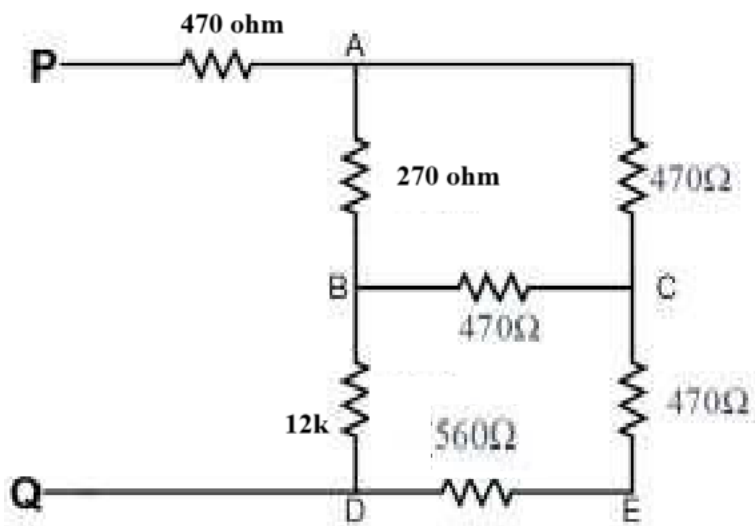
AIM:

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:

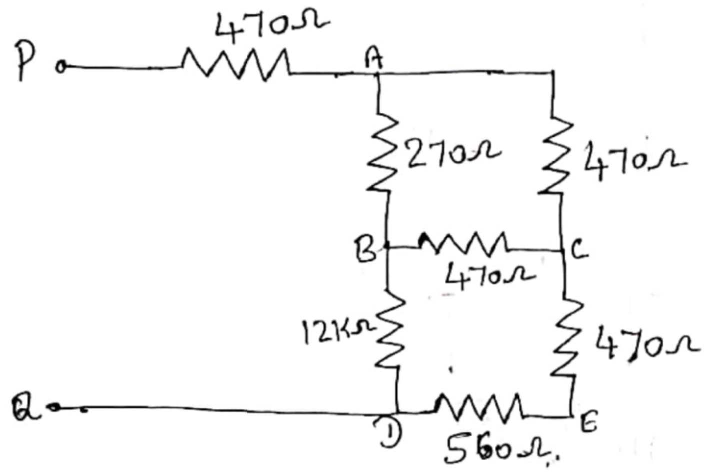


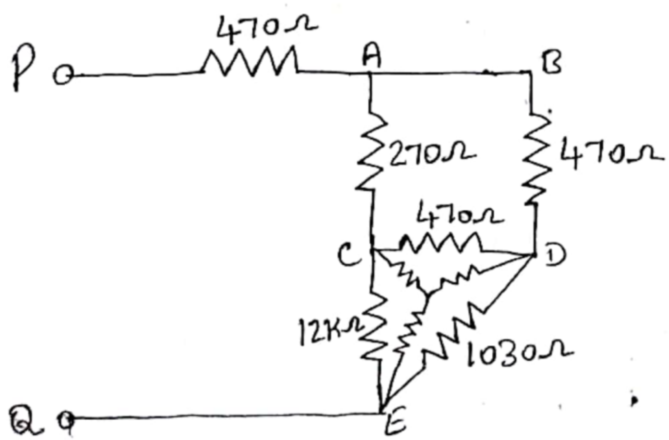
PROCEDURE:

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

Theoretical Calculation

Circuit Diagram:





$$R_C = \frac{R_{CE}\, R_{CD}}{R_{CE} + R_{ED} + R_{CD}}$$

$$R_C = \frac{12\times10^3 \times 470}{470 + 1030 + (12\times10^3)}$$

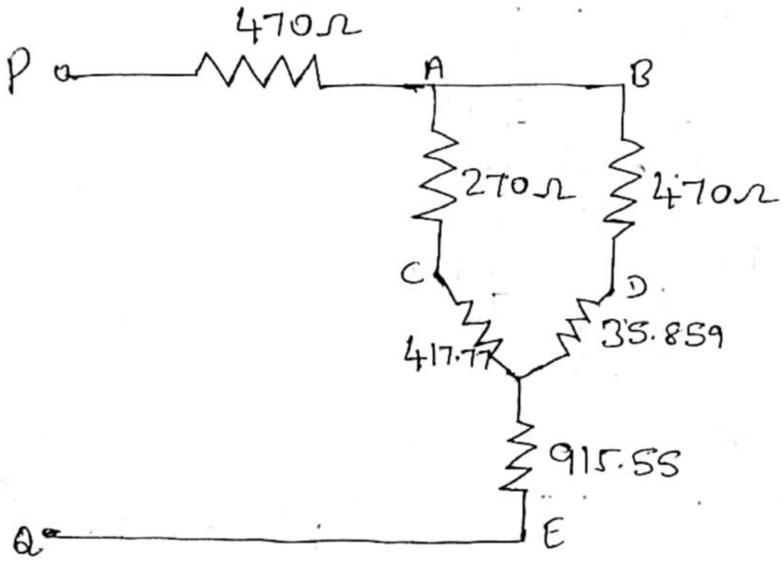
$$\boxed{R_C = 417.77\,\Omega}$$

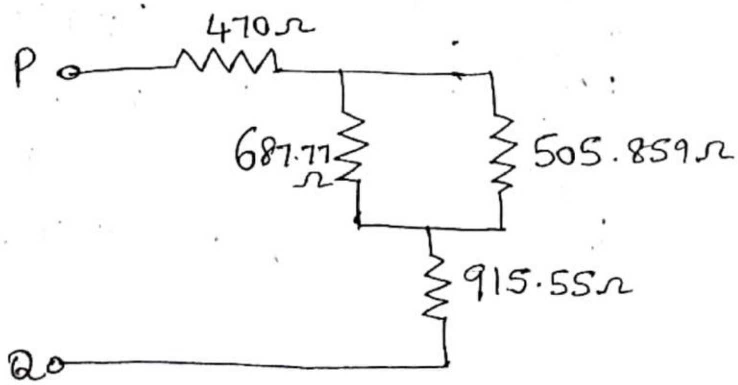
$$R_E = \frac{R_{EC} \cdot R_{ED}}{R_{CE} + R_{ED} + R_{CD}} = \frac{12\times10^3 \times 1030}{(12\times10^3)+1030+470}$$

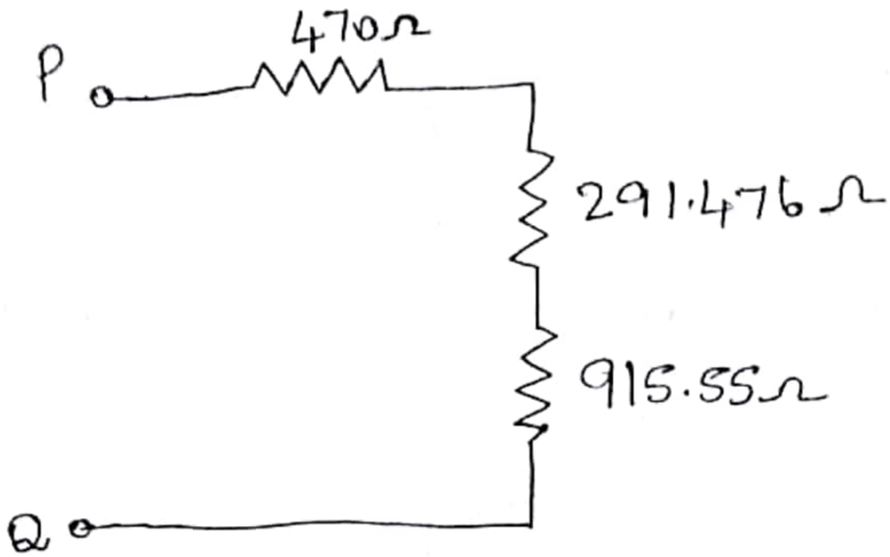
$$\boxed{R_E = 915.55\,\Omega}$$

$$R_D = \frac{R_{CD}\,R_{DE}}{R_{CE} + R_{ED} + R_{CD}} = \frac{470\times1030}{(12\times10^3)+1030+470}$$

$$\boxed{R_D = 35.859\,\Omega}$$







$$R_{PQ} = 1.677\ K\Omega$$

$$\boxed{R_{PQ} = 1.7\ K\Omega}$$

OBSERVATIONS:

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

RESULT:

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

BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LAB

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

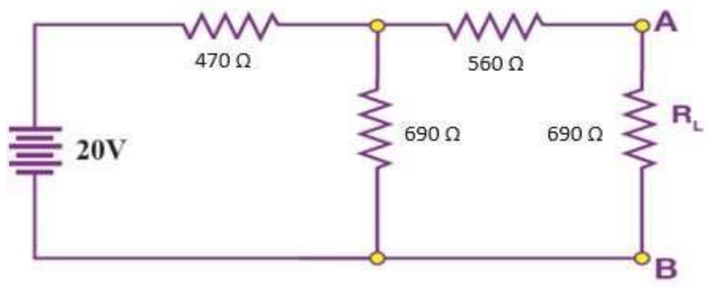
AIM:

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:



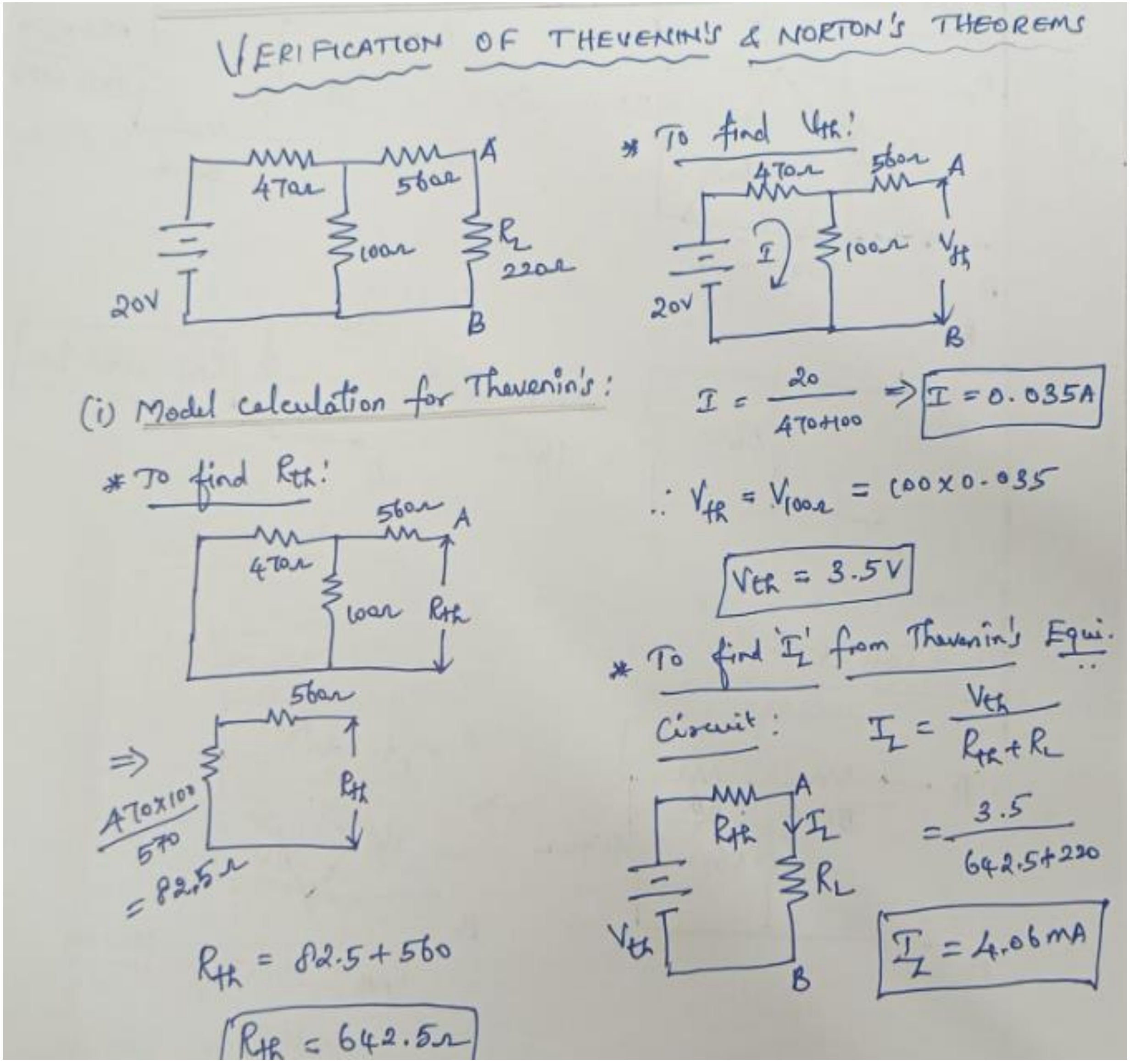
PROCEDURE FOR THEVENIN'S THEOREM:

