ELECTRICAL ENGINEERING

LABORATORY MANUAL

(NEE 151/251)

DEPARTMENTS OF ELECTRONICS & COMMUNICATION ENGINEERING/ ELECTRICAL ENGINEERING

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EXPERIMENT 1a

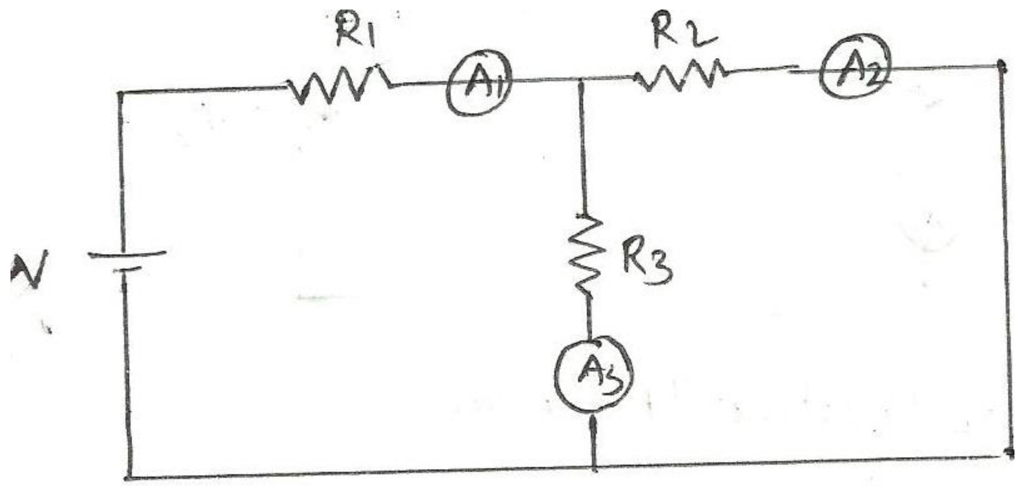
1. OBJECTIVE: VERIFICATION OF KIRCHHOFF'S CURRENT LAW.

2. APPARATUS REQUIRED:

Serial No.	Equipment	Specification	Quantity	Remark
1	Regulated power supply or Battery	0-24 V or 24V	1	
2	PMMC ammeter	0 – 1A	3	
3	Rheostats	10 Ω, 1A	3	
4	Connecting wires			

3.BRIEF THEORY: According to Kirchhoff's current law, in any network of wires carrying currents, the algebraic sum of all currents meeting at a junction (or node) is zero or the sum of incoming currents towards any junction (or node) is equal to the sum of outgoing currents away from that junction.

4. CIRCUIT DIAGRAM:



5. PROCEDURE: Three rheostats R_1, R_2 and R_3 and ammeters A_1, A_2 and A_3 are connected to 24 V battery or regulated power supply as shown in figure. The three rheostats are set their maximum values, supply is switched on and the reading of the ammeter A_1, A_2 and A_3 are noted. The process may be repeated by varying either of rheostats R_1, R_2 and R_3.

6. OBSERVATIONS:

Sr. no	**Reading of ammeter A_1 (I_1)**	**Reading of ammeter A_2 (I_2)**	**Reading of ammeter A_3 (I_3)**	**$I_2 + I_3$**
1				
2				
3				
4				
5				

7. CALCULATION:

8. RESULT AND DISCUSSION: It is found that current I_1 is equal to the sum of currents I_2 and I_3.Hence kirchhoff's current law is verified.

9. Precautions:

1. All connections should be tight.
2. All steps should be followed carefully.
3. Readings and calculation should be taken carefully.
4. Don't touch the live terminals.

10. PRE EXPERIMENT QUESTIONS:

1. What is KCL?

2. What is ohm's law?

11. POST EXPERIMENT QUESTIONS:

1. What is difference between emf and potential difference?

2. Why ammeters are connected in series to measure current?

3. If the length of a wire of resistance R is uniformly stretched to n times its original value, what will be its new resistance?

EXPERIMENT 1b

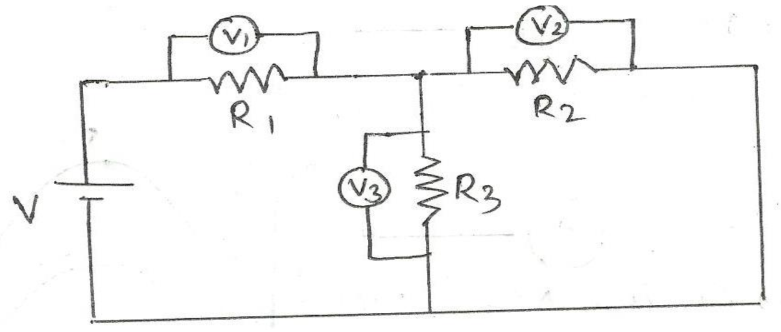
1. OBJECTIVE: VERIFICATION OF KIRCHHOFF'S VOLTAGE LAW.

2. APPARATUS REQUIRED:

Serial No.	Equipment	Specification	Quantity	Remark
1	Regulated power supply or Battery	0-24 V or 24V	1	
2	PMMC voltmeter	0 –24V	3	
3	Rheostats	10 Ω, 2.5A	2	
4	Connecting wires			

3. BRIEF THEORY: According to Kirchhoff's voltage law, in any closed circuit or mesh, the algebraic sum of emfs acting in the circuit or mesh is equal to the algebraic sum of the products of the currents and resistances of each part of the circuit or mesh.

4. CIRCUIT DIAGRAM:



5. PROCEDURE: Two rheostats R_1 , R_2 , R_3 and three voltmeters V_1 , V_2 and V_3 are connected to 24V battery or regulated power supply as shown in figure. Three rheostats are set their maximum values, supply is switched on and the reading of the voltmeters V_1 , V_2 and V_3 are noted. The process may be repeated by varying either of rheostats R_1 , R_2 or R_3.

