EXPERIMENT NO. 01

AIM: To verify the Thevenin's theorem

OBJECTIVE:

1. To determine the Thevenin's voltage (V_{th}) and Thevenin's Resistance (R_{th}) of the given circuit
2. To determine the current (I_L) flowing through the load branch.
3. To verify the experimental result with analytic one and calculate the percentage of error.

BRIEF THEORY:

Thevenin's theorem states that any linear bilateral circuit can be replaced by a simple equivalent Thevenin's circuit with a single voltage source (V_{th}) and a single series resistor (R_{th}). The value of V_{th} is the open circuit voltage at the load terminal known as Thevenin's equivalent voltage and the value of R_{th} is the net equivalent resistance of the circuit viewed back from the open load terminal after deactivating all the sources.

The circuit to be solved using Thevenin's theorem is shown in Fig. 1(a) and the Thevenin's equivalent circuit is shown in Fig. 1(b). The current flowing through a load resistance (R_L) of the circuit can be calculated by: $\boxed{I_L = \frac{V_{th}}{R_{th}+R_L}}$

EXPECTED OUTCOME:

Evaluation of R_{th}:

Deactivating 5 V and 12 V sources and removing the load as in Fig. 1(d), the Thevenin's resistance, $R_{th} = (100||25)||25 = 11.1111\ \Omega$

Evaluation of V_{th}:

Considering the 12 V source as in Fig. 1(e) and applying voltage division rule, V_{th1}= (12*100)/(100+25)= 9.6 V.

Considering the 5 V source as in Fig. 1(f) and applying voltage division rule, V_{th2}= (5*100)/(100+25)= 4 V.

Applying Superposition theorem, $V_{th} = V_{th1} + V_{th2}$ = 9.4+4.0=13.4 V.

Now, the current flowing through load branch in Fig. 1(b) could be determined by $I_L = \frac{V_{Th}}{R_{Th}+R_L}$ = 0.1206A

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LIST OF APPARATUS:

Sl. No.	Name of the apparatus	Range	Make	Make No.	Quantity
1	DC Power supply				
2	Voltmeter				
3	Ammeter				
4	Rheostats				
5	Connecting wires				As per requirement

CIRCUIT DIAGRAMS:

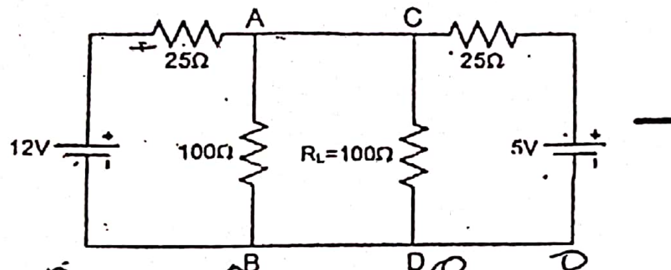

Fig. 1(a). Circuit diagram to be solved using Thevenin's Theorem

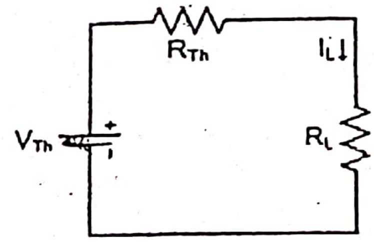

Fig. 1(b). Thevenin's Equivalent Circuit

1

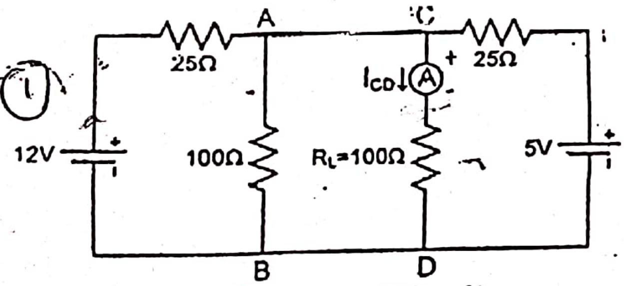

Fig. 1(c). Circuit for evaluation of I_{CD}

4

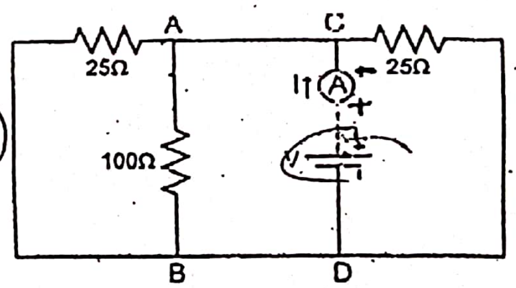

Fig. 1(d). Circuit for evaluation of R_{Th}

2

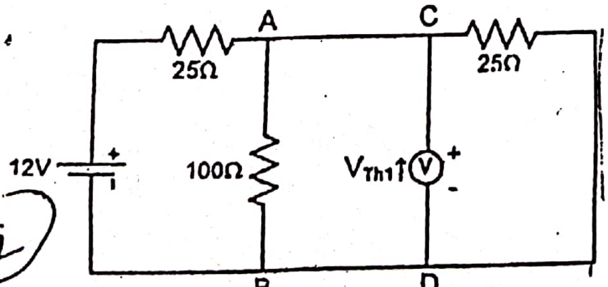

Fig. 1(e). Circuit for evaluation of V_{Th1}

3

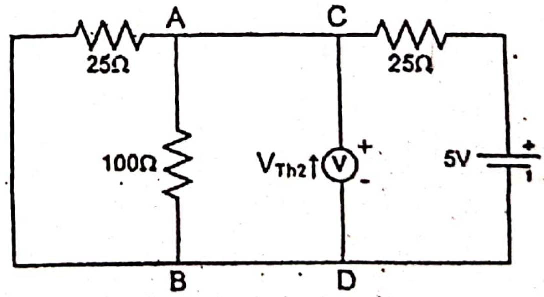

Fig. 1(f). Circuit for evaluation of V_{Th2}

I_{CD}, V_{th_1}, V_{th_2} } $V_{th} = V_{th_1} + V_{th_2}$ | Practical 7

SC 18V SC 12V

R_{th}

PROCEDURE:

NOTE: The value of R_{AB} will vary from group to group. R_{AB} for group-I = (50 + 4*I) Ω, I = 1 to 12.

1. The connections are made as shown in the circuit diagram.

Current through the load resistance:

2. Initially, the ammeter is connected to the branch CD to measure the branch current (I_{CD}), as shown in Fig. 1(c).

To find the V_{th}:

3. A voltmeter is connected across the branch CD, after removing the load resistance (R_L). Note the voltmeter reading.
4. Then the 5V source is removed, as shown in the Fig. 1(e) and the voltmeter reading is noted as V_{th1}.
5. Similarly, the 12V source is removed, as shown in the Fig. 1(f) and the voltmeter reading is noted as V_{th2}.
6. These two readings of the voltmeter are summed up to give the Thevenin's voltage (V_{th}) of the circuit which should the same as the voltmeter reading in step-3.