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:

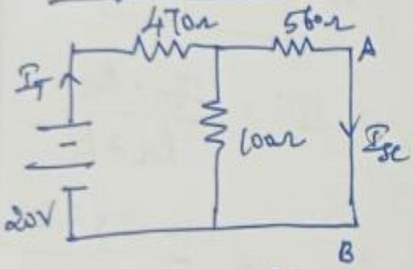
1. Give the connections as per the circuit diagram.
2. Measure R_{th} using a multimeter by killing sources (O.C the current source and S.C the voltage source) and open circuit R_L.
3. Measure I_N through A & B (Short circuit R_L)
4. Measure load current I_L through R_L.
5. Draw the Norton's Equivalent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



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

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

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

$\boxed{I_T = 0.036A}$

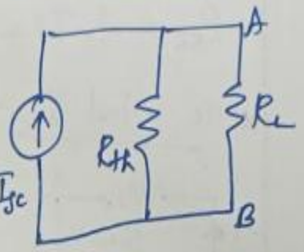
By Current division Rule:

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

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

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

* 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.

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

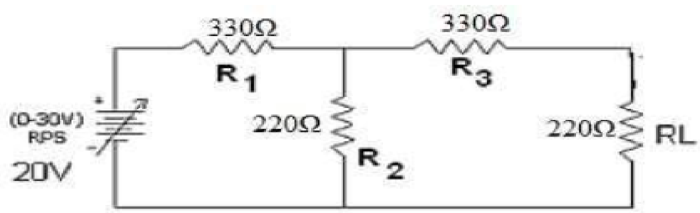
5(a). Verification of Maximum Power Transfer

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:

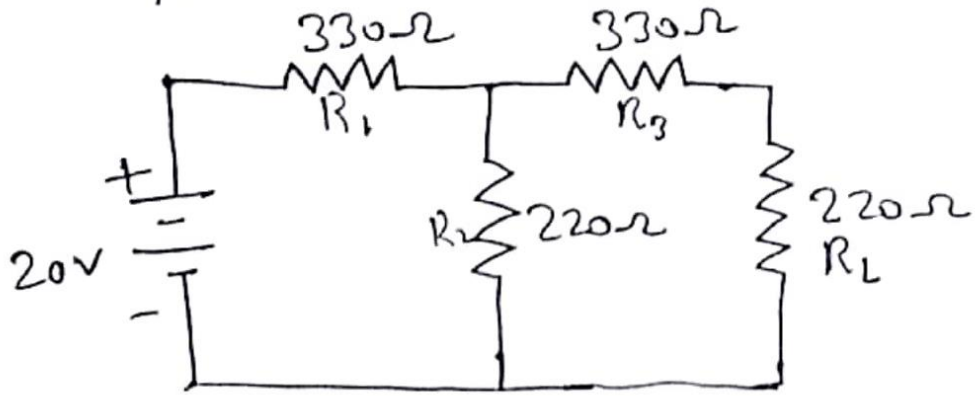
1. Give the connections as per the circuit diagram.
2. Measure R_{th} using a multimeter
3. Measure V_{th} across 220Ω (R_2)
4. Measure load current I_L through R_L
5. Calculate the maximum power transferred to the load

OBSERVATIONS:

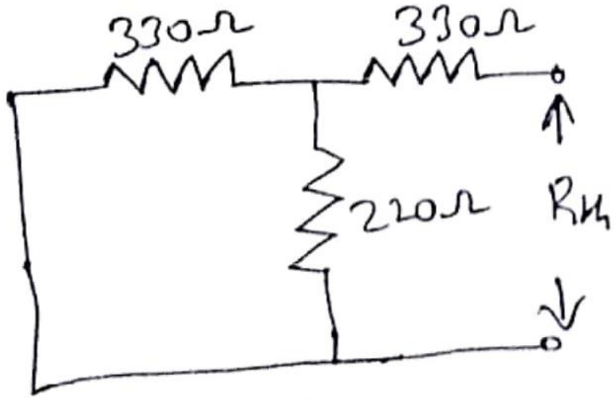
S.No.	Supply Voltage (V)	Theoretical values			Measured values			Maximum Power
		$R_{th}(\Omega)$	$V_{th}(V)$	$I_L(mA)$	$R_{th}(\Omega)$	$V_{th}(V)$	$I_L(mA)$	$P_{max} = I_L^2 . R_L$ (watts)
1								

Manual Calculation:

Maximum Power Transfer



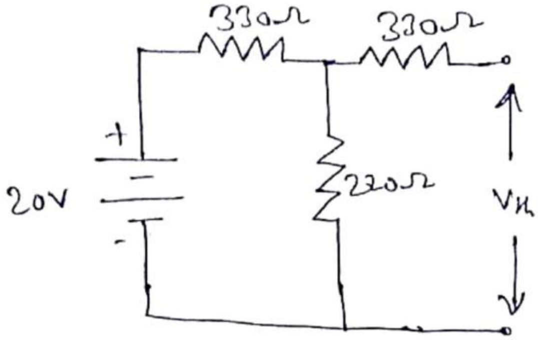
To find R_{th}



$$R_{th} = 330 \parallel 220 + 330$$

$$R_{th} = 462\,\Omega$$

To find V_{th}



$$V = IR$$

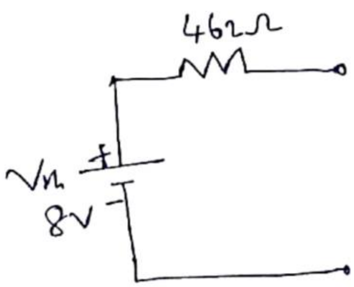
$$I = \frac{V}{R} = \frac{20}{330+220} = 0.03636\,A$$

$$V_{th} = IR$$

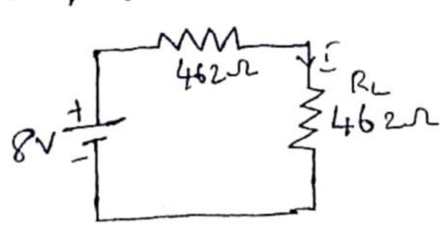
$$= 0.03636 \times 220$$

$$\boxed{V_{th} = 8V}$$

Thevenin Equivalent Circuit



To find load current



$$I = \frac{V}{R_{th}+R_L} = \frac{8}{(462+462)} = 8.658\,mA$$

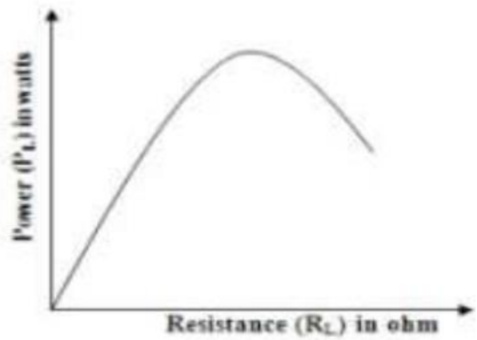
To find maximum power

$$P_{max} = \frac{V^2}{4R} = \frac{8^2}{4 \times 462} = 0.03463\,W$$

$$\boxed{P_{max} = 34.63\ mW}$$

S.No	V (V)	R (Ω)	I_L (mA)	P_{max} (mW)	
1.	8	150	13.072	25.63	
2.	8	300	10.498	33.06	
3.	8	450	8.77	34.61	
4.	8	462	8.658	34.63	$R_{th} = R_L$
5.	8	500	8.316	34.57	
6.	8	650	7.194	33.63	
7.	8	800	6.339	32.146	

MODEL GRAPH:



RESULT:

Thus the Maximum Power Transfer Theorem is verified.

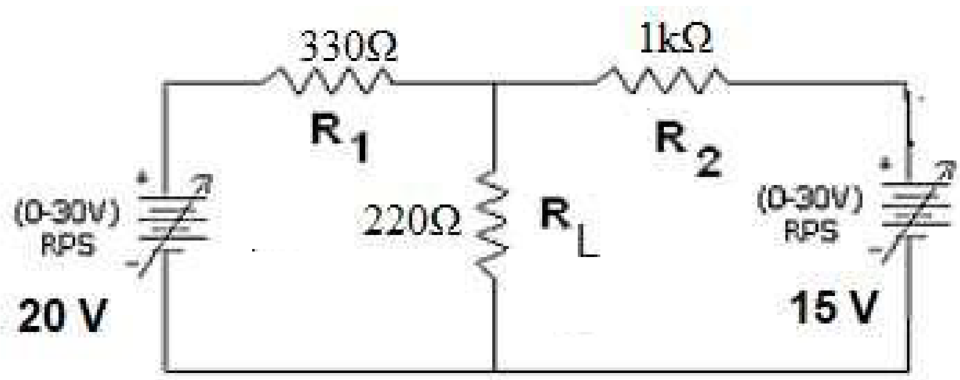
5(b). Verification of Superposition Theorem

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:

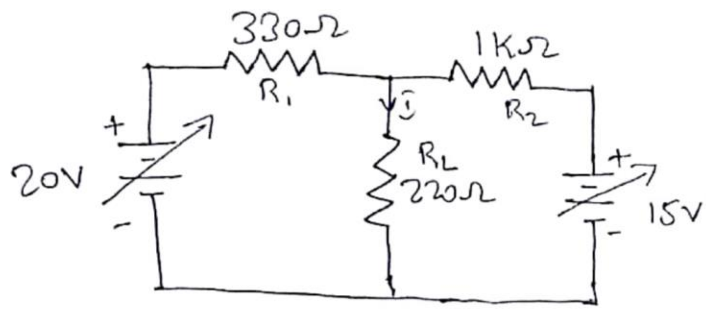


PROCEDURE:

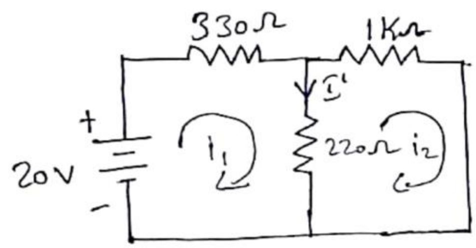
1. Give the connections as per the circuit diagram.
2. Measure current flow through 220Ω by connecting both the supplies.
3. Short circuit 15 V source.
4. Measure current flow through 220Ω by connecting 20 V supply.
5. Short circuit 20 V source.
6. Measure current flow through 220Ω by connecting 15 V supply.
7. Verify the net current through 220Ω resistor.