6. OBSERVATIONS:

Sr. no	Reading of Voltmeter V_1 in Volts	Reading of Voltmeter V_2 in Volts	Reading of Voltmeter V_3 in Volts
1			
2			
3			

4			
5			

7. CALCULATION:

8. RESULT AND DISCUSSION: It is found that, in first loop, voltage V is equal to the sum of voltages V_1 and V_3 and in second loop $V_2 = V_3$ .Hence Kirchhoff's voltage law is verified.

9. PRECAUTION:

1. All connections should be tight.
2. All steps should be followed carefully.
3. Readings and calculation should be taken carefully.
4. Don't touch the live terminals.

10. PRE EXPERIMENT QUESTIONS:

1. What is KVL?

11. POST EXPERIMENT QUESTIONS:

1. Why voltmeters are connected in parallel to rheostats to measure voltage?

2. How does the resistance of a homogeneous material having constant length vary with the changing cross sectional area.

3. What is Fleming's left hand rule?

4. What is Fleming's right hand rule?

5. Define junction and node.

6. Define Mesh and loop.

EXPERIMENT 2a

1. OBJECTIVE: VERIFICATION OF SUPERPOSITION THEOREM.

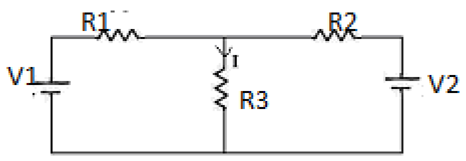
2. APPARATUS REQUIRED:

Serial No.	Equipment	Specification	Quantity	Remark
1	Two Batteries	12V and 6 V	1	
2	PMMC ammeters	0 –2A	3	
3	Rheostats	10 Ω, 2.5A	3	
4	Keys		02	
5	Connecting Wires			

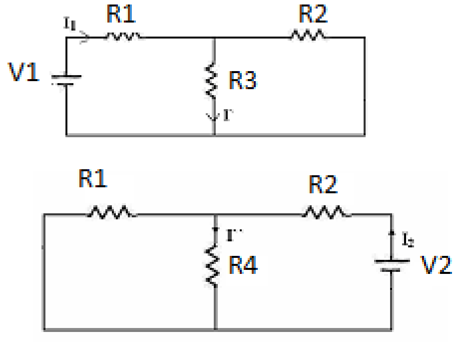
3. THEORY:

Statement of superposition theorem: In a linear resistive network containing two or more voltage sources, the current through any element may be determined by adding together algebraically the currents produced by each source acting alone, when all others voltage sources are replaced by their internal resistances. If a voltage source has no internal resistance, the terminal to which it was connected is joined together. If there are current sources present they are removed and the network terminals to which they are connected are left open.

4. CIRCUIT DIAGRAM:



Circuit 1.



Circuit 2 & 3.

5. PROCEDURE:

(i) Make the connections as shown in the circuit diagram.
(ii) Connect the ammeter in the appropriate branch of the circuit.

(iii) Switch on the power supply.
(iv) Measure the currents I_1, I_2, and I by using ammeter.
(v) Tabulate the readings.

Now repeat the above procedure for circuit diagram 2 and circuit diagram 3.

6. OBSERVATIONS:

Practical Values								
I_1	I_2	I	I_1'	I_2'	I'	I_1''	I_2''	I''

7. CALCULATION:

8. RESULT AND DISCUSSIONS:

It is found that

$I_1 = I_1' + I_1''$

$I_2 = I_2' + I_2''$

$I = I' + I''$

So superposition theorem is verified.

9. PRECAUTION:

5. All connections should be tight.
6. All steps should be followed carefully.
7. Readings and calculation should be taken carefully.
8. Don’t touch the live terminals.

10. PRE EXPERIMENT QUESTIONS:

1. Describe Linear & Non-linear circuits?

2. Describe Active & Passive elements?

3. What are energy sources?

11. POST EXPERIMENT QUESTION:

1. State the superposition theorem.

2. What are the limitations of superposition theorem?

3. What is the utility of superposition theorem?

EXPERIMENT 2b

1. OBJECTIVE: VERIFICATION OF THEVENIN'S THEOREM.

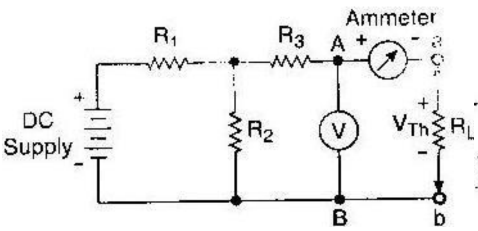
2. APPARATUS REQUIRED:

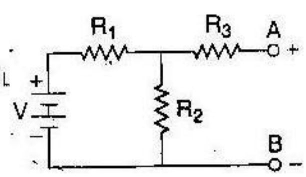
Serial No.	Equipment	Specification	Quantity	Remark
1	Two Batteries	12V and 6 V	1	
2	PMMC ammeters	0 –5A	1	
3	PMMC voltmeter	0-10V	1	
3	Rheostats	10 Ω, 2.5A	3	
4	Resistor	10 Ω	1	
5	Keys		04	
6	Connecting Wires			

3. THEORY: According to this theorem if a resistor of R_L ohms be connected between any two terminals of a linear bilateral network, then the resulting current through resistor will be equal to $\frac{V_{TH}}{R_L + R_{TH}}$ where V_{TH} is the potential difference across these two points and R_{TH} is the resistance of network measured between these two points.

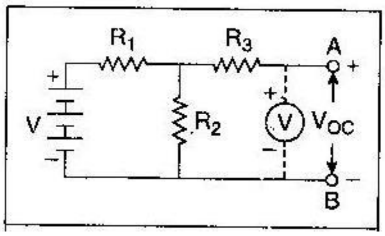
V_{Th} is the open circuit voltage across the terminals, R_{Th} is the equivalent resistance across the terminals , R_L is the load resistance .

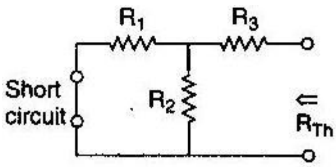
4. CIRCUIT DIAGRAM:





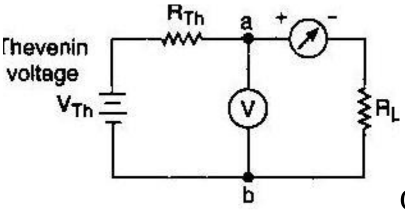
Circuit 1. Circuit 2.





