DEPARTMENT OFAPPLIED SCIENCES AND HUMANITIES

LAB MANUAL

BASIC ELECTRICAL ENGINEERING (REE-151/REE-251)

Branch - CSE/IT/EE/ME/ECE/CE
B.Tech - First Year

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Basic Electrical Engineering Lab REE-151/REE-251

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EXPERIMENT NO. – 1

AIM: To Verify KCL and KVL.

APPARATUS REQUIRED:

S. No.	Item Description	Specification	Quantity
1	Regulated D.C. Power Supply	0-15V,1A	1
2	Bread Board		1
3	Carbon Resistances	1K, 2K, 5K, 10K etc.	5
4	M.C. Voltmeter (Digital Multimeter)	0-10V	3
5.	M.C. Ammeter (Digital Multimeter)	0-50mA	3
6.	Connecting leads		As per Requirement

CIRCUIT DIAGRAM:

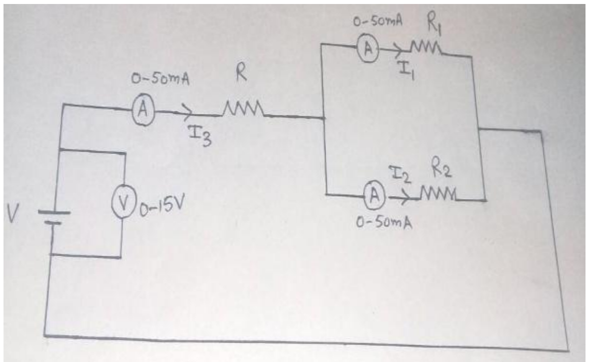


Figure 1

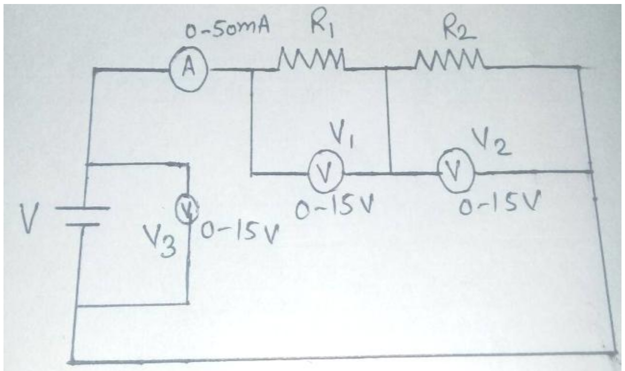


Figure 2

THEORY:

KCL: It states that at any instant of time the algebraic sum of currents meeting at a junction of conductors is zero. Mathematically, at a junction $\Sigma I=0$. Kirchoff's current law can also be stated as: the algebraic sum of incoming currents is equal to the algebraic sum of outgoing currents meeting at a junction. This law is illustrated in Figure 3.

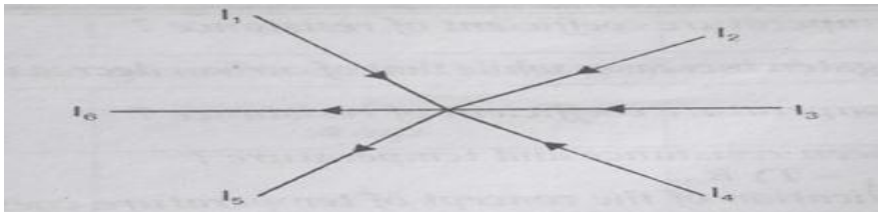


Figure 3: Illustration of Kirchoff's Current Law

There are six currents I_1, I_2, I_3, I_4, I_5, I_6 meeting at a junction. Assuming that the currents entering into the junction as positive and the currents leaving the junction as negative, we can take the algebraic sum of these six currents and equate it to zero:

$$I_1 + I_2 + I_3 + I_4 - I_5 - I_6 = 0$$

Alternatively we can write KCL as the sum of currents flowing towards the junction is equal to the currents flowing away from the junction.

$$I_1 + I_2 + I_3 + I_4 = I_5 + I_6$$

Kirchoff's Current law is nothing more than a restatement of principle of conservation of charge. Since the accumulation of electric charge is not possible, the amount of charge leaving the junction entering at a junction at an instant must be same as that the amount of charge leaving the junction.

KVL: It states that at any instant of time, the algebraic sum of voltages around a closed circuit or a loop is zero i.e. $\Sigma E=0$. Kirchoff's Voltage law can also be stated as: In any closed circuit, the algebraic sum of product and resistance in each of the conductor is equal to the algebraic sum of emfs of batteries. To apply KVL first mark the polarity of the voltage across element. In a resistance, the polarity depends upon the assumed direction of current. As shown in Figure 4 the end into which current enters is marked positive, the end from which current leaves is marked negative. Note that the polarity of the voltage (emf) across a battery does not depend upon the assumed direction of current flowing through the circuit.

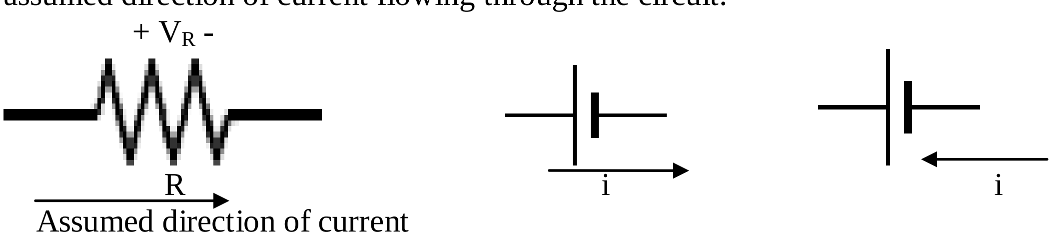


Figure 2

PROCEDURE:

For KCL

1. Make the circuit diagram as in Figure 1.
2. Switch on the supply. Set input Voltage.
3. Note down the readings of ammeters and voltmeters.
4. Either change the input voltage or change the resistances.
5. Repeat step 3 for several times.
6. Switch off the D.C. Supply.

For KVL

1. Make the circuit diagram as in Figure 2.
2. Switch on the supply. Set input voltage.
3. Note down the readings of ammeters and voltmeters.
4. Either change the input voltage or change the resistances.
5. Repeat step 3 for several times.
6. Switch off the D.C. Supply.

OBSERVATION TABLE 1 for KCL:

S. No.	Voltage (V)	Current I_1 (mA)	Current I_2 (mA)	Current I_3 (mA)	Current $I_3 = (I_1 + I_2)$ mA
1					
2					
3					
4					

OBSERVATION TABLE 2 for KVL:

S. No.	Current I (mA)	Voltage (V_1)	Voltage (V_2)	Voltage (V_3)	Voltage $V_3 = (V_1 + V_2)$ V
1					
2					
3					
4					

CALCULATIONS:

1. Add the currents I_1 and I_2 recorded in column 3 and 4 in Table 1 and record the same in the last column of this table. Check that the current I_3 of column 5 agrees with the currents **$(I_1 + I_2)$** recorded in the last column of the table.
2. Add the currents V_1 and V_2 recorded in column 4 and 5 in Table 2 and record the same in the last column of this table. Check that the current V_3 of column 6 agrees with the currents **$(V_1 + V_2)$** recorded in the last column of the table.

RESULT:

1. As the Current **I_3** and **(I_1+I_2)** are equal as shown in table 1. Hence KCL is verified.
2. As the Voltage **V_3** and **$(V_1 +V_2)$** are equal as shown in table 2. Hence KVL is verified.

PRECAUTIONS:

1. All the connections must be tight.
2. Before connecting the instruments, Check their zero readings.
3. The direction of current and voltages should be identified correctly.
4. At no instant of time reading in the ammeter should not exceed the rating of resistances.

VIVA VOCE QUESTIONS WITH ANSWERS

Q1. Is the Kirchoff's current law applicable to a.c. circuits too?

Ans. Yes, Kirchoff's current law is applicable to a.c. circuit too. In case of a.c circuits we should consider the phasor sum rather than algebraic sum.

Q2. In what respect Kirchoff's laws are better than Ohm's law.

Ans. Using Ohm's law simple series and parallel circuits can be solved. If we have a Complicated circuit containing a number of elements, voltage sources and current sources, nodes and meshes Kirchoff's laws can be used to solve it efficiently.

Q3. What is the difference between a mesh and a loop?

Ans. A loop is any closed path of a network. However, a mesh is also a loop cannot be further subdivided in other loops.

Q4. Define the term loop?

Ans. A loop is a closed path in the circuit. This means if you start from one point in the circuit, it should be possible to come back to the same point traversing along the different branches of circuit without repeating any branch.

EXPERIMENT NO. – 2

AIM: To Verify Superposition Theorem.

APPARATUS REQUIRED:

S. No.	Item Description	Specification	Quantity
1	Regulated D.C. Power Supply	0-30V,1A	2
2	Bread Board		1
3	Carbon Resistances	1K, 2K, 5K	3
4	M.C. Voltmeter (Digital Multimeter)	0-15V	2
5	M.C. Ammeter (Digital Multimeter)	0-50mA	1
6	Connecting Leads		As per requirement

CIRCUIT DIAGRAM:

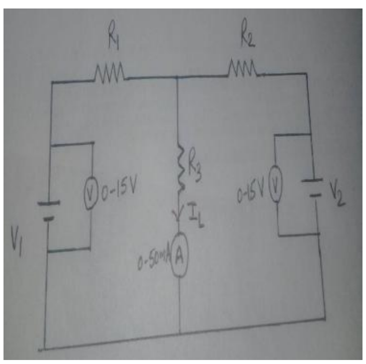


Figure 1

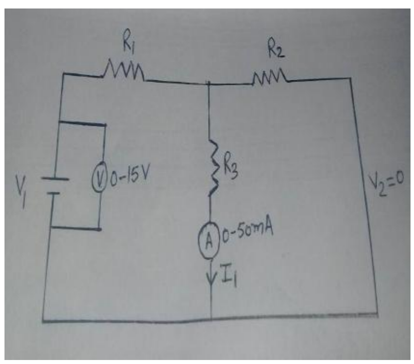


Figure 2

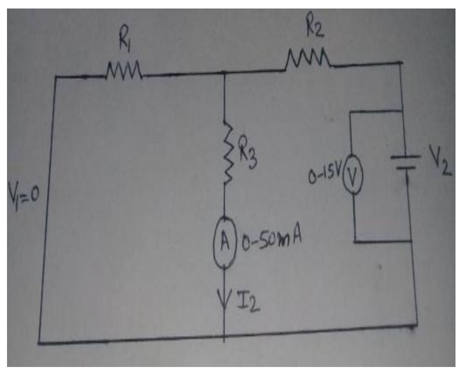


Figure 3

THEORY:

According to superposition theorem if there are two or more than two sources of e.m.f.s (or energy) acting simultaneously in a linear bilateral network then the current flowing through any section is equal to the algebraic sum of all the currents which would flow in the section if each source of e.m.f. (or energy) acting separately and all other sources are replaced by their internal resistances.