CALCULATION:

Manual Calculation



Case(i) Find Current through 220Ω by Connecting 20V Supply (SC 15V)



$$V = IR$$

$$\begin{bmatrix} 550 & -220 \\ -220 & 1220 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 20 \\ 0 \end{bmatrix}$$

$$\Delta = \begin{bmatrix} 550 & -220 \\ -220 & 1220 \end{bmatrix} = 671000 - 48400 = 622600$$

$$\Delta_1 = \begin{bmatrix} 20 & -220 \\ 0 & 1220 \end{bmatrix} = 24400$$

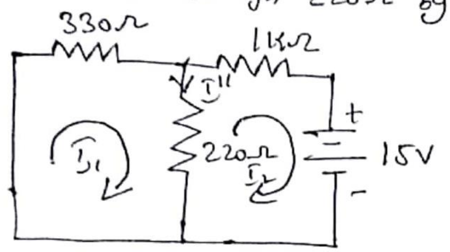
$$\Delta_2 = \begin{bmatrix} 550 & 20 \\ -220 & 0 \end{bmatrix} = 4400$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{24400}{622600} = 0.03919\,A$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{4400}{622600} = 7.067\,mA$$

$$I' = 39.19 - 7.067 = 32.123\,mA$$

Case (ii) Find Current through 220Ω by Connecting 15V Supply (S.C 20V)



$$V = IR$$

$$\begin{bmatrix} 550 & -220 \\ -220 & 1220 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 0 \\ -15 \end{bmatrix}$$

$$\Delta = \begin{bmatrix} 550 & -220 \\ -220 & 1220 \end{bmatrix} = 671000 - 48400 = 622600$$

$$\Delta_1 = \begin{bmatrix} 0 & -220 \\ -15 & 1220 \end{bmatrix} = -3300$$

$$\Delta_2 = \begin{bmatrix} 550 & 0 \\ -220 & -15 \end{bmatrix} = -8250$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{-3300}{622600} = -5.3004\,mA$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{-8250}{622600} = -13.25\,mA$$

$$\hat{I}'' = \hat{I}_1 - \hat{I}_2$$

$$= -5.3004 + 13.25$$

$$\hat{I}'' = 7.9496 \text{ mA}$$

By Superposition theorem

$$\hat{I} = \hat{I}' + \hat{I}''$$

$$\hat{I} = 32.123 + 7.9496$$

$$\hat{I} = 40.0726 \text{ mA}$$

Find net current

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.

Expt. No. 6	Load Test on a 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	1ϕ, (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 :
- Rated H.V side Voltage :
- Rated H.V side Current :
- Rated L.V side Voltage :
- Rated L.V side Current :

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

=

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

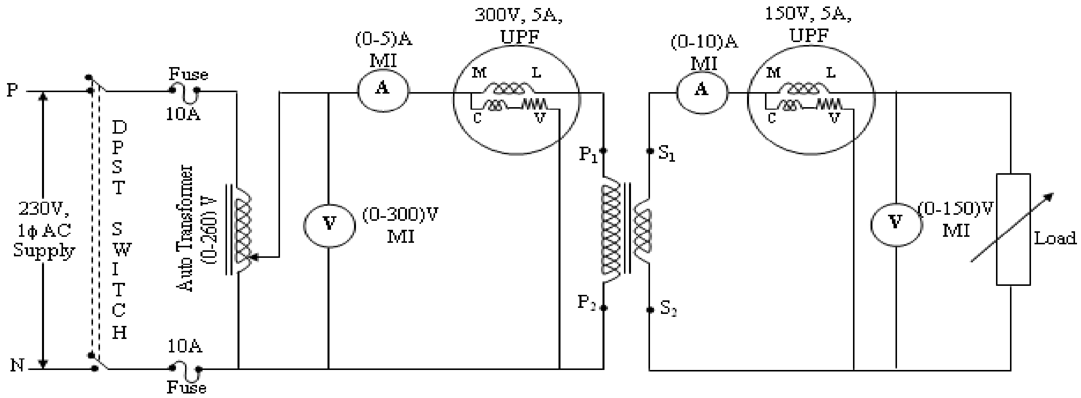
= (120/100) x Rated current on H.V. Side

=

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. After checking the no load condition, minimum position of auto transformer and DPST switch is closed.
3. Ammeter, Voltmeter and Wattmeter readings on both primary side and secondary side are noted.
4. The load is increased and for each load, Voltmeter, Ammeter and Wattmeter readings on both primary and secondary sides are noted.
5. Again no load condition is obtained and DPST switch is opened.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 5}{100} = 6.25A$$

NAME PLATE DETAILS:

	Primary	Secondary
Rated Voltage :	230V	115V
Rated Current :	5A	10 A
Rated Power :	1KVA	1KVA

TABULAR COLUMN:

S.No.	Load	Primary			Secondary			Input Power W_1 x MF	Output Power W_2 x MF	Efficiency η %	% Regulation
		V_1 (Volts)	I_1 (Amps)	W_1 (Watts)	V_2 (Volts)	I_2 (Amps)	W_2 (Watts)				

FORMULAE:

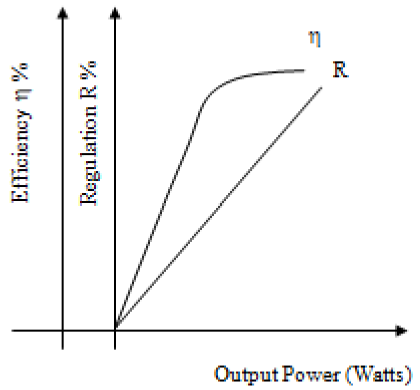
Output Power = W_2 x Multiplication factor

Input Power = W_1 x Multiplication factor

$$\text{Efficiency } \eta \% = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

$$\text{Regulation } R\ \% = \frac{V_{NL} - V_{FL}\ \text{(Secondary)}}{V_{NL}} \times 100\%$$

MODEL GRAPHS:



RESULT:

Thus the load test on single phase transformer is conducted.

Expt. No. 7	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	1ϕ, (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 :
- Rated H.V side Voltage :
- Rated H.V side Current :
- Rated L.V side Voltage :
- Rated L.V side Current :

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

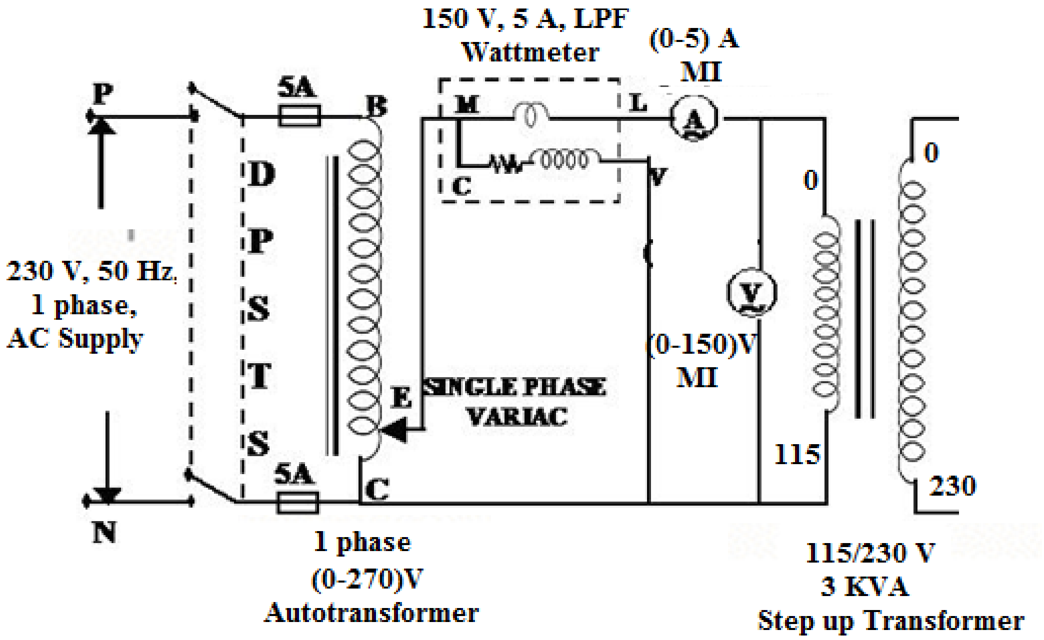
=

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

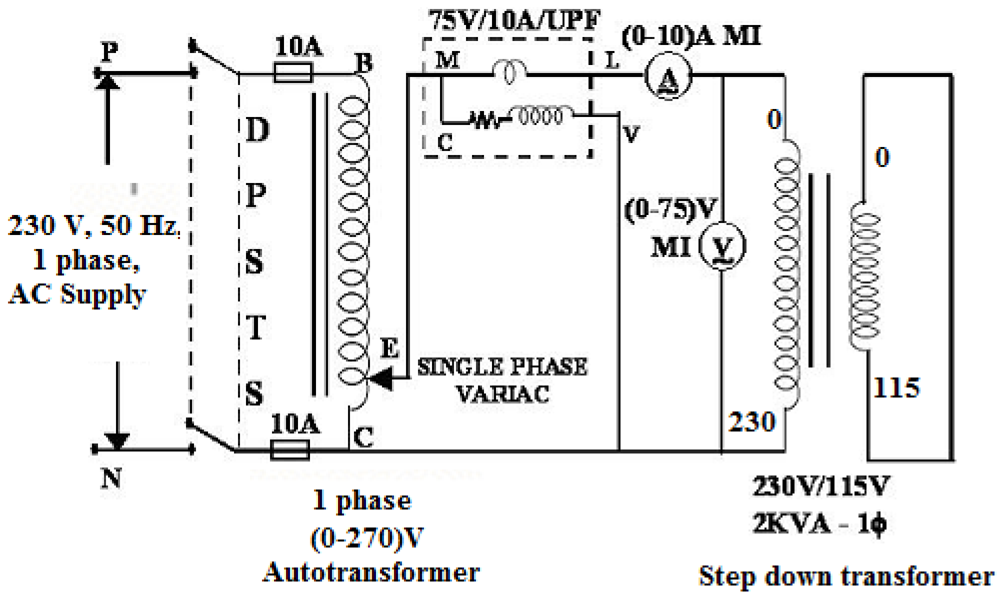
= (120/100) x Rated current on H.V. Side

=

OPEN CIRCUIT TEST



SHORT CIRCUIT TEST



PROCEDURE:

I) O.C. TEST:

1. The circuit connections are made as per the circuit diagram.
2. Keeping the H.V. winding open and the autotransformer in its minimum position the main supply is switched ON.

3. By slowly and carefully adjusting the autotransformer, the rated voltage (115V) is applied to L.V. winding of the transformer.
4. Under this condition the ammeter (Io), Voltmeter (Vo) and Wattmeter (Wo) readings a noted down.
5. After the experiment is completed, the autotransformer is slowly brought back to minimum position and then the main supply is switched OFF.

II) S.C. TEST:

1. The circuit connections are made as per the circuit diagram.
2. Short circuiting the LV winding and keeping the autotransformer in its minimum position, the main supply is switched ON.
3. By slowly and carefully adjusting the autotransformer the rated current (which is calculated as H.V current.= KVA Rating *1000 / H.V. is circulated through the H.V. winding.
4. Under this condition, the ammeter (ISC), the voltmeter (VSC) and the Wattmeter (WSC) readings are noted down.
5. After the experiment is completed, the autotransformer is brought back to its minimum position and main supply is switched OFF.

TABULATION:

TEST	VOLTAGE(V)	CURRENT(A)	POWER(W)
O.C TEST (On L.V side)	Vo =	Io =	Wo =
S.C. TEST (On H.V side)	Vsc =	Isc =	Wsc=

MODEL CALCULATIONS:

1. To obtain the equivatent circuit parameters w.r.t. H.V side

i). From the O.C test the; constant loss Iron loss is noted

$W_c = W_o =$ _________watts.

ii). From the S.C test full load copper loss is noted

$W_{cu} = W_{sc} =$ ___________watts.