Circuit 4.

Circuit 3.



Circuit 5.

5. PROCEDURE:

1. Remove the resistance (called Load Resistance R_L).
2. Find the open circuit voltage V_{OC} which appears across the two terminals from where resistance is removed. It is also called Thevenin's voltage V_{Th}
3. Compute the resistance of the whole network as looked into from these two terminals after all sources of e.m.f. are treated as short circuited while all the current sources are treated as open circuited
4. Connect R_L back to its terminals from where previously it was removed and measure the current flowing through R_L.
5. **5.** Finally, calculate the current flowing through R_L using the equation

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

6. OBSERVATION TABLE:

Open circuit voltage across terminals A& B (V_{OC})	**Equivalent resistance across the terminals A&B, R_{Th}**	**Load current** $I_L = \frac{V_{TH}}{R_L + R_{TH}}$	**Measured I_L**

7. CALCULATION:

The load current $I_L = \frac{V_{TH}}{R_L + R_{TH}}$

I_L = …… amp.

8. RESULT AND DISCUSSIONS:

The value of open circuit voltage (V_{OC}) is …..volts.
The value of Thevenin's resistance is …..ohms.
The value of current across load is ……amps.

It will be found that measured value of current flowing through the load I_L are the same as determined by Thevenin's theorem.

9. PRECAUTIONS:

1. All connections should be tight.
2. All steps should be followed carefully.
3. Readings and calculation should be taken carefully.
4. Don't touch the live terminals.

10. PRE EXPERIMENT QUESTIONS:

1. What do you mean by bilateral and unilateral circuits?

2. What is voltage source?

11. POST EXPERIMENT QUESTION:

1. State of Thevenin's theorem.

2. What is the utility of Thevenin's theorem?

EXPERIMENT 2c

1. OBJECT: TO VERIFY THE MAXIMUM POWER TRANSFER THEOREM.

2. APPARATUS REQUIRED:

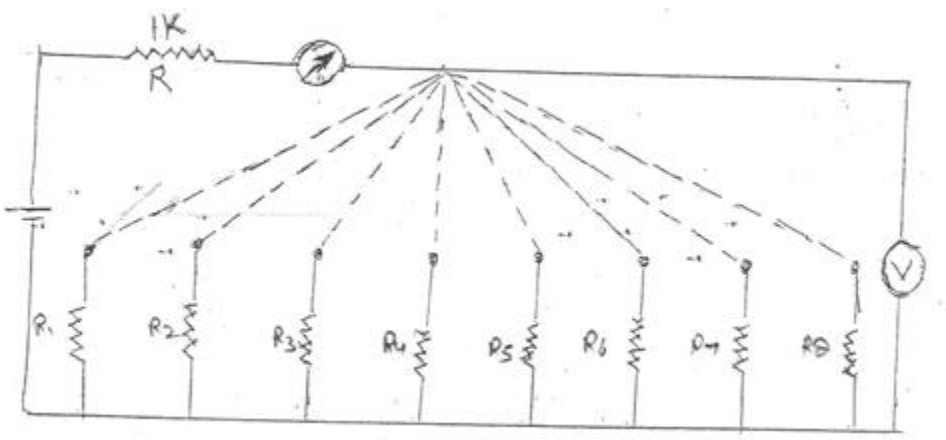
Serial No.	Equipment	Specification	Quantity	Remark
1	Battery	12V	1	
2	PMMC ammeters	0 –5A	1	
3	PMMC voltmeter	0-10V	1	
3	Resistance Box		1	
4	Rheostat	10 Ω, 2.5A	1	
5	Connecting Wires			

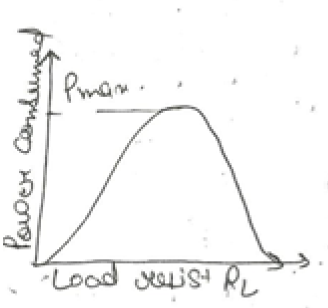
3. THEORY:

According to maximum power transfer theorem a resistive load will abstract maximum power from a network when the load resistance is equal to the resistance of network as viewed from the output terminal, with all the energy sources replaced by their internal resistances.

4. CIRCUIT DIAGRAM:

The circuit diagram is shown below.





5. PROCEDURE:

1. Connect 12V DC power supply at the terminals provided for the same at the lower left hand corner near the mains On/OFF switch.
2. Connect 0 – 20 mA DC current meter and 0 – 15V DC voltmeter at the appropriate positions as shown in the circuit diagram.
3. Connect resistor R1 in the circuit with the help of jumper link.
4. Observe and record the current meter reading I and voltmeter reading V.
5. Calculate the power transferred to the load .
6. Similarily calculate the power for all different load resistor from R 1 and R8 and find out at which load resistor maximum power is transferred. Compare its value with the source resistor R.

6. OBSERVATION TABLE:

Load Resistor R_L	Load Current I (mA)	Load Voltage (Volts)	Power Transferred P = VI (Watts)

7. CALCULATION:

Calculate the value of load resistor at which maximum power is transferred and also calculate the maximum power.

Compare it with value practically obtained

8. RESULT AND DISCUSSION:

Maximum power is obtained at resistance:______________

As practical value is same as theoretical value maximum transfer theorem is verified.

9. PRECAUTIONS:

1. All connections should be tight.
2. All steps should be followed carefully.
3. Readings and calculation should be taken carefully.
4. Don’t touch the live terminals.

10. PRE EXPERIMENT QUESTIONS:

1. Statement of Maximum power transfer theorem.

11. POST EXPERIMENT QUESTION:

1. What is the condition for maximum power transfer?

2. What is the efficiency under maximum power transfer condition?

3. What are the applications for Maximum power transfer theorem?

EXPERIMENT 3

1. OBJECTIVE: MEASUREMENT OF POWER AND POWER FACTOR IN A SINGLE PHASE AC SERIES INDUCTIVE CIRCUIT AND STUDY OF IMPROVEMENT OF POWER FACTOR USING CAPACITOR.