To find the R_{th}:

7. Then, both the sources (5V and 12V) are replaced by their respective internal resistance and a voltage source is connected across CD in series with an ammeter, as shown in Fig. 1(d).
8. The reading of the ammeter (I) and the value of the voltage source (V) are noted. R_{th} is then calculated using, $R_{Th} = \frac{V}{I}$.
9. Finally, the current through the load resistance is calculated using, $I_L = \frac{V_{th}}{R_{th}+R_L}$. It should be same as I_{CD}, noted in step-2.
10. The percentage of error is evaluated by, $\%Error = \frac{|I_{CD}-I_L|}{I_{CD}} \times 100$
11. Repeat the steps once more, find the difference in readings. Comments on the causes of such difference.

OBSERVATION TABLE:

Sl. No.	I_{CD} (A)	Evaluation of V_{th}				Evaluation of R_{th}			$I_L = V_{th}/(R_{th}+R_L)$ (Ω)	%Error
		V_{th1} (V)	V_{th2} (V)	$V_{th} = V_{th1}+V_{th2}$ (V)	V_{th} (V)	V (V)	I (A)	$R_{th} = V/I$ (Ω)		
1										
2										

RESULTS AND DISCUSSION:

Note: 1. Students should draw the Thevenin's equivalent circuit with values.
2. Compare the values between the experimental and analytical results.

The discussion should cover the following points:

1. Analytically results and experimental results are to be compared:
2. Discuss all possible causes for the difference in (1).
3. Causes of error during the experiment.
4. Precautions to be taken during the experiment.
5. Any other comments on the experiment, if required.

CONCLUSIONS:

PRECAUTIONS:

1. All the connections should be properly tightened.
2. The voltmeter and ammeter should be checked for their zero positions before connection.
3. The connections should be verified by the laboratory technician before switching the supply on.

VIVA QUESTIONS:

1. Why are voltage sources replaced by short circuit whereas current sources replaced by an open circuit when applying the superposition theorem?
2. How to determine Thevenin's equivalent voltage of a given circuit?
3. How to determine Thevenin's equivalent resistance of a given circuit?
4. What should be the value of V_{th} of a given circuit if its I_L reduces to half for the same R_L? $\frac{V_{th}}{2}$
5. What should be the value of I_L for same R_L of a given circuit if its V_{th} is doubled?
6. Why are ammeters connected in series?
7. Why are voltmeters connected in parallel? $V \propto R$
8. What is voltage division rule? series
9. What is current division rule? $V \propto R$ linear

$V_{th} = \frac{I_L}{2}(R_i + R_{th})$ $\quad P = \frac{V^2}{4R_L} \rightarrow \frac{V^2}{4}$ $\quad \frac{V}{I_L}$

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EXPERIMENT NO-2

Aim: To verify maximum power transfer theorem.

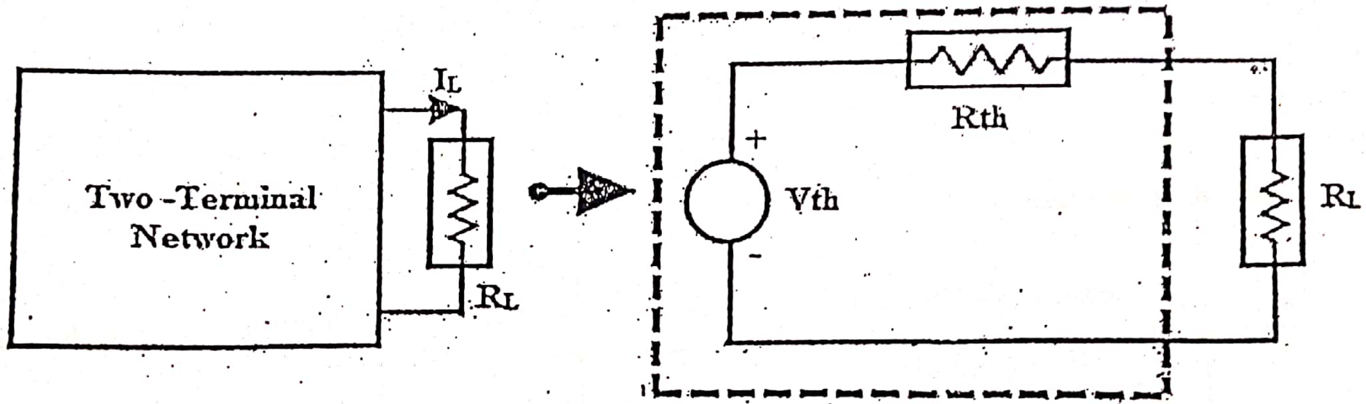
Objective: (i) To find the source resistance of the given circuit.

(ii) To find the value of the load resistance when the power transfer is maximum.

Brief Theory:

Statement: The maximum power transfer theorem states that in a linear, bilateral DC network, maximum power is delivered to the load when the load resistance is equal to the internal resistance of a source.

Proof:



Thevenin's Equivalent Circuit

The original two terminals circuit is replaced with a Thevenin's equivalent circuit across the variable load resistance. The current through the load for any value of load resistance is

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

The power absorbed by the load is

$$P_L = I_L^2 \times R_L$$

$$= \left[\frac{V_{Th}}{R_{Th} + R_L}\right]^2 \times R_L$$

From the above expression, it is clear that the power delivered depends on the values of R_{Th} and R_L. However, the Thevenin's equivalent network remain same; thus, the power delivered from this equivalent source to the load entirely depends on the load resistance R_L. The required value of R_L is calculated by differentiating P_L with respect to R_L and equating it to zero as:

$$\frac{dP(R_L)}{dR_L} = V_{Th}^{\,2}\left[\frac{(R_{Th}+R_L)^2 - 2R_L \times (R_{Th}+R_L)}{(R_{Th}+R_L)^4}\right] = 0$$

$$\Rightarrow (R_{Th}+R_L) - 2R_L = 0$$

$$\Rightarrow R_L = R_{Th}$$

Therefore, the maximum power delivered to the load is:

$$P_{max} = \left[\frac{V_{Th}}{R_{Th}+R_L}\right]^2 \times R_L \Bigg|_{R_L = R_{Th}}$$

$$= \frac{V_{Th}^{\,2}}{4R_{Th}}$$

List of Apparatus:

Sl. No.	Name of the apparatus	Range	Make	Make No.	Quantity
1.	Voltage supply				
2.	Rheostat				
3.	Ammeter				
4.	Voltmeter				

10

12. Calculate $R_L = V_{max}/I_{max}$.

13. Compare R_L, R_{Th}, and calculated value of load resistance for maximum power.

Observation Table:

Table 1

Sl. No.	Ammeter (I_s)	Voltmeter (V_s)	Power $P_L = V_s I_s$	$R_L = V/I_{max}$

Table 2

Sl. No.	I_S (A)	V_s (V)	$R_s = V_s/I_s$ Ω

Results and Discussion:

Note: 1. Students should draw the plot P_L *vs* R_L and find the value of R_L when the maximum power is transferred.

2. Compare the values between the experimental and analytical results.

The discussion should cover the following points:

1. Analytically results and experimental results are to be compared.
2. Discuss all possible causes for the difference in (1).
3. Causes of error during the experiment.
4. Precautions to be taken during the experiment.
5. Any other comments on the experiment, if required.