For a transformer, the equivalent circuit parameters can be determined ether w.r.t H.V side or L.V side. If the parameters are estimated on the H.V side ;the resulting equivalent circuit is called H.V side equivalent circuit of the transformer.

From the O.C test Ro and Xo are calculated using the following expressions,

R_o (L.V) $= V_o / I_w =$ Ohms

X_o (L,V) $= V_o / I_m =$ Ohms

Where $I_W = I_o \cos\theta =$

$I_\mu = I_o \sin\theta =$ and

$\theta = \cos^{-1}[Wo/VoIo] =$

Since these values are calculated w.r.t L. V side (because O.C test is conducted on the I.V side), the equivalent values of 'R_o' and 'X_o' as referred to H.V side are determined as

Ro(H.V) = Ro (L.V) / K^2 = &

Xo(H.V) = Xo (L.V) / K^2 =

Where K= (secondary voltage) / (primary voltage)

= 115/230 for a step down operation.

= 230/115 for a step up operation.

Since we are assuming a step down operation k = 115 / 230 = 0.5.

R_T (H.V) $= W_{sc}/ I_{sc}^2$ =

Z_T (H.V) $= V_{sc} / I_{sc}$ =

X_T (H.V) $= [Z_T^{\,2}$ (H.V) $- R_T^{\,2}$ (H.V)$]^{1/2}$ =

R_T (H.V) and X_T (H.V) are the total equivalent resistance and reactance of the transformer as referred to the H.V side whose values are calculated from the S.C test. Now the H.V side equivalent circuit is drawn

2. To Predetermine The Efficiency:

The percentage efficiency is then predetermined for different load conditions for a specified load power factor using the expression,

$$\% \text{ Efficiency} = \frac{X*KVA * \cos\phi * 1000}{(X* KVA * \cos\phi * 1000) + W_o + X^2 W_{F.L}}$$

When X is the fraction ;of the full load which is 0.25 for 25% load, 0.5 for 50% load, 0.75 for 75% load, 1.0 for full load and 1.25 for 125% load and Cosϕ is the load p.f (usually assumed as 0.8 lag) The efficiency valued so calculated are entered in the tabular column as shown. A graph is plotted between percentage efficiency and the output as shown in model graph

TABULATION:

% Of load X	**Power factor cos ϕ**	**sin ϕ**	**Power factor cos ϕ**	**sin ϕ**
	0.8	**1.0**	**0.8**	**1.0**
0.25				
0.5				
0.75				
1.0				

% Of load X	**Output power = X*KVA*cosϕ*100 (watts)**		**Copper loss = $X^2 w_{sc}$(f.l) (watts)**	**Total loss = W_c + copper loss (watts)**	**Input power = O/p power + losses (watts)**		**Efficiency% = [(o/p)/(i/p)] x 100 (watts)**	
	pf 0.8	pf 1.0			0.8	1.0	0.8	1.0
0.25 0.5 0.75 1.0								

3. To pre-determine the Percentage Regulation:

The regulation on full load for different leading and lagging power factors are predetermined by formula,

$$\% \text{ Regulation} = \frac{[\, I\,(H.V) * R_T\,(H.V) \cos\phi \,] + [I\,(H.V) * X_T\,(H.V) \sin\phi \,]}{V\,(H.V)} * 100$$

$$\% \text{ Regulation} = \frac{[\, I\,(H.V) * R_T\,(H.V) \cos\phi \,] - [I\,(H.V) * X_T\,(H.V) \sin\phi \,]}{V\,(H.V)} * 100$$

Where + for lagging power factor, - for leading power factor.

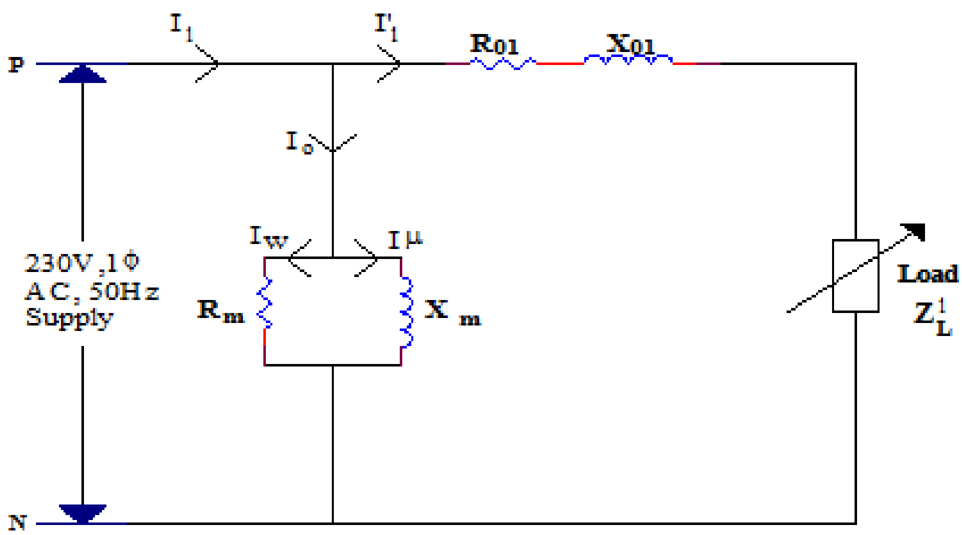
LH.V = Rated current on H.V side, VH.V = Rated voltage on H.V side. By assuming different leading and lagging power factor such as 0.2, 0.4, 0.6, 0.8 and 1.0 the regulation of the transformer for full load are determined and tabulated as shown below.

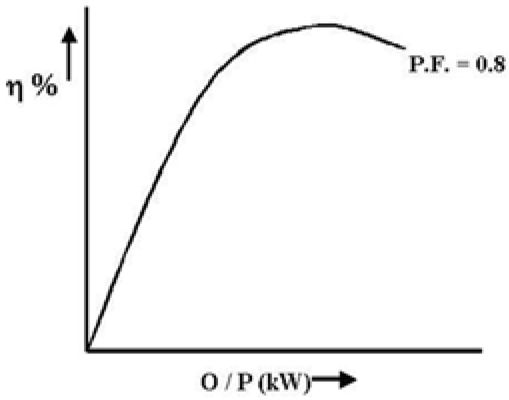
TABULATION:

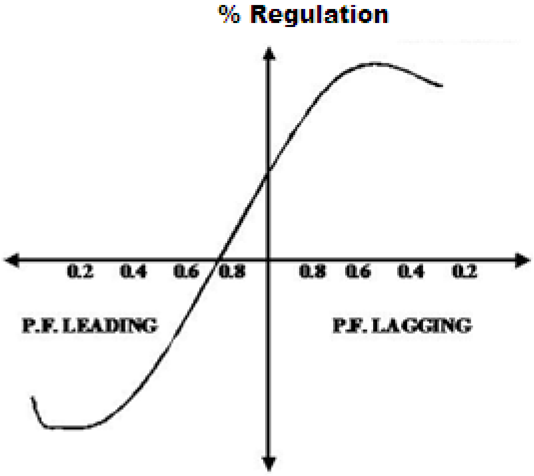
POWER FACTOR	% Regulation	% Regulation
	For lagging power factor	For leading power factor
0.2		
0.4		
0.6		
0.8		
1.0		

Now a graph is plotted between the percentage regulation and P.F as shown in figure which is known as the regulation graph.

EQUIVALENT CIRCUIT DIAGRAM:







REGULATION CURVE

RESULT:

Thus the O.C and S.C tests are conducted on the single phase transformer and the efficiency and regulation graphs and also the equivalent circuit as referred to H.V side is drawn.

OC and SC Test

OC

V_0	I_0	W_0 or P_0
220V	0.5A	60

SC

V_{sc}	I_{sc}	W_{sc}
12V	4.5A	40

OC Test

$P_0 = V_0 I_0 \cos\phi_0$

$60 = 220 \times 0.5 \cos\phi_0$

$\cos\phi_0 = \dfrac{60}{220 \times 0.5} = 0.545$

$\phi_0 = 56.97$

$I_w = I_0 \cos\phi_0$

$= 0.5 \times 0.545$

$I_w = 0.2727\,A$

$I_m = I_m \sin\phi_0$

$= 0.5 \times \sin(56.97)$

$I_m = 0.419$

$R_0 = \dfrac{V_0}{I_w} = \dfrac{220}{0.2727} = 806.74\,\Omega$

$X_0 = \dfrac{V_0}{I_m} = \dfrac{220}{0.419} = 525.059\,\Omega$

Pf = 0.2

$\% R = \dfrac{1.840 \pm 7.48}{230}$

$\% R = 4.05\%$ (lagging)

$\% R = -2.45\%$ (leading)

Pf = 1

$\% R = 4\%$ (lagging)

$\% R = 4\%$ (leading)

SC Test

$P_{sc} = I_{sc}^2 R_{02}$

$R_{02} = \frac{P_{sc}}{I_{sc}^2} = \frac{40}{4.5^2} = 1.975\,\Omega$

$Z_{02} = \frac{V_{sc}}{I_{sc}} = \frac{12}{4.5} = 2.666\,\Omega$

$X_{02} = \sqrt{Z_{02}^2 - R_{02}^2} = \sqrt{2.666^2 - 1.975^2} = 1.790\,\Omega$

$X_{02} = 1.790\,\Omega$

To predetermine the efficiency:

i) $\cos\phi = 1$; $x = 1$

Copper loss $P_{cu} = x^2 P_{sc}$

$= 1^2 \times 40 = 40\,W$

Core loss $P_0 = 60\,W$

Total loss $P_L = P_{cu} + P_0$

$= 40 + 60$

$= 100\,W$

output power $P_{out} = x\,[Q_{rated} \cdot \cos\phi]$ (∴ Transformer rating 1 KVA)

$= 1\,[1000 \times 1]$

$P_{out} = 1000\,W$

Input power $P_{in} = P_{out} + P_L$

$= 1000 + 100$

$P_{in} = 1100\,W$

Efficiency $\eta = \frac{P_{out}}{P_{in}} = \frac{1000}{1100} \times 100\,\% = 90.9\,\%$

ii) $\cos\phi = 0.8$; $x = 1$

Copper loss $P_{cu} = x^2 P_{sc}$

$= 1^2 \times 40 = 40W$

Core loss $P_0 = 60W$

Total loss $P_L = P_{cu} + P_0$

$= 40 + 60$

$= 100W$

Output Power $P_{out} = x\,[Q_{rated} \cdot \cos\phi]$

$= 1\,[1000 \times 0.8]$

$= 800W$

Input Power $P_{in} = P_{out} + P_L$

$= 800 + 100$

$= 900W$

Efficiency $\eta = \dfrac{P_{out}}{P_{in}} = \dfrac{800}{900} \times 100\% = 88.88\%$

% Regulation $= \dfrac{I_1 R_{01} \cos\phi \pm I_1 X_{01} \sin\phi}{V_1} \times 100$

VA rating $= V_1 I_1$

$P_{cu} = I_1^2 R_{01}$

$Z_{01} = \dfrac{V_{sc}}{I_1} = \dfrac{12}{4.34} = 2.76$

$Z_{01} = \sqrt{R_{01}^2 + X_{01}^2} = X_{01}^2 = Z_{01}^2 - R_{01}^2$

$X_{01} = 1.76$

$R_{01} = 2.12$

$I_1 = 4.34$

$Pf = 0.8$

$$\% R = \frac{4.34 \times 2.12 \times 0.8 \pm 4.34 \times 1.76 \times 0.4}{230}$$

$$= \frac{7.3606 \pm 4.583}{230}$$

$\% R = 5.19\%$ (lagging) $\left\{ \frac{7.3606 + 4.583}{230} \right\}$

$\% R = 1.207\%$ (leading) $\left\{ \frac{7.3606 - 4.583}{230} \right\}$

$Pf = 0.6$

$$\% R = \frac{5.52 \pm 6.11}{230}$$

$\% R = 5.05\%$ (lagging) $\left\{ \frac{5.52 + 6.11}{230} \right\}$

$\% R = -0.25\%$ (leading) $\left\{ \frac{5.52 - 6.11}{230} \right\}$

Expt. No. 8	Calculation of Secondary turns and Current in a transformer

AIM:

To calculate the secondary turns and current in a single phase transformer.