PROCEDURE:

1. Make the circuit diagram as shown in Figure 1.
2. Set the voltage V_1 and V_2. Note down the current flowing through the ammeter. This gives load current I_L.
3. Now make the circuit diagram as shown in figure 2. In this case supply voltage V_2 is replaced by its internal resistance.
4. Note down the value of current through the ammeter. This gives current I_1.
5. Now make the circuit diagram as shown in figure 3. In this case supply voltage V_1 is replaced by its internal resistance.
6. Note down the value of current through the ammeter. This gives current I_2.
7. As observed the direction of current I_1 and I_2 are same. Hence add these currents.

OBSERVATION AND CALCULATIONS:

For Figure 1

S. No.	Voltage V_1 (V)	Voltage V_2 (V)	Current I_L (mA)

For Figure 2

S. No.	Voltage V_1 (V)	Voltage V_2 (V)	Current I_2 (mA)

For Figure 3

S. No.	Voltage V_1 (V)	Voltage V_2 (V)	Current I_2 (mA)

$$I_L = I_1 + I_2$$

PRECAUTIONS:

1. All the connections must be checked before switch on the power supply.
2. Reading must be noted carefully.
3. The direction of current must be noted carefully.
4. Before connecting the instruments check their zero reading.
5. The direction of current and voltage should be identified correctly.

RESULT: Superposition theorem is verified.

VIVA VOCE QUESTIONS WITH ANSWERS

Q1. Define Superposition Theorem.

Ans. According to superposition theorem if there are two or more than two sources of e.m.f.s (or energy) acting simultaneously in a linear bilateral network then the current flowing through any section is equal to the algebraic sum of all the currents which would flow in the section if each source of e.m.f. (or energy) acting separately and all other sources are replaced by their internal resistances.

Q2. What are the limitations of superposition theorem?

Ans. 1. At least two sources are required to solve.
2. It is time consuming.
3. It is lengthy process as the numbers of sources are more.
4. Circuit must be linear and bilateral.

Q3. Is superposition theorem is applicable to a.c. circuits too?

Ans. Yes, Superposition theorem is applicable to a.c. circuits too. Instead to algebraic sum phasor sum is used.

Q4. Can superposition theorem be applied to non-linear network? Why?

Ans. No, superposition theorem cannot be applied to non-linear network because the principle of superposition is not applicable to non-linear quantities.

Q5. What is a bilateral circuit element?

Ans. A circuit which behaves in exactly same manner if connected in the reverse order is said to be bilateral.

EXPERIMENT NO. – 3

AIM: To Verify Thevenin's Theorem.

APPARATUS REQUIRED:

S. No.	Item Description	Specification	Quantity
1	Regulated D.C. Power Supply	0-30V,1A	1
2	Bread Board		1
3	Carbon Resistances	1K, 2K,5K, 10K	4
4	M.C. Voltmeter (Digital Multimeter)	0-15V	1
5.	M.C. Ammeter (Digital Multimeter)	0-50mA	1
6.	One Way Key		1`
7.	Connecting leads		As per requirement

CIRCUIT DIAGRAM:

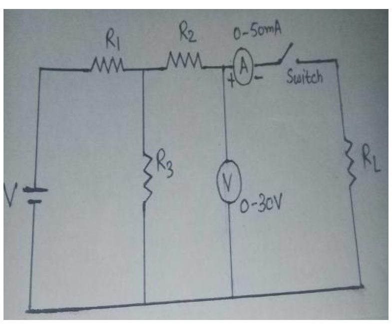


Figure A

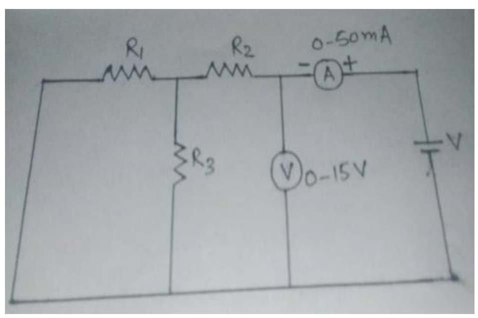


Figure B

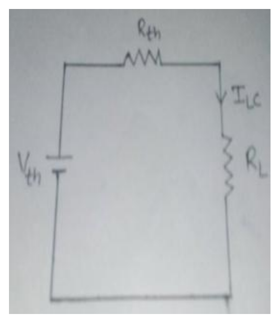


Figure C

THEORY:

This theorem states that the current flowing through a resistance connected across any two terminals of a active, linear bilateral network then the whole network is converted into an equivalent voltage source having voltage V_{th} with a resistance connected in series R_{th}.
Where V_{th} is the open circuit voltage between the selected terminals when they are open circuited. It is called Thevenin's Voltage (V_{OC} or V_{th})
R_{TH} it is the equivalent resistance of the network as seen from selected terminals when all other sources are replaced by their internal resistances. It is called Thevenin's Resistance.

$$I_{LC}= V_{th}/ (R_{TH} +R_L)$$

PROCEDURE:

1. Make the circuit diagram as shown in Figure A.
2. Switch on the supply. Keep the Switch S closed, note down the reading of Ammeter (I_L) and voltmeter (V_L). This gives load current I_L and value of load resistance $R_L = V_L/I_L$.
3. Next open the load resistance (When the switch S open). Note down the reading of voltmeter. This gives open circuit voltage V_{OC} or V_{th}.
4. Next connect the circuit as shown in Figure B. Note down the readings of voltmeter and ammeter. This gives value of R_{TH}.
5. Switch off the supply.

OBSERVATIONS:

The observations made in the experiments are recorded as under:

1. When switch is closed (from step 2 of procedure)

   I_L=..................mA, V_L=...................V

2. When switch is open (from step 3 of procedure)

   V_{OC} or V_{th} = ...Volts

3. From step 4 of procedure

   V=.........................Volts, I=................................mA

CALCULATIONS:

1. $R_L = V_L/I_L$ (From observation first)
2. $R_{TH} = V/I$ (From observation third)
3. $I_{LC} = V_{th}/(R_{TH} + R_L)$

PRECAUTIONS:

1. All the connections must be checked before switch on the power supply.
2. Reading must be noted carefully.
3. The direction of current must be noted carefully.
4. Before connecting the instruments check their zero reading.

RESULT: The actual value of the load current I_L (From observation first) and the calculated Value of load current I_{LC} (From calculation third) are equal. Hence Thevenin's Theorem is verified.

VIVA VOCE QUESTIONS WITH ANSWERS

Q1. State Thevenin's Theorem.

Ans. This theorem states that the current flowing through a resistance connected across any two terminals of a active, linear bilateral network then the whole network is converted into an equivalent voltage source having voltage V_{th} with a resistance connected in series R_{th}.

Q2. Define V_{th}.

Ans. V_{th} is the open circuit voltage between the selected terminals when they are open circuited. It is called Thevenin's Voltage (V_{OC} or V_{th})

Q3. Define R_{th}.

Ans. R_{th} it is the equivalent resistance of the network as seen from selected terminals when all other sources are replaced by their internal resistances. It is called Thevenin's Resistance.

Q4. Do you know another network theorem which serves a similar purpose as that of Thevenin's theorem?

Ans. Yes, it is Norton's Theorem.

Q5. Why do we use Network theorems and techniques to solve electrical circuits?

Ans. Network theorems are used to solve electrical circuits because of following advantages:

i) A complicated network can be reduced to its simplest form.

ii) Many times we don't need current in all the branches of a network. Rather we are interested only in current through a particular branch or voltage across a particular branch only. In such case solving the network fully using Kirchoff's laws is time consuming exercise which may not be advisable at least for large networks. Network theorems are then used to an advantage in such cases.

EXPERIMENT NO. – 4

AIM: To Verify Maximum Power Transfer Theorem in D.C. Circuit.

APPARATUS REQUIRED:

S. No.	Item Description	Specification	Quantity
1	Regulated D.C. Power Supply	0-15V,1A	1
2	Bread Board		1
3	Carbon Resistances	1K,2K,5K,10K etc	10
4	M.C. Voltmeter (Digital Multimeter)	0-15V	2
5.	M.C. Ammeter (Digital Multimeter)	0-50mA	1
6.	Connecting leads		

CIRCUIT DAIGRAM:

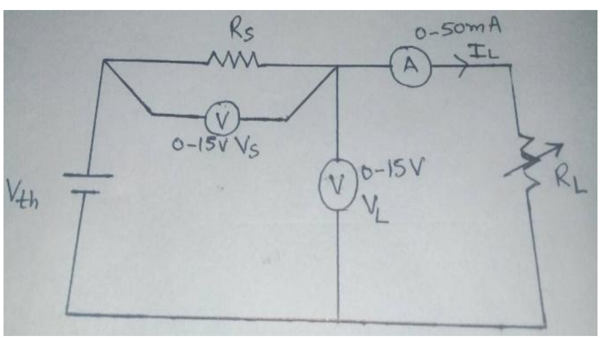


Figure 1

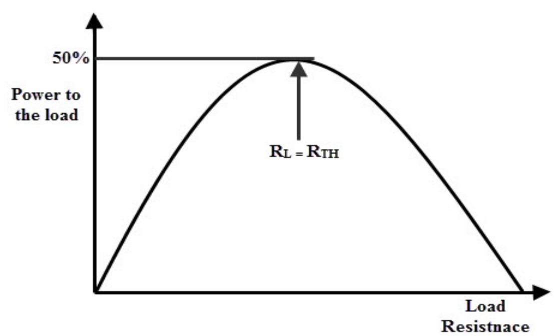


Figure 2

THEORY:

According to maximum power transfer theorem as applied to D.C. network, a resistive load will abstract maximum power from a network when the load resistance is equal to the resistance of the network as viewed from the output terminals, with all energy sources replaced by their internal resistances i.e. Thevenin's equivalent resistance R_{TH}.

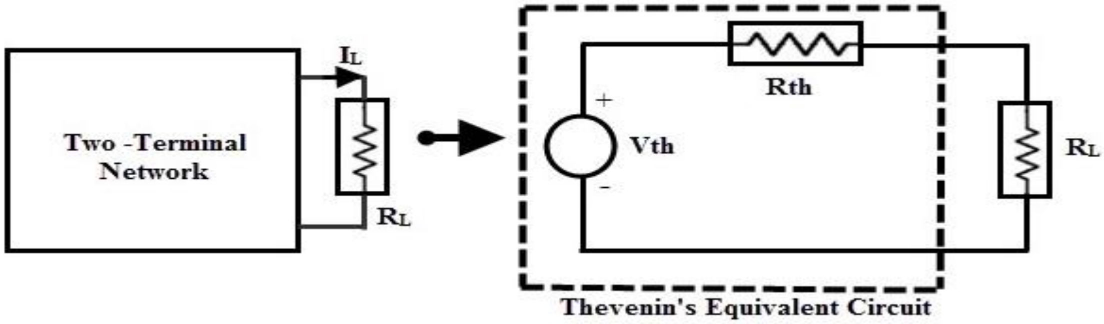


Figure 3

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

The power absorbed by the load is

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

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

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

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

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

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

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

PROCEDURE:

1. Make the circuit diagram as shown in Figure 1.
2. R_S is fixed value, load resistance R_L is kept Maximum.
3. Note down the readings of ammeter and Voltmeters.
4. Reduce the Load resistance in steps and each time ammeter and voltmeter readings are noted.
5. Repeat the step 2, 3 and 4 for different values of Rs.

OBSERVATION AND CALCULATION TABLE

S. No.	V_S (Volt)	V_L (Volt)	I_L(mA)	$R_S = V_s/I_L$ (KΩ)	$R_S = V_L/I_L$ (KΩ)	$P_L = V_L I_L$(W)
1						
2						
3						
4						
5						
6						
7						
8						
9						

PRECAUTIONS:

1. All the connections must be checked before switch on the power supply.
2. Reading must be noted carefully.
3. The direction of current must be noted carefully.
4. Before connecting the instruments check their zero reading.

RESULT and CONCLUSION:

From the last column of calculation table the value of R_L for which power, P is maximum should be chosen and compared with the value of R_S. These should come out to be the same. Hence the maximum power transfer theorem verified.

VIVA VOCE QUESTIONS WITH ANSWERS

Q1. Define Maximum power transfer theorem in case of D.C. circuit.

Ans. A resistive load will abstract maximum power from a network when the load resistance is equal to the resistance of the network as viewed from the output terminals, with all energy sources replaced by their internal resistances i.e. Thevenin's equivalent resistance R_{TH}.

Q2. What is the maximum efficiency of maximum power transfer theorem?

Ans. Maximum efficiency of maximum power transfer theorem is 50%.

Q3. What is formula for maximum power transfer theorem?

Ans. $P_{max} = Vth^2/4R_L$

Q4. In maximum power transfer theorem which resistance has to be varying R_{th} or R_L?

Ans. R_L

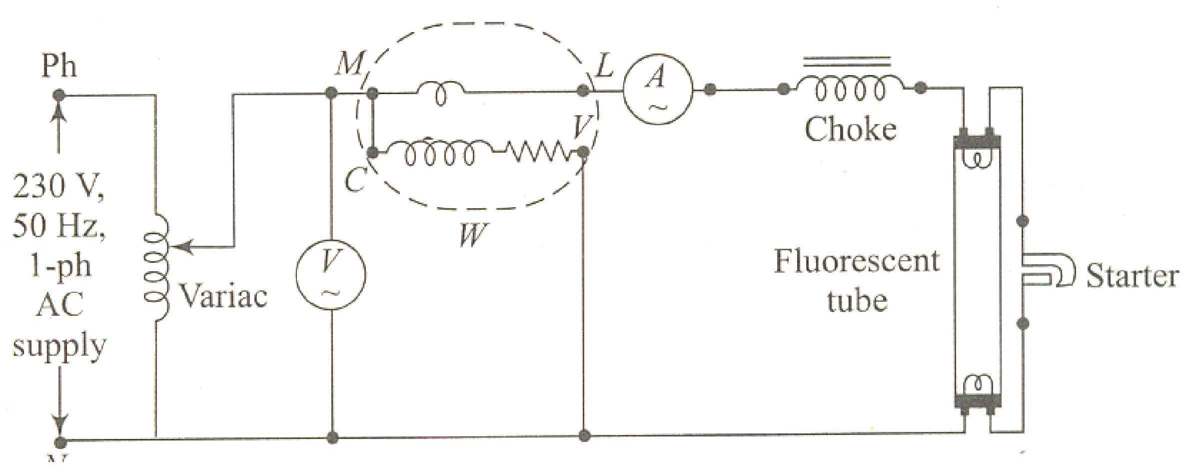
EXPERIMENT NO. – 5

AIM: Connection and measurement of power consumption of a fluorescent lamp.

APPARATUS REQUIRED

S. No.	Item Description	Specification	Quantity
1	M.I. Ammeter	0-2A	1
2	M.I. Voltmeter	0-300 V	1
3	Dynamometer Type Wattmeter	230V/5A	1
4	Choke	40W, 230 V	1
5	Starter Glow Type	230V, 50Hz	1
6	Fluorescent Tube	40W, 230V, 50Hz	1
7	Single Phase Auto Transformer	230/0-270V, 8A	1
8	Connecting Wires	$1mm^2$	As per Requirement

CIRCUIT DIAGRAM:



THEORY:

A fluorescent lamp or a fluorescent tube is a low weight mercury vapour lamp that uses fluorescence to deliver visible light. An electric current in the gas energizes mercury vapour which delivers ultraviolet radiation through discharge process which causes a phosphor coating of the lamp inner wall to radiate visible light. A fluorescent lamp changes over electrical vitality into useful light a great deal more proficiently than incandescent lamps. The normal luminous

Visibility of fluorescent lighting frameworks is 50-100 lumens for every watt, a few times the adequacy of incandescent lamps with equivalent light yield.

Working of Fluorescent Tube Light

- When the switch is ON, full voltage will come across the tube light through ballast and fluorescent lamp starter. No discharge happens initially i.e. no lumen output from the lamp.
- At that full voltage first the glow discharge is established in the starter. This is because the electrodes gap in the neon bulb of starter is much lesser than that of inside the fluorescent lamp.
- Then gas inside the starter gets ionized due to this full voltage and heats the bimetallic strip that is caused to be bent to connect to the fixed contact. Current starts flowing through the starter. Although the ionization potential of the neon is little bit more than that of the argon but still due to small electrode gap high voltage gradient is appeared in the neon bulb and hence glow discharge is started first in starter.
- As voltage gets reduced due to the current causes a voltage drop across the inductor, the strip cools and breaks away from the fixed contact. At that moment a large Ldi/dt voltage surge comes across the inductor at the time of breaking.
- This high valued surge comes across the tube light electrodes and strike penning mixture (mixture argon gas and mercury vapour).
- Gas discharge process continues and current gets path to flow through the tube light gas only due to low resistance as compared to resistance of starter.
- The discharge of mercury atoms produces ultraviolet radiation which in turn excites the phosphor powder coating to radiate visible light.
- Starter gets inactive during operation of tube light.

PROCEDURE:

1. Do the connection as per the circuit diagram.
2. Keep the variac in the zero position and switch on the power supply.
3. Increase the variac voltage slowly until the fluorescent tube flickers and glows. Measure the current, voltage, and power.
4. Take another 4 sets of ammeter, voltmeter, and wattmeter reading at different positions of variac while the tube is glowing.
5. Record the reading in observation table.
6. Switch off the power supply.

OBSERVATION TABLE:

S. No.	Voltmeter Reading(V)	Ammeter Reading(A)	Wattmeter Reading(W)	Power Factor

CALCULATION:

(I) Power Factor, Cos ϕ= W/VI.
(II) Calculate mean power factor.

CONCLUSION:
From the above experiment we have learnt how to connect the fluorescent lamp and measured the power of fluorescent lamp and power factor.

VIVA VOCE QUESTIONS WITH ANSWERS

Q1. What is the function of choke in fluorescent tube light?
Ans. Firstly, it induces a high emf across the fluorescent tube to start the discharge in the tube. Secondly, it limits the discharge current to a safe value. Finally, it makes the output of the tube more uniform during voltage fluctuations of the supply system.

Q2. What is the function of starter in the fluorescent tube light assembly when the fluorescent tube is working?
Ans. In fact the starter is thrown out of the circuit while the fluorescent tube light is working; it has no function at all. The starter can even be taken out from the assembly without effecting the functioning of the fluorescent tube light. Starter performs its function only in switching on the fluorescent tube light.

Q4. Name the two types of starter used in fluorescent tube light.
Ans. Glow type starter, Thermal starter

Q5. What are the drawbacks of fluorescent tube light?
Ans. Radio interference, stroboscopic effect

Q6. In a glow type starter used with fluorescent tubes, the contact between electrodes is open or close?
Ans. The contact between electrodes of a glow type starter used with fluorescent tube light is open.

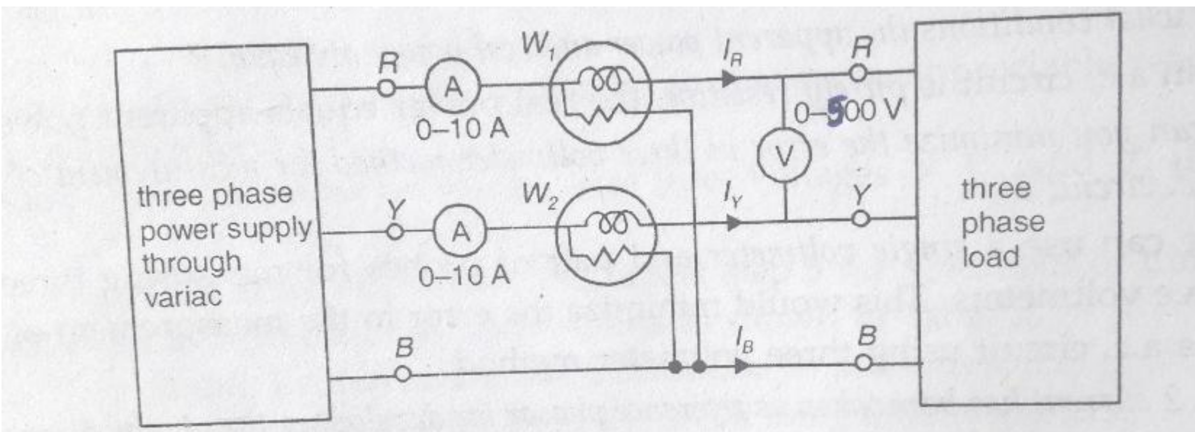
EXPERIMENT NO. – 6

AIM: Measurement of power in 3-phase circuit by two wattmeter methods and determination of its power factor for star connected load.

APPARATUS REQUIRED:

S. No.	Item Description	Specification	Quantity
1	3-Phase Variac	415/0-470V, 15A	1
2	Variable 3-Phase Resistive Load	5.25KW, 415V, 7A	1
3	M.I. Ammeter	0-10A	2
4	M.I. Voltmeter	0-500V	1
5	Wattmeter	5/10A, 150/300/600V	2
6	Connecting Wires	PVC 1.5mm^2	As per requirement

CIRCUIT DIAGRAM:



THEORY: The sum of the two wattmeter readings is equal to √3 times of the phase voltage and line voltage ($\sqrt{3}V_LI_L\,Cos\phi$) which is the actual power consumed in a 3 phase balanced load and power factor of the load is given by

$P = W_1+W_2 = \sqrt{3}V_LI_L\,Cos\phi$

$$cos\emptyset = \cos tan^{-1}\sqrt{3}\frac{W_1 - W_2}{W_1 + W_2}$$

OBSERVATION AND CALCULATION TABLE:

S. No.	Current I (Amp)	Voltage V(Volts)	Wattmeter W_1(Watts)	Wattmeter W_2 Watts)	Input Power = W_1+ W_2 (Watts)	tanϕ	Cosϕ
1							
2							
3							
4							

PRECAUTIONS:

1. All the connections must be tight.
2. Reading must be noted carefully.
3. If one of the wattmeter gives negative reading then change the connection of current coil/potential coil. This reading will be noted as negative.
4. Always check the connections of current coil and potential coil whenever connect the wattmeter in the circuit i.e. current range and voltage range of the wattmeter.
5. Before perform the experiment ensure that variac is at minimum position and load is off.

VIVA VOCE QUESTIONS WITH ANSWERS

Q1. What do mean by term phase sequence in reference to three phase circuit?

Ans. Phase sequences in 3-phase circuited means the order in which the individual phase voltage attain their respective maximum positive values.

Q2. What is phase sequence of a 3-phase system in general?

Ans. Generally the phase sequence of a three phase system is R, Y, B.

Q3. How many coils are there in single phase wattmeter?

Ans. There are two coils in the wattmeter. One is known as current coil and another is known as potential coil.

Q4. What would be the readings of two wattmeter's if load is purely reactive?

Ans. In case of purely reactive load the real power is zero.

We know that the real power is given by W_1+W_2.

i.e. $W_1+W_2 = 0$

or $W_1 = -W_2$

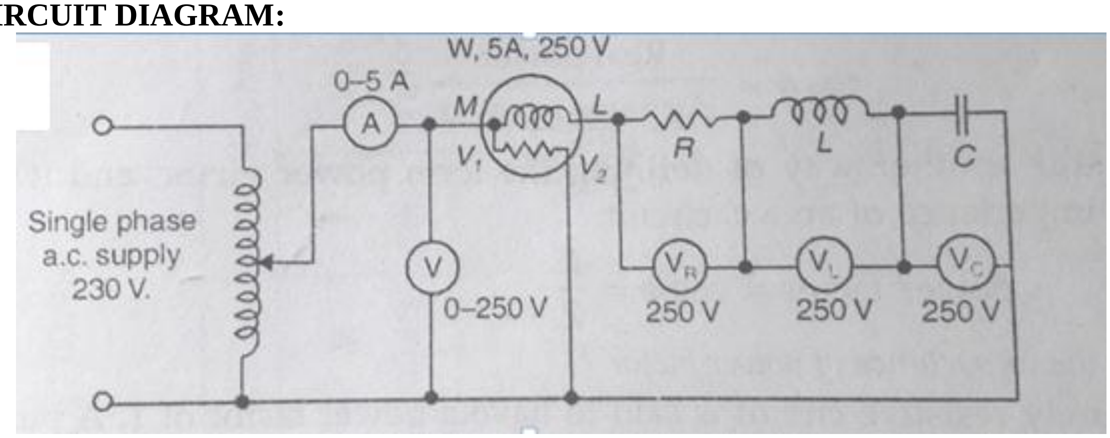
EXPERIMENT NO. – 7

AIM: Determination of parameters of ac single phase series RLC circuit.

APPARATUS REQUIRED:

S. No.	Item Description	Specification	Quantity
1	Single Phase Auto transformer	230/0-270V, 8A	1
2	Rheostat	150Ω, 2A	1
3	Choke Coil		1
4	Capacitor	15 µF	1
5	M.I. Voltmeter	0-300V	3
6	M.I. Ammeter	0-5/10A	1
7	Dynamometer Type Wattmeter	5A/300V	1
8	Connecting leads	PVC 1mm^2	As per requirement

CIRCUIT DIAGRAM:



THEORY:

In this experiment, we are mainly interested in verification of Kirchhoff's voltage law for AC circuit. When an A.C. voltage (RMS) is applied to RLC series circuit as shown in circuit diagram of series circuit, it establishes RMS current I given by equation I =V/Z

$$Z = \sqrt{R^2 + \left(wL - \frac{1}{wC}\right)^2}$$

$$I = \frac{V}{\sqrt{R^2 + \left(wL - \frac{1}{wC}\right)^2}}$$

In the circuit diagram the RMS value of supply voltage is equal to the vector addition of the voltage across inductor (V_L), voltage across resistance (V_R) & voltage across capacitor (Vc). The phasor diagram for the circuit can be drawn which shown the magnitude as well as the phase relationship between the various voltages (V_R, V_L, Vc, Vs) & the total current I. The phasor diagrams will be of different nature for the cases X_L >Xc (inductive circuit), Xc > X_L(Capacitive circuit) and X_L = Xc is said to be condition of resonance & the circuit will be resistive only. For the case when X_L >Xc, power factor of the circuit is lagging in nature, since the current I lags behind V by an angle ϕ.

$$\text{Where } \phi = \tan^{-1}\frac{(XL - Xc)}{R}$$

PROCEDURE:

1. Make the connections as per circuit diagram.
2. Set the rheostat for maximum resistance.
3. Set the variac to zero output & switch on the mains.
4. Adjust the variac so as to apply a suitable voltage to the circuit, measure the current I & voltages V_R, V_L, V_C and supply voltage Vs at the output of variac.
5. Take different sets of reading by applying different voltage and different positions of the variac.
6. Make the calculations as shown in table.

OBSERVATION TABLE:

S. No.	Position of Rheostat	Power (W)	I (A)	V_S (V)	V_R (V)	V_L (V)	V_C (V)
1	Middle Position						
2	Middle Position						
3	Maximum Position						
4	Maximum Position						

CALCULATIONS:

S. No.	R = V_R/I	$X_L = V_L/I$	L= $X_L/2\Pi f$	$X_C = V_c/I$	C= $1/2\Pi FXc$	Z= $\sqrt{R^2 + (X_L - X_C)^2}$	P.F. = R/Z
1							
2							
3							
4							

PRECAUTIONS:

1. All the connections must be tight.
2. Do not touch any terminal while supply is ON.
3. Before switch on the supply set variac at minimum position and rheostat at maximum position.
4. Reading must be noted carefully.

RESULT: From the experiment we have determine the value of R, L, C and power factor of the circuit.

VIVA VOCE QUESTIONS WITH ANSWERS

Q1. What do you mean by lagging power factor?

Ans. When the current flowing in the a.c circuit lags behind the applied voltage, the circuit is said to have a lagging power factor. This happens in case when inductive reactance is more than capacitive reactance.

Q2. What do you mean by leading power factor?

Ans. When the current flowing in the a.c circuit leads the applied voltage, the circuit is said to have a leading power factor. This happens in case when inductive reactance is less than capacitive reactance.

Q3. If an a.c circuit is purely capacitive, what is the phase relationship between voltage and current of that circuit?

Ans. The current will lead the voltage by an angle of 90°.

Q4. Suppose an inductor is connected in series with a lamp. What would be its effect?

Ans. The lamp will be dim. The current in the circuit will reduced due to inductance.

EXPERIMENT NO. – 8

AIM: **Determination of (i) Voltage ratio (ii) polarity and (iii) efficiency by load test of a single phase transformer**

APPARATUS REQUIRED:

S. No.	Item Description	Specification	Quantity
1	Single Phase Transformer,	1KVA, 220/110V	1
2	M.I. Voltmeter	0-300V	3
3	M.I. Ammeter	0-5A	1
4	M.I. Ammeter	0-10A	1
5	Dynamometer Type Wattmeter	5/10A, 300	1
6	Single phase auto transformer	230/0-270V, 8A	1
7	PVC Connected leads	PVC 1mm^2	As per requirement

THEORY:

Polarity: - As such polarity is used in D.C. circuits. In a.c. circuits polarity has less meaning in general. However, in case of transformers, particularly under the following situations the polarity has a definite meaning in case of when we connect two single phase transformers are to be connected in parallel and to connect two three phase transformers are to be connected in parallel to share the total load on the system.

In case of a transformer, each terminal of primary (as well as secondary) winding is alternatively positive and negative with respect to each other. It is very important to know the relative polarities of the primary and secondary terminals at any instant of time for making the correct connections under the situations of parallel operation of transformers.

For determining the polarities of primary and secondary windings of a transformer, following procedure and the set up as shown in figure 2 can be used. Let us first of all mark the terminal P_1 of the primary winding of transformer under test as positive. We indicate this by putting a dot at the terminal P_1. If the supply frequency is 50Hz then the terminal P_1 and P_2 interchange the polarities 50 times a second. The same is true with the secondary terminals S_1 and S_2. The purpose of this experiment is to determine out of S_1 and S_2 which one is at positive potential at the time when P_1 is at positive terminal. For this we connect P_2 and S_2 so that P_2 and S_2 are at the same potential at all instants of time. Now there are two possibilities about the polarities of P_1 and S_1.

Both of them are being discussed below:

1. P_1 and S_1 are of same polarity. Let the transformer be 2:1 ratio. We apply a lower voltage, of the primary of the transformer say 100V. Then the voltmeter V_1 should read 100V, Voltmeter should read 50V. Since P_2 and S_2 have been short circuited and S1 is assumed

to be of same polarity as that of P_1 the reading in voltmeter V_3 should be 50V i.e. (100-50)V

2. P_1 and S_1 are of opposite polarity. The conditions are same as in case 1 above. If S_1 is of opposite polarity than P_1, then one can visualize that the reading in the voltmeter V_3 should be 150V i.e. (100+50) V.

We can now conclude that if the reading in the voltmeter V_3 is less than the voltage applied, the terminal S_1 should be marked positive, where as if the voltmeter V_3 reads more than the voltage applied, the terminal S_1 should be marked as negative.

Voltage Ratio Test:

Let

N_1 = Numbers of turns in primary winding

N_2 = Number of turns in secondary winding

E_1= RMS value of primary induced emf

E_2 = RMS value of secondary induced emf

Primary and secondary induced emfs are

$E_1 = 4.44f\, N_1\Phi_m$ and $E_2 = 4.44f\, N_2\Phi_m$

$E_2/ E_1 = N_2 /N_1= K$

Thus the ratio of secondary voltage to primary voltage is the same as that of secondary winding turns to the primary winding turns. The ratio of N_2/N_1 is known as transformation ratio. It is denoted by K. By selecting this ratio properly, transformation can be done from any input voltage to any convenient output voltage.

There can be two cases:

1. If N_2 is greater than N_1 then E_2 is greater than E_1 the device is known as step up transformer (K>1)
2. If N_2 is less than N_1 then E_2 is less than E_1 the device is known as step down transformer (K<1)

Load Test:

The input to the transformer is observed with the help of a wattmeter, Let it be W_1. The output of the transformer is calculated from product of the voltage V_2 and current I_2 in the secondary of the transformer. The load is taken as resistive load and therefore, it has power factor of unity. So we can write

$$\%\text{ Efficiency of the transformer} = \frac{(\text{Output Power x } 100)}{Input\ Power}$$

$$\%\,\eta = \frac{V_2 I_2 * 100}{W_1}$$

A graph of efficiency v/s the load current should be drawn. The shape of the graph is shown in Figure 1.

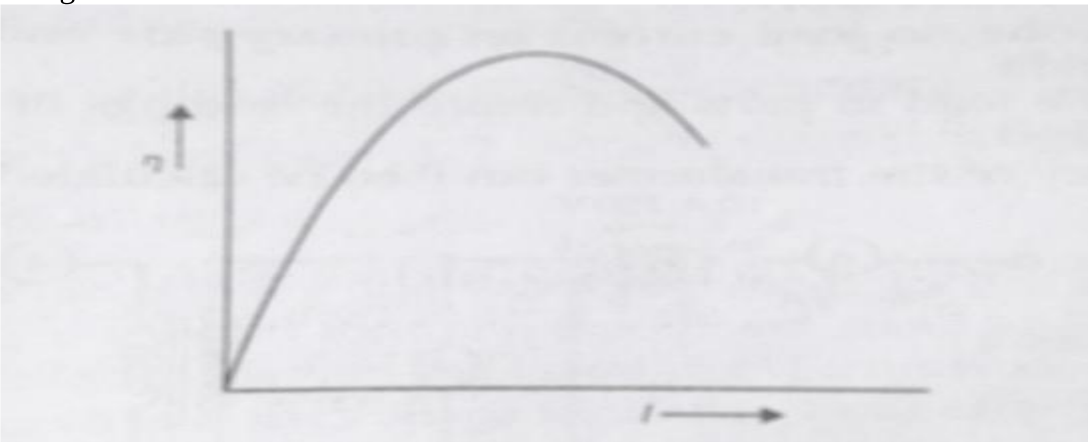


Figure 1: Graph of efficiency v/s Load Current

Voltage Regulation: With the increase in load on the transformer, there is a change in its terminal voltage. The voltage falls if the load power factor is lagging. It is increasing if the load power factor is leading. The change in secondary terminal voltage from full load to no load is expressed as a percentage of full load voltage is called percentage voltage regulation of the transformer.

If E is the no load terminal voltage, and V is the full load terminal voltage, then

% Voltage Regulation = (E-V)*100/E

PROCEDURE: The step wise procedures for conducting different parts of the experiments are given below:

a) Polarity Test

1. Connect the circuit as shown in Figure 2.

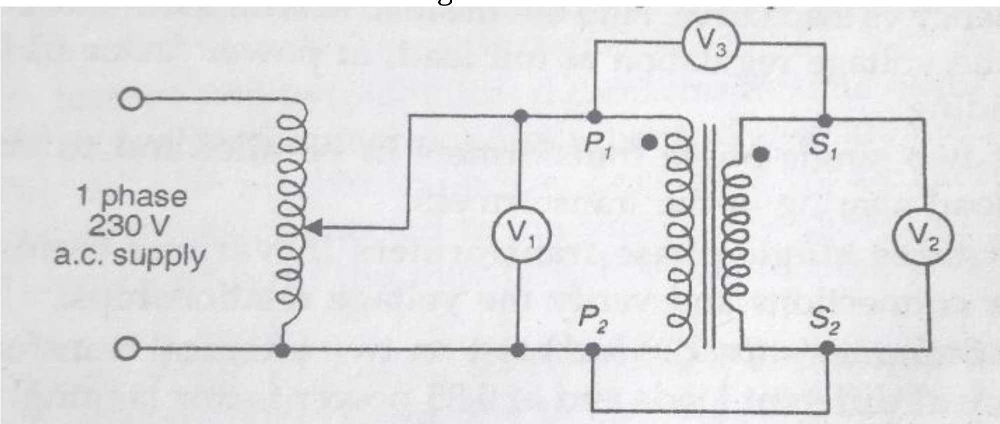


Figure 2: Circuit for Polarity Test

2. Switch on single phase ac supply.
3. Adjust the variac so that voltmeter V_1 reads 100V.
4. Record the readings of all Voltmeters.
5. If $V_3 < V_1$ then mark S1 as positive. If $V_3 > V_1$ then marks S_1 as negative.

b) Voltage Ratio Test

1. Connect the circuit as shown in figure 3.

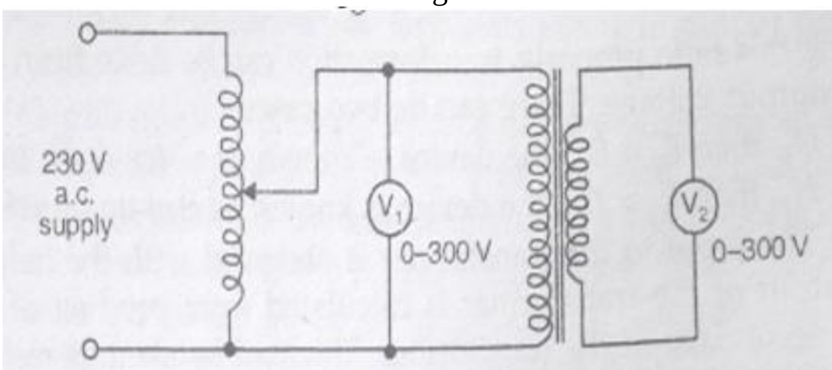


Figure 3: Circuit for Voltage Ratio Test

2. Switch on single phase ac supply.
3. Adjust the variac for various values of input voltage V_1, note down the output voltage V_2.
4. For each reading calculate V_2/V_1. This is the value of voltage ratio.
5. If N_2 is greater than N_1 then E_2 is greater than E_1 the device is known as step up transformer (K>1)
6. If N_2 is less than N_1 then E_2 is less than E_1 the device is known as step down transformer (K<1)

c) Load Test

1. Connect the circuit as shown in Figure 4.

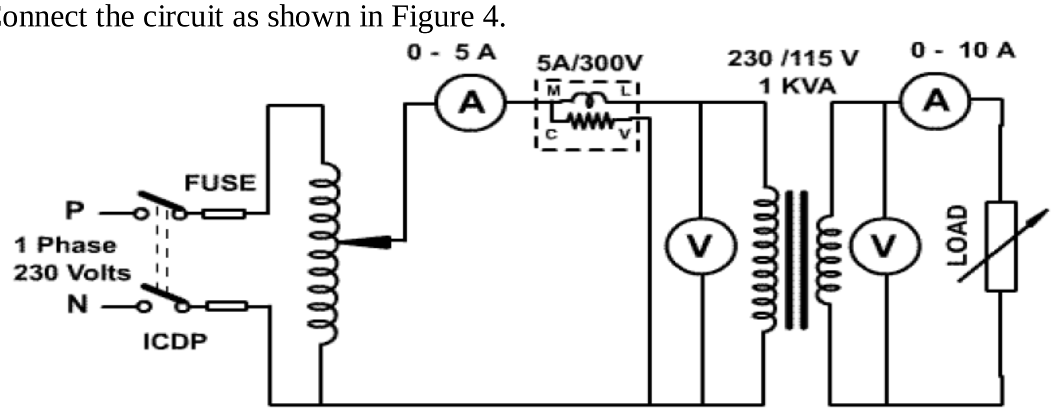


Figure 4: Circuit Diagram for Load test on Transformer

2. Switch off the load.
3. Switch on the a.c. supply.
4. Note down the no load current on primary side and no load voltage on the secondary side.
5. Switch on the load in parts and record the readings of all the meters till the full load is reached.

OBSERVATION AND CALCULATIONS

Table for observation for voltage ratio test

S. No.	V_1	V_2	Voltage Ration $=V_2/V_1$

Table for observations for same polarity

S. No.	V_1	V_2	$V_3=V_1-V_2$

Table for observations for opposite polarity

S. No.	V_1	V_2	$V_3=V_1+V_2$

Table for observations of Load Test

S. No.	I_1 (A)	V_1 (V)	Input W_1(W)	I_2 (A)	V_2 (V)	Output = V_2I_2	%$\eta = V_2I_2*100/W_1$

Secondary voltage at no load (E) = ...V

Secondary voltage at full load (V) = ...V

% Voltage Regulation = (E-V)*100/E

CONCLUSION: The experiment is performed & seen that as load current increases voltage drop in transformer winding is also increases, voltage and hence voltage regulation is increased. Also when we increase the load current the efficiency is also increase up to certain limit after this efficiency decreases with increase load current.

RESULT:

1. The polarities of primary and secondary winding have been marked.
2. The voltage ratio calculated from the experiment should agree with the specified value of the transformer within the limits of the experimental errors.
3. The efficiency curve and the voltage regulation have been determined.

PRECAUTIONS:

Following precautions should be observed while performing the different parts of the experiment.

1. All the connections should be neat and tight.
2. The meters should be of proper range.
3. Before switching on the supply, the zero settings of all the instruments should be checked.
4. While performing the polarity test, full rated voltage should not be applied. Only half the rated voltage should be applied.
5. While performing the load test, we must use an ammeter in series with the wattmeter. It is to check that the current through the wattmeter does not exceed the rating of wattmeter.

VIVA VOCE QUESTIONS WITH ANSWERS

Q1. What is a transformer?

Ans. A transformer is an electrical a machine having no moving parts. It is used for transferring electric power from one circuit to another at the same frequency, at the same or different voltages.

Q2. Why we perform polarity test on transformer?

Ans. When two single phase transformers are connected in parallel or when two three phase transformers are connected in parallel polarity of transformer terminals has to be known otherwise there may be dead short circuit. In Sumpner's back to back test we also require the polarity of primary and secondary windings.

Q3. Which type of load connected on the secondary side of transformer?

Ans. Electrical load

Q4. What do you mean by step-up transformer?

Ans. When a lower voltage is applied on the primary side and a higher voltage is obtained on the secondary side, the transformer is known as step-up transformer.

Q5. What is the condition for maximum efficiency of transformer?

Ans. When Iron Loss = Copper Loss, Efficiency of the transformer is maximum.

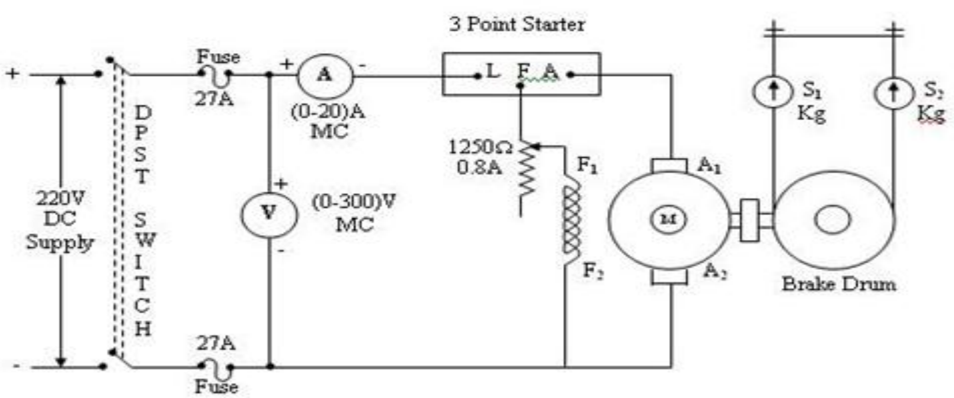
EXPERIMENT NO. – 9

AIM: Determination of efficiency of a dc shunt motor by load test.

APPARATUS REQUIRED:

S. No.	Item Description	Specification	Quantity
1	DC Shunt Motor	2H.P. 230V, 8A, 4Pole, 1500RM	1
2	MC ammeter	0-10A	1
3	MC Voltmeter	0-300V	1
4	3-point Starter	230V, 20A	1
5	Tachometer	0-10000RPM	1
6	Brake pulley		1
7	Connecting Leads	PVC 1 mm^2	As per requirement

CIRCUIT DIAGRAM:



THEORY:

The variation of terminal voltage V across the armature with load current is known as load characteristics or external characteristics. It is seen that the terminal voltage falls as the load current increases. This is mainly due to the ohmic drop. Brake test is carried out on DC Shunt motor. In this test a belt is wound round a pulley and the two ends are attached to the spring balance. The force acting on the pulley is equal to the difference between readings of the two spring balances. If r is the radius of the pulley and W_1 and W_2 are the weights on te two springs then shaft torque is given by $T_{sh} = (W_1 - W_2)$ r Kg-m.

Motor output power = $2*3.14*N*T_{sh}*9.81 /60$ Watts
Motor Input Power = V*I Watts
% Efficiency = Output Power*100/ Input Power

PROCEDURE:

1. Connect the circuit as shown in figure.
2. Start the machine with the help of three point starter.
3. Apply rated voltage to the DC shunt motor.
4. Increase the load on the motor slowly to its full capacity.
5. Note down the reading of ammeter, voltmeter W_1, W_2 and diameter of pulley.
6. Using above formula calculates shaft torque, input power, output power and efficiency of the motor.

OBSERVATION AND CALCULATION TABLE:

S. No.	Voltage (V)	Current (I)	N (rpm)	W_1 (Kg)	W_2 (Kg)	%η=Po*100/Pi

RESULT: Efficiency of D.C. Shunt motor is ....%

PRECAUTIONS:

1. Increase the load on the motor slowly.
2. While measuring rpm keep the tachometer in the line with the pulley.
3. Take the readings of ammeter and voltmeter accurately.
4. Give a gap of sometime between two tests to avoid overheating of motor.
5. Do not touch any connection of the circuit when supply is on.

VIVA VOCE QUESTIONS WITH ANSWERS

Q1. What is the function of three point starter?

Ans. The function of three point starter is to reduce to reduce the starting current. Another function of three point starter is to provide protection from overload, short circuit.

Q2. Name the different types of D.C. motors?

Ans. D.C. Shunt Motor, D.C. Series Motor and D.C. Compound Motor.

Q3. How can the direction of rotation D.C. Shunt motor can be reversed?

Ans. Direction of D.C. Shunt motor can be reversed by reversing the current flow through either the armature winding or the field winding.

Q4. Why flux is constant in D.C. Shunt motor?

Ans. Flux is directly proportional to field current. As field current is given by $I_{sh} = V/R_{sh}$ is constant. Since V and R_{sh} are constant so I_{sh} is constant.

Q5. Name the parts of D.C. motor.

Ans. Outer Frame or Yoke, Pole core and Pole shoe, Field winding, Armature core, Armature winding, Commutator, Brush and Brush holder, Bearing, Shaft, End Housing.

EXPERIMENT NO. – 10

AIM: To study running and speed reversal of a 3-phase induction motor and record the speed in both directions.

APPARATUS REQUIRED:

S. No.	Item Description	Specification	Quantity
1	3-Phase induction motor	2H.P.,415V,1440rpm, 3.6A	1
2	Star – Delta Starter	20A,415V	1
3	M.I. Ammeter	0-5/10A	1
4	M.I. Voltmeter	0-600V	1
5	Tachometer	0-10000rpm	1
6	PVC Connecting Leads	$1mm^2$	As per requirement

CIRCUIT DIAGRAM:

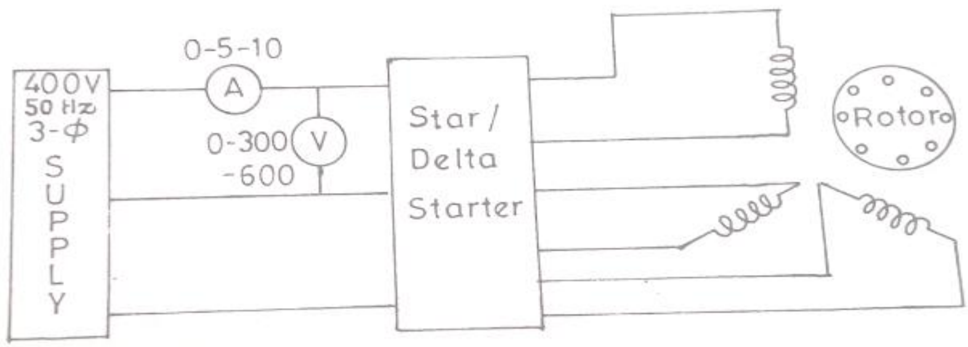


Figure 1

THEORY:

An induction motor is rarely used as a generator since its performance characteristics are not satisfactory from most generator application point of view. However it is true that most of the generated electrical power in the world is consumed by an induction machine as a motor. Therefore three phase induction motors find extensive application in industry. Single phase induction motors find extensive application for domestic purposes though it is not self starting. On the other hand, a three phase induction motor is a self starting motor. It develops a torque at a non-synchronous speed. The direction of rotation can be reversed by changing any two phases of the supply.

PROCEDURE:

1. Make the circuit diagram as shown in Figure 1.
2. Start the squirrel cage induction motor with the help of star-delta starter.
3. Note down the voltmeter, ammeter and tachometer readings.
4. Now interchange any two terminals to get the direction of rotation in reverse order with the help of forward reverse main switch or by in changing any two supply terminals.
5. Again start the squirrel cage induction motor with the help of star-delta starter.
6. Note the voltmeter, ammeter and tachometer readings.
7. Switch off the star delta starter and supply.

OBSERVATION TABLE

Table 1 - In Forward Direction

S. No.	Current (A)	Voltage at the time of starting	Voltage at the time of running	Speed in rpm

Table 2 - In Reverse Direction

S. No.	Current (A)	Voltage at the time of starting	Voltage at the time of running	Speed in rpm

RESULT:

From the experiment by the application of star delta starter we find that at the time of starting less voltage appears across motor terminals and when the motor is running full voltage appears at motor terminals and starting current is reduced. The direction of rotation can be changed by interchange any two supply terminals. The speed is same in both directions and the voltage at the time of start and the time of running is also the same.

PRECAUTIONS:

1. All the connections must be tight.
2. Reading must be noted carefully.
3. Never changes supply terminals when supply is on.
4. For Star-Delta starter all six terminals must be available.
5. Before start of experiment note down name plate data of 3-phase induction motor.

VIVA VOCE QUESTIONS WITH ANSWERS

Q1. Are three phase induction motors self starting?
Ans. Yes, three phase induction motors are self starting.

Q2. If three phase induction motors are self starting, then why do we use starters for three-phase induction motors?
Ans. 1. Reducing the starting current
2.Providing protection to the motor.

Q3 . Name the two types of three phase induction motor.
Ans. 1. Squirrel cage induction motor 2. Slip ring induction motor (Phase Wound).

Q4. Name the different types of starters used for three phase induction motor.
Ans. Direct on Line Starter (DOL), Star-Delta Starter, 3-phase auto transformer starter, Stator Rheostat starter, Rotor Rheostat starter (For slip ring Induction motor)

Q5. How can be changing the direction of rotation of three phase induction motor?
Ans. We can change the direction of rotation of three phase induction motor by changing any two phases of the supply with stator terminals.

EXPERIMENT NO. – 11

AIM: Study of phenomenon of resonance in RLC series circuit and obtain resonant frequency.

APPARATUS REQUIRED:

1. RLC Series Resonant Apparatus Kit
2. Function Generator
3. Connecting Leads

CIRCUIT DIAGRAM:

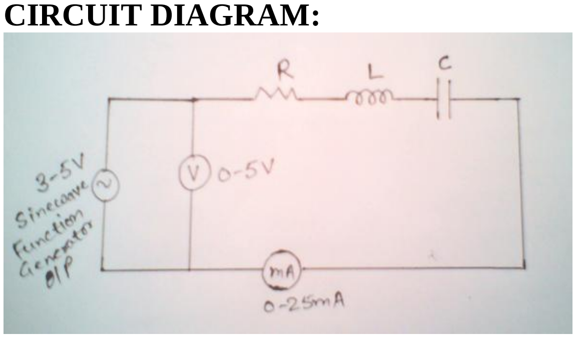


Figure 1

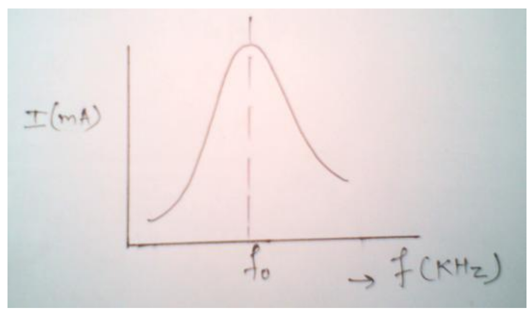


Figure 2

THEORY:

In a series R − L − C circuit current I is given by $I = \frac{V}{Z}$

$$Z = \sqrt{R^2 + \left(wL - \frac{1}{wC}\right)^2}$$

$$I = \frac{V}{\sqrt{R^2 + \left(wL - \frac{1}{wC}\right)^2}}$$

In a series R-L-C circuit one cannot definitely say whether the current leads or lags the voltage. It depends the relative values of the term ωL and ωC.

There are three possibilities:

1. ωL >1/ ωC
2. ωL< 1/ωC
3. ωL =1/ ωC

In case 1: when $\omega L > 1/\omega C$ the angle Φ is negative. It means that the current lags the voltage. So the circuit behaves as an inductive circuit. This condition ($\omega L > 1/\omega C$) can be achieved by increasing L, ω or C.
In case 2: when $\omega L < 1/\omega C$ the angle Φ is positive. It means that the current leads the voltage. So the circuit behaves as a capacitive circuit. This condition ($\omega L < 1/\omega C$) can be achieved by decreasing L, ω or C.
In case 3: when $\omega L = 1/\omega C$ the angle Φ is zero. It means that the current through the circuit becomes in phase with the source voltage. So the circuit behaves as a resistive circuit. This condition is known as resonance. At resonance condition Z=R and current is maximum. The resonant frequency is given by $F_O = 1/2\pi\sqrt{LC}$. The shape of the graph is given in Figure 2.

PROCEDURE:

1. Connect the circuit as shown in Figure 1. Connect resistance R. Capacitor C and inductance L in the circuit.
2. For input sine wave signal connect the function generator.
3. Set the function generator voltage of approximately 4 volts RMS and at 1KHz. Note down the frequency and current.
4. Increase the signal frequency from 1 KHz to higher side. Current will also increase. Keep on noting down the observations. At a particular frequency current starts decreasing. The frequency at which current starts decreasing is the resonant frequency.
5. Repeat the procedure for different values of R and C.

OBSERVATION TABLE

S. No.	Frequency (KHz)	Current (mA)
1		
2		
3		
4		
5		
67		
8		
9		
10		
11		
12		
13		
14		
15		
16		

CALCULATIONS :

R= .... ohms
L= ....mH
C= .... µF
Resonant Frequency $F_O = 1/2\pi\sqrt{LC}$
Result Resonant Frequency = ...Hz.
Resonant Frequency observed by calculation = ...Hz
% Error=...........................

PRECAUTIONS:

1. All the connections must be tight.
2. Reading of the frequency of function generator and ammeter should be noted carefully.
3. Increase the frequency in steps.
4. The value of the sine wave voltage must be less than 5V.

VIVA VOCE QUESTIONS WITH ANSWERS

Q1. What do you mean by impedance of a.c. circuit?
Ans. To ratio of voltage to current in an a.c. circuit is defined as impedance. It is represented by Z and unit as Ohm (Ω).

Q2. What is the formula for resonant frequency of R-L-C series circuit?
Ans. Resonant Frequency $F_O = 1/2\pi\sqrt{LC}$ Hz

Q3. Explain all about the resonance in Series R-L-C circuit.
Ans. Resonance in Series R-L-C circuit can be defined in following ways:

1. An a.c. circuit is resonant when the circuit power factor is unity.
2. An a.c. circuit is resonant current has maximum value.
3. An a.c. circuit is resonant impedance of the circuit is minimum.
4. An a.c. circuit is resonant inductive reactance equals capacitive reactance.
5. An a.c. circuit is resonant when Resonant Frequency $F_O = 1/2\pi\sqrt{LC}$ Hz

Q4. What are the main parameters of a.c circuit?
Ans. The main parameters of a.c. circuits are resistance, inductance and capacitance.

EXPERIMENT NO. – 12

AIM: To observe the B-H loop of a ferromagnetic core material on CRO.

APPARATUS REQUIRED:

S. No.	Item Description	Specification	Quantity
1	CRO		1
2	Single Phase Transformer	1KVA, 230/115V	1
3	Single Phase Autotransformer	230/0-270V, 8A	1
4	Resistance R_1	100Ω	1
5	Resistance R_2	1MΩ	1
6	Capacitor	10µF	1
7	PVC Connecting Leads	1mm^2	As per requirement

CIRCUIT DIAGRAM:

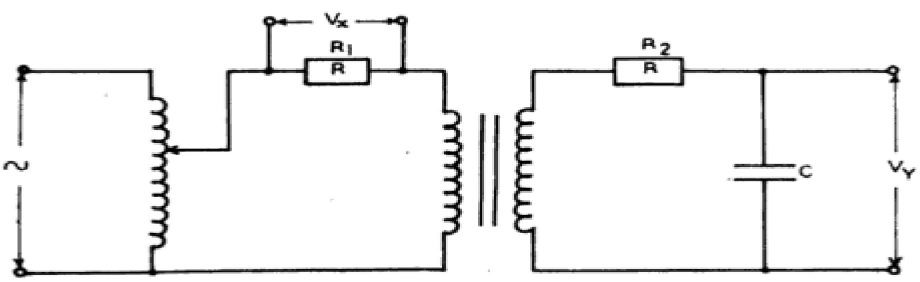


Figure 1

THEORY:

The B-H (or magnetization) curve of a ferromagnetic material is not a straight line due to variation in the permeability of iron at different flux densities. The iron also undergoes magnetic saturation at higher values of flux densities. The core of transformer is carrying alternating flux and therefore, undergoes magnetic reversal during each cycle. Complete cycle of magnetic reversal is called hysteresis loop. Hysteresis loop of a transformer's core can be observed on an oscilloscope by using Figure 1.

A capacitor C and a high resistance R_2 is connected across the secondary of the transformer. The transformer may be considered as operating at no load because of negligible loading effect of R_2 –C network. Current in the transformer primary will, therefore comprise of only magnetizing current and voltage drop across R_1 will be proportional to the magnetizing intensity H. This voltage, if connected to the oscilloscope's horizontal input, will deflect the beam which will be proportional to H.

The magnitude of i_2 (i.e. secondary current), however small it may be, will be in phase with secondary induced emf e_2 because R_2 is of the order of mega ohms and Xc of the order of kilo ohms (R_2>Xc) and Z_2= R_2.

Therefore $i_2 \alpha e_2$

or $i_2=e_2/ R_2$

$$V_y = \frac{1}{C}\int i_2\,dt = \frac{1}{CR_2}\int e_2\,dt \ \ (put\ e_2 = N_2\frac{d\emptyset}{dt})$$

$$= \frac{N_2}{CR_2}\int \frac{d\emptyset}{dt}dt = \frac{N_2}{CR_2}\int d\emptyset = K\emptyset$$

Thus voltage across the capacitor at any instant is proportional to the flux in the core and is in phase with it. Since φ =B.A_i, Vy represents B in the core as the cross-sectional area A_i is constant. This Vy if connected to vertical input of the oscilloscope will deflect the beam proportional to the flux density B. Thus, the trace on CRO screen is the B-H loop of the transformer core material. The shape of the B-H loop or hysteresis loop will be as shown in Figure 2.

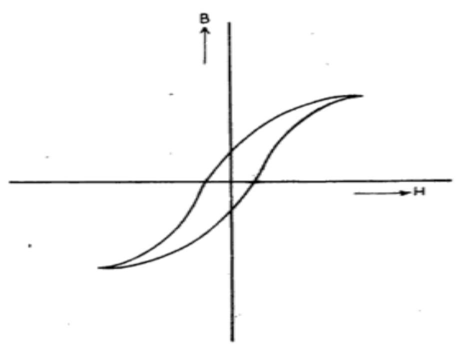


Figure 2- Hysteresis loop of a Transformer core

PROCEDURE:

1. Connect the circuit diagram as shown in Figure 1.
2. Vary the input voltage by using variac.
3. Connect the CRO with the transformer.
4. Adjust the horizontal and vertical gain of the CRO to observe the BH loop on the screen.

PRECAUTIONS:

1. CRO must be operated carefully.
2. All the connections must be tight.
3. Before start the experiment ensures that the variac must be at minimum position.

OBSERVATION AND RESULTS

Trace the B-H loop observed on the CRO on tracing paper and comment on its shape.

VIVA VOCE QUESTIONS WITH ANSWERS

Q1. What is B-H Curve?

Ans. The graph between the flux density (B) and the magnetic field strength (H) for the magnetic material is called as its magnetization curve or B-H curve.

Q2 .How we can reduce Hysteresis and Eddy current losses in electrical machines.

Ans. We can reduce hysteresis loss by using silicon steel material and reduce eddy current loss by using laminations.

Q3. What is magnetic material?

Ans. Materials in which a state of magnetisation can be induced are known as magnetic materials.

Q4. What do you mean by retentivity?

Ans. The power retaining the residual magnetism is called retentivity.

Q5. On what factors do the magnetic reluctance depends?

Ans. The reluctance of the magnetic circuit is directly proportional to the length l, Area of cross-section and dependent upon the nature of the material of the magnetic circuit.

EXPERIMENT NO. – 13

AIM: Measurement of power and power factor in a single phase AC circuit and to study improvement of power factor using Capacitor.

APPARATUS REQUIRED:

S. No.	Item Description	Specification	Quantity
1	Digital Wattmeter	200W	1
2	Digital Ammeter	0-2A	3
3	Digital Voltmeter	0-300V	1
4	Single phase variac	230/0-270V, 8A	1
5	Inductive Coil		1
6	Capacitor	15µF	1
7	Rheostat	1.4A, 260 ohm	1
8	Connecting Leads	PVC 1mm^2	As per requirement

THEORY: Power in a single phase AC circuit with inductive load (Combination of resistance and inductance) is given by

$P = VICos\Phi$

Where P = power consumed by load in Watts, V= Load voltage in volts

I= Load current in Amps, $Cos\Phi$ = Power factor of the load

For the circuit consisting of wattmeter, voltmeter and ammeter to record the values of power consumed by the load, voltage across the load and the current drawn by the load, the power factor can be calculated as

$$\text{Power factor} = Cos\Phi = P/(VI)$$

$$\text{Power Factor angle of load } \Phi = Cos^{-1} P/(VI)$$

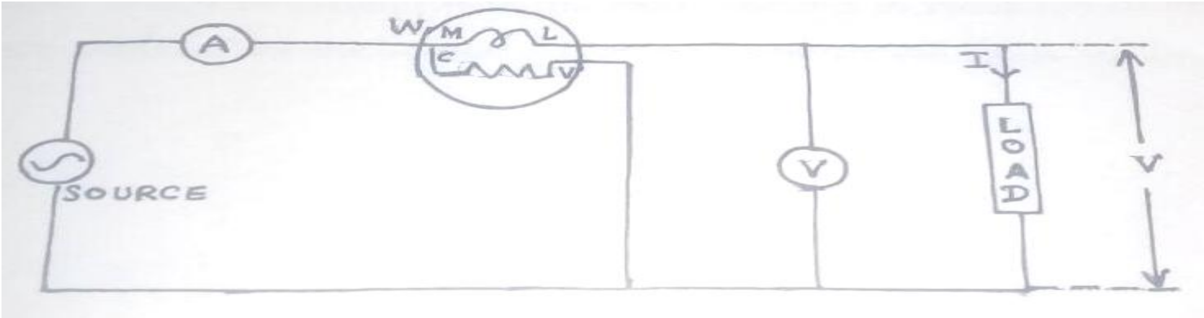


Figure 1

For the circuit given in Figure 1

Active power P = VICosΦ Watts
Reactive power Q = VI SinΦ VAR
Apparent power S =VI VA
Apparent Power S = $\sqrt{P^2 + Q^2}$
Power Factor = P/S

Because of the inductive nature of the load active as well as reactive power in a circuit is supplied by the load.

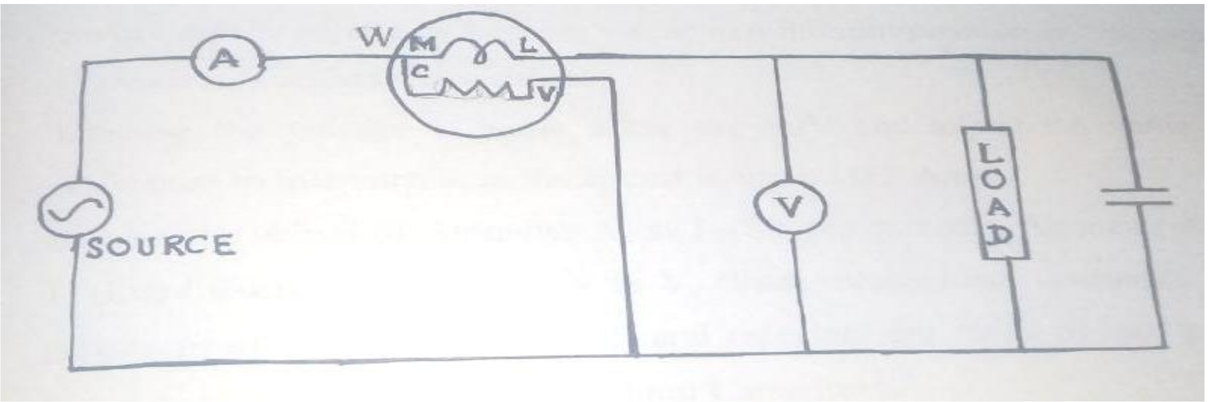


Figure 2

By adding capacitor in parallel with load as shown in Figure 2, some of the reactive power is supplied by the capacitor depending upon value of the capacitance added in parallel with the load resulting in reduction of apparent power (S) supplied by the source and hence power factor of the circuit being CosΦ = P/S increases. Hence power factor improves.

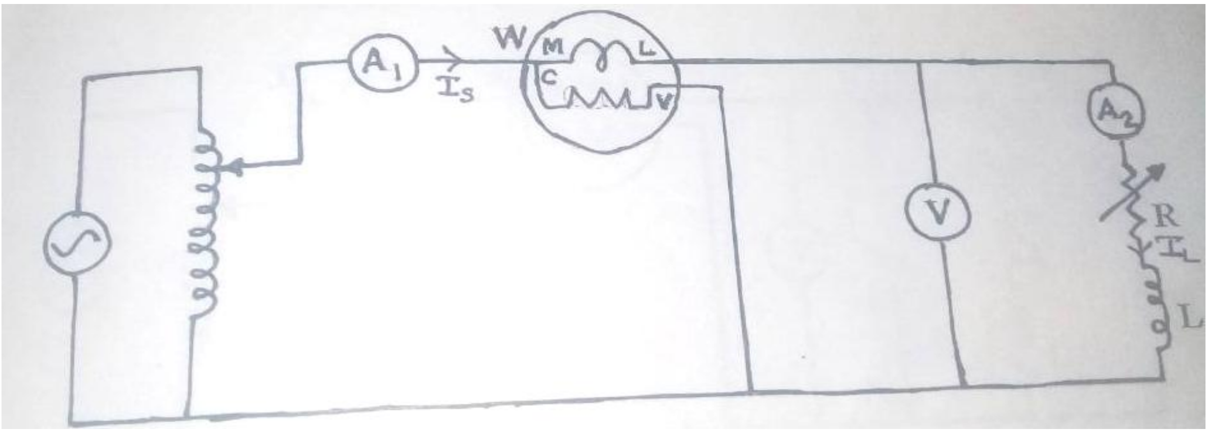


Figure 3

PROCEDURE:

1. Make circuit as shown in Figure 3.
2. Switch on the supply by keeping variac in minimum position and rheostat in maximum resistance position.
3. Increase the voltage to some value say 90V and adjust the value of the resistance so that the current in the circuit is 0.2Amp.
4. Record the values of ammeter A_1 as Is (Source current), Ammeter A_2 as I_L (Load current), Voltmeter V as V_L (load voltage) and wattmeter as P (active power consumed by load) and calculate the value of the load power factor as tabulated in table 1 (without capacitor).
5. Switch off the supply.
6. Connect capacitor in parallel with load (Series combination of resistance and inductance) as shown in Figure 4 without disturbing the position of variac and rheostat.

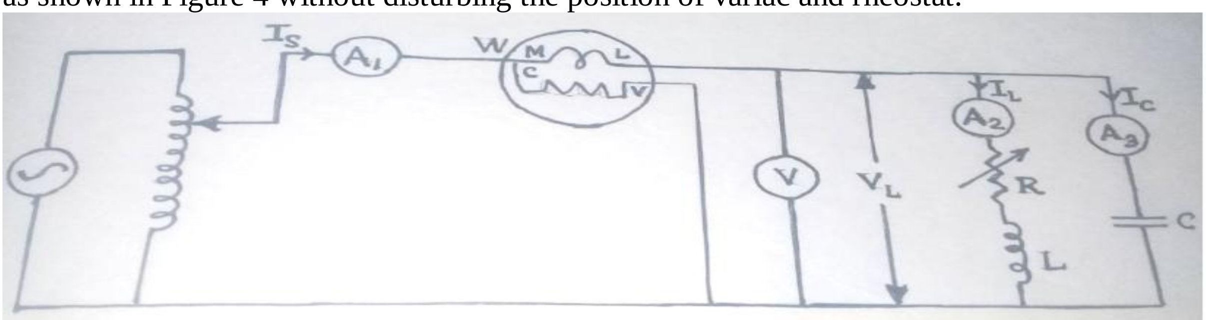


Figure 4

7. Record the values of ammeter A_1 as Is (Source current), Ammeter A_2 as I_L (Load current), Ammeter A_3 as I_C(Capacitor Current), Voltmeter V as V_L (load voltage) and wattmeter as P (active power consumed by load) and calculate the value of the load power factor as tabulated in table 2. (with capacitor)
8. Compare the power factor tabulated in table 1 and table 2 and calculate the improvement of power factor.
9. Repeat the step 3 to 8 for different values of voltages say 105, 120, 135 and 150 Volts.

OBSERVATION and CALCULATIONS:

Table 1(Without Capacitor)

S. No.	V_L (Volts)	P (Watts)	Is (Amp)	I_L (Amp)	$\cos\Phi = P/VsI_L$

Table 2 (With Capacitor)

S. No.	V_L (Volts)	P (Watts)	Is (Amp)	I_L (Amp)	I_C (Amp)	$Cos\Phi= P/VsI_L$

PRECAUTIONS:

1. All the connections must be tight.
2. Wattmeter must be connected carefully.
3. Switch off the supply when change the connection from circuit without capacitor to circuit with capacitor.
4. At the time of starting ensure that the rheostat must be at maximum position and variac must be at minimum position.

RESULT:

We calculate the single phase power and power factor without capacitor and with capacitor and find that power factor will improve with the presence of capacitor in the circuit.

VIVA VOCE QUESTIONS WITH ANSWERS

Q1. Define Power Factor.

Ans. 1. It is the Cosine of angle between voltage and current.
2. It is the ratio of resistance to the impedance of the circuit.
3. It is the ratio of active power to the apparent power of the circuit.

Q2. What are different methods for power factor improvement?

Ans. By connecting a capacitor in parallel with the circuit and by using synchronous condenser

Q3. Name the type of power measured by Wattmeter.

Ans. Active Power (Unit of active power is watt).

Q4. Name the three types of power.

Ans. Active Power, Reactive Power and Apparent Power.

Q5. What do you mean by lagging power factor?

Ans. When the current flowing in the a.c circuit lags behind the applied voltage, the circuit is said to have a lagging power factor. This happens in case when inductive reactance is more than capacitive reactance.