2. APPARATUS REQUIRED:

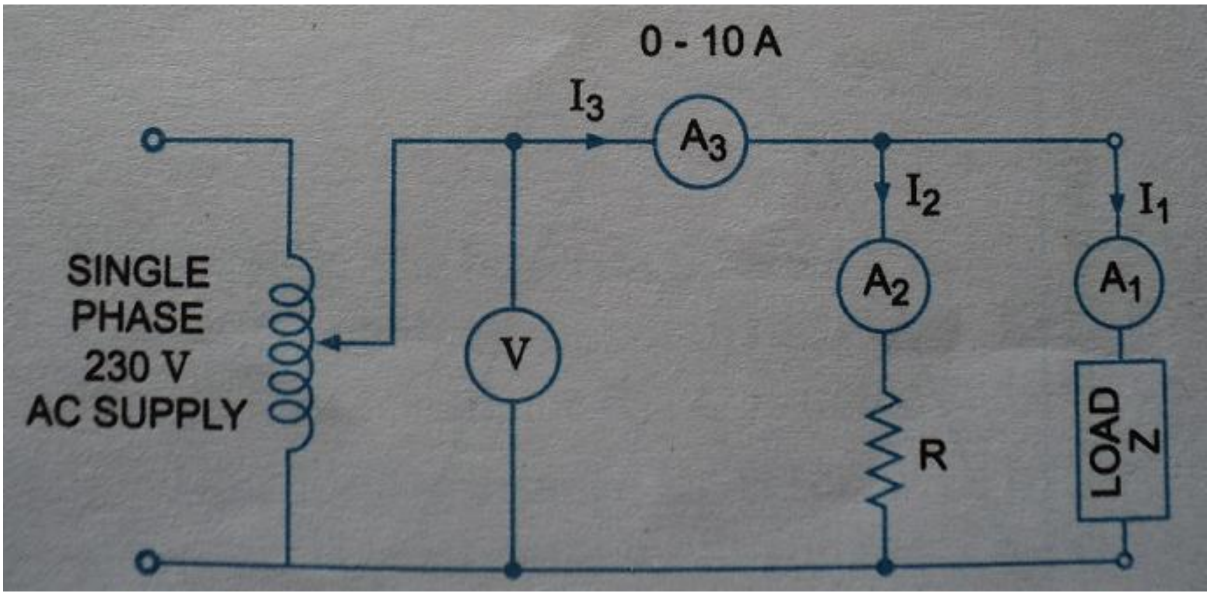
Serial No.	Equipment	Specification	Quantity	Remark
1	AC ammeter	0-5A	3	
2	AC voltmeter	0-300V	1	
3	single phase inductive load		1	
4	variac	10A,250V	1	
5	non-inductive resistor		1	
6	capacitor		1	
7	connecting wire.			

3. THEORY: Real power (P) in a single phase ac series inductive circuit can be measured either by wattmeter or with the help of three ammeters.

P= VICosΦ ; Watt

Power factor (cosΦ) can be measured either by power factor meter or with the help of three ammeters.

4. CIRCUIT DIAGRAM:



5. PROCEDURE:

Keeping the variac at its minimum position, supply is switched on.Variac position is gradually varied to increase the voltage applied to the circuit so that the reading of the ammeter A_3 and voltmeter are appreciable. Reading of ammeter A_1 ,A_2 and A_3 are noted down. Supply is switched off, Capacitor C is connected across the load as shown in figure and supply is switched on. Readings of ammeter A_1 , A_2 and A_3 are noted down.Process may be repeated for different inductive load or different non inductive resistors R.

6. OBSERVATIONS:

Sr. No	Reading of Ammaters in A						Power in W		Power factor of load	
	Without Capacitor			With Capaitor			Without capacitor	With Capacitor	Without capacitor	With Capacitor
	I_1	I_2	I_3	I_1'	I_2'	I_3'	$P = (I_3^2 - I_1^2 - I_2^2) \times \frac{R}{2}$	$P = (I_3'^2 - I_1'^2 - I_2'^2) \times \frac{R}{2}$	$\cos\phi = \frac{(I_3^2 - I_1^2 - I_2^2)}{2I_1 I_2}$	$\cos\phi' = \frac{(I_3'^2 - I_1'^2 - I_2'^2)}{2I_1' I_2'}$

7. CALCULATION: $P = (I_3^2 - I_1^2 - I_2^2) \times \frac{R}{2}$ $\qquad$ $P = (I_3'^2 - I_1'^2 - I_2'^2) \times \frac{R}{2}$

$$\cos\phi = \frac{(I_3^2 - I_1^2 - I_2^2)}{2I_1 I_2} \qquad \cos\phi' = \frac{(I_3'^2 - I_1'^2 - I_2'^2)}{2I_1' I_2'}$$

8. RESULT AND DISCUSSION: Power consumed by the circuit remains unchanged on connecting capacitor C across the load but the power factor improves.

9. PRECAUTIONS:

1. All connections should be tight.
2. All steps should be followed carefully.
3. Readings and calculation should be taken carefully.
4. Don’t touch the live terminals.

10. PRE EXPERIMENT QUESTIONS:

1. What are Real Power, Reactive Power and Apparent Power? What is relation amongst them?

2. What do you mean by power factor?

11. POST EXPERIMENT QUESTION:

1. What is power consumed in a purely inductive or purely capacitive circuit?

2. What is desirable power factor, lower or higher?

3. What are the methods to improve power factor?

4. What are the values of power factor for (i) purely resistive circuit (ii) purely inductive circuit (iii) purely capacitive circuit?

EXPERIMENT 4

1. OBJECTIVE: STUDY THE PHENOMENON OF RESONANCE IN RLC SERIES CIRCUIT AND OBTAIN RESONANT FREQUENCY.

2. APPARATUS REQUIRED:

Serial No.	Equipment	Specification	Quantity	Remark
1	AC Voltmeters	0- 300V	2	
2	AC ammeter	0-5A		
3				
3	Resistance Box		1	
4	Rheostat	10 Ω, 2.5A	1	
5	Connecting Wires			

3. BRIEF THEORY:

Consider an ac circuit containing R,L,C in series .