APPARATUS REQUIRED:

Sl No.	Apparatus	Range	Quantity
1.	Single phase transformer	230/115 V	1
2.	Auto transformer	0-300V AC	1
3.	Voltmeter	0-300V AC	2
	Ammeter	0-10A AC	1
4.	Connecting wires	-	As required
5.	Single phase AC power supply	-	-

THEORY:

It is essential to know the relative polarity at any instant of primary and secondary terminals for making correct connections. When the two transformers are to be connected in parallel to share the load on the system. The marking is correct if voltage V3 is less than V1, such a polarity is termed as subtractive polarity. The standard practice is to have subtractive polarity because it reduces the voltage stress between adjacent loads. In case V3 > V1, the EMF induced in primary and secondary have additive relation and transformer is said to have additive polarity

NAME PLATE DETAILS:

- KVA Rating :
- Rated H.V side Voltage :
- Rated H.V side Current :
- Rated L.V side Voltage :
- Rated L.V side Current :

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

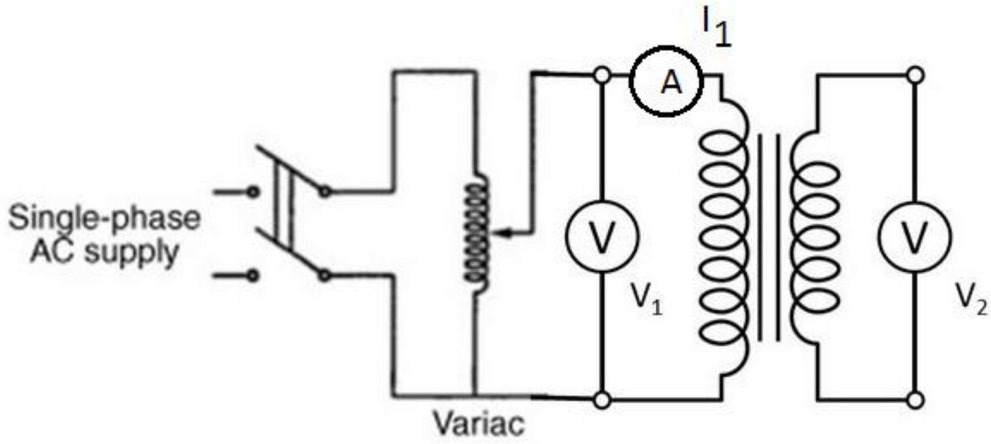
=

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

=

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect the circuit as shown in the diagram.
2. Switch on the a.c. supply.
3. Record voltage V1 across primary and V2 across various tappings of secondary.
4. If V1>V2 then transformer is step down.
5. If V2> V1 then transformer is step up.
6. Switch off a.c. supply

TABULAR COLUMN:

S.NO	Primary Voltage (V1) in volts	Secondary voltage (V2) in volts	Primary Current (I1) in amps	Turn ratio (k=V1/V2)	Secondary current, I2=I1/k

RESULT:

Thus the transformation ratio and the secondary current are measured for a given single phase transformer.

9. 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 = $2\Pi R$ (m)
   R = Radius of the brake drum

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

3. Torque (T) = 9.81* R * ($S_1 \sim S_2$) (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.

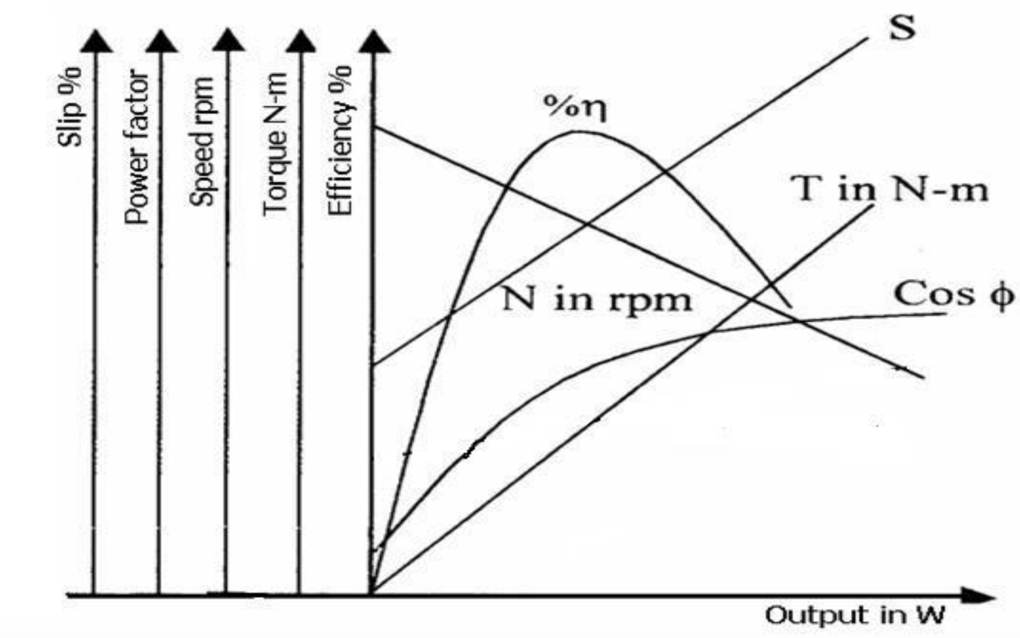
PROCEDURE:

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.

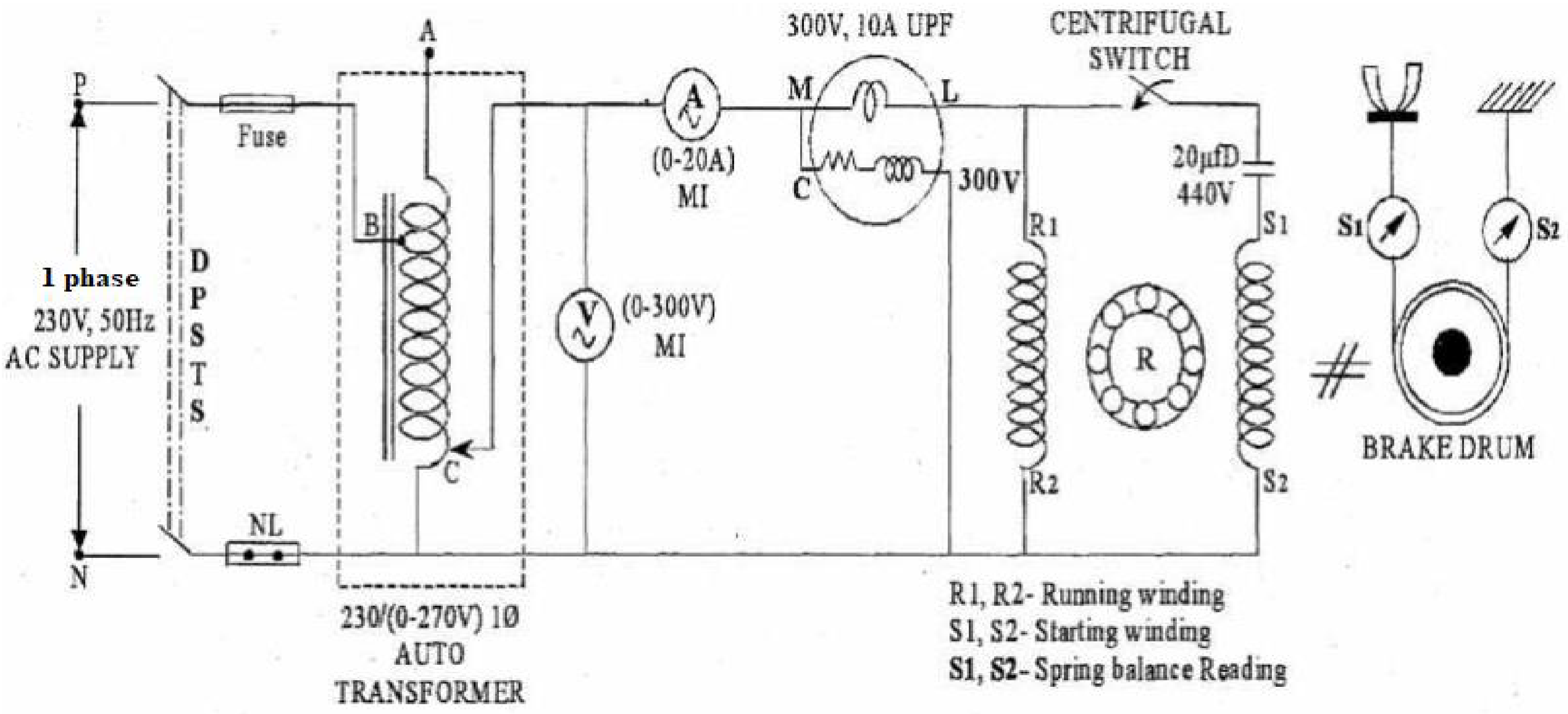
TABULAR COLUMN:

V volts	I Amps	Speed N (rpm)	Wattmeter reading		Spring balance readings			torque (T) = 9.81* R * (S_1 ~ 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:


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

Expt. No. 10	Output Characteristics of LVDT

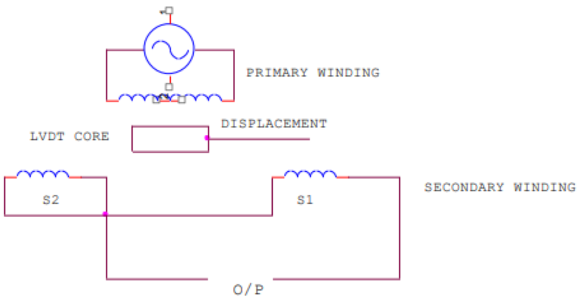
AIM:

To plot the output characteristics of LVDT.

APPARATUS REQUIRED:

S.No.	Apparatus	Quantity
1	LVDT kit	1
2	Multimeter	1
3	Connecting Wires	As required

CIRCUIT DIAGRAM:



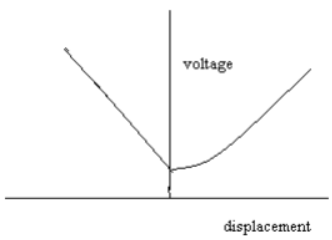
PROCEDURE:

1. Connect the circuit according to circuit diagram.
2. Switch on the power supply.
3. The core is initially brought to null position.
4. First turn the nut in clockwise direction to move core inwards i.e. left of null position & take respective voltage readings on the voltmeter.
5. Now turn nut in anticlockwise direction to move the core towards right of null point & again take respective voltage reading from voltmeter.
6. Plot the graph from the observations taken.

TABULAR COLUMN:

Direction of displacement	Displacement (mm)	Voltage (V)

MODEL GRAPH:



RESULT: Thus the output characteristics of LVDT is plotted.