Conclusions:

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Connection/Circuit Diagram:

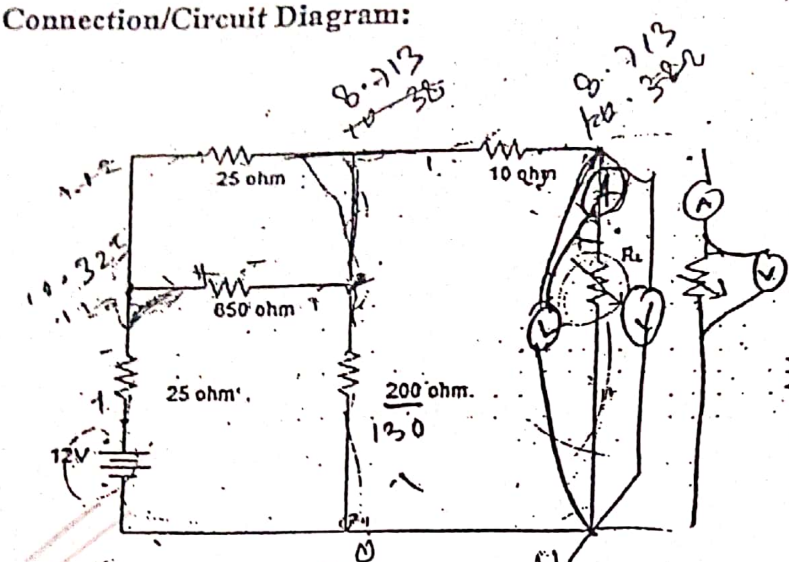


Fig:1

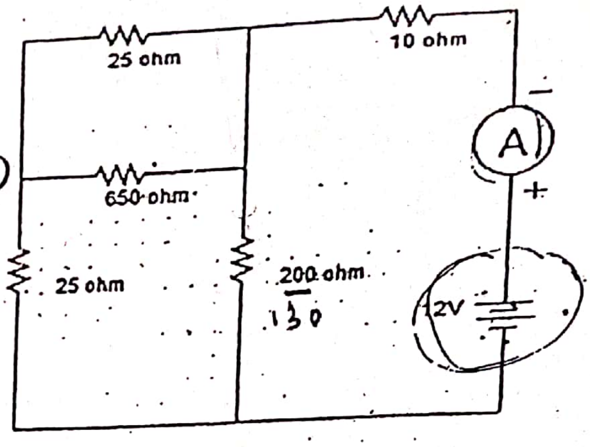


Fig:2

Procedure:

Note: The value of R = 200 Ω will vary from group to group. It will be for group-I = (100 + 5*I) Ω, I = 1 to 12.

1. Connections are made as per the circuit diagram.

$\frac{V_{th}^2}{4R_L}$

To find the V_{Th}:

2. Remove the load resistance and connect a voltmeter to the load terminal.
3. Note the reading of the voltmeter. This is V_{Th}.

To find the R_{Th}:

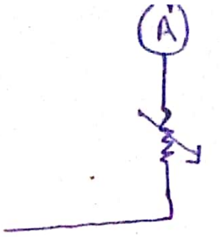
4. Remove the load resistance and connect a voltage source to the load terminal.
5. Connect an ammeter in series with the voltage source.
6. Find $R_{Th} = \frac{V}{I}$, where V is the terminal voltage of the voltage source and I is current through the ammeter.

To find the maximum power using Thevenin's equivalent network:

7. Find $P_{max} = \frac{V_{Th}^2}{4R_{Th}}$;

To find the maximum power using the given circuit:

8. In Fig. 2, connect a voltmeter across the load resistance and an ammeter in series with the load resistance.
9. Note down different values of the voltmeter (V_a) and the ammeter (I_a) for different values of the load resistance.
10. Calculate the power consumed by the load for each set of voltmeter and ammeter reading.
11. Note the readings of the ammeter (I_{max}) and voltmeter (V_{max}) corresponding to the maximum value of power.



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PRECAUTIONS:

1. All the connections should be properly tightened.
2. The voltmeter and ammeter should be checked for their zero positions before connection.
3. The connections should be verified by the laboratory technician before switching the supply on.

Assessment Questions:

1. While calculating Thevenin's resistance why we have to short-circuit voltage sources?
2. While calculating Thevenin' resistance why we have to open circuit current sources?
3. Applications of maximum power transfer theorem.
4. How to decide fuse rating in the circuit?
5. Why should voltmeter be connected in parallel across the load, if it connected in series what will happen?
6. Why should ammeter be connected in series with the load, if it is connected in parallel what will happen?
7. How can the inductance effect be neglected in wire wound resistors?
8. Why is a symbol of the resistor in a zig-zag manner?
9. Can we replace DC source by AC source in connection diagram shown above?

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EXPERIMENT NO: 3

Aim: To verify Norton's theorem.

Objective:

1. To determine Norton's current (I_N) and Norton's Resistance (R_N) of the given circuit
2. To determine the current (I_L) flowing through the load branch.
3. To verify the experimental result with analytic one and calculate the percentage of error.

Brief Theory: Norton's theorem states, "A linear active network consisting of independent and or dependent voltage and current sources and linear bilateral network elements can be replaced by an equivalent circuit consisting of a current source in parallel with a resistance, the current source being the short-circuited current across the load terminal and the resistance being the internal resistance of the source network looking through the open-circuited load terminals."

Explanation of theory- In order to find the current through r_L, the load resistance (Fig.1), by Norton's theorem, we need to remove r_L and short circuit the branch (Fig.2).

Obviously, $I = V_S/(r_1 + r_2 r_3/(r_2 + r_3))$ and $I_N = I.r_3/(r_3 + r_2)$

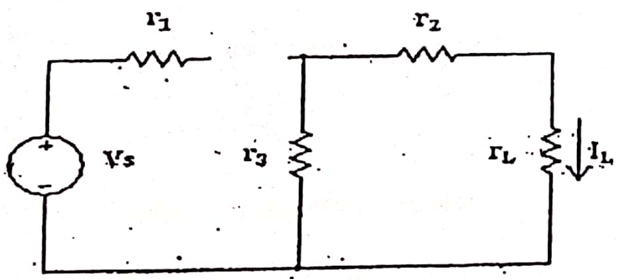


Fig.1. A DC network

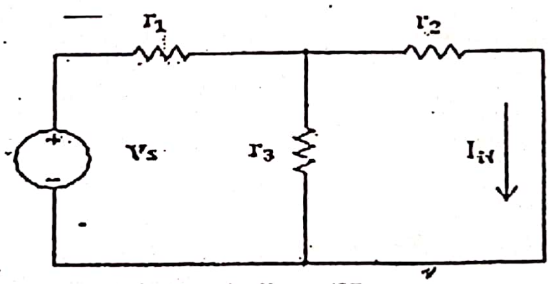


Fig.2. Finding of I_N

Next, the short circuit is removed and the independent sources are replaced by their internal resistance, as shown in Fig.3.