1. Impedance of the circuit $Z=(R^2+(X_L-X_C)^2)^{1/2}$

2. At resonance voltage $X_L=X_C$

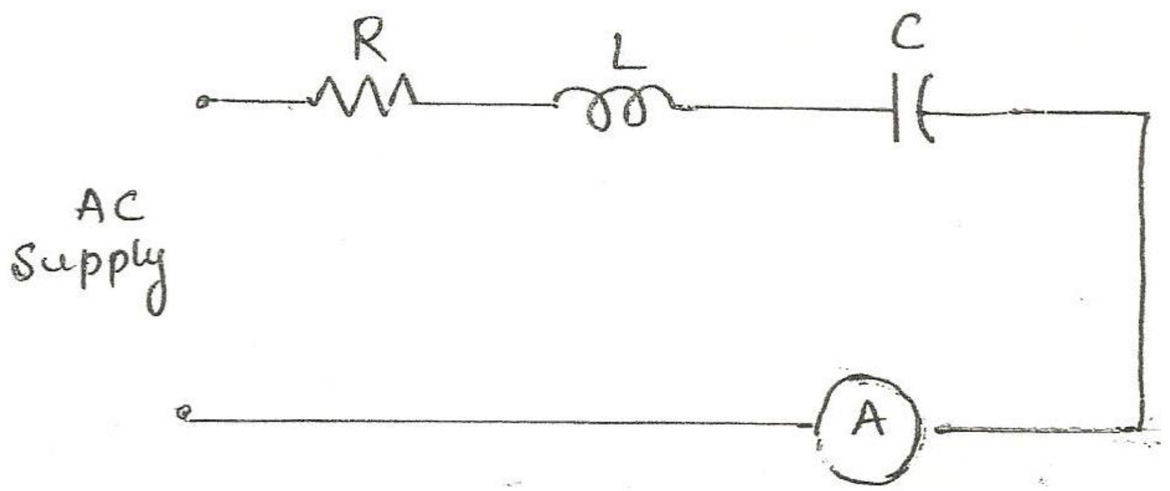
3. Net reactance of the circuit is zero, so Z=R.

4. Current flowing in the circuit is maximum I =V/R

5. Voltage across inductor is equal to capacitor

6. Power factor is unity at resonance condition

4. CIRCUIT DIAGRAM:



5. PROCEDURE:

1. Connect the inductor and capacitor in series with a resistance by shorting link; say C, L and R, as per the circuit diagram.
2. Calculate the resonant frequency theoretically by the following formulae $f_r = \frac{1}{2\pi\sqrt{LC}}$

3. Keep oscillator output at about 1 KHz and 2V p.p and observe it on the C. R.O.

4. Observe the voltage across the condenser on the C. R.

5. Observe the voltage across inductor on the other channel of C. R.O.

6. Vary the input frequency in steps from about 100Hz to 100 KHz. Keep on recording the values of voltage, current, and frequency. At resonant frequency you will get a minimum output voltage and maximum output current

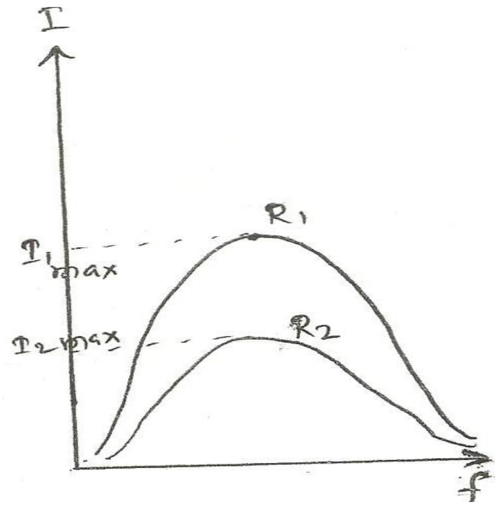
7. Record this resonance frequency and compare it with the calculated value by using formula, tabular your results in observation table.

6. OBSERVATION TABLE:

Sr. No	Observed Frequency (Hz)	Voltage	Current

7. CALCULATION: Calculate resonant frequency $f_r = \frac{1}{2\pi\sqrt{LC}}$ **theoretically.**

8. RESULT AND DISCUSSION: Plot the graph between frequency and current i.e. Resonance Curve. If the value of Resistance is changed, observe the nature of graph.
Resonance occurs at ___________Hz.



9. PRECAUTIONS:

9. All connections should be tight.
10. All steps should be followed carefully.
11. Readings and calculation should be taken carefully.
12. Don't touch the live terminals.

10. PRE EXPERIMENT QUESTIONS:

1. What do you mean by resonant frequency?

Ans: The frequency of the supply at which two reactances i.e. inductive and capacitive, are equal.

2. What is series resonance?

Ans: An R-L-C series circuit in which the inductive reactance equals capacitive reactance is called series resonance.

11. POST EXPERIMENT QUESTIONS:

1. Why series resonance called the voltage resonance?
2. What is resonance curve?
3. Why series resonance circuit is also called acceptor circuit and parallel resonance circuit is called rejector circuit?
4. What is the Quality factor of series resonant circuit?
5. What is the Quality factor of parallel resonant circuit?

Experiment 5

1. OBJECTIVE: TO STUDY POWER MEASUREMENT IN A THREE PHASE AC CIRCUITS BY TWO -WATTMETERS METHOD AND TO DETERMINE THE POWER FACTOR OF THE LOAD.