Expt. No. 11	Three phase Power measurement using Two Wattmeter method

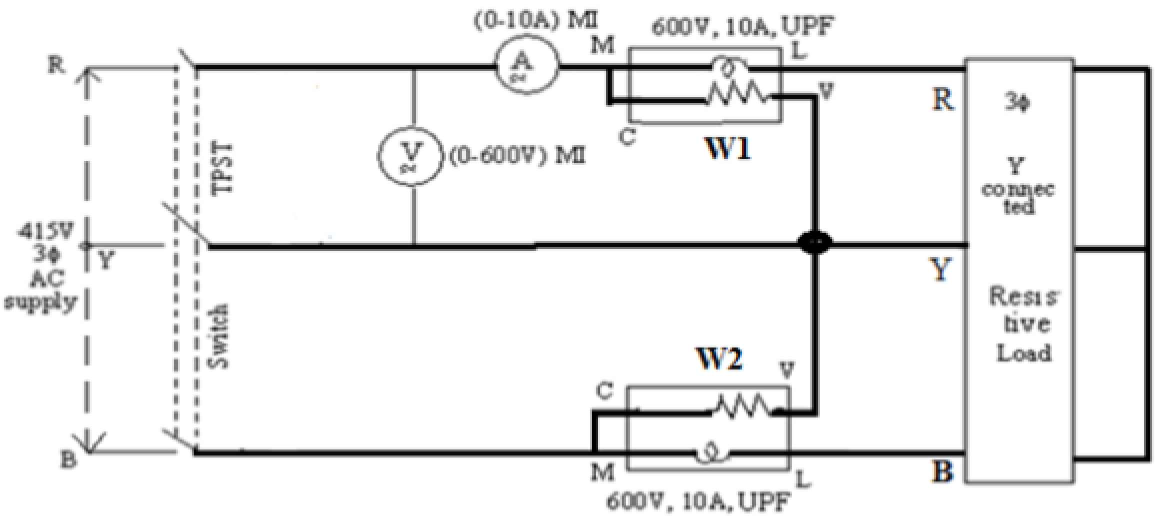
AIM:

To measure the power in three phase balanced star connected load using two wattmeter method.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-10)A	MI	1
2	Voltmeter	(0-600) V	MI	1
3	Wattmeter	(600V, 10 A)	Lpf	2
4	Auto Transformer	3ϕ, (0-600)V	-	1
5	Lamp load	-	-	1
6	Connecting Wires	2.5sq.mm	Copper	Few

CIRCUIT DIAGRAM



PROCEDURE:

1. Make the connections as per the circuit diagram shown in Fig 5.1.
2. Switch ON 3 phase AC supply.
3. Apply load and measure the values of wattmeters, ammeter and voltmeter.
4. Switch OFF all the loads and supply.

TABULAR COLUMN:

Sl No.	Line voltage V_L (V)	Line current I_L (A)	Wattmeter (W1)	Wattmeter (W2)	W= W1 + W2	Calculated power (W)

MODEL CALCULATIONS:

1. Total Power, P = W1 + W2 Watts.
2. Power Factor Cos Ø = Cos [tan-1{ √3 (W1 – W2) / (W1 + W2) }]
3. Calculated Power =√3 VL*IL*Cosϕ

RESULT:

Thus, the power in three phase balanced star connected load using two wattmeter method is measured and calculated.

Expt. No. 12	Energy consumption measurement using a Single Phase Energy Meter

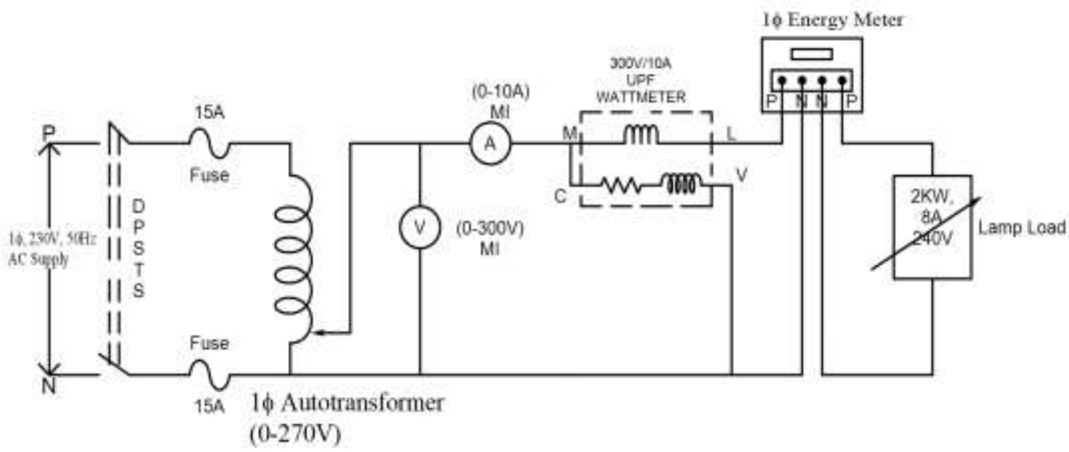
AIM:

To measure the energy consumption using single phase energy meter.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MI	1
2	Voltmeter	(0-300) V	MI	1
3	Auto Transformer	1ϕ, (0-270)V	-	1
4	Lamp load	-	-	1
5	Connecting Wires	2.5sq.mm	Copper	Few

CIRCUIT DIAGRAM



PROCEDURE:

1. Connect the circuit as shown in circuit diagram.
2. Connect the load rheostat 10 Ω/12A in series with load.
3. Keep the variac in minimum output voltage position.
4. Keep the load in maximum position.
5. Adjust the variac output equal to the rated voltage of energy meter.
6. Adjust the load till rated current of energy meter passes through it.
7. Note down the voltmeter and ammeter readings.
8. Note down the time taken for 2 revolutions of disc in the energy meter.
9. Switch off the supply.
10. Repeat the above steps for different currents.

TABULAR COLUMN:

Sl No.	Line voltage V_L (V)	Line current I_L (A)	Time taken for 2 revolutions (sec)	No.of revolutions (n)	Calculated Energy (Whr)	Measured Energy (Whr)

MODEL CALCULATIONS:

1. Calculated energy consumed during ‘n’ revolutions Wa = V*I*t / 3600 = (watt-hour)
   where V= Voltage (V)
   I= Current (A)
   t = Time (S)
2. Measured Energy by energy meter WR = n / meter constant

RESULT:

Thus the energy consumption using single phase energy meter is measured.

Expt. No. 13	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

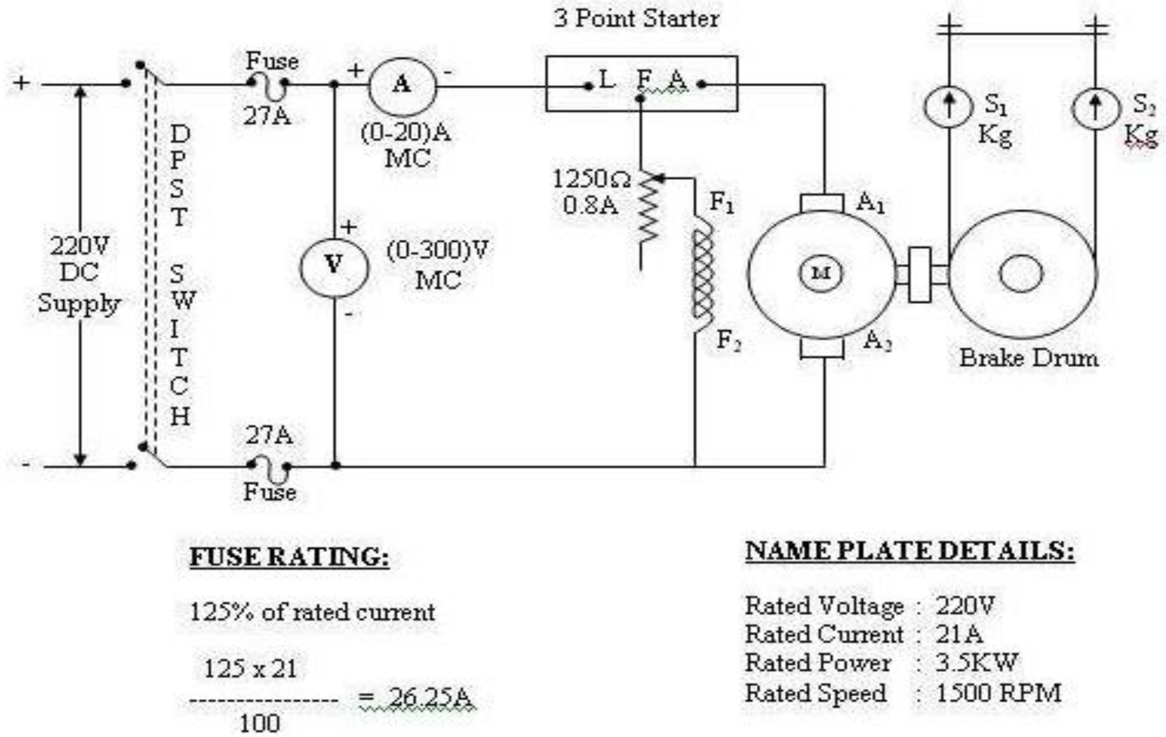
THEORY:

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

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

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

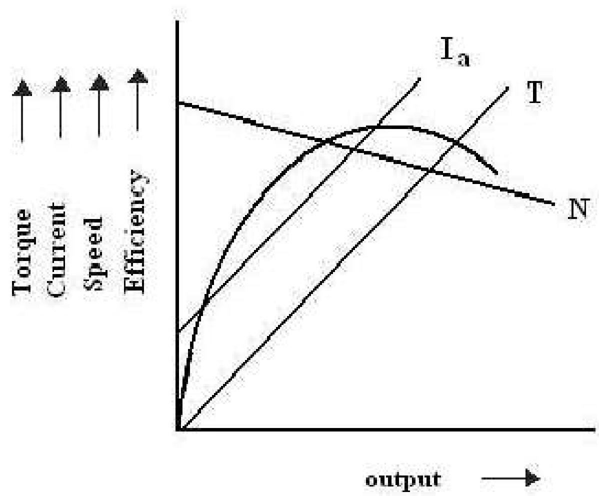
$$\text{Efficiency } \eta = \frac{871.04}{1476} = 59.01\%$$

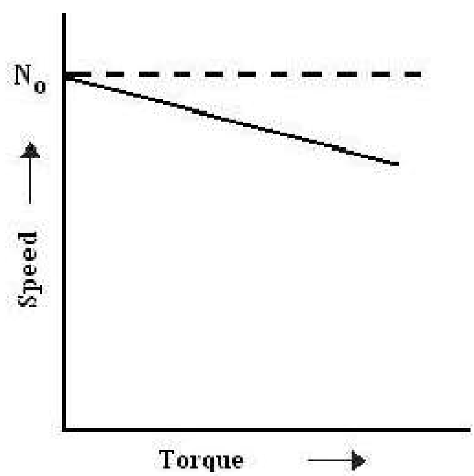
$$\text{Efficiency } \eta = \frac{995.74}{1800} = 55.32\%$$