Here, $R_N = r_2 + r_1 r_3/(r_1 + r_3)$

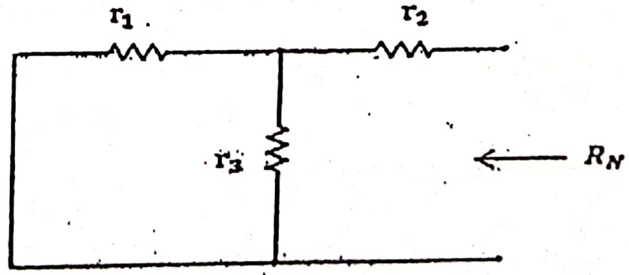


Fig.3. Finding of R_N

As per Norton's theorem, the equivalent circuit contains a current source in parallel to the internal resistance, the current source being the short-circuited current through the shorted terminals of the load resistor (Fig.4).

Obviously, $I_L = I_N R_N/(R_N + r_L)$

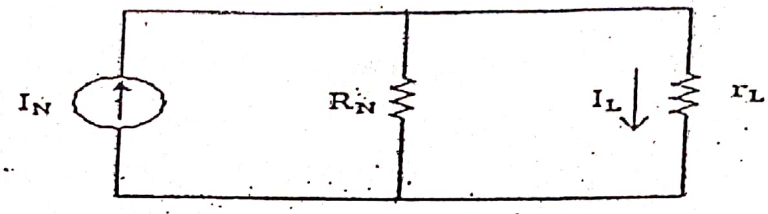
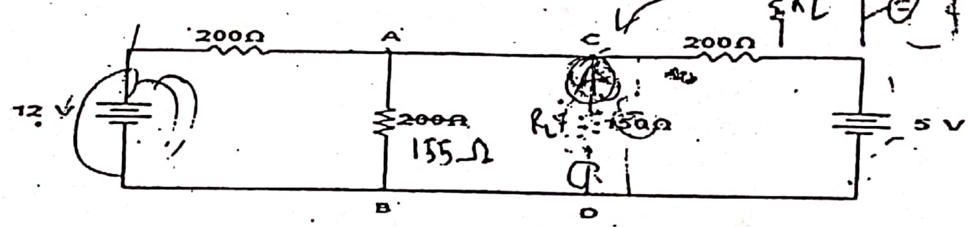


Fig.4. Norton's equivalent circuit

List of Apparatus:

Sl. No.	Name of the apparatus	Range	Maker's Name	Maker's No	Quantity
1.	Ammeter				
2.	Voltage Supply				
3.	Rheostat				

Circuit Diagram:



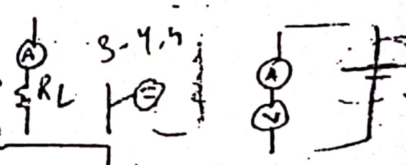


Fig.5. Circuit diagram for Norton's theorem

Procedure:

NOTE: The value of R_{AB} will vary from group to group. R_{AB} for group-I = (125 + 5*I) Ω, I = 1 to 12.

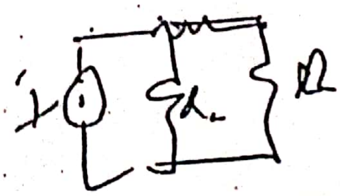
1. The connections are made as shown in the circuit diagram.

Find the current through the load:

2. An ammeter is connected through the branch CD to read the branch current (I_{CD}).

Find Norton's equivalent current source:

3. Now, the 5V source is removed and an ammeter is connected through CD after removing the load resistance (R_L).The reading of the ammeter is noted as I_{N1}.
4. Again, the 12V source is removed and an ammeter is connected through CD after removing the load resistance (R_L). The reading of the ammeter is noted as I_{N2}.
5. The sum of these two readings of the ammeter gives Norton's equivalent current source (I_N).



Find Norton's equivalent resistance:

6. Now, both the voltage sources are replaced by their respective internal resistance and the load resistance (R_L) is removed. A voltage source (approx. 5V-12V) is connected across CD in series with an ammeter. The reading of the ammeter (I) and the value of the voltage source (V) are noted.
7. The Norton's equivalent resistance, R_N is then calculated using $R_N=V/I$.

Verification:

8. Finally, the current through the load impedance is calculated using $I_L= I_N R_N / (R_L+R_N)$.
9. Compare the value of I_{CD} with I_L.
10. Repeat the steps once again and observe if there is any difference in reading. Comments on the possible causes of difference, if any.

Observation Table:

Sl. No.	I_{CD}	I_{N1}	I_{N2}	$I_N=I_{N1}+I_{N2}$	Readings from experiment		$R_N=V/I$	$I_L=I_N R_N/(R_N+R_L)$
					Voltage(V)	Current(I)		
1								
2								

Results and Discussion:

Note: 1. Students should draw Norton's equivalent circuit with values.
2. Compare the values between the experimental and analytical results.

The discussion should cover the following points:

1. Analytically results and experimental results are to be compared.
2. Discuss all possible causes the difference in (1).
3. Causes of error during the experiment.
4. Precautions to be taken during the experiment.
5. Any other comments on the experiment, if required.

Conclusions:

Assessment Questions:

1. What is an active network and a linear network?
2. What are dependent and independent sources?
3. How to convert Norton's theorem into Thevenin's theorem and vice versa?
4. Can we connect a voltmeter in series?
5. Differentiate between the ideal and a non-ideal voltage source.
6. How would we calculate power loss in a resistor?
7. How many types of circuit loads are there in a common electrical circuit?
8. What is the difference between an overload and a short circuit?
9. Differentiate between the ideal and a non-ideal current source.
10. What is the method to solve circuit using source transformation?
11. Can we connect an ammeter in parallel?

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C = 36μ

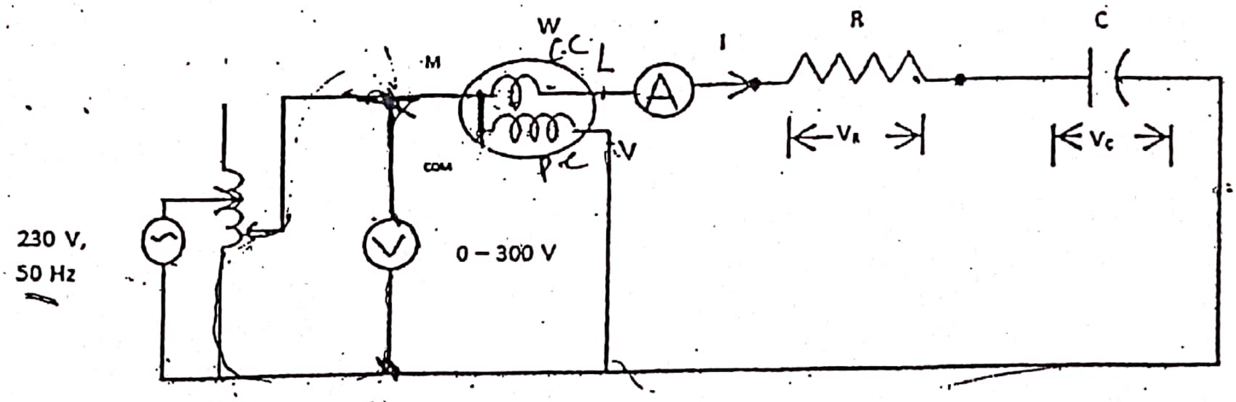
EXPERIMENT NO: 4

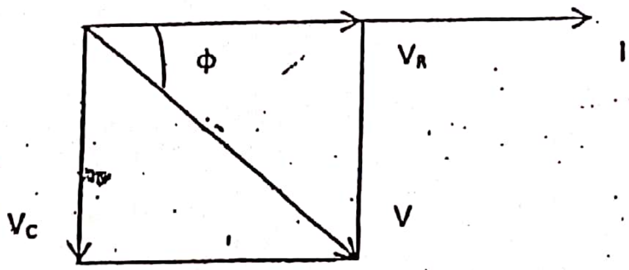
Aim of the experiment: To determine the value of parameters of a series RC circuit.

Objective: To establish the phase relationship between voltage and current in a series R-C circuit and to determine values of the parameters.

Brief theory: Fig. 1 shows an ac circuit consisting of a resistor (R) and capacitor (C) in series. I represent the current flowing through R and C. V_R and V_C represents the respective voltage drops across R and C. Applied voltage V is the phasor sum of V_R and V_C.

Circuit Diagram:





Since this is an R-C circuit, the current I lead voltage V by an angle ϕ. Hence, the power factor can be calculated by measuring the power input to the circuit using a wattmeter. Following equations are to be used to calculate the parameters of the R-C circuit:

$$W = VI\cos\phi$$

$$\therefore \cos\phi = \frac{W}{VI}$$

The total impedance of the circuit, $Z = \frac{V}{I}$

180 2 9610

180 - 230

Also, $\cos\phi = \frac{R}{Z}$

$\therefore \boxed{R = Z\cos\phi} = \frac{V}{I}\frac{W}{VI} = \frac{W}{I^2}$

Capacitive reactance, $X_C = \frac{1}{\omega C} = Z\sin\phi$

$\therefore \boxed{C = \frac{1}{\omega X_C}}$

The expectation from the experiment:

1. Note the value of the capacitance from the laboratory.
2. Consider the value of R for your group.
3. Theoretically calculate the Z and $\cos\phi$
4. Compare it with the experimental results.

List of Apparatus:

Sl. No.	Name of the instrument	Range	Maker's Name	Maker's Number	Quantity
1.	Variac/ Dimmerstat/ Auto transformer				
2.	Ammeter				
3.	Voltmeter				
4.	Wattmeter				
5.	Rheostat				
6.	Capacitor				

Procedure:

NOTE: The value of R will vary from group to group. R_{AB} for group-I = (50 + 4*I) Ω, I = 1 to 12.

1. Connect the circuit as shown in Fig. 1.
2. Vary the input voltage from 150 V to 230 V in a step of 10 V.
3. Observe the readings of voltmeter, wattmeter and ammeter.
4. Calculate R and C.
5. Draw the phasor diagram for any one set of the reading.

$\theta = 84.79$

Observation:

Sl. No.	Voltmeter reading (V)	Ammeter reading (A)	Wattmeter reading (W)	Power factor $\cos\phi = \frac{W}{VI}$	Impedance $Z = \frac{V}{I}$	Resistance $R = Z\cos\phi$	Capacitive reactance $X_C = Z\sin\phi$	Capacitance $C = \frac{1}{\omega X_C}$
1								
2								
3								

1 ~ 29)   29)

Results and Discussion:

Note: 1. Draw the phasor diagram for any one set of the reading and compare with the theoretical value. a

The discussion should cover the following points:

1. Analytically results and experimental results are to be compared.
2. Discuss all possible causes for the difference in (1).
3. Causes of error during the experiment.
4. Precautions to be taken during the experiment.
5. Any other comments on the experiment, if required.

Conclusion:

PRECAUTIONS:

1. All the connections should be properly tightened.
2. The voltmeter and ammeter should be checked for their zero positions before connection.
3. The connections should be verified by the laboratory technician before switching the supply on.

Questions:

1. What happens when frequency increases to RC circuit?
2. In a 20 Vac series *RC* circuit, if 20 V is read across the resistor and 40 V is measured across the capacitor, what is the applied voltage?
3. In a series RC circuit, what is the effect of increasing resistance?
4. What is the reference vector for parallel *RC* circuits and why?
5. In a series RC circuit, current leads or lags the source voltage?
6. How to make the capacitor voltage greater than the resistor voltage?
7. In an AC circuit consists of a resistor and a capacitor. To increase the phase angle above 45°, which condition must be satisfied?
8. When the frequency of the voltage applied to a series RC circuit is decreased, the impedance
9. The power that is measured in volt-amperes is called
10. When the frequency of the voltage applied to a series RC circuit is increased, the phase angle
11. In a series RC circuit, when the frequency and the resistance are halved, the impedance
12. In a series RC circuit, the voltage across the resistance is?
    A. In phase with the source voltage
    B. In phase with the circuit current
13. In a series RC circuit, 10 V is measured across the resistor and 10 V is measured across the capacitor. What is the arms source voltage?
14. When R=Xo in RC circuit, the phase angle is?
15. A 10 kilo-ohm capacitive reactance equals 100 microsiemens capacitive susceptance. True or false?
16. In a purely capacitive circuit, the amount of energy converted to heat is proportional to the circuit's current. True or false?

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EXPERIMENT NO. 5

C = 36 μF

Aim: To measure the power and power factor by three ammeters method.

Objectives:

1) Find the power and power factor when only the low-wattage bulb is connected.
2) Find the power and power factor when only the high-wattage bulb is connected.
3) Find the power and power factor when both the bulbs are connected.

Circuit Diagram:

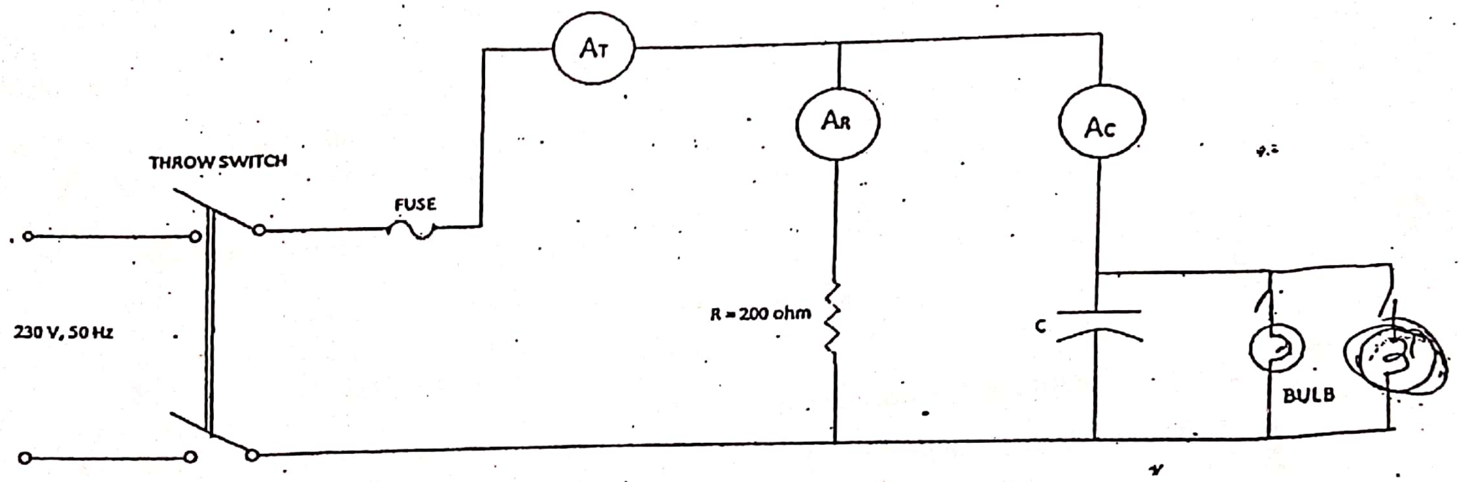


Figure 1

Theory:

The circuit used for the measurement of power in an AC circuit using three ammeters methods is shown in Fig. 1. In an AC circuit, power is given by the product of voltage, current and power factor. This method demonstrates that the power in a single phase AC circuit can be measured by using three ammeters method.

In the circuit diagram, A_T, A_C and A_R are the three ammeters and R is the non inductive resistance in parallel with the capacitor. There are two bulbs connected in parallel with the capacitor.
From Fig 2, we have

$$I_T^2 = I_R^2 + I_c^2 + 2 I_R I_C \cos\phi$$

$$\Rightarrow \cos\phi = \frac{\left(I_T^2 - I_R^2 - I_C^2\right)}{2 I_R I_C}$$

Power consumed by the load is

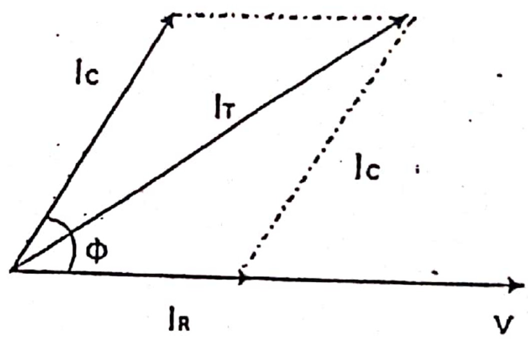
$$P_L = VI_C \cos\phi$$

$$\Rightarrow P_L = I_R R I_C \cos\phi$$

$$\Rightarrow P_L = \frac{\left(I_T^{\,2} - I_R^{\,2} - I_c^{\,2}\right)R}{2}$$

$Z = \sqrt{R^2 + X_C^2}$

$\cos\phi =$



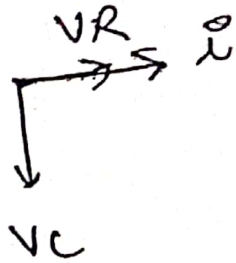


Figure 2: Phasor diagram of the above circuit.

The expected outcome of the experiment:

1. Note the values of capacitor and details of the bulbs.
2. Do the theoretical calculation to find the power in all three cases.
3. Compare the results with the experimental results.

I.R.

Apparatus Required:

Sl No	Item	Range	Maker's name	Maker's No	Quantity
1	Ammeter				
2	Capacitor				
3	Bulb				
4.	Rheostat				

Procedure:

NOTE: The value of R will vary from group to group. R for group-I = (100 + 5*I) Ω, I = 1 to 12.

1. Connect the circuit diagram as shown in Fig.1. Keep the switches of both the bulbs off.
2. Switch on the low-wattage bulb and take the reading of three ammeters.
3. Switch on the high-wattage bulb and take the reading of three ammeters.
4. Switch both the bulb and take the reading of three ammeters.

5. Calculate power and power factor for each load using above formulae.
6. Draw the vector diagram for each load.
7. Calculate the power factor from vector diagram.

Observation Table:

Sl. No.	I_T (A)	I_R (A)	I_C (A)	Power (Watt)	Power factor from	
					Calculation	Vector Diagram
1						
2						
3						

Results and Discussion:

Note: 1. Students should draw the phasor diagram for each case.
2. Compare the values between the experimental and analytical results.

The discussion should cover the following points:

1. Analytically results and experimental results are to be compared.
2. Discuss all possible causes for the difference in (1).
3. Causes of error during the experiment.
4. Precautions to be taken during the experiment.
5. Any other comments on the experiment, if required.

Conclusions:

PRECAUTIONS:

1. All the connections should be properly tightened.
2. The voltmeter and ammeter should be checked for their zero positions before connection.
3. The connections should be verified by the laboratory technician before switching the supply on.

Assessment questions:

1. In an AC circuit which power is more, apparent or real and why?
2. What is power factor?
3. What is the maximum value of power factor?
4. What is the difference between apparent power and real power?
5. What is reactive power?

6. What is leading and lagging power factor?
7. What will be the power factor when the capacitor is replaced by the inductor?
8. Can we calculate power factor removing the capacitor from the circuit?
9. How ammeter should be connected in the circuit and why?
10. Is there any other method known to calculate the power factor?
11. What is a throw switch? In this experiment which throw switch has been used?
12. Why power factor can't be more than unity?
13. What is Auto-transformer? What are the differences between autotransformer and DC voltage regulator?
14. What is the difference between Fuse and Switch?
15. What is the purpose of the bar connected between the double-pole of the single-throw switch?

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EXPERIMENT NO. 6

AIM: To calibrate a milliammeter as a voltmeter.

OBJECTIVES:

1. To know the basics of ammeter & voltmeter and their proper connections in electrical circuits.

2. To learn about the basics of calibration to use an ammeter as a voltmeter or vice-versa.

BASIC THEORY:

A voltmeter measures the voltage drop across resistance by putting it in parallel to the resistance as shown in Figure 1. The internal resistance of a voltmeter is quite high ($R_{mv} >> R_L$) and therefore, when connected in parallel, the current through the voltmeter is quite small ($I_v \approx 0$). This keeps the current I_r flowing through the resistance R_L almost the same value when the voltmeter was not connected. Hence, the voltage drop (I_rR_L) measured across the resistance by a voltmeter is also almost the same as the voltage drop without the voltmeter across the resistance. On the other hand, ammeter measures the current through resistance by connecting it in series with the resistance, Fig. 1. An ammeter has very low resistance ($R_{ma} \ll R_L$) and changes the effective resistance of the circuit only by a tiny amount ($R_L + R_{ma} \approx R_L$), not altering the original current by too much. Therefore, the current measured by the ammeter is about the same as without the ammeter in the circuit.

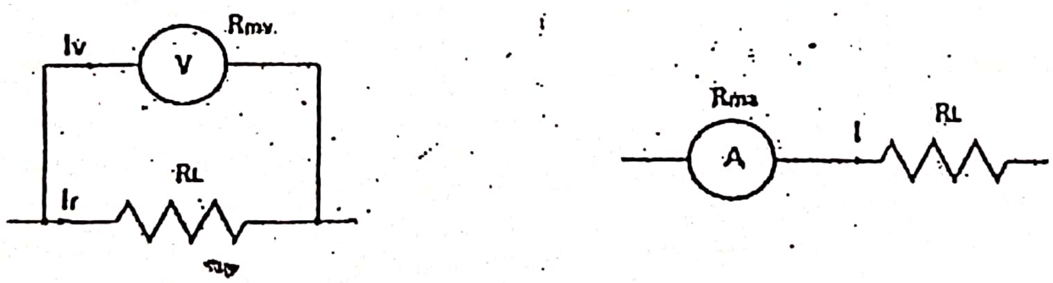

Figure 1. Schematic diagram of voltmeter and ammeter connections.

For calibration of a 500 mA milliammeter as the full-scale deflection of as a voltmeter, the internal resistance, R_m of the milliammeter is to be determined. To use it as a voltmeter of a full-scale deflection of 15 V (suppose), the external resistance, R_x to be connected in series with the ammeter is calculated as below:

The voltage across the ammeter, $V_A = I_A R_m$, where I_A is the full-scale ammeter current (500 mA in the present case).

$$R_X = (15 - V_A)/I_A \qquad (1)$$

R_X is called multiplier or bobbin.

Now, connecting R_X in series with the ammeter, the combination is to be connected in parallel with a voltmeter as shown in circuit diagram for calibration purpose.

CIRCUIT DIAGRAM:

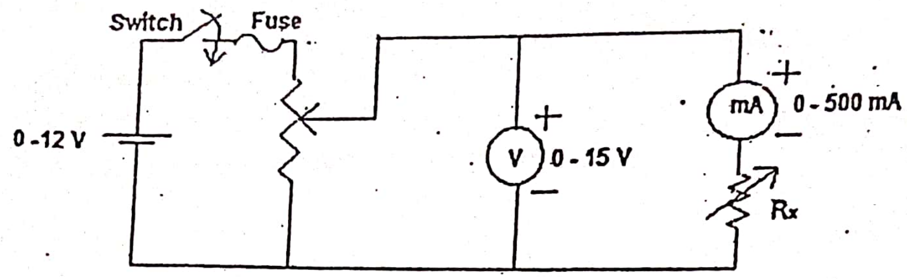

Figure 2. Circuit diagram for calibration of a milliammeter as a voltmeter.

APPARATUS REQUIRED:

Sl No.	Name of apparatus	Range	Make	Make No.	Quantity
1.	Power supply				
2.	Ammeter				
3.	Voltmeter				
4.	Rheostat				

PROCEDURE:

1. Determine the internal resistance R_m of the milliammeter. To determine the ammeter resistance, use the circuit shown in Fig. 3. Let R_m be the internal resistance of the ammeter, then the current flowing through the ammeter is $I = E/(R + R_m)$, where E is the input voltage. The voltage drop across R is V_r and the current is $I_r = V_r/R$. Since $I = I_r$, the ammeter resistance R_m is obtained as,

$$Rm = ((E - Vr)R)/Vr \qquad (2)$$

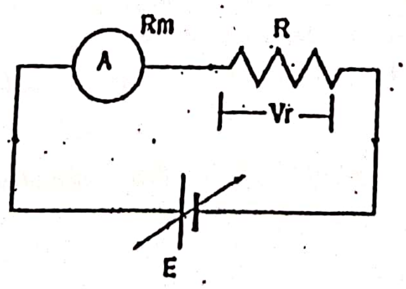

Figure 3. Circuit for determination of ammeter resistance.

2. Make connections as shown in the circuit diagram (Fig. 2).
3. Decide the range of scale for the voltmeter for calibration.
4. Calculate the R_X using equation number 1.

5. Take the readings from maximum towards minimum for entire scale of the milliammeter.

OBSERVATION TABLE:

Sl No.	V	I_A	K_{eq}	V_{eq}	%Error
1.					
2.					
3.					

$$K_{eq} = (V_1/I_{A1} + V_2/I_{A2} + V_3/I_{A3} + V_4/I_{A4} + \ldots + V_n/I_{An}) / n \quad (3)$$

$$V_{eq1} = K_{eq} \times I_{A1},\ V_{eq2} = K_{eq} \times I_{A2},\ V_{eq3} = K_{eq} \times I_{A3}, \ldots \quad (4)$$

$$\%Error = ((V_{eq} - V) / V) \times 100 \quad (5)$$

RESULTS AND DISCUSSION:

Note: 1. Students should draw the plot of I_A vs. V on a graph sheet and get the value of K_{eq} from the plot.

The discussion should cover the following points:

1. Analytically results and experimental results are to be compared.
2. Discuss all possible causes for the difference in (1).
3. Causes of error during the experiment.
4. Precautions to be taken during the experiment.
5. Any other comments on the experiment, if required.

CONCLUSIONS:

PRECAUTIONS:

1. All the connections should be properly tightened.
2. The voltmeter and ammeter should be checked for their zero positions before connection.
3. The connections should be verified by the laboratory technician before switching the supply on.

ASSESSMENT QUESTIONS:

1. Why the voltmeter has to be connected in parallel with the load? Justify.
2. Why the ammeter has to be connected in series with the load? Justify.
3. Why should we add a high resistance in series to use an ammeter as a voltmeter?
4. What is the lowest resistance of the rheostat to prevent damage and why?
5. To increase the measuring range of the voltmeter what should we do?
6. What is multiplier?
7. How many types of voltmeter available?
8. What is the difference between AC Voltmeter and DC Voltmeter?
9. What are the properties required in the material used for rheostats?
10. What are the materials used for rheostat?

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EXPERIMENT NO ~~3~~ 7

›jective – To verify Reciprocity Theorem

›paratus Required –

N	Name of the apparatus	Type	Range	Quantity
	Power Supply			
	Rheostat			
	Ammeter			

·ief Theory –

For a linear bilateral network contalnlng generators and Impedances , the ratio of a ›ltage "V" introduced in one branch to current "I" produced in another branch is the same as ıe ratio of voltage and current obtalned if the positlon of voltage sources "V" and the ırrent measured are Interchanged .

To illustrate the reciprocity theorem let voltage "V" in Fig. 1.1 produce a current "I_3" In ıe branch having Impedance "Z_3". In Flg. 1.2 we just Interchange the voltage source and nmeter.

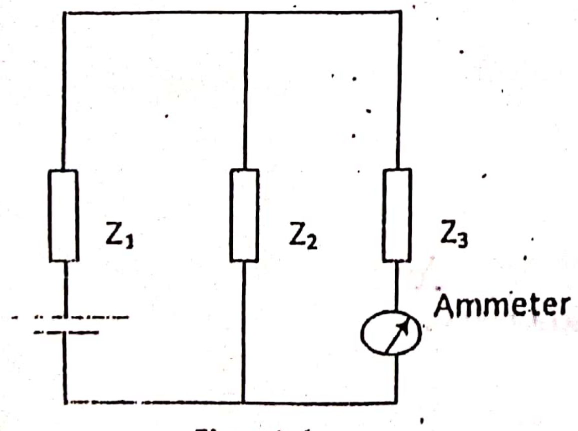
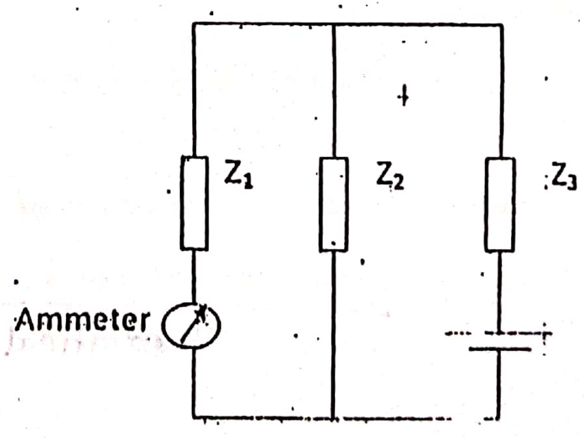


Fig – 1.1



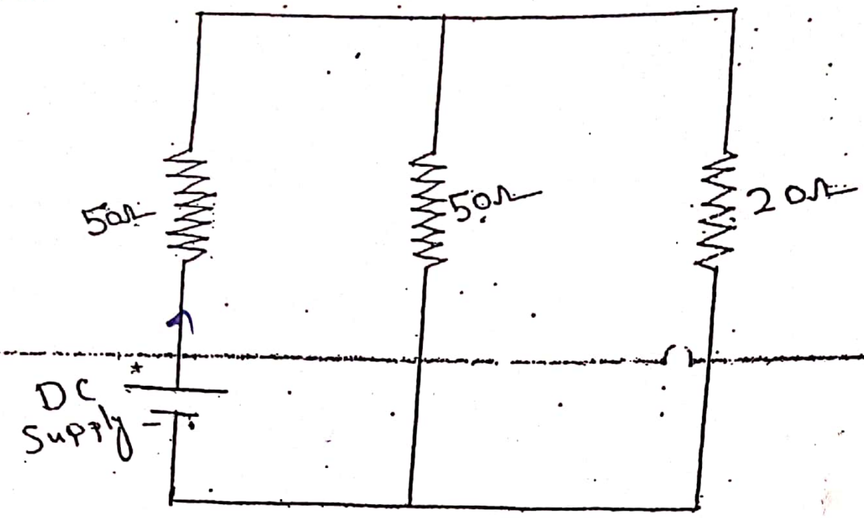
Flg – 1.2

As per Reclprocity Theorem

$$\frac{V}{I3} = \frac{V}{I1}$$

i.e $I_3 = I_1$

Circuit Diagram



Procedure

1) The connentions are made as shown in fig. 2
2) Ammeter is connected in series with 20 Ω Rheostat .
3) Take the reading of that Ammeter supplying 12V DC Supply.
4) Now interchange the position of power supply and ammeter . Note down the readings of ammeter for 12V supply.
5) Repeat the same procedure for 5V also.

Theoritical Calculation –

Find theoriticaly the current obtained from the scheme as shown in the figure for both 12V and 5V DC Supply.

Also find the corresponding % error using the formula

$$\% \text{ error} = \frac{(\text{Theoritical Calculation} - \text{Practical Calculation})}{\text{Theoritical calculation}} \times 100$$

Conclusion-

Observations and Results:

S.No	When $I_2=0$			A	C	When $V_2=0$			B	D
	V_1	I_1	V_2			V_1	I_1	I_2		
Average										

Comments and discussions on results:

SL NO.	Voltage (V)	Current I_1	I_2	% error

EXPERIMENT NO 0 8

Objective

To measure the supply frequency using series Resonant circuit.

Brief Theory

Resonance in series circuit

We know that in a series R-L-C, total Impedance $Z = \sqrt{[R^2 + (X_L - X_C)^2]}$

Where $X_L = \omega L = 2\pi fL$ and $X_C = \{1/\omega C\} = 1/(2\pi fC)$

If for some frequency of the applied voltage, $X_L = X_C$ (in magnitude), then $Z = R$. Then voltage $V_L = V_C$ are therefore, equal in magnitude but opposite in direction. Hence, they cancel each other and net voltage acting in the circuit is V_R, which is equal to the supply voltage V. The two reactances taken together act as a short circuit and net voltage across them is zero. The current I in the circuit at this stage will be maximum being equal to V/Z, where Z is equal to R. The frequency at which X_L becomes equal to X_C is called resonant frequency f_0 and the phenomenon is called series resonance.

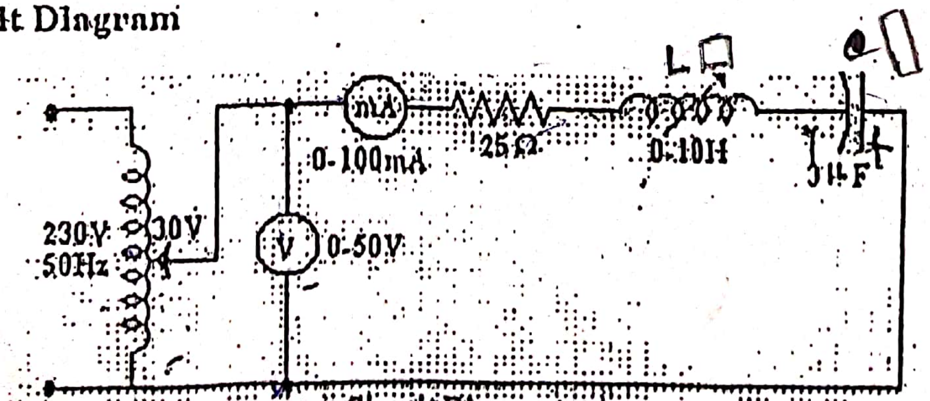
The resonant frequency is $f_0 = 1/[2\pi\sqrt{(LC)}]$

Apparatus Used

Sl No	Name of the apparatus	Range	Make	Make No.	Quantity
1	Supply source	0 – 30V, AC			1
2	Ammeter	0 – 100mA			1
3	Voltmeter	0 – 50V			1
4	Resistance	25 Ω			1
5	Inductance	0 – 10H			1
6	Capacitance	3μF			1

NOTE: Students should fill up the apparatus table at the time of experiment.

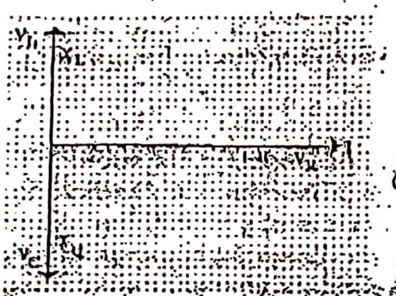
Circuit Diagram



Circuit Diagram

Procedure:

1. Connect the circuit as shown in figure.
2. Keep supply voltage constant at 30V.
3. Keeping the value of capacitance constant, increase the value of inductance stepwise.
4. Note down the different readings of ammeter.



Observation Table

Sl No	Ammeter value (mA)	C in µF	L in H	Value of L at I_{max} Current (H)	f_0 in Hz
1					
2					
3					
4					
5					

Results

NOTE: 1. Students should write the results of the experiment.

Discussion

Discussion should cover the following points:

1. Analysis the circuit and find out the values analytically and compare the result obtained from the experiment.
2. The percentage of error in the experiment with the analytical value.
3. Causes of error during experiment.
4. Precautions to be taken during experiment.
5. Any other comments on the experiments.