2. APPARATUS REQUIRED

Serial No.	Equipment	Specification	Quantity	Remark
1	Dynamometer type Wattmeters	500V, 10A	2	
2	MI ammeters	0 –10A	1	
3	MI voltmeter	0-500V	1	
3	3-Phase Balanced load	440V, 50Hz	1	
4	TPIC switch		1	
5	Connecting Wires			

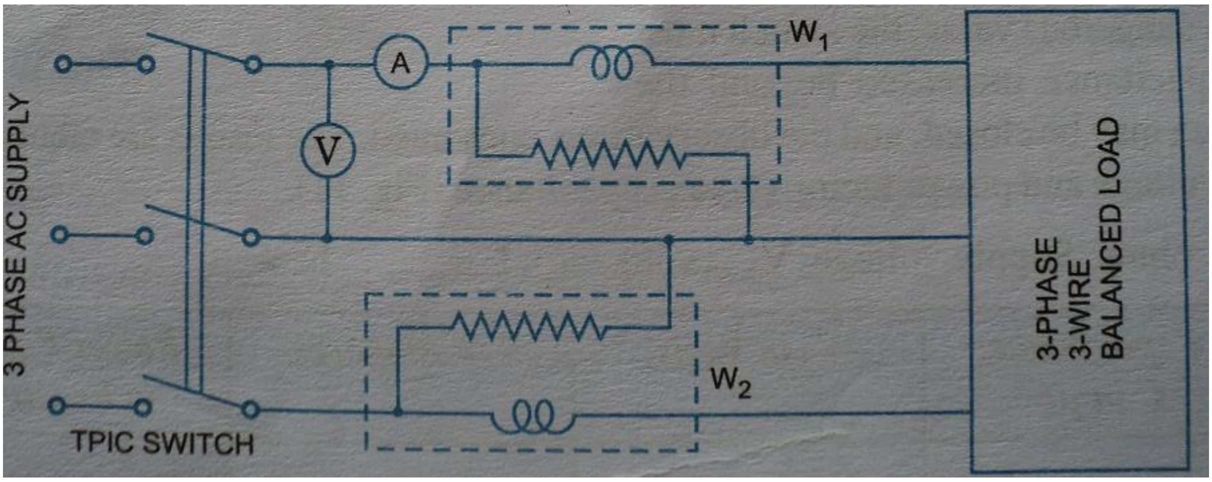
3.BRIEF THEORY: The connection diagram is shown in figure below. The sum of two wattmeter readings gives the total power of the circuit irrespective of the fact that the circuit is balanced or unbalanced and star-connected or delta-connected.

The total power is given as the sum of two wattmeter readings W_1 and W_2.

Total power of the load $P = W_1 + W_2$.

Power factor of the load, $\cos\phi = \cos(\tan^{-1}\sqrt{3}\frac{W_1 - W_2}{W_1 + W_2})$

4.CIRCUIT DIAGRAM:



5.PROCEDURE: -

(i) Connect the circuit as per circuit diagram.
(ii) Vary the load.
(iii) Note down all the readings carefully in the observation table.
(iv) If one wattmeter reads negative or gives reverse readings, the readings of the wattmeter are taken by reversing the current coil terminal.

6. OBSERVATION TABLE:

S.No.	Voltage V_L (in volts)	Current I_L (in amps.)	Power P_1 (watts)	Power P_2 (watts)	Total Power (P)	Power factor cosΦ

7.CALCULATIONS:

Total power (P) = $P_1 + P_2$

P = …….watts

Power factor = $\cos\phi = \cos(\tan^{-1}\sqrt{3}\frac{W_1 - W_2}{W_1 + W_2})$

8. RESULT AND DISCUSSION: The sum of two wattmeter readings gives the total power of the circuit no matter whether the circuit is balanced or unbalanced and star-connected or delta-connected. Power consumed and power factor at various loads is shown in the observation table.

9. PRECAUTIONS:

(i) All connections should be tight.
(ii) All apparatus should be of suitable range & ratings.

(iii) Readings should be taken carefully.
(iv) Never touch the live terminals and wires.
(v) Before reversing the connections of CC or PC, switch off the supply.

10. PRE EXPERIMENT QUESTIONS:

1. What is the relation between line voltage & phase voltage & line current & phase current in star and delta connections?

Ans: for star connection

$$I_L = I_{PH}$$
$$V_L = \sqrt{3}V_{PH}$$

For delta connection:

$$V_L = V_{PH}$$

$$I_L = \sqrt{3}I_{PH}$$

2. What is the value of power consumed in star & Delta?

Ans:
$$P = \sqrt{3}V_L I_L \cos\phi$$
$$Q = \sqrt{3}V_L I_L \sin\phi$$
$$S = \sqrt{3}V_L I_L$$

3. How to determine power factor from Wattmeter readings?

Ans: power factor = $\cos\phi$

As $\phi = \tan^{-1}\sqrt{3}\frac{W_1 - W_2}{W_1 + W_2}$; for lagging power factor

$\phi = \tan^{-1}\sqrt{3}\frac{W_2 - W_1}{W_1 + W_2}$; for leading power factor

11. POST EXPERIMENT QUESTIONS:
1. What do you mean by three-phase balanced load?
2.What is phase sequence in a three-phase system?
3. How is given phase sequence reversed?
4. What is the cause for wattmeter reading being negative? How will you take the reading?
5. What are different methods for power measurement in three phase ac circuits?

EXPERIMENT 7a

1. **OBJECTIVE: DETERMINATION OF POLARITY AND VOLTAGE RATIO OF A SINGLE PHASE TRANSFORMER.**

2. **APPARATUS REQUIRED:**

Serial No.	Equipment	Specification	Quantity	Remark
1	Transformer		1	
2	AC Voltmeter	0-500V	3	
3	Variac		1	
3	Connecting leads			

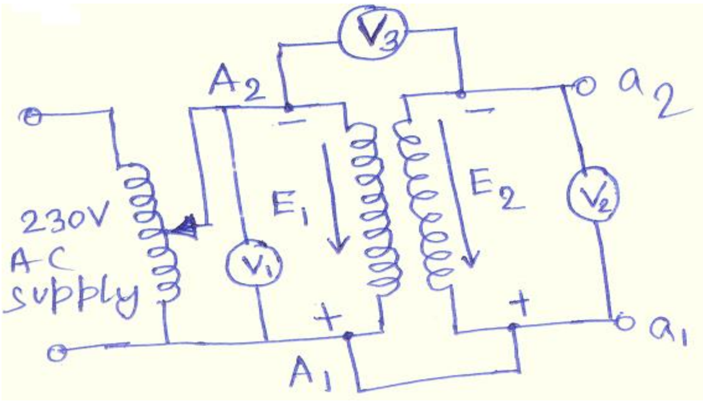
3. **THEORY:**

Polarity Test: On the primary side of a two winding transformer, one terminal is positive with respect to the other one at any instant. At the same instant, one terminal of the secondary winding is positive with respect to the other one. Polarity test is performed to determine the terminals having the same instantaneous polarity. The relative polarities of the primary and secondary terminals at any instant must be known for connecting windings of the same transformer in parallel, or series, or for interconnecting two or more transformers in parallel, or for connecting single phase transformers for polyphase transformation of voltages.

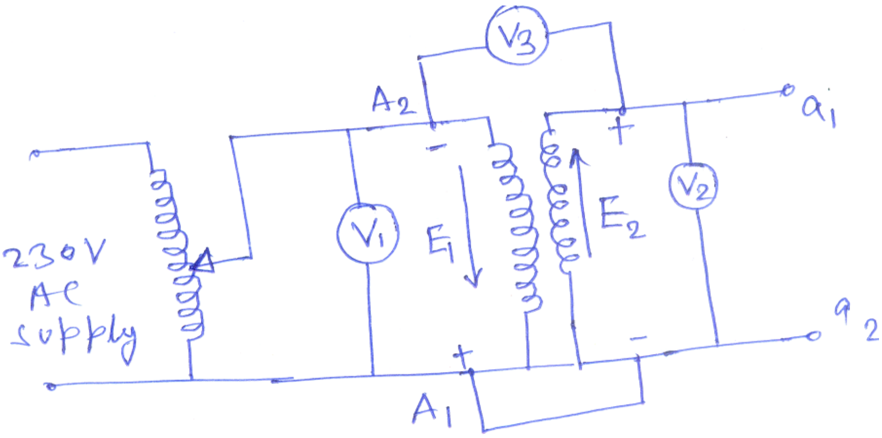
In subtractive polarity, the voltage between A_1 and a_1 is reduced. The leads connected to these terminals and the two windings are, therefore, not subjected to high voltage stress. On the other hand in additive polarity the two windings and leads connected to A_1, A_2, a_1 and a_2 are subjected to high voltage stresses. This is the reason that subtractive polarity is preferred over additive polarity.

Voltage ratio Test: the true ratio is based on turn-ratio. If the secondary and primary voltages are measured on no load, their ratio is very nearly equal to the true value. Measurement of primary and secondary currents in short –circuit test also gives fairly accurate result (voltage ratio = $\frac{V_2}{V_1} = \frac{I_1}{I_2}$), especially if the transformer has little leakage flux and low core reluctance.

4. CIRCUIT DIAGRAM:



Subtractive Polarity



Additive Polarity

5. PROCEDURE:

<u>Polarity Test:</u>

1. As per circuit diagram, terminals A_1 and A_2 are marked plus and minus arbitrarily.

2. Now terminal A_1 is connected to one end of secondary winding and a voltmeter is connected between A_2 and other end of secondary winding.

3. A voltage V_3 of suitable value is applied to the high voltage winding.

4. Measure E_1 and E_2 by connecting voltmeters V_1 and V_2 across two windings.

5. If the voltmeter V_3 reading, measured in step 3 , is equal to $E_1 - E_2$, then secondary terminal connected to A1 is +ve and another terminal –ve.

6. If the voltmeter V_3 reading is equal to $E_1 + E_2$, then secondary terminal connected to A_1 is -ve and another terminal +ve.

6. OBSERVATION:

Subtractive Polarity:

Sr. No.	Reading for V_1	Reading for V_2	Reading for V_3	$V_3 = V_2 - V_1$

Additive Polarity:

Sr. No.	Reading for V_1	Reading for V_2	Reading for V_3	$V_3 = V_2 + V_1$

<u>Voltage ratio:</u>

Procedure:

1. Connect one voltmeter on the primary and the other on the secondary side, on open circuit.

2. Note down readings of both voltmeters.

Observation:

Sr. No.	Reading for V_1	Reading for V_2	Voltage ratio= $\frac{V_2}{V_1}$

7. CALCULATION:

8. RESULT AND DISCUSSIONS:

When the voltmeter reads the difference E1-E2 , the transformer is said to possess a subtractive polarity and when the voltmeter reads E1+E2 , the transformer is said to possess a additive polarity.

The voltage ratio of a transformer is obtained from the readings of the two voltmeters one on the primary, and the other on the secondary side, on open circuit.

Voltage ratio= $\frac{V_2}{V_1}$ on open circuit

9. PRECAUTION:

1. All connections should be tight.
2. All steps should be followed carefully.
3. Readings and calculation should be taken carefully.
4. Don't touch the live terminals.

10. PRE EXPERIMENT QUESTIONS:

1. Define Transformer.

2. What do you understand by step-up and step-down transformer?

3. What are the properties of ideal transformer?

11. POST EXPERIMENT QUESTIONS:

1. What is the difference between ideal and practical transformer?

2. What happens when a transformer is connected with DC supply?

3. What is the need for performing polarity test on a transformer?

4. What is the need for performing voltage ratio test on a transformer?

EXPERIMENT 7 b

1. OBJECTIVE:

TO DETERMINE EFFICIENCY BY LOAD TEST OF A SINGLE PHASE TRANSFORMER.

2. APPARATUS REQUIRED:

Serial No.	Equipment	Specification	Quantity	Remark
1	1-Φ Transformer	1KVA	1	
2	Ammeter	(0-10)A (0-5) A	1 1	MI MI
3	Voltmeter	(0-150)V (0-300) V	1 1	MI MI
4	Wattmeter	(300V, 5A) (150V, 5A)	1 1	Upf Upf
5	Auto Transformer	1ϕ, (0-260)V	1	-
6	Resistive Load	5KW, 230V	1	-
7	Connecting Wires	2.5sq.mm	Few	Copper

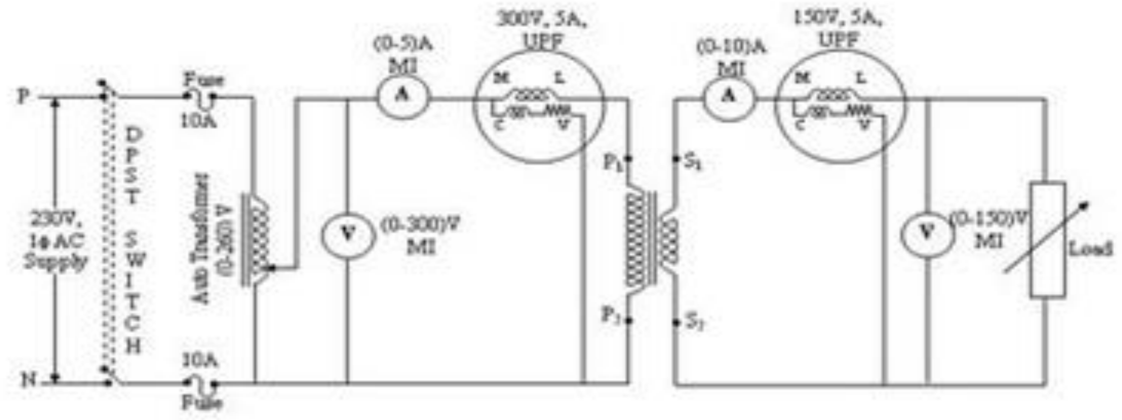
3. THEORY:

The efficiency of a transformer is given as

$$\eta = \frac{OutputPower}{InputPower} \times 100 = \frac{V_2 I_2 \cos\phi_2}{V_1 I_1 \cos\phi_1} \times 100$$

It is inconvenient and costly to have necessary loading devices of the correct current and voltage ratings and power factor to load the transformer. There is also wastage of large amount of power and no information is available from such a test about proportion of copper and iron losses.

4. CIRCUIT DIAGRAM:



5. PROCEDURE:

1. Connections are made as per the circuit diagram.

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

6. OBSERVATION:

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

7. CALCULATION:
Output Power = W_2 x Multiplication factor
Input Power = W_1 x Multiplication factor

Efficiency,
$$\eta = \frac{OutputPower}{InputPower} \times 100$$

8. RESULT AND DISCUSSIONS:
Due to lack of rotating parts in a transformer, there are no frictional and windage losses. The other losses such as iron losses are also comparatively small because of better magnetic material. So transformer efficiency is quite high compared to other electrical machines.

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

10. PRE EXPERIMENT QUESTIONS:
1. Why the transformer efficiency quite high compared to other electrical machines?
2. Does the transformer draw any current when its secondary winding is open?

11. PRE EXPERIMENT QUESTIONS:

1. Generally, what is the value of efficiency of a transformer?
2. What are different losses of transformer?
3. When secondary current increases, primary current also increases in a transformer. Why?
4. What is the value of efficiency of a transformer when its secondary winding is open?

EXPERIMENT 8

1. OBJECTIVE:

TO STUDY SPEED CONTROL OF A DC SHUNT MOTOR USING

(I) FIELD CURRENT

(II) ARMATURE CURRENT.

2. APPARATUS REQUIRED:

Serial No.	Equipment	Specification	Quantity	Remark
1	DC shunt motor	250V, 2kW	1	
2	PMMC ammeter	0 –10A	2	
3	Rheostats		2	
3	Tachometer		1	
4	3-point starter		1	
5	DPIC switch		1	
6	Connecting Leads			

3. THEORY:

We know that, in DC Shunt motor, the back emf is given by

$$Eb = V - IaRa = \frac{\phi ZNP}{60A}$$

So Speed

N = (V-IaRa) / ZΦP x 60A ***(1)***

$$N \propto 1/\Phi \text{ and } N \propto 1/Ra \qquad \text{(N is speed in RPM)}$$

Where Φ is flux per pole & Ra is armature resistance.

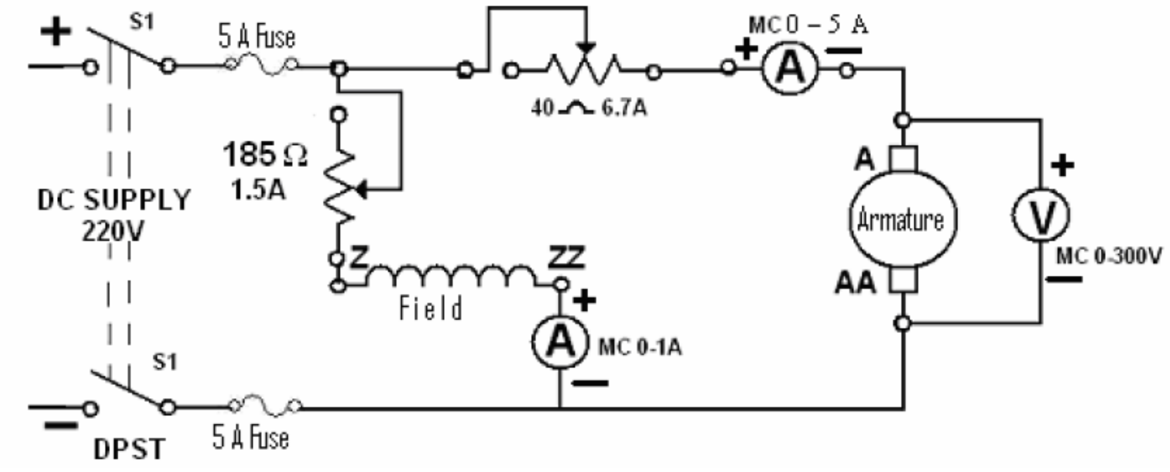
(a) *Field Control Method:*

This method is applied, where we have to obtain the speed greater than normal rated speed. If we insert a resistance in field winding, field current becomes less, consequently flux also becomes less & speed increases.

(b) Armature Control Method:

If we need the speed less than the rated speed, we use this method. When we insert a resistance in the series of armature, IaRa will increase; therefore the speed of shunt motor reduces by the equation (1)

4. CIRCUIT DIