MUFFAKHAM JAH COLLEGE OF ENGINEERING & TECHNOLOGY

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DEPARTMENT OF ELECTRICAL ENGINEERING

LABORATORY MANUAL

CIRCUITS AND MEASUREMENTS LAB

For

B.E. II/IV (I – SEM) EEE& EIE

2014-15

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MUFFAKHAM JAH COLLEGE OF ENGINEERING & TECHNOLOGY

ELECTRICAL ENGG. DEPARTMENT

LIST OF EXPERIMENT

Circuits And Measurements Lab. (EE- 242)

PART A (CIRCUTS):

1. **Charging and discharging characteristics of RC series circuit**
2. **Locus diagram of RC/RL circuit**
3. **Frequency response of a RLC series circuit**
4. **Parameters of two port network**
5. **Verification of Theorems (a) Thevenin's Theorem (b) Norton Theorem (c) Super Position Theorem (d) Max power transfer theorem**

PART B (MEASUREMENTS):

6. **Measurement of low resistance by Kelvin's double bridge**
7. **Measurement of Inductance by Maxwell's and Andersons Bridge**
8. **Measurement of capacitance by DeSauty's bridge.**
9. **Use of DC Potentiometer for measurement of unknown voltage and impedance**
10. **Calibration of Single phase energy meter by Phantom loading**

EXPERIMENT 1

CHARGING AND DISCHARGING CHARACTERISTICS OF RC SERIES CIRCUIT

AIM: To obtain the transient response of an RC circuit.

1. When charging through a Resistor from constant voltage source.
2. When discharging through a Resistor.

APPARATUS:

1. Regulated power supply.
2. Digital Voltmeter.
3. Stop watch.
4. RC Network.

THEORY:

When an increasing DC voltage is applied to a discharged capacitor, the capacitor draws a charging current and "charges up", and when the voltage is reduced, the capacitor discharges in the opposite direction. Because capacitors are able to store electrical energy they act like small batteries and can store or release the energy as required.

The charge on the plates of the capacitor is given as: $Q = CV$. This charging (storage) and discharging (release) of a capacitors energy is never instant but takes a certain amount of time to occur with the time taken for the capacitor to charge or discharge to within a certain percentage of its maximum supply value being known as its **Time Constant** (τ).

If a resistor is connected in series with the capacitor forming an RC circuit, the capacitor will charge up gradually through the resistor until the voltage across the capacitor reaches that of the supply voltage. The time also called the transient response, T

This transient response time T, is measured in terms of $\tau = R \times C$, in seconds, where R is the value of the resistor in ohms and C is the value of the capacitor in Farads.

CHARGING:

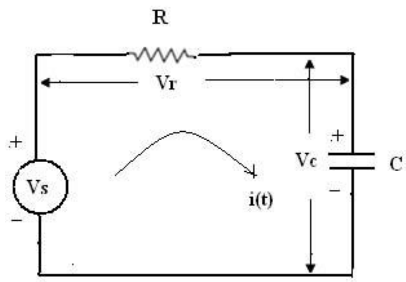


Fig -1

Applying KVL across the RC circuit (Fig.1) and solving, we get,

$$i(t) = \frac{V_S}{R}\, e^{\frac{-t}{RC}} \qquad \rightarrow (1)$$

$$V_C(t) = V_S - V_R(t) = V_S - R.i(t)$$

$$= V_S\left(1 - e^{\frac{-t}{RC}}\right) \qquad \rightarrow (2)$$

The equation gives the variation of voltage across the capacitor with the time i.e. the charging of the capacitor. See also Fig.2. which gives charging curve i.e. the relation between voltage and time during charging.

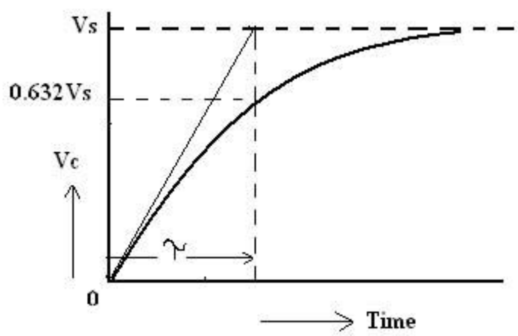


Fig- 2

Differentiating equation (2)

$$\frac{dV_C}{dt} = \frac{V_S}{RC} e^{-t/_{RC}} \qquad \rightarrow (3)$$

$$\left(\frac{dV_C}{dt}\right)_{t=0} = \frac{V_S}{RC} \ \ volts/\sec \qquad \rightarrow (4)$$

If this rate of rise (Eqn.4.) is maintained, then the time taken to reach voltage V_S would be

$$\frac{V_S}{V_S/_{RC}} = RC$$

This time is known as Time constant (τ) of the circuit. ie. the time constant of the RC circuit is defined as time during which the voltage across the capacitor would have reached its maximum value VS had it maintained its initial rate of rise.

From equation (3) at $t = \tau$,

$$V_C = V_S\left(1 - e^{-t/_\tau}\right) = V_S(1 - e^{-1}) = V_S(1 - 1/e)$$

$$= V_S\left(1 - \frac{1}{2.718}\right) = 0.632Vs$$

Hence, time constant may be defined as the time during which capacitor voltage actually rises to 0.632 of its final value.

DISCHARGING:

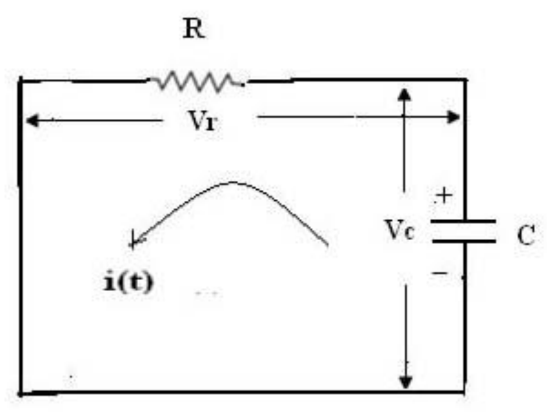


Fig- 3

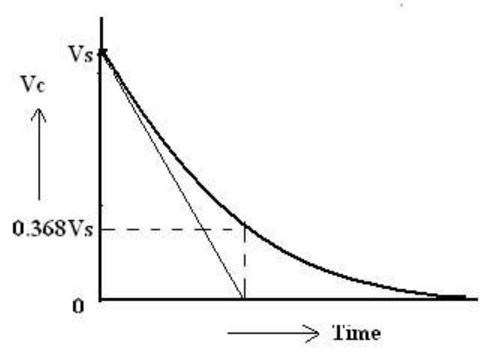


Fig-4

Referring to fig.3

$$i(t) = \frac{V_S}{R} e^{-t/_\tau} \qquad \rightarrow (5)$$

$$\& \ \ V_C(t) = -V_R(t)$$

$$= -R.i(t) = -V_S e^{-t/\tau} \quad \rightarrow (6)$$

$$\left(\frac{dV_c}{dt}\right) = \frac{V_s}{\tau} e^{-t/\tau} \quad \rightarrow (7)$$

$$\left(\frac{dV_c}{dt}\right)_{t=0} = \frac{V_S}{RC}\ volts/\sec \quad \rightarrow (8)$$

From (6) at t=τ, V_C=$V_S\, e^{-1} = V_S/2.718 = 0.368V_S \rightarrow (9)$

Equation (6) gives the relation between the voltage and time during discharging. The tangent on the discharging curve at t=0, (Fig.4) yields the time constant and the voltage across the capacitor will be 0.368 of the full voltage at t=τ.

CONNECTION DIAGRAM:

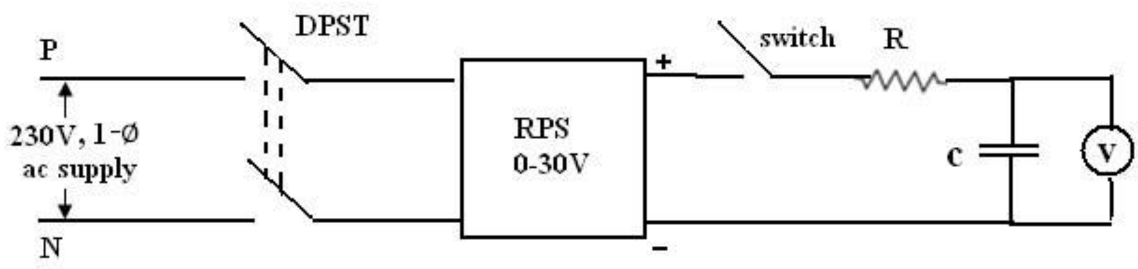


Fig-5

PROCEDURE:

1. Make the connections as shown in Fig.5.

2. Note the values of the Resistor and Capacitor and hence determine the theoretical time constant of the circuit RC

3. Switch on the RPS and adjust it to a voltage of 5V.

4. Simultaneously close the switch SW and start the stop clock.

5 Take the readings of the capacitor voltage every 15 secs. Continue this for 4-5 time constants.

6. Replace RPS by a short circuit and simultaneously restart stop clock.

7. Take readings of capacitor voltage every 1.5secs for 4-5 time constants.

8. Plot the charging and discharging curves (Vs versus t)

9. From charging curve, find the time taken to reach $0.632V_S$ (τ). Compare this with the theoretical value. Also observe that the tangent of the curve at t=0 touches the horizontal line from Vs at t= τ

10. Draw the tangent at t=0 on the discharging curve and note the time when it touches the X-axis (τ). Compare this with the theoretical value. Also observe that the voltage at t= τ is equal to 0.368 Vs.

OBSERVATION:

SUPPLY VOLTAGE = ------------ V

CHARGING		**DISCHARGING**	
Time(sec)	**Charging voltage (V)**	**Time(sec)**	**Discharging voltage(V)**
0	**0**	**0**	**5**

MODEL CALCULATIONS:

FOR SUPPLY VOLTAGE = 5V

R = 46.9 KΩ C = 1000µF

τ = RC

$= (46.9 * 10^{3} * 1000 * 10^{-6})$

= 46.9 sec

Charging Voltage = 0.632(5) = 3.16 V

Discharging Voltage = 0.368(5) = 1.84 V

RESULT:

Charging and discharging of RC circuit is studied at constant voltage.

DISCUSSION OF RESULTS:

Compare theoretical & practical value of time constant for charging and discharging Obtain time constant from the graph for charging and discharging.

EXPERIMENT 2

LOCUS DIAGRAM OF RC/RL CIRCUIT

AIM: To plot locus diagram of series R-L and R-C circuits by varying resistance parameter.

APPARATUS:

1. Locus diagram kit.
2. Function generator.
3. AC Ammeter (0-200mA).
4. Connecting wires etc.

THEORY:

A phasor diagram may be drawn and is expanded to develop a curve known as a locus. Locus diagrams are useful in determining the behavior or response of an R-L-C circuit when one of its parameters is varied while the frequency and voltage kept constant. The magnitude and phase of the current vector in the circuit depends upon the values of R, L and C and frequency at the fixed source voltage.

The path traced by the terminus of the current vector when the parameter R, L or C are varied while the frequency and voltage are kept constant is called the current locus.

R-C series circuit: To draw the loci current of constant capacitive reactance, the circuit is as shown below. The current semi-circle for the R-C circuit with variable R will be as shown of voltage vector OI_m with diameter V/ Xc as shown. The current vector leads voltage by theta. The active component of current is OImCosϴ which is proportional to power consumed in R-C circuit.

$Xc = 1/2\pi fc$

$\Theta = \tan^{-1}(-Xc/R)$

R-L series circuit: The circuit to be considered is as below and it has constant reactance but variable resistance. The applied voltage will be assumed with constant rms voltage V. The power factor angle is designed by ϴ. If R=0, IL is obviously equal to V/X_L and has maximum value. Also I lags V by 90^0. This is as shown below. If R is increased from zero value, the magnitude of I becomes less than V/X_L and ϴ becomes less than 90^0 and finally when the limit is reached, i.e. when R equals to infinity, I equals to zero and ϴ equals to zero.

$X_L = 2\pi fL$

$\Theta = \tan^{-1}(X_L/R)$

CIRCUIT DIAGRAMS:

R-C Series Circuit:

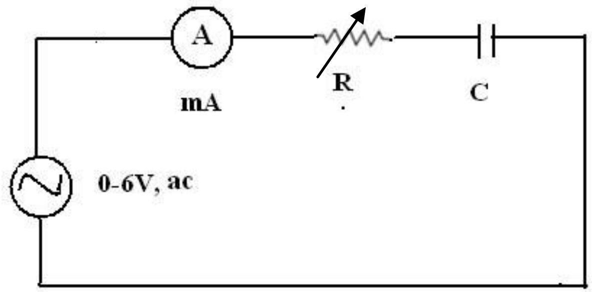


Fig-1

R-L Series Circuit:

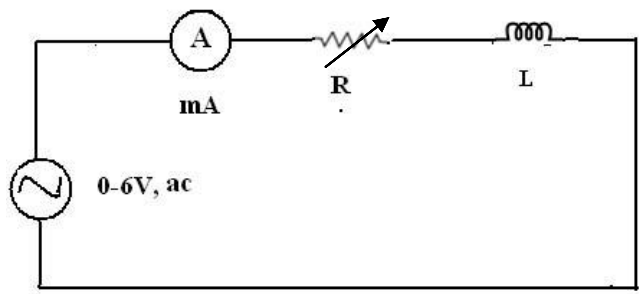


Fig-2

PROCEDURE:

1. Connect the circuit as shown in fig1
2. Apply signal of maximum amplitude to the circuit from the signal generator with minimum R applied, which is provided on the panel.
3. Note the readings on ammeter by varying the R provided.
4. Draw the locus for current as R is varied.
5. Repeat the procedure by replacing L with C

OBSERVATION:

R-C Series Circuit: C = 4.7μF

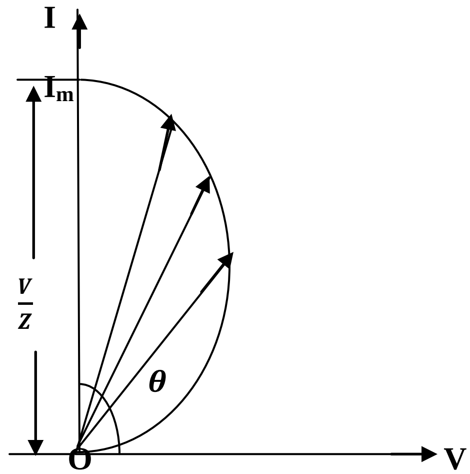
S.NO.	Variable R	I(mA)	$\Theta = \tan^{-1}(-Xc/R)$
1	467	7.29	-55.4

R-L Series Circuit: L = 50mH

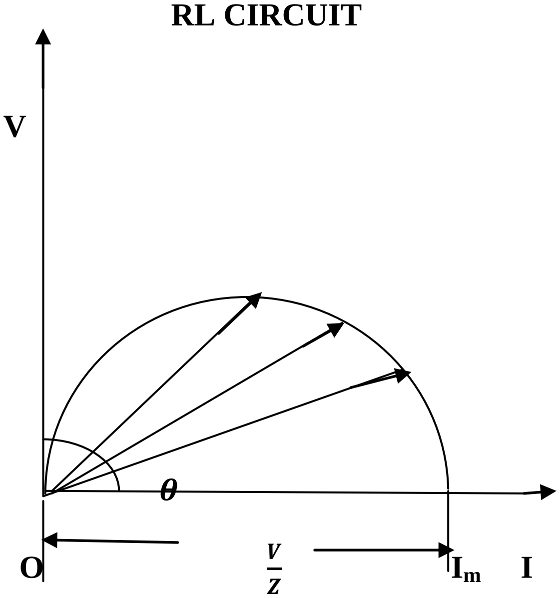
S.NO.	Variable R	I(mA)	$\Theta = \tan^{-1}(X_L/R)$
1	467	12.8	1.92

EXPECTED GRAPHS:

RC CIRCUIT



RL CIRCUIT



MODEL CALCULATIONS:

<u>For RC circuit</u>:

R = 467Ω   C = 4.7µF   V = 6V

X_C = 1/2$\pi f C$ = 1/(2*3.14*50*4.7*10^{-6}) = 677.59Ω

Z = $\sqrt{R^2 + {X_C}^2}$ = $\sqrt{467^2 + 677.59^2}$ = 822.9Ω

I = V/Z = 6 / 822.9 = 7.29mA

$\Theta = \tan^{-1}$(-Xc/R)

= $\tan^{-1}$ (-677.59 / 467)

= -55.4^o

For RL circuit:

R = 467Ω L = 50mH V = 6V

$X_L = 2\pi f L$ = (2*3.14*50*50*10^{-3}) = 15.7Ω

Z = $\sqrt{R^2 + {X_L}^2}$ = $\sqrt{467^2 + 15.7^2}$ = 467.2Ω

I = V/Z = 6 / 467.2 = 12.8mA

Ɵ= $\tan^{-1}$(X_L/R)

= $\tan^{-1}$ (15.7 / 467)

= 1.92^o

RESULT:

Locus diagram of series RL and RC circuit by variable resistance is drawn.

DISCUSSION OF RESULTS:

Compare theoretical & practical value of current with variable R for RL & RC circuit.

Also analyse the value of theta for both circuits.

EXPERIMENT 3

FREQUENCY RESPONSE OF A RLC SERIES CIRCUIT

AIM: To determine the resonant frequency of a series circuit.

APPARATUS: 1. Circuit Board.

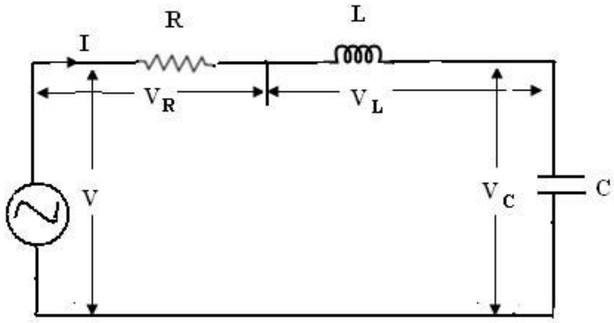
2. Connecting Wires.

3. Digital Voltmeter.

4. Ammeter.

5. Signal Generator.

THEORY:



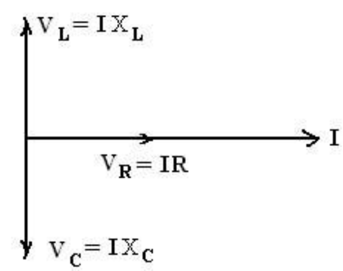


Fig-1 Fig-2

We know that the net reactance of a series RLC circuit is $X = X_L - X_C$ and Z = $\sqrt{R^2 + (X_L - X_C)^2 = .}\sqrt{R^2 + X^2}$

If for some frequency of the applied voltage $X_L = X_C$ then $X = 0$ and $Z = R$.

$V_L = X_L.I$ and $V_C = X_C.I$ and they are equal in magnitude but opposite in direction (phase).Then the voltage is in phase with VR and it acts as a pure resistive circuit. The frequency at which the net reactance is zero is given from the relation $X_L - X_C = 0$ or $X_L = X_C$

$$X_L - X_C = 0 \text{ (or) } X_L = X_C$$

$$\omega L = 1/\omega C$$

$$\omega^2 = 1/LC$$

$$\omega = 1/\sqrt{LC}$$

$$2\pi f_0 = 1/\sqrt{LC}$$

$$f_0 = 1/2\pi\sqrt{LC}$$

Then the impedance of circuit is equal to the holmic resistance R and the current has a maximum value of $I = V/R$ and is in phase with 'V'. (Refer the vector diagram of Fig.2).

The condition is known as series resonance and frequency at which it occurs is called resonant frequency f_0.

CIRCUIT DIAGRAM:

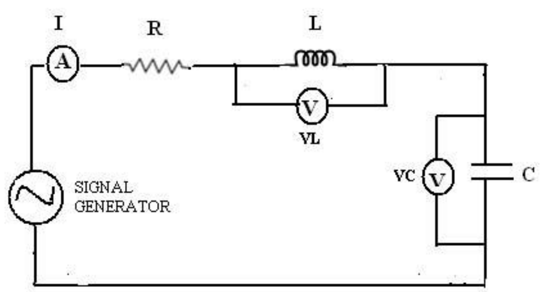


Fig- 3

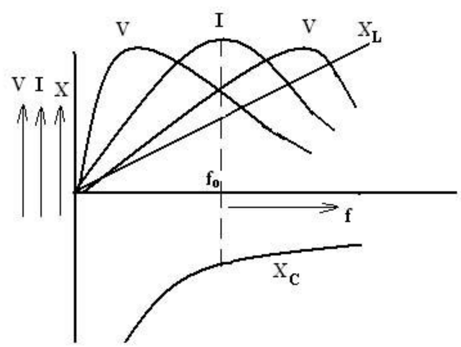


Fig-4

PROCEDURE:

1. Connect the circuit as shown in fig 3.
2. Fix the frequency at a particular point (i.e. 500HZ).
3. Note down the current, V_L & V_C.
4. Vary the frequency with the help of a signal generator in steps of 500HZ.
5. Note the corresponding values of I, V_L, V_C.
6. Plot the curve frequency V_S, I, V_L, V_C. (Fig.4)
7. From the graph find the value of the frequency at which the current is maximum. This is the resonant frequency. Also note at f_0, V_L=V_C.
8. Verify the above value with the theoretical value.

OBSERVATIONS

S. No.	F(Hz)	I(mA)	$X_L(\Omega)$	$X_C(\Omega)$	V_L(V)	V_C(V)
1	4000	0.04	261.4	383.14	10.44	15.3

MODEL CALCULATIONS:

R = 22.1Ω L = 10.4mH C = 0.104μF

$$f_0 = 1/2\pi\sqrt{LC}$$

$$= 1/\left(2*3.14*\sqrt{0.0104 * 0.104 * 10^{-6}}\right)$$

= 4.85 KHz

For f = 4000Hz, V =5V **:**

I = V / Z

$X_L = 2\pi f L = 2*3.14*4000*10.4*10^{-3} = 261.24\Omega$

$X_C = 1 / (2\pi f C) = 1/ (2*3.14*4000*.104*10^{-6}) = 383.14\Omega$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{22.1^2 + (261.24 - 383.14)^2}$$

= 123.88Ω

I = 5 / 123.88

= 0.04A

$V_L = IX_L = 0.04*261.24 = 10.44V$

$V_C = IX_C = 0.04*383.14 = 15.3V$

RESULT:

Frequency response of series RLC circuit is studied and drawn.

DISCUSSION OF RESULTS:

Compare theoretical & practical values of current, voltage across inductor & capacitor.

Comment on the behavior of circuit at the value of resonance.

EXPERIMENT4

PARAMETERS OF TWO PORT NETWORK

AIM: To determine Z, Y, ABCD and h parameters for a two port network.

APPARATUS:

1. Two port network board.
2. Digital ammeters.
3. Connecting wires.

THEORY:

A two port network (fig1) can be represented by

(a) Open circuit impedance parameters (Z).

(b) Short circuit admittance parameters(Y)

(c) ABCD parameters.

(d) Hybrid parameters (h)

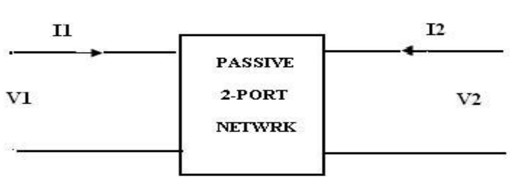


Fig-1

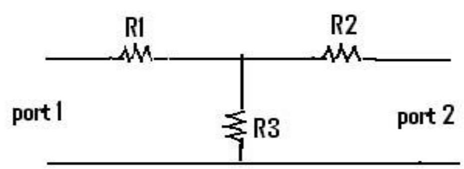


Fig-2

The various input-output relationships between the voltages and currents may be described by the following matrix equations.

Any set of above four types of parameters may be used to describe the network as far as its behavior at the external terminals is concerned.

DETERMINATION OF Z-PARAMETERS:

CONNECTION DIAGRAM:

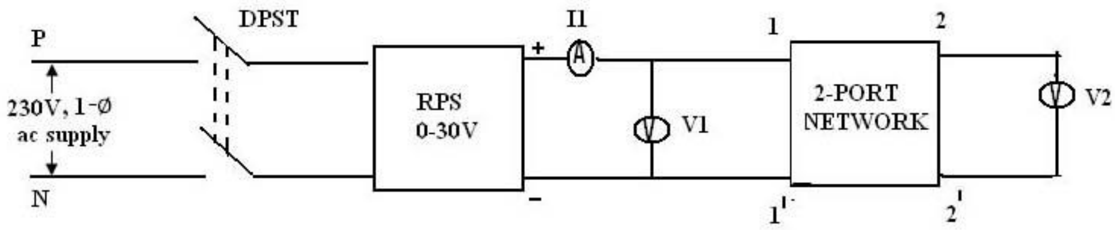


Fig- 3

PROCEDURE:

1. Connect the circuit as shown in fig.3.
2. For different values of input voltages, obtain the values of V1, I1 and V2 with port 2 open circuited (i2=0)

3. Connect the source of port 2 and open circuiting port 1, as in Fig 4.

Obtain the values of V2, I2, and V1. (I1=0)

FORMULAE & MODEL CALCULATIONS:

Calculate the Z-parameters using the following relations.

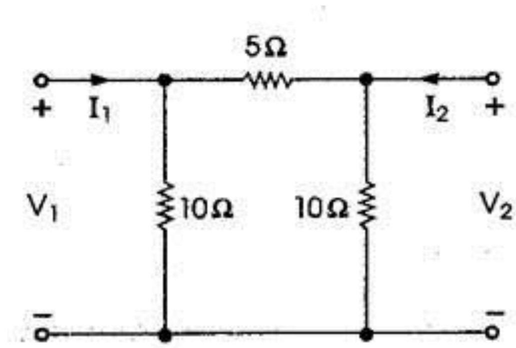
$Z_{11}=V_1/I_1$ $|I_2=0$ Driving point impedance at port 1.

$Z_{21}=V_2/I_1$ $|I_2=0$ Transfer impedance.

$Z_{12}=V_1/I_2$ $|I_1=0$ Transfer impedance

$Z_{22}=V_2/I_2$ $|I_1=0$ Driving point impedance at port 2.

Find the z parameters for the symmetrical N network of Fig. a
(a)



(b)

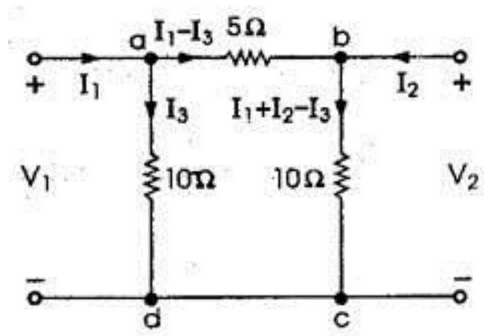


Fig.a

Let I_3 be the current through the 10 resistor ,the currents in different branches of the network after application of KCL at nodes a and b.

By KVL in the left-hand mesh

$$V_1 = 10I_3 = 0$$

$$\text{or} \quad V_1 = 10I_3$$

By KVL in mesh a b c a

$$-5(I_1 - I_3) - 10\,(I_1 + I_2 - I_3) + 10I_3 = 0$$

$$-5I_1 - 10I_2 + 25I_3 = 0$$

$$\text{or} \qquad 3I_1 + 2I_2 - I_3 = 0$$

By KVL in the right-hand mesh

$$V_2 - 10(I_1 + I_2 - I_3) = 0$$

$$\text{or} \qquad V_2 = 10I_1 + 10I_2 - 10I_3$$

Since I_3 does not appear in the defining equations of the z parameters, we eliminate it from the mesh equations. Multiplying Eq. by 2 on both sides

$$6I_1 + 4I_2 = 10I_3$$

Combination of above equations,it gives

$$V_1 = 6I_1 + 4I_2$$

Substituting the value of $10I_3$, we get

$$V_2 = 10I_1 + 10I_2 - (6I_1 + 4I_2)$$

Or $V_2 = 4I_1 + 6I_2$

The defining equations of z parameters are

$V_1 = z_{11}I_1 + z_{12}I_2$

$V_2 = z_{12}I_1 + z_{22}I_2$

Comparison of all derived equations will give:

$z_{11} = 6\Omega$, $z_{12} = 4\Omega$, $z_{21} = 4\Omega$ $z_{22} = 6\Omega$

DETERMINATION OF Y-PARAMETERS:

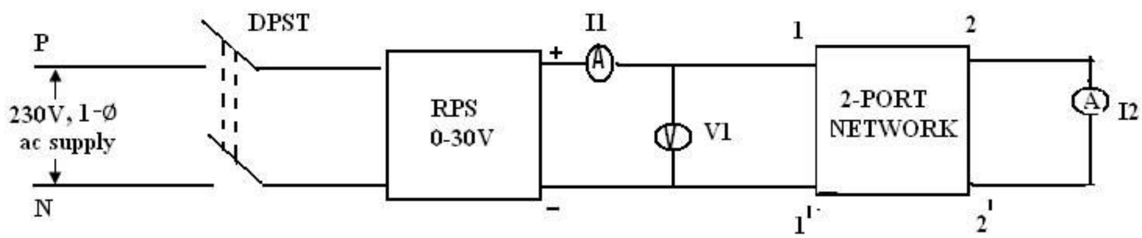


Fig-4

PROCEDURE:

1. Short circuit the port 2 (fig. 3) through an ammeter and apply voltage at port 1 (V2=0).
2. Obtain the values of V1, I1, and I2 for different values of supply voltages.
3. Short circuit the port 1 through an ammeter and apply voltage at port 2.Note the values of V2, I2 and I1 for various values of V2. (V1=0)

FORMULAE & MODEL CALCULATIONS:

Calculate the Y-parameters using the following relations.

$Y_{11}=I_1/V_1 \ |V_2=0$ Driving point admittance at port 1

$Y_{21}=I_2/V_1 \ |V_2=0$ Transfer admittance.

$Y_{12}=I_1/V_2 \ |V_1=0$ Transfer admittance

$Y_{22}=I_2/V_2 \ |V_1=0$ Driving point admittance at port 2.

Relation of Y parameter in terms of Z parameter

$Y_{11}= Z_{22} / \Delta Z = 6 / (36 – 16) = 0.3$mho

$Y_{12}= -Z_{12} /\Delta Z = - 4 / (36-16) = -0.2$ mho

Y_{21}= -Z_{21} / ΔZ = -4 / (36-16) = -0.2mho

Y_{22}= Z_{11} / ΔZ = 6 / (36-16) = 0.3mho

CALCULATION OF ABCD PARAMETERS :

Obtain the ABCD parameters by using the following relations from the readings obtained in expt. 1 and expt. 2.

$A=V_1/V_2 \; |I_2=0$

$B=V_1/-I_2 \; |V_2=0$.

$C=I_1/V_2 \; |I_2=0$

$D=I_1/-I_2 \; |V_2=0$

Relation of ABCD parameter in terms of Z parameter

A = Z_{11} / Z_{12} = 6 / 4 = 1.5

B = ΔZ / Z_{21}= (36-16) / 4 = 5ohms

C = 1 / Z_{12} = 1 / 4 =0.25mhos

D = Z_{22} / Z_{21} = 6 / 4 = 1.5

CALCULATION OF h-**PARAMETERS :**

Obtain the hybrid(h) parameters using the following relations from the readings obtained in expt. 1and expt. 2.

$h_{11}=V_1/I_1 \; |V_2=0$

$h_{12}=V_1/V_2 \; |I_1=0$

$h_{21}=I_2/I_1 \; |V_2=0$

$h_{22}=I_2/V_2 \; |I_1=0$

Relation of h parameter in terms of Z parameter

$h_{11} = \Delta Z / Z_{22}$ = (36-16) / 6 = 3.3ohms

$h_{12} = -Z_{21}/ Z_{22}$ = -4 / 6 = -0.66

$h_{21} = Z_{12}/ Z_{22}$ = 4 / 6 = 0.66

$h_{22} = 1 / Z_{22}$= 1 / 6 = 0.16mhos

RESULT:

Z, Y, ABCD, h parameters of two port network is calculated.

DISCUSSION OF RESULTS:

Compare theoretical and practical values of various parameters and their relations.

EXPERIMENT 5

VERIFICATION OF THEOREMS (A) THEVENINS THEOREM (B) NORTON THEOREM (C) SUPER POSITION THEOREM (D) MAX POWER TRANSFER THEOREM

AIM: To verify Thevenin's Theorem and Norton's Theorem.

APPARATUS:

1. Regulated power supply.
2. Digital multimeter.
3. Decade resistance box.
4. Resistance network.

THEORY:

THEVENIN'S THEOREM:

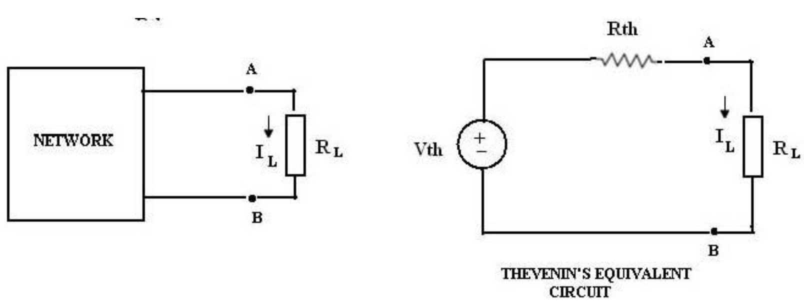


Fig:1

Any linear bilateral network with respect to two terminals (A and B) can be replaced by a single voltage source V_{th} in series with a single resistance R_{th}. Where, V_{th} is the open circuit voltage across the load terminals and R_{th} is the internal resistance of the network as viewed back into the open circuited network from the terminals A and B with voltage sources and current sources replaced by their internal resistances. Then the current in the load resistance is given by,

$$I_L = V_{th} / (R_{th} + R_L)$$

NORTON'S THEOREM:

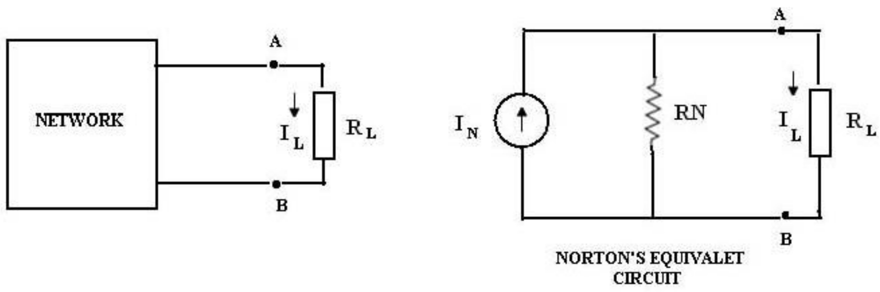


Fig:2

Any linear bilateral network with respect to a pair of terminals (A and B) can be replaced by a single current source I_N in parallel with a single resistance R_N.Where,I_N is the short circuit current in between the load terminals and R_N(=R_{th}) is the internal resistance of the network as viewed back into the open circuited network from the terminals A and B with voltage sources and current sources replaced by their internal resistances. Then the current in the load resistance is given by,

$$I_L = I_N R_N / (R_N + R_L)$$

SUPERPOSITION THEOREM:

In a bilateral network consisting of a number of sources, the response in any branch is equal to sum of the responses due to individual sources taken one at a time with all other sources reduced to zero. When a network consists of several sources, this theorem helps us to find the current in any branch easily, considering only one source at a time.

MAXIMUM POWER TRANSFER THEOREM:

A resistance load will absorb Maximum power from a network when its resistance equals to the resistance of the network as viewed from the output terminals with all the sources removed leaving behind their internal resistances if any**.**

(A)THEVENIN'S THEOREM:

CIRCUIT DIAGRAMS:

To find Thevenin's Voltage:

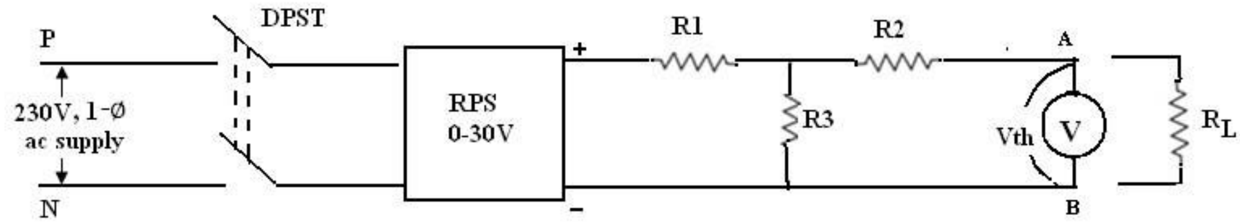


Fig:3

To find Thevenin's resistance :

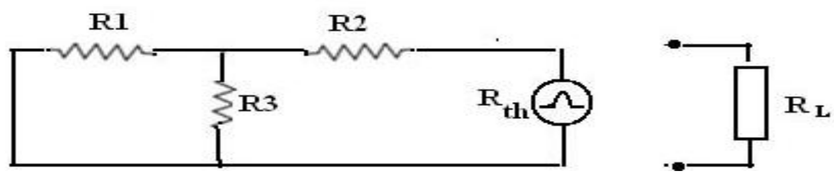


Fig:4

To find load current :

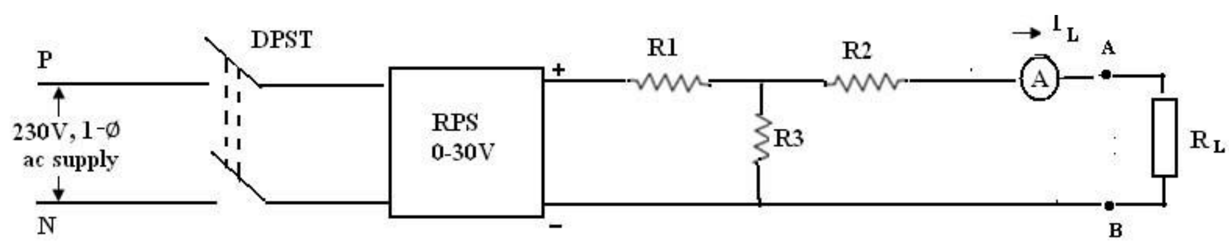


Fig-5

PROCEDURE:

1. Connect the circuit as shown in fig.3 and apply suitable voltage. Note down the open circuit voltage (V_{th}).
2. Connect the circuit as shown in fig.4 and note the Thevenin's resistance R_{th} by means of a multimeter.
3. Connect the circuit as shown in fig.5.For a particular value of load resistance R_L, keeping the voltage of RPS at the same value as in step1, note the value of the current. Verify the current value obtained by applying the Thevenin's theorem i.e I_L should be equal to V_{th} / (R_{th}+R_L).
4. Repeat step3 for various values of load resistances and compare with the calculated values, as obtained by applying Thevenin's theorem.
5. Vary the input voltage and take three sets of readings (step 2 need not be repeated as long as the network is not changed).

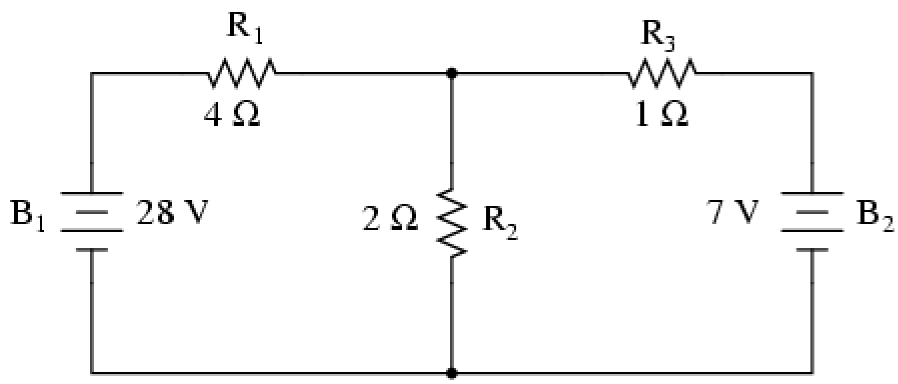
OBSERVATIONS:

R_{th}= 0.8 ohms.

S.No.	V_s	V_{th}	R_L	I_L(Measured Value)	I_L(By applying theorem) $I_L=V_{th}/(R_{th}+R_L)$
1	28V	11.2V	2Ω	3.9A	4A

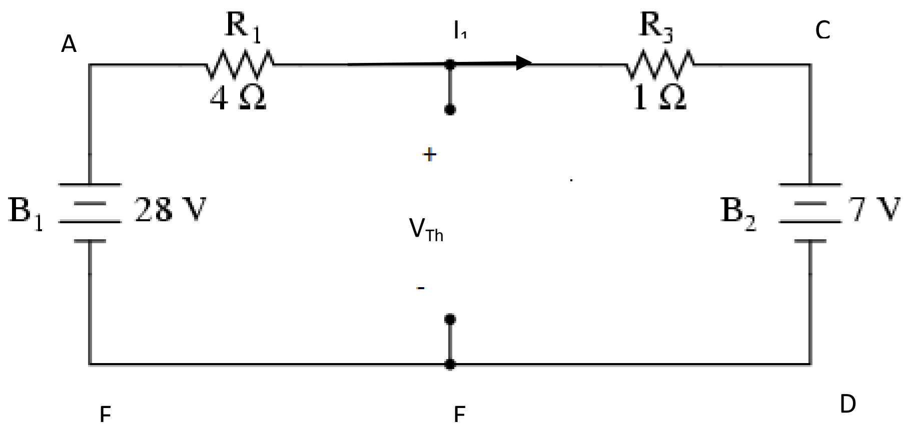
MODEL CALCULATIONS:

Find current through 2Ω by Thevenin's theorem



Step 1: Remove 2Ω resistor and find Thevenin's voltage across open circuit terminal

B



Consider loop ABCDEFA :

$$-4I_1 – I_1 -7 + 28 = 0$$

$$-5I_1 + 21 = 0$$

$$I_1 = 21 / 5 = 4.2A$$

Consider loop ABEFA:

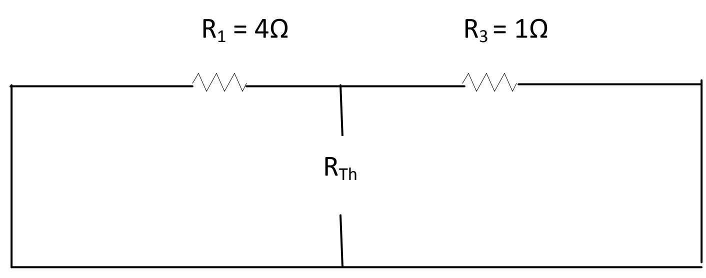
$$-4I_1 – V_{th} + 28 = 0$$

$$-4(4.2) +28 = V_{th}$$

$$-16.8 +28 = V_{th}$$

$$V_{th} = 11.2V$$

Step 2: To find Thevenin's resistance replace all the sources with their internal resistance



R_1 is in parallel with R_3

$$R_{Th} = (R_1 * R_3) / (R_1 +R_3)$$

$$= (4 * 1) / (4 +1)$$

$$= 4 / 5$$

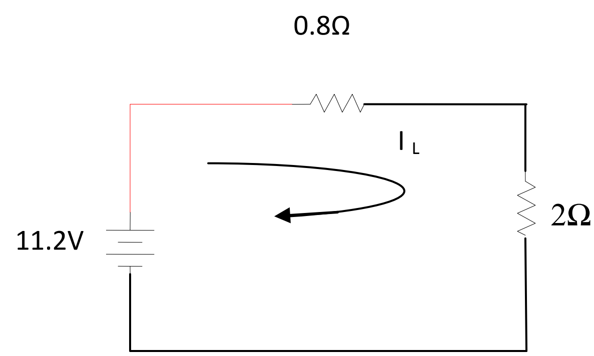
$= 0.8\Omega$

Step 3: Draw equivalent circuit with voltage source in series with resistance and connect 2Ω back in the circuit to find current through it.

$I_L = V_{Th} / (R_{Th} + R_L)$

$= 11.2 / (0.8 + 2)$

$= 4A$



(B)NORTON'S THEOREM:

CIRCUIT DIAGRAMS:

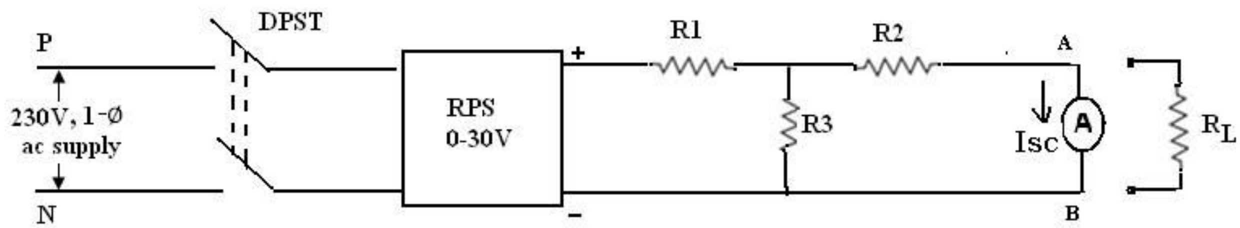


Fig-6

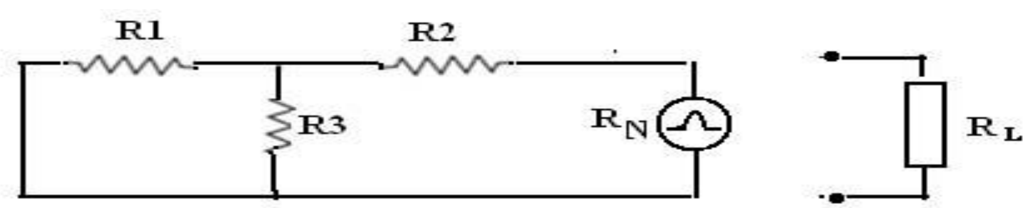


Fig - 7

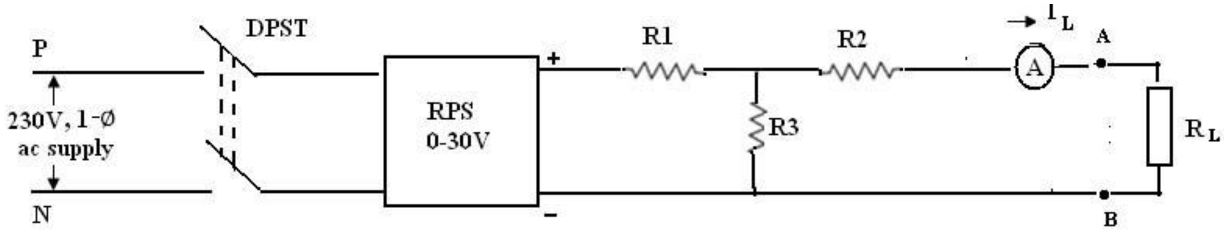


Fig - 8

PROCEDURE:

1. Connect the circuit as shown in fig.6 and by applying suitable voltage through RPS, determine the short circuit current (I_N / I_{sc}.).
2. Note down the load currents for various values of load resistance (R_L) and compare with the theoretical values obtained using Norton's equivalent circuit.
3. Repeat steps 1 & 2 for various values of source voltages.
   (Note R_N is same as R_{th} obtained in Thevenin's equivalent circuit).

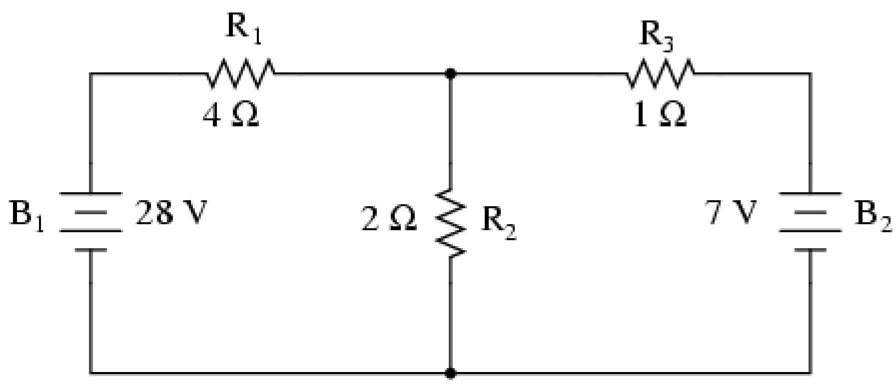
OBSERVATIONS:

R_N =0.8 ohms.

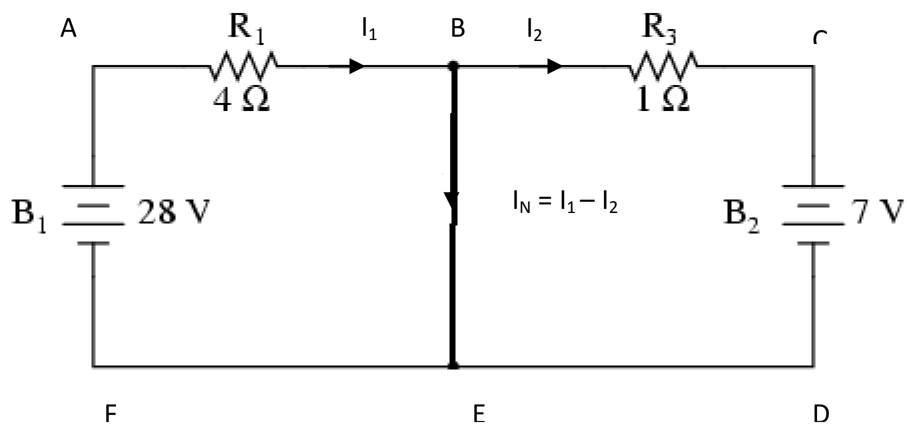
S.No.	V_s	I_N /I_{sc}	R_L	I_L(Measured Value)	I_L(By applying theorem) $I_L=I_N R_N/(R_N + R_L)$
1	28V	13.6A	2Ω	3.8A	4A

MODEL CALCULATIONS:

Find current through 2Ω by Norton's theorem



Step 1: Remove 2Ω resistor and find Norton's current in short circuited terminals.



Consider loop ABEFA:

$$-4I_1 + 28 = 0$$

$$I_1 = 7A$$

Consider loop BCDEB:

$$-I_2 - 7 = 0$$

$$I_2 = -7A$$

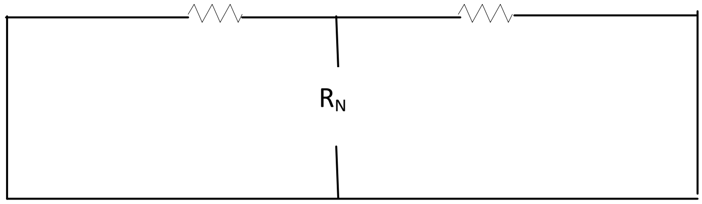
$$I_N = (I_1 - I_2)$$

$$= (7 + 7)$$

$$= 14A$$

Step 2: To find Norton's resistance replace all the sources with their internal resistance

$R_1 = 4\Omega$ $R_3 = 1\Omega$



R_1 is in parallel with R_3

$$R_N = (R_1 * R_3) / (R_1 + R_3)$$

$$= (4 * 1) / (4 + 1)$$

$$= 4 / 5$$

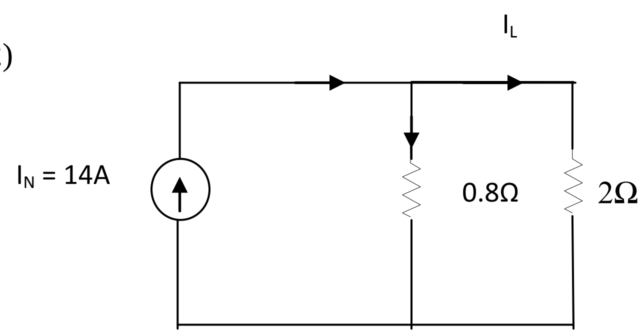
$$= 0.8\Omega$$

Step 3: Draw equivalent circuit with current source in parallel with resistance and connect 2Ω back in the circuit to find current through it.

$$I_L = I_N R_N / (R_N + R_L)$$

$$= (14*0.8) / (0.8 + 2)$$

$$= 4A$$



(C) SUPERPOSITION THEOREM

CIRCUIT DIAGRAMS:

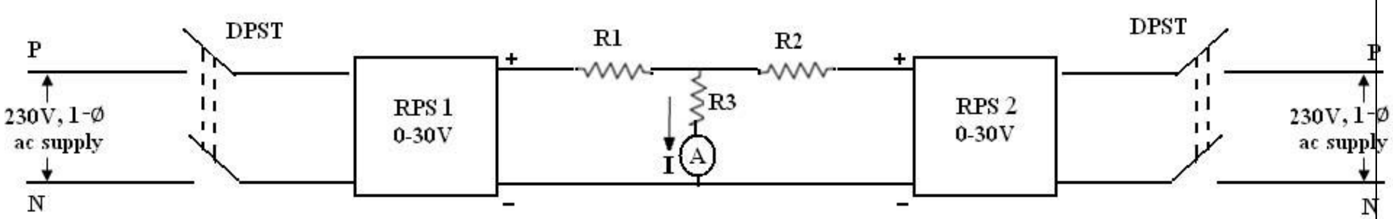


Fig-9

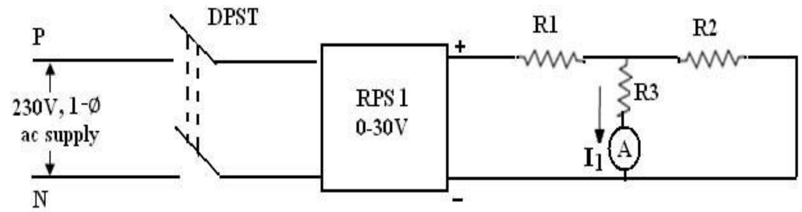


Fig-10

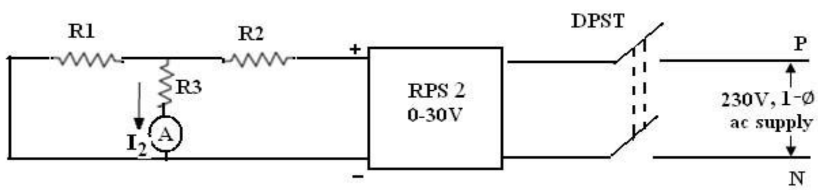


Fig-11

PROCEDURE:

1. Connect the circuit as shown in fig.9.
2. Adjust the voltage of the source (1) to 5V and that of source (2) to 10V.Note the current (I) read by the ammeter.
3. Disconnect source (2) and short the terminals as in fig(10) with source Voltage (1) at 5V read the ammeter current (I_1).
4. Disconnect source and short the terminals as in fig(11).With source (2) voltage at 10V read the ammeter current (I_2).
5. Verify the equation $I = I_1 + I_2$.
6. Repeat steps 2 to 5 for different voltages.

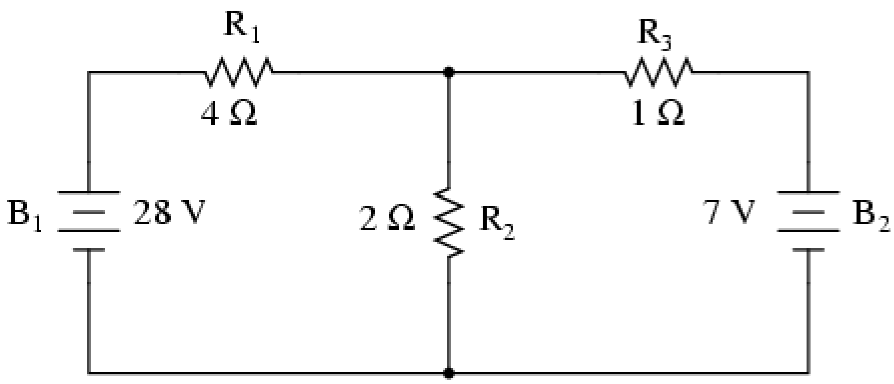
OBSERVATIONS:

S.No	V_1	V_2	I	I_1	I_2	$I=I_1+I_2$
1	28V	7V	-4A	----	----	-4A
	28V	----	----	-6A	4A	-2A

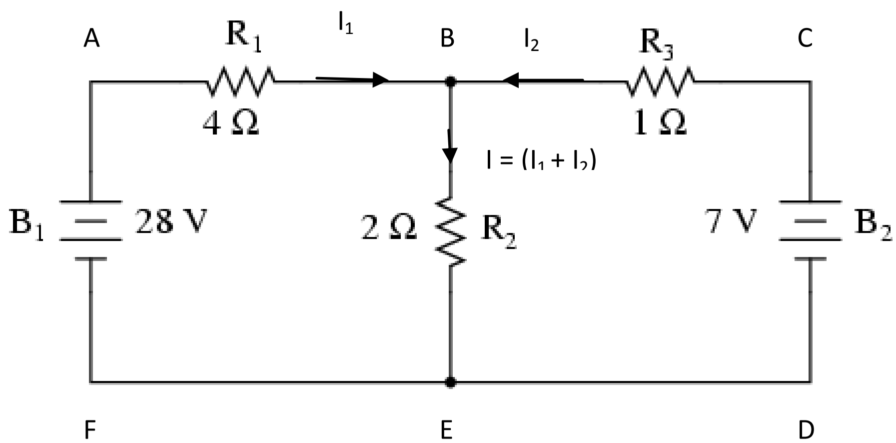
	----	7V	----	1A	-3A	-2A

MODEL CALCULATIONS:

Find current through 2Ω by Superposition theorem.



Step 1: Keep B_1 and B_2 and find current through 2Ω



Consider loop ABEFA:

$$-4I_1 - 2(I_1 + I_2) + 28 = 0$$

$$-6I_1 - 2I_2 + 28 = 0 \text{---------------(1)}$$

Consider loop BCDEB:

$$I_2 - 7 + 2(I_1 + I_2) = 0$$

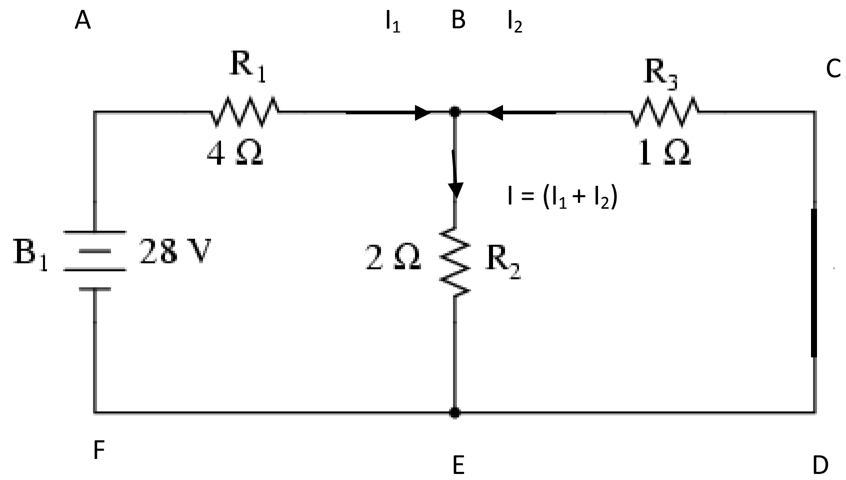
$$2 I_1 + 2(I_1 + I_2) - 7 = 0 \text{--------------(2)}$$

Solving equation (1) and (2)

$$I_1 = -5A \qquad I_2 = 1A$$

Current through 2Ω is $I = (I_1 + I_2) = -5 + 1 = -4A$

Step 2: Consider B_1 and find current through 2Ω by replacing other source by its internal resistance.



Consider loop ABEFA:

$$-4I_1 - 2(I_1 + I_2) + 28 = 0$$

$$-6I_1 - 2I_2 + 28 = 0\text{---------------}(1)$$

Consider loop BCDEB:

$$I_2 + 2(I_1 + I_2) = 0$$

$$2I_1 + 3I_2 = 0\text{--------------}(2)$$

Solving equation (1) and (2)

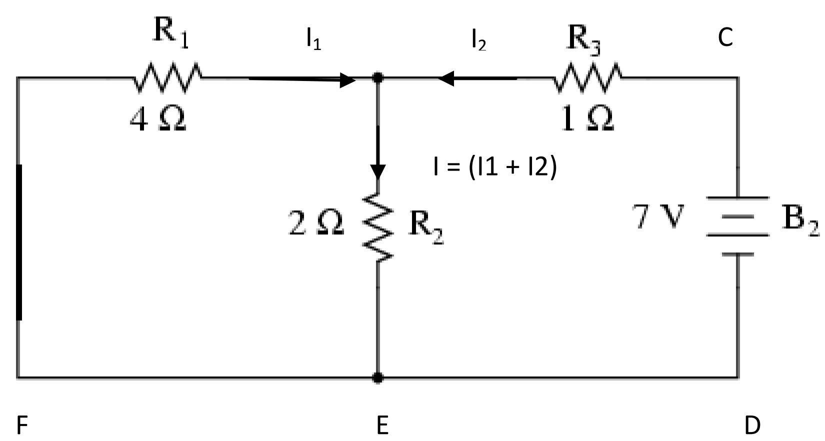
I_1 = -6A I_2 = 4A

Current through 2Ω is I = (I_1 +I_2) = -6 +4 = -2A

Step 3: Consider B_2 and find current through 2Ω by replacing other source by its internal resistance.

A

B



Consider loop ABEFA:

$$-4I_1 - 2(I_1 + I_2) = 0$$

$$-6I_1 - 2I_2 = 0 \text{--------------}(1)$$

Consider loop BCDEB:

$$I_2 - 7 + 2(I_1 + I_2) = 0$$

$$2I_1 + 3I_2 - 7 = 0 \text{-------------}(2)$$

Solving equation (1) and (2)

$I_1 = 1A$ $\quad\quad$ $I_{2\,=}$ -3A

Current through 2Ω is $I = (I_1 + I_2) = 1\text{-}3\ \text{-}2A$

Total current in 2Ω is -2 -2 = -4A

(D) MAXIMUM POWER TRANSFER THEOREM:

CIRCUIT DIAGRAMS:

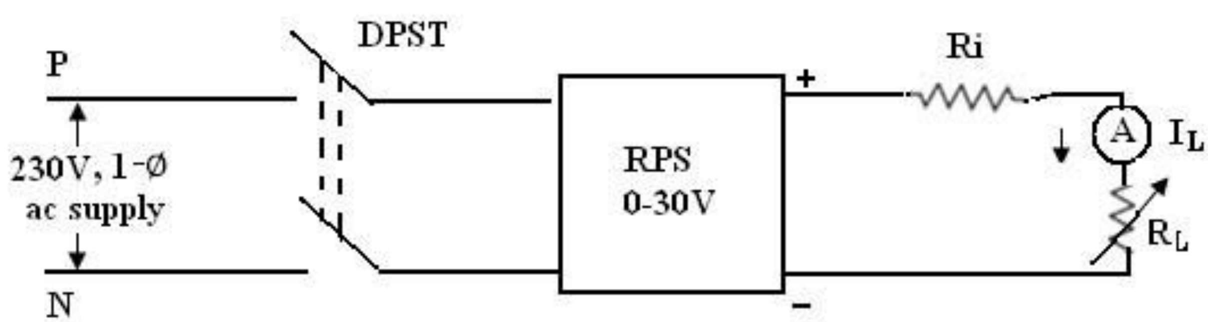


Fig-12

PROCEDURE:

1. Connect the circuit as shown in the fig.12
2. Vary the load resistance RL from values lower than R_i and measure the current I_L. Calculate the power output in each case ($P = I_L^2 R_L$)
3. Tabulate the readings of R_L, I_L and power P.
4. Plot the curve R_L versus power
5. From the curve, observe that Maximum power occurs when $R_L = R_i$

OBSERVATION:

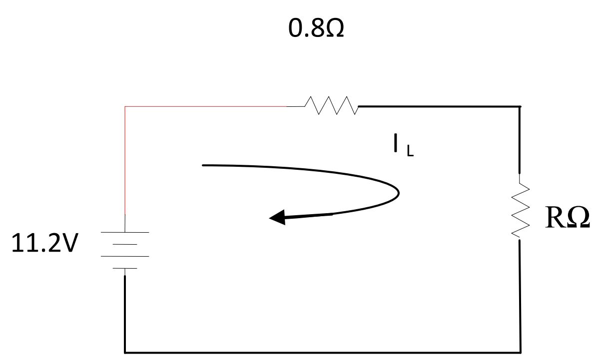
R_i = 1000 ohms.

S.No	R_L	I_L	$P = I_L^2 R_L$

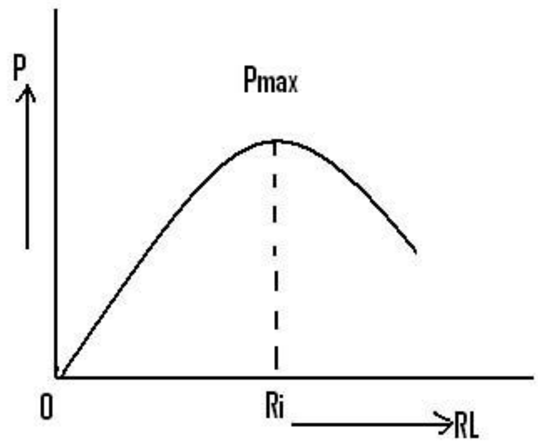
MODEL CALCULATIONS:

For maximum power R = 0.8ohms , therefore

$$P_{max} = V_{th}^2 / 4R_{th}$$



EXPECTED GRAPHS:



RESULT:

Thevenin’s , Norton’s, Superposition and Maximum power transfer theorems are verified.

DISCUSSION OF RESULTS:

Compare theoretical values with practical values.

Comment on the application of theorems.

EXPERIMENT 6

MEASUREMENT OF LOW RESISTANCE BY KELVIN'S DOUBLE BRIDGE

AIM: To determine the unknown resistance using Kelvin's double bridge.

APPARATUS:

1. Kelvin's double bridge.
2. Galvanometer.
3. Connecting wires.

THEORY:

Kelvin's double bridge is best suited for the measurement of low resistance (less than 1ohm) .The Bridge is shown schematically in fig.1

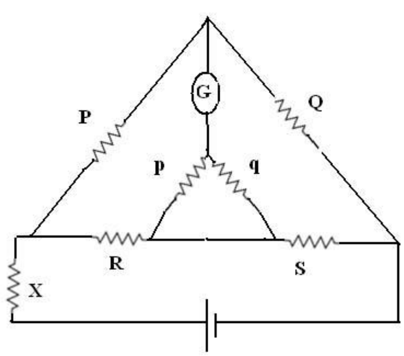


Fig-1

R is the unknown resistance. Resistor R another variable resistor S is connected with a short link along with rheostat X and a battery. The rheostat is used to limit the current in the circuit P,Q,R,S are four non-inductive resistors with P and Q as variables. A suitable galvanometer is connected as shown in fig. (1).

The ratio P/Q is kept same as p/q. By varying S, balance is obtained such that the galvanometer reads zero.

At balance R/S=P/Q

Or unknown resistance R=P/Q*S.

CONNECTION DIAGRAM:

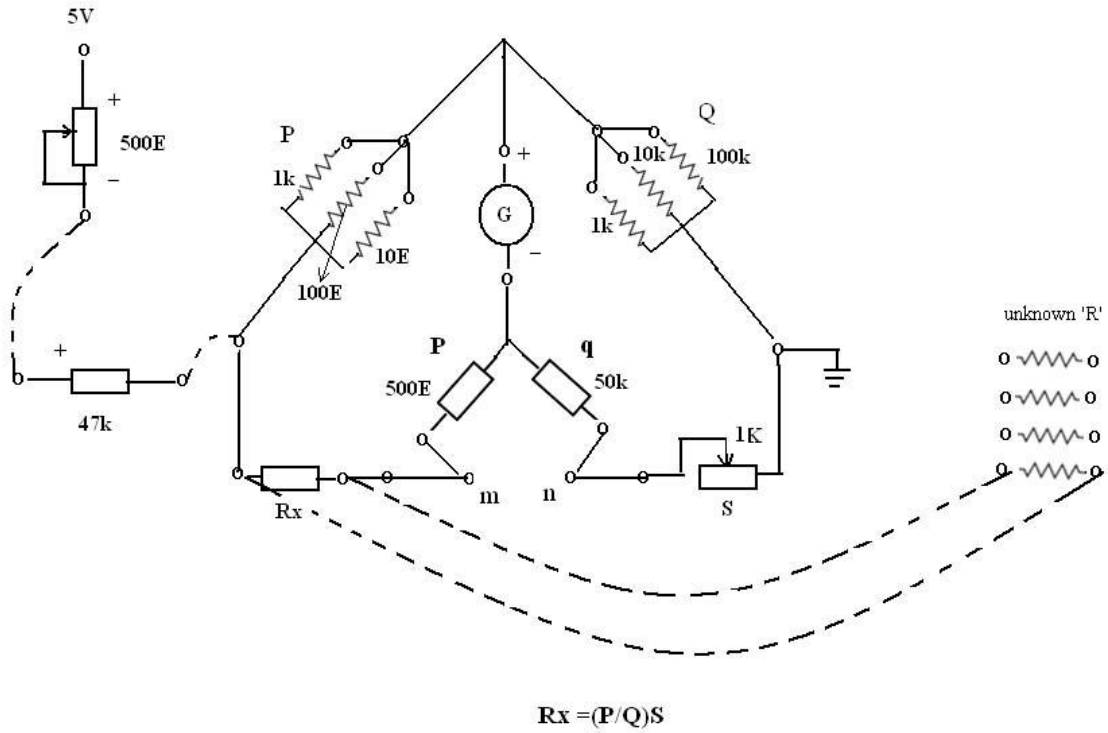


Fig-2

PROCEDURE:

1. Short the 500Ω terminal to 47Ω terminal and short other terminal of 47Ω to terminal.

2. Select any particular resistance for P and Q, such that P/Q = p/q.

3. Connect galvanometer across G terminals.

4. Connect any one resistor provided on the trainer to the R_X terminals.

5. Short p and m; q and n; and m and n terminals.

6. Switch on PHYSITECH'S Kelvin's double bridge trainer.

7. Adjust S for proper balance and at the balancing condition remove all the connections and measure the S value using multimeter.

8. Calculate the value of unknown resistance using the formula,

$R_X = (P/Q)*S$.

9.Repeat the experiment for various values of R_X.

OBSERVATION:

S.No	P (Ω)	Q(KΩ)	S (Ω)	R_X(Ω) measured	R_X(Ω) calculated
1	100	10	408	4.1	4.08

MODEL CALCULATIONS:

For unknown resistance R_X= 4.1Ω

$$P = 100\Omega \qquad Q = 10K\Omega \qquad S = 408\Omega$$

$$R_X = (P / Q) *S$$
$$= (100 / 10) *408$$
$$= 4.08\Omega$$

RESULT:

Kelvin’s Double bridge is used to find the value of unknown resistance.

DISCUSSION OF RESULTS:

Comment on how we balance the bridge to find the value of unknown resistance.

<u>EXPERIMENT 7</u>

MEASUREMENT OF INDUCTANCE BY MAXWELL'S AND ANDERSONS BRIDGE

(a) MAXWELL'S BRIDGE

AIM: To determine unknown inductance value in terms of known capacitance.

APPARATUS:

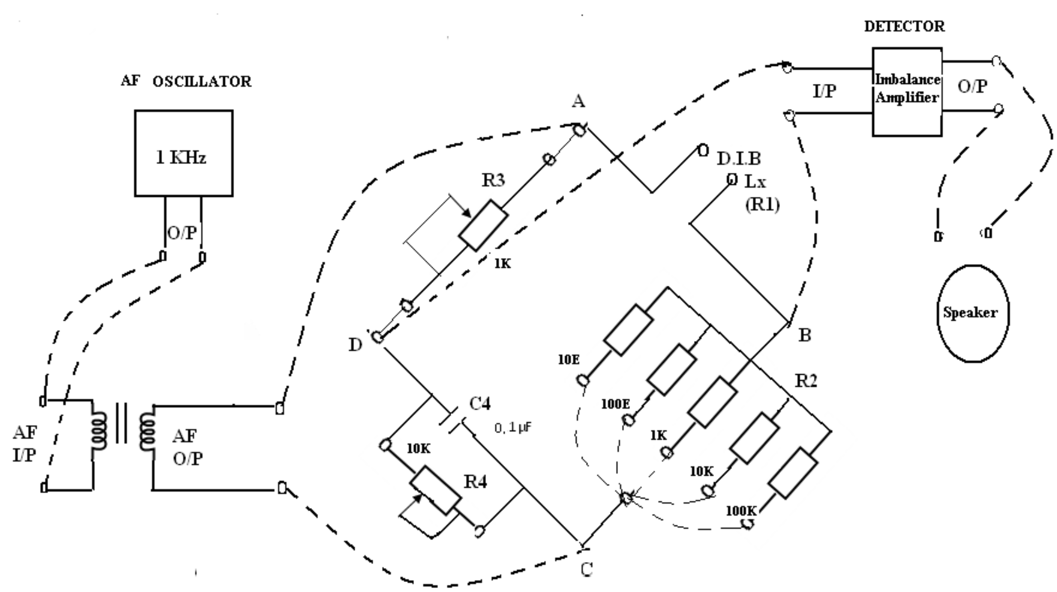
1. Physitech's Maxwell's Bridge trainer.
2. Inductors.
3. CRO.
4. Multimeter.
5. BNC probes and connecting wires.

THEORY:

It is a modification to a Wheatstone bridge used to measure an unknown inductance (usually of low Q value) in terms of calibrated resistance and capacitance. It is a *real product* bridge.It uses the principle that the positive phase angle of an inductive impedance can be compensated by the negative phase angle of a capacitive impedance when put in the opposite arm and the circuit is at resonance; i.e., no potential difference across the detector and hence no current flowing through it. The unknown inductance then becomes known in terms of this capacitance.

$$Lx=R_2C_4\,R_3$$

CONNECTION DIAGRAM:



Lx = R2R3C4

PROCEDURE:

1. Connect AF oscillator O/P(output) to the AF I/P(input) of the Isolation Transformer.
2. Connect AF O/P to the AB terminals of the bridge and connect CD terminals of the bridge to the I/P terminals of an imbalance amplifier.
3. Connect the amplifier output to the speaker terminals.
4. Connect the unknown inductor to the arm marked Lx of the bridge.
5. Switch ON Maxwell’s Bridge trainer.
6. Select a particular value for R_2 and by varying R_1 and R_3 observe the balance position, i.e., minimum sound in the loud speaker.
7. At the balance condition, by disconnecting the circuit, measure R_1 and R_3 values.
8. Calculate the inductance value, by substituting R_2, R_3 and C_4 values in the formula $Lx=R_2C_4\,R_3$.

OBSERVATION:

S.NO	R_2(KΩ)	C_4(μF)	R_3(Ω)	L_X(mH) measured	L_X(mH) Calculated
1	1	0.1	132	12.3	13.2

MODEL CALCULATIONS:

For unknown Inductance $L_X = 12.3$mH

$R_2 = 1$KΩ C = 0.1μF $R_3 = 0.392$Ω

$Lx=R_2C_4\,R_3 = (1*10^3*0.1*10^{-6}*132)$

$= 13.2$mH

(b) ANDERSONS BRIDGE

AIM: To determine the inductance value in terms of a standard capacitor.

APPARATUS:

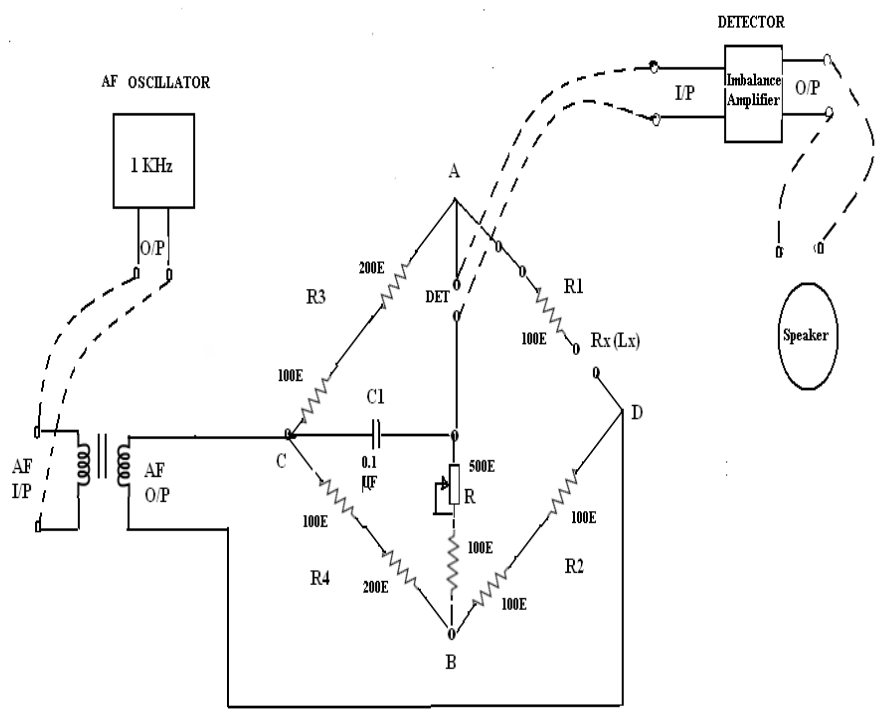
1. PHYSITECH's Anderson's bridge trainer.
2. Inductances.
3. CRO.
4. Multimeter.
5. BNC probes and connecting wires.

THEORY:

AC bridges are often used to measure the value of unknown impedance (self/mutual inductance of inductors or capacitance of capacitors accurately). A large number of AC bridges are available and Anderson's Bridge is an AC bridge used to measure self inductance of the coil. It is a modification of Wheatstones Bridge. It enables us to measure the inductance of a coil using capacitor and resistors and does not require repeated balancing of the bridge.

The bridge is balanced by a steady current by replacing the headphone H by moving coil galvanometer and A.C source by a battery. This is done by adjusting the variable resistance, r. After a steady balance has been obtained, inductive balance is obtained by using the A.C source and headphone.

CONNECTION DIAGRAM:



$L_x = C(R_3/R_4)[R(R_4+R_2)+R_2R_4]$

PROCEDURE:

1. Connect AF oscillator O/P to the I/P terminals of isolation transformer.
2. Connect an inductance across Lx terminals.
3. Switch on PHYSITECH'S Anderson's Bridge trainer.
4. Connect the DET terminals of the bridge to the I/P terminals of the Imbalance Amplifier.
5. Connect the output of detector to the speaker terminals. By varying R_1 and R observe the minimum sound in the loudspeaker.
6. At the balancing condition, by disconnecting all connections, measure R and R_1 values.
7. Calculate the inductance value by substituting the measured values in the equation.

$$L_X = C_1 (R_3/R_2) [R (R_2+R_4) + R_2R_4]$$

OBSERVATION:

S.NO	C_1(µF)	R(Ω)	R_2(Ω)	R_3(Ω)	R_4(Ω)	L_X(mH) measured	L_X(mH) Calculated
1	0.1	118	147.5	258	145	10	10.7

MODEL CALCULATIONS:

For unknown inductance L_X = 10mH

C1 = 0.1µF   R = 118Ω   R2 = 147.5Ω   R3 = 258Ω   R4 = 145Ω

$$L_X = C_1 (R_3/R_2) [R (R_2+R_4) + R_2R_4]$$

$$= 0.1(258 / 147.5) [118(147.5 + 145) + (147.5*145)]$$

$$= 10.7\text{mH}$$

RESULT:

Maxwell's and Anderson's bridges are used to find the value of unknown Inductance.

DISCUSSION OF RESULTS:

Comment on how we balance the bridge to find the value of unknown inductance by using Maxwell's and anderson's bridge.

EXPERIMENT 8

MEASUREMENT OF CAPACITANCE BY DESAUTY'S BRIDGE

AIM: To study about Desauty's Bridge and to determine the unknown value capacitance.

APPARATUS:

1. Desauty's bridge trainer.
2. Capacitors.
3. BNC probes and connecting wires.

THEORY:

A basic capacitance comparison bridge also known as Desauty's Bridge is shown in fig.1.This bridge is the simple method of comparing two capacitances. The ratio arms are both resistive and are represented by R_2 and R_3.The standard arm consists of capacitor C_1 in series with resistor R_1, where C_1 is a high quality standard capacitor and R_1 is a variable resistor. Cx represents the unknown capacitances. To write the balance equation, we first express the impedances of the four bridge arms in complex notation and we find that

$$Z_1=R_1-j/\omega C_1;\ \ Z_2=R_2;\ Z_3=-j/\omega Cx;\ Z_4=R_3.$$

By substituting these impedances in the general equation for a bridge, that is

$$Z_1Z_4=Z_2Z_3$$

$$(R_1-j/\omega C_1)(R_3)=R_2(-j/\omega Cx)$$

$$R_1R_3-R_3j/(\omega C_1)=-R_2j/\omega Cx$$

By equating the imaginary part;

$$R_3j/\omega C_1=R_2j/\omega Cx$$

$$Cx=R_2C_1/R_3.$$

This equation describes the balance condition and also shows that the unknown Cx is expressed in terms of the known bridge components. To satisfy the balance condition, the bridge must contain two variable elements in its configuration. Any two of the available four elements could be choosen, although in practice capacitor C_1 is a high-precision standard capacitor of fixed value and is not available for adjustment. Inspection of the balance equation shows that R_1 does not appear in the expression for Cx. The balance can be obtained by varying either R_2 or R_3.

The advantage of this bridge is its simplicity. But this advantage is nullified by the fact that it is impossible to obtain balance if both the capacitors are not free from dielectric loss. Thus with this method only loss-less capacitors like air capacitors can be compared.

CONNECTION DIAGRAM:

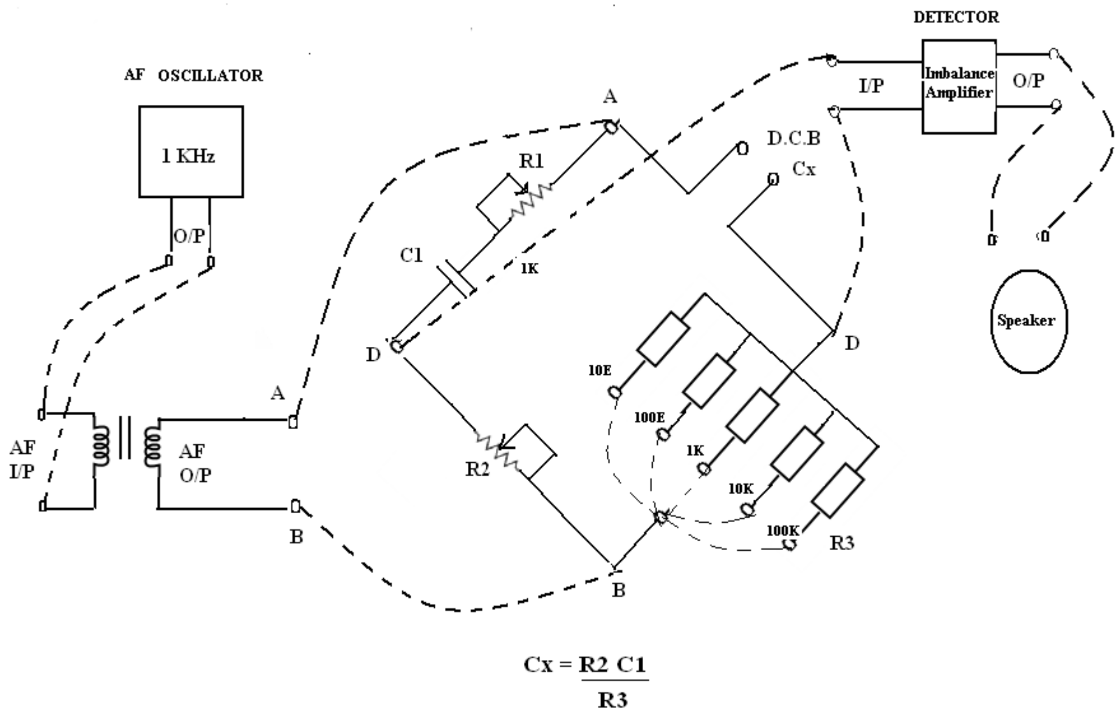


Fig-1

PROCEDURE:

1. Connect the AF oscillator O/P (output) to the AF I/P (input) of oscillation transformer.
2. Connect AB terminals of transformer output to the AB terminals of bridge circuits.
3. Connect the unknown capacitor in the arm marked C_x and select any particular value of R_3.
4. Connect the output of the bridge (CD terminals) to the input of the imbalance amplifier.
5. Connect the amplifier output to the speaker terminals.
6. Switch ON Physitech’s Desauty’s Bridge trainer.
7. Alternately adjust R_2 and R_3 for a minimum sound in the loudspeaker.(The process of manipulation of R_2 is typical of the general balancing procedure for AC bridge and is said to cause convergence of the balance point. It should also be noted that the frequency of the voltage source does not enter in the balance equation and the bridge is therefore, said to be independent of the frequency of the applied voltage).
8. Calculate the value of the unknown capacitance using the equation $Cx = R_2C_1/R_3$ by substituting the values of R_2 and R_3 obtained at the balance point.

OBSERVATION:

S.No	R_2(KΩ)	C_1(µF)	R_3(KΩ)	C_X(KPF) Measured	C_X(KPF) Calculated
1	4.91	0.1	10	49.5	49.1

MODEL CALCULATIONS:

For unknown capacitance $C_X = 49.5$KPF

$R_2 = 4.91$KΩ $C_1 = 0.1$µF $R_3 = 10$KΩ

$$Cx = R_2C_1/R_3 = (4.91*10^3*0.1*10^{-6}) / 10*10^3$$

$$= 49.1 \text{ KPF}$$

RESULT:

Desauty's bridge is used to find the value of unknown Capacitance.

DISCUSSION OF RESULTS:

Comment on how we balance the bridge to find the value of unknown Capacitance.

EXPERIMENT 9

DC POTENTIOMETER FOR MEASUREMENT OF UNKNOWN VOLTAGE AND IMPEDANCE

AIM: To calibrate the given D.C Voltmeter using D.C. Potentiometer.

APPARATUS: R.P.S, A sensitive galvanometer, D.C. Crompton's Potentiometer, Voltmeter, Ammeter, Rheostat, Standard cell and Standard resistance.

THEORY:

A potentiometer is an instrument used for the measurement of unknown EMF by a known potential difference by the flow of current in a network. This is used where precision required is higher than that of ordinary deflection instruments. By using in addition, a standard resistance, current can also be measured.

The potentiometer works on the principle of opposing the unknown EMF by a known EMF. A simple arrangement is shown in the Fig.1.

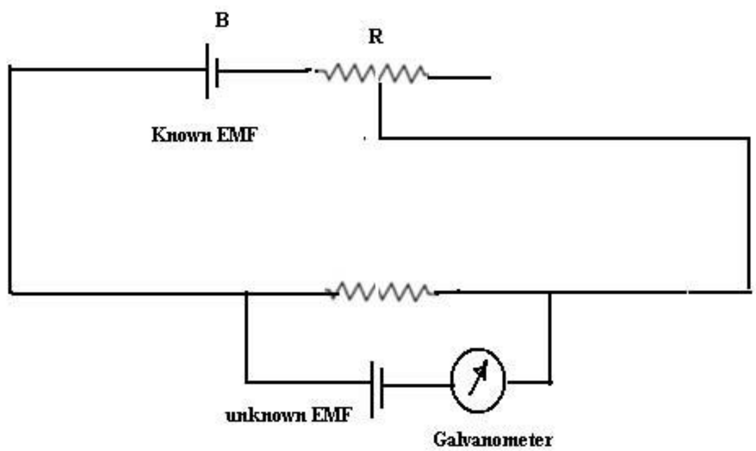
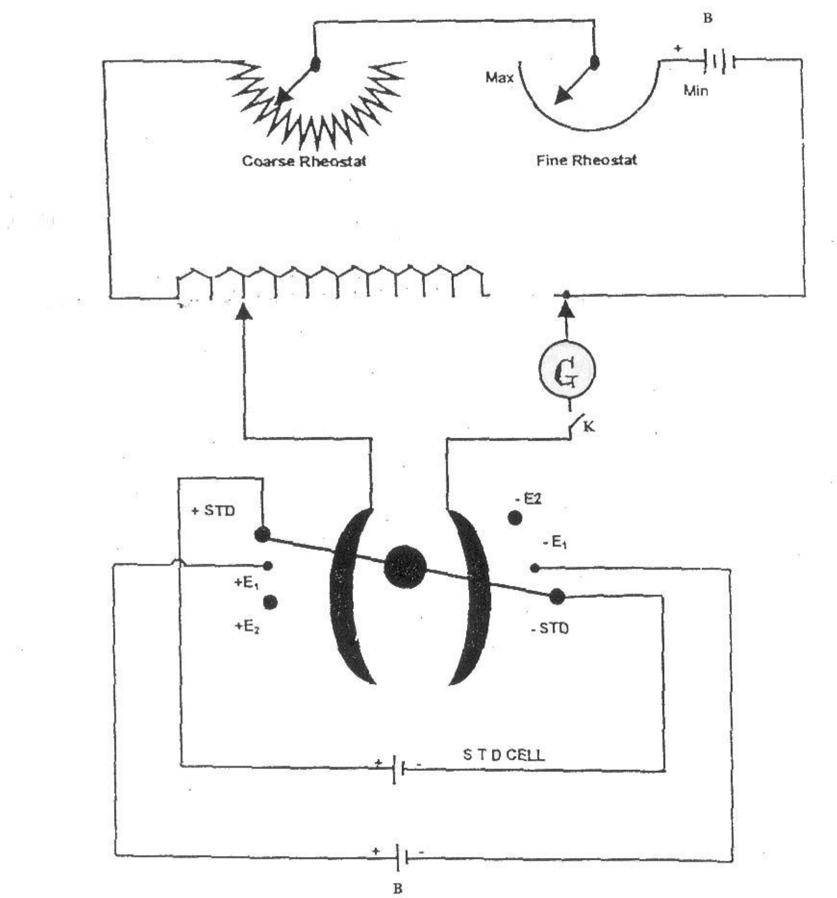


Figure - 1

The unknown EMF is connected in parallel with and in opposition to a voltage drop in a resistor as shown in the Fig. By varying the current in the resistor with fine adjustment, any desired voltage can be obtained. This voltage drop is measured accurately after calibration with a known EMF (standard cell).



CALIBRATION OF A VOLTMETER:

PROCEDURE:

1. Make the connections as shown in the Fig.2.
2. Switch the D.C. Supply and adjust it to 2V keeping all the potentiometer dials to zero position.
3. Standardize the potentiometer as follows:
   Connect the standard cell whose EMF is 1.0186v to the terminal Std. cell. Set the main knob at 1.0v and the circular dial at 18.6 divisions (since each division corresponds to 0.25/250=0.001v).
   The switch is to be kept at STD position. Now the coarse and fine rheostats are so adjusted that there is no deflection in the galvanometer when Galv. Key is pressed. Now the system is pressed. Now the system is ready to measure any unknown voltage.
4. Connect the voltmeter to be calibrated, which is across the voltage source (RPS) to the terminals E1 or E2 (Fig.3).Set a particular value, say, 0.5 by varying the rheostat. Note the voltmeter reading.

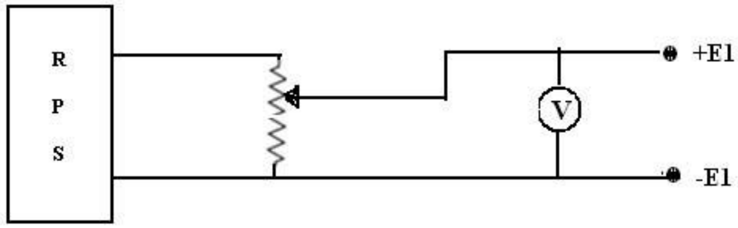


Figure-3

5. Change the switch from Std. to E1 or E2 depending upon the terminals to which the voltmeter is connected.
6. Balance the voltage by adjusting the voltage dial without disturbing course and fine rheostats.
7. Repeat 4 and 6 for different values of voltmeter readings.
8. Tabulate the readings of voltmeter, potentiometer values and find the %Error.

Note: If the calibrated voltage is more than 1.75v, voltage ratio box is to be used.

OBSERVATIONS:

S.No.	Voltmeter reading(E_1)	Potentiometer reading(E_2)	%Error= $(E_1-E_2)/E_2*100$
1	0.452	0.250+0.157 = 0.407	11.05

MODEL CALCULATIONS:

$E_1 = 0.452$ $\qquad\qquad$ $E_2 = 0.407$

%Error= $(E_1-E_2)/E_2*100$

$=[(0.452 – 0.407) / 0.407]*100$

$= 11.05$

RESULT:

Calibration of D.C voltmeter is performed by using D.C potentiometer**.**

DISCUSSION OF RESULTS:

Comment on the calibration of voltmeter and explain the need of calibration.

EXPERIMENT 10

CALIBRATION OF SINGLE PHASE ENERGY METER

AIM: To calibrate the single-phase energy meter using wattmeter and also to find meter constant by using Phantom Loading.

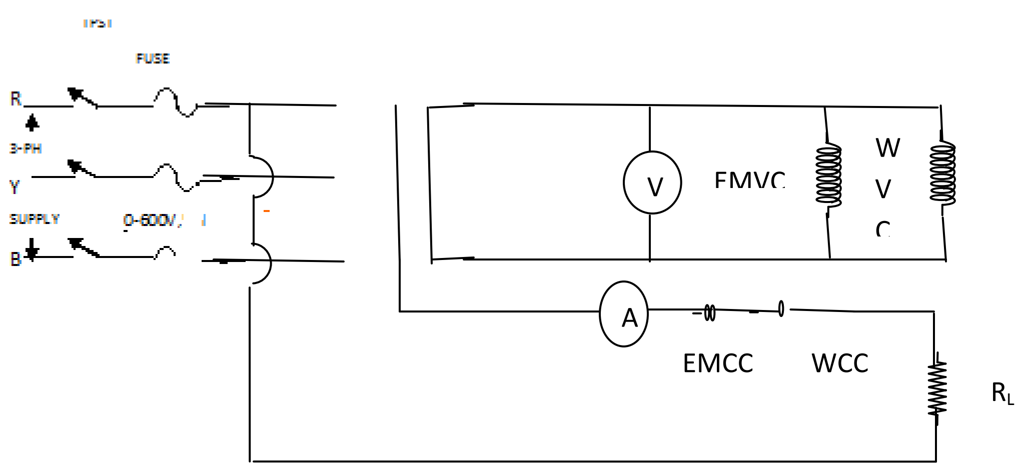
APPARATUS REQUIRED:

1. Single phase energy meter 5A, 220V.
2. Wattmeter (A.C) 300V, 10A.
3. Ammeter (A.C) 0-10A.
4. Voltmeter (A.C) 0-300V.
5. Variac (220/0-270).
6. Rheostat 20Ω, 6A.
7. Stop watch.

THEORY:

nergy meter is an instrument which measures electrical energy. It is also known as watt hour (Wh) meter. It is an integrating meter. There are several types of energy meters. Single phase induction type energy meters is very commonly used to measure electrical energy consumed in domestic and commercial installations. Electrical energy is measured in kilo watt hours (kWh) by these energy meters. In this experiment the purpose is to calibrate the energy meter. This means we have to find out the error/ correction in the energy meter readings. This calibration is possible only if some other standard instrument is available to know the correct reading.

CIRCUIT DIAGRAM:



PROCEDURE:

1. Make the connections as shown in the circuit diagram. Note the Meter Constant of the energy meter.
2. Switch ON the supply, keeping maximum resistance and zero position in the variac.
3. Adjust the variac such that the current of 4A flows in the circuit. Note down the wattmeter reading.
4. Find the time taken for 10 revolutions of the disc using stopwatch. Also note down the reading of the wattmeter and the ammeter.
5. With the same current note down the time taken for increasing number of revolutions.(say,20,30,40).
6. Repeat the above procedure for different currents by varying the variac position and obtain another set of readings.
7. Tabulate the readings and calculate %Error and Meter Constant.

OBSERVATIONS:

Power factor = 1

S.No.	I_L	Power (P)	No. of revolutions	Time t	A	E	%Error	Meter constant
1	2.6A	660W	12	60sec	36	39.6	-9	1090.9

CALCULATIONS:

Actual Energy (A) =Nx3600/1200KW-sec

Calculated Energy (E) = (Pxt/1000) KW-sec

W is in Watts and t is in seconds.

%Error= {(A-E)/E} x100

Meter Constant (k) =Revolutions per KWH.

= (Nx3600x1000)/ (wxt).

MODEL CALCULATIONS:

Actual Energy (A) =Nx3600/1200KW-sec

= (12*3600) /1200

= 36

Calculated Energy (E) = (Pxt/1000) KW-sec

= (660*60) / 1000

= 39.6

%Error= {(A-E)/E} x100

Meter Constant (k) =Revolutions per KWH.

= (Nx3600x1000)/ (Pxt).

= (12*3600*1000) / (660*60)

= 1090.9

GRAPH:

Draw graphs between Actual energy versus %Error for different currents.

RESULT:

Calibration of single-phase energy meter using wattmeter and meter constant by using Phantom Loading is done.

DISCUSSION OF RESULTS:

Discuss about Phantom loading.