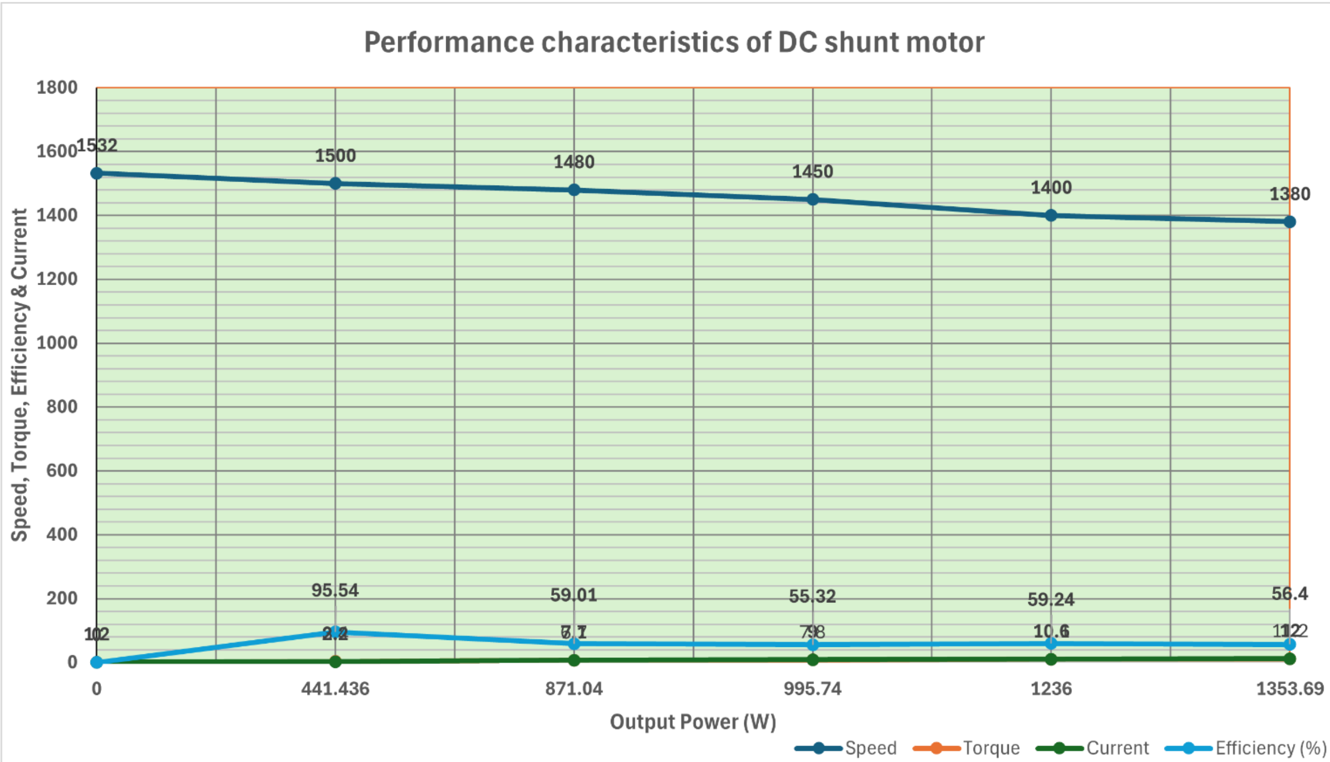
$$\text{Efficiency } \eta = \frac{1256}{2120} = 59.24\%$$

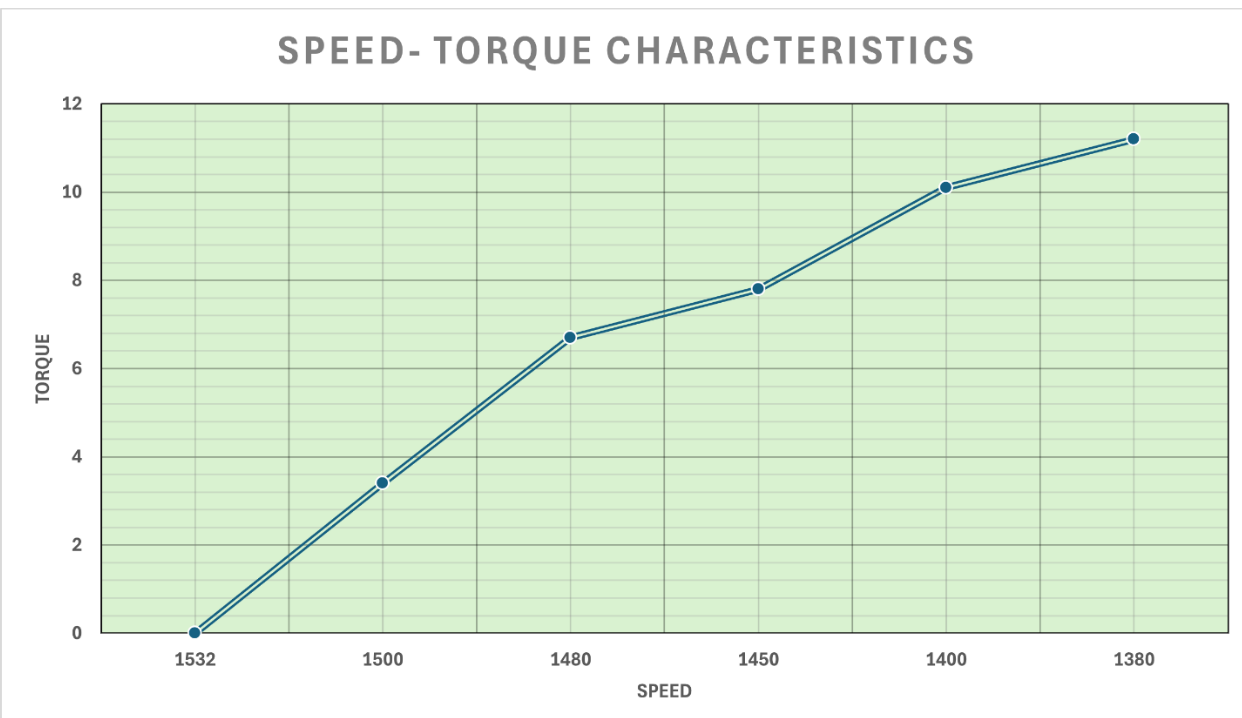
$$\text{Efficiency } \eta = \frac{1353.69}{2400} = 56.4\%$$

MODEL GRAPH:









RESULT:

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

Expt. No. 14(a)	Staircase Wiring

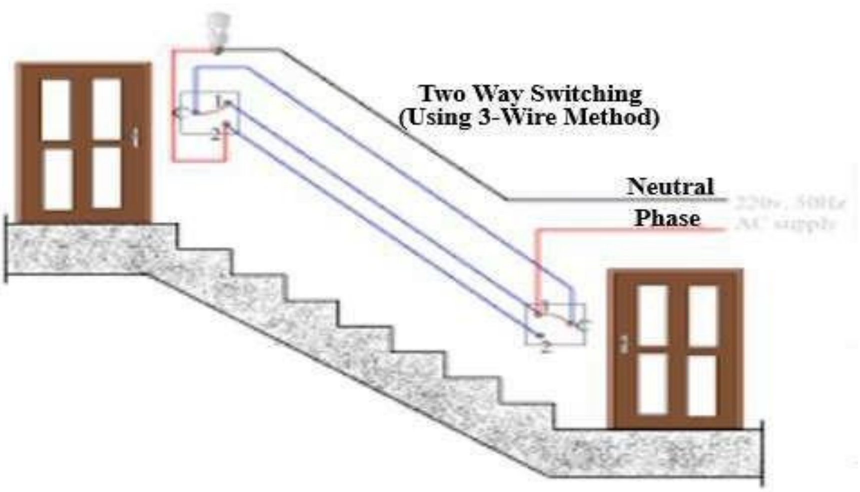
AIM:
To control the status of the given lamp using two-way switches.

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.

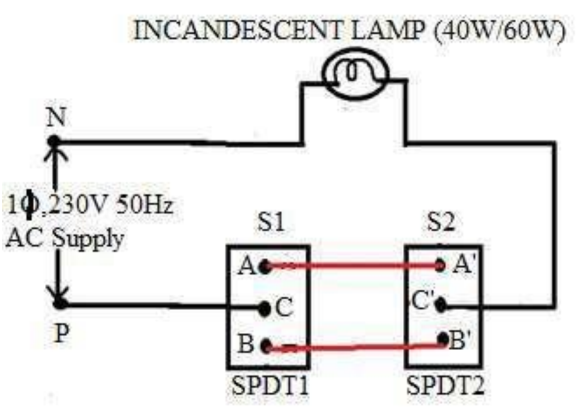


PROCEDURE:

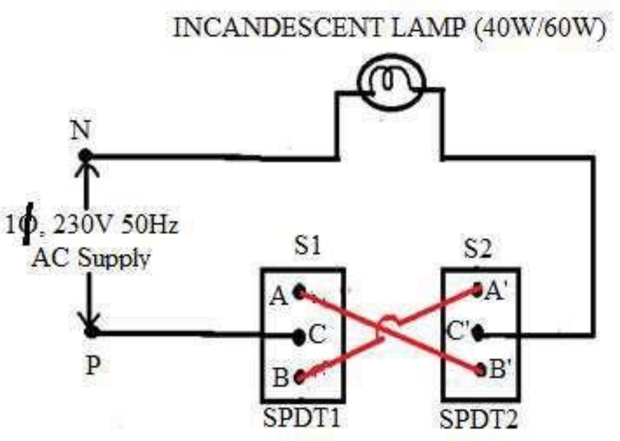
1. A piece of wire is connected to the phase side and other end to the middle point of SPDT switch1.
2. Another point of lamp holder is connected to neutral line.
3. Upper point of SPDT switch 1 is connected to the upper point of SPDT switch 2.Lower point of SPDT switch 1 is connected to the lower point 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. 14(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:

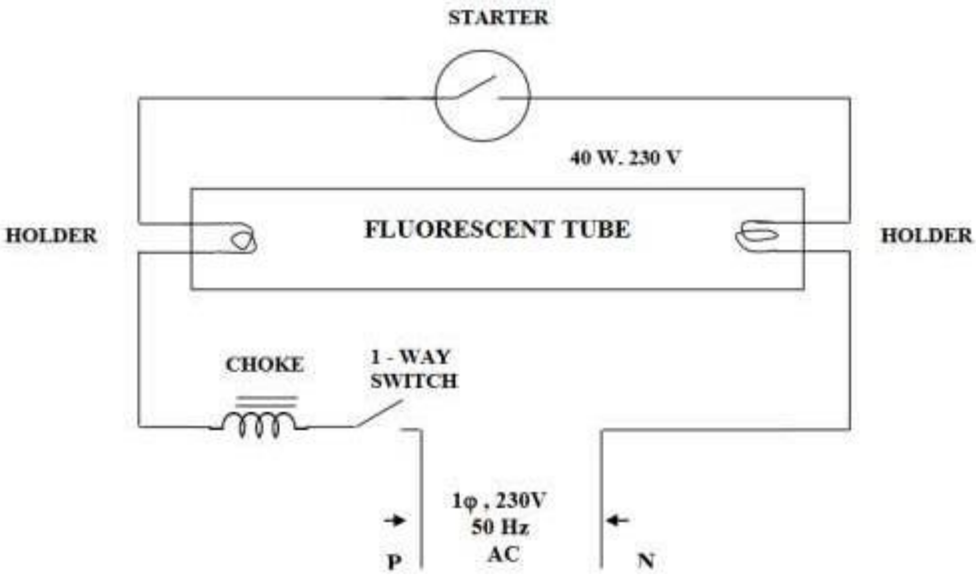
Working of the Fluorescent Tube Light:

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.

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.

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 $x[n] = A * \alpha^n$, 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 $x[n] = A * \cos(\omega n + \varphi)$, 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.

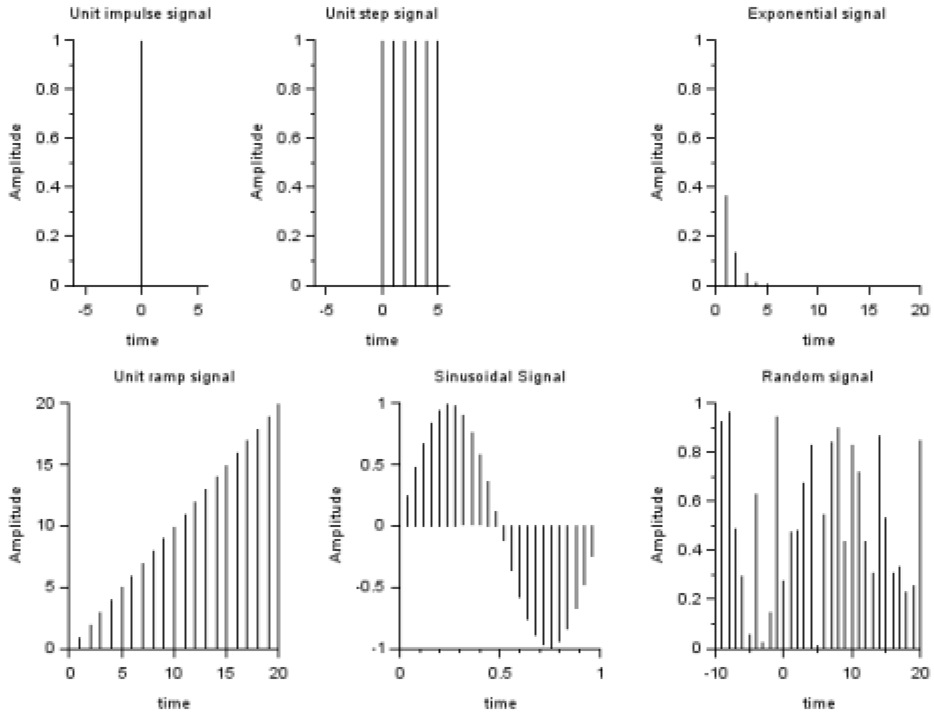
Random Signal: A random signal represents random variations or noise in a system. It's often generated using a random number generator. In digital communication, noise can introduce errors in the received signal, impacting the quality of communication.

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.

EX NO: 19	
DATE:	**Analog Filter design Using Transformation method**

(i) Validate Transformation with Standard Sampling Period T=1.Convert Analog transfer function into Digital using Bilinear Transformation of H(s)=(s^2+4.525)/(s^2+0.692*s+0.504) using sci lab

Aim

To convert the continuous-time analog transfer function H(s)=s2+4.525/s2+0.692s+0.504 into a discrete-time digital transfer function using the bilinear transformation method with a standard sampling period T=1

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:

In digital signal processing, converting an analog filter design into a digital filter is crucial for implementing filtering operations in digital systems. The bilinear transformation is a widely used method for this purpose. It maps a continuous-time (analog) filter's transfer function into a discrete-time (digital) filter's transfer function while preserving the filter's characteristics such as stability and frequency response.

Bilinear Transformation

The bilinear transformation is a technique used to convert an analog filter's transfer function H(s)H(s)H(s) into a discrete-time transfer function H(z)H(z)H(z). The transformation is defined by the mapping:

$$s = \frac{2}{T}\frac{1 - z^{-1}}{1 + z^{-1}}$$

where T is the sampling period. This mapping converts the Laplace variable S to the Z-transform variable Z.

Program

```
clear;
clc ;
close ;
s=%s;
z=%z;
HS=(s^2+4.525)/(s^2+0.692*s+0.504);
T=1;
HZ=horner(HS,(2/T)*(z-1)/(z+1));
disp(HZ,'H(z) =');
```

Output:

```
H(z) =
                              2
   1.4478601 + 0.1783288z + 1.4478601z
   -----------------------------------
                         2
        0.5298913 - 1.1875z + z
```

Result: Thus the discrete-time transfer function H(z) obtained after applying the bilinear transformation. Include the coefficients of the numerator and denominator of H(z).

(ii)Validate Transformation with Standard Sampling Period T=0.2Convert Analog transfer function into Digital using Impulse Invariant Transformation of H(S)=10/(s^2+7*s+10) using sci lab

Aim

To convert the continuous-time analog transfer function H(S)=10/(s^2+7*s+10) into a discrete-time digital transfer function using Impulse Invariant transformation method with a standard sampling period T=0.2

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:

Impulse Invariant Transformation is a method used to convert an analog filter design into a digital filter. This method ensures that the impulse response of the digital filter closely approximates the impulse response of the analog filter. It is particularly useful when designing digital filters that need to maintain a similar impulse response to their analog counterparts.Impulse Invariant Transformation maps the continuous-time (analog) filter to a discrete-time (digital) filter by preserving the impulse response of the analog filter. This method ensures that the discrete-time filter has the same impulse response as the continuous-time filter sampled at discrete intervals.

Program

```
//To Design the Filter using Impulse Invarient Method

clear;

clc ;

close ;

s=%s;

T=0.2;

HS=10/(s^2+7*s+10);

elts=pfss(HS);

disp(elts,'Factorized HS = ');

//The poles comes out to be at -5 and -2
```

```
p1=-5;

p2=-2;

z=%z;

HZ=T*((-3.33/(1-%e^(p1*T)*z^(-1)))+(3.33/(1-%e^(p2*T)*z^(-1))))

disp(HZ,'HZ = ');
```

Output:

```
Factorized HS =

       (1)

    3.3333333

    ---------

      2 + s

       (2)

  - 3.3333333

    ---------

      5 + s

 HZ  =

           0.2014254z

    --------------------------


0.2465970 - 1.0381995z + Z2


 HZ =

           0.2014254z

    --------------------------


    0.2465970 - 1.0381995z + z2
```

Result: Thus the discrete-time transfer function H(z) obtained after applying the Impulse Invariant transformation. Include the coefficients of the numerator and denominator of H(z).

EXNO: 20	**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:

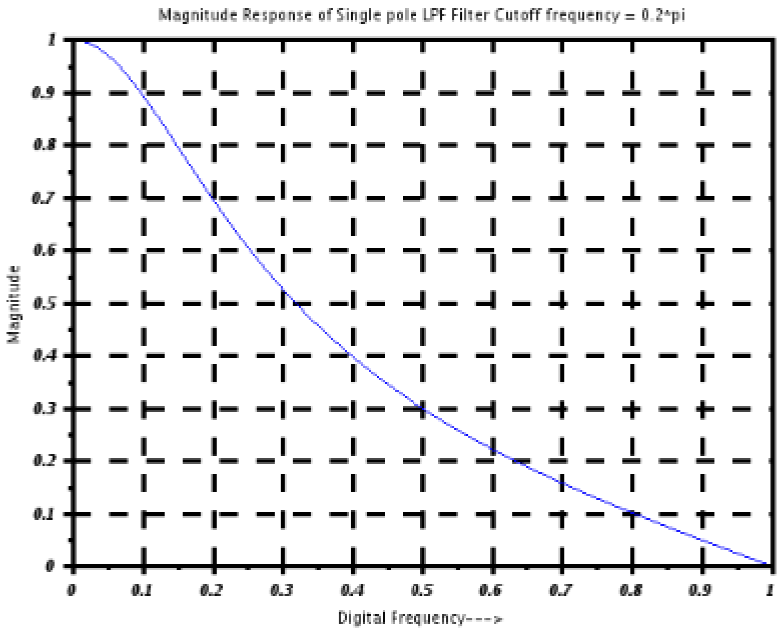
//First Order Butterworth Low Pass Filter

```
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

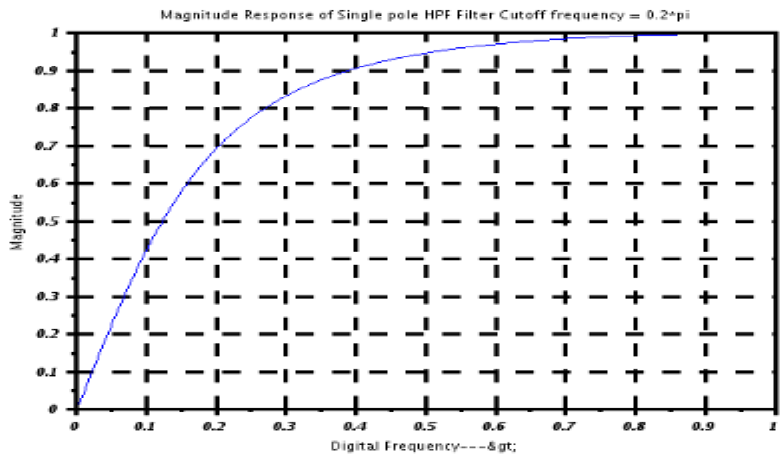
//High Pass Filter Using Digital Filter Transformation

```
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)=

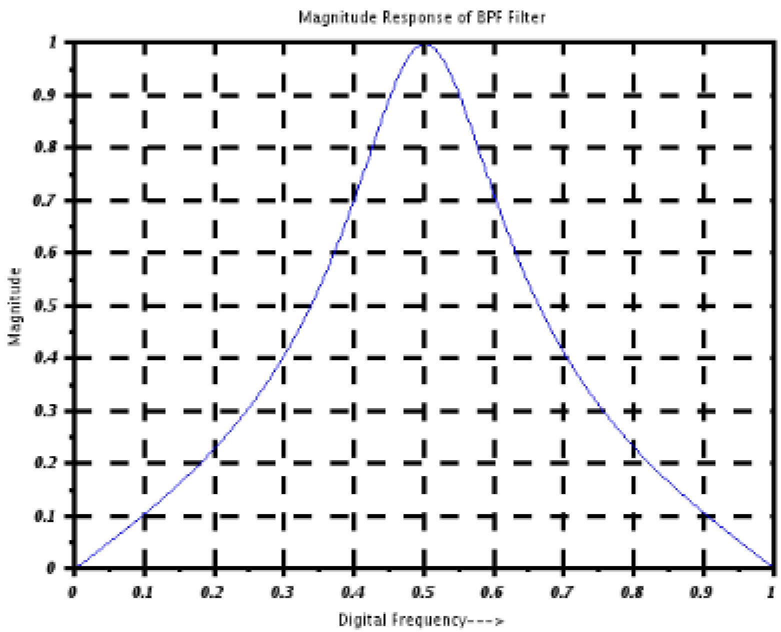
                        2   3   4

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.

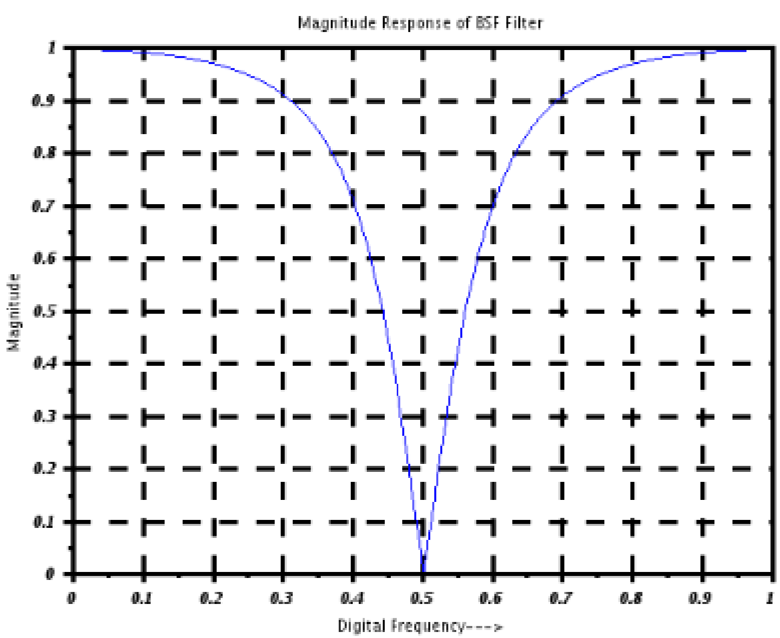
Program:

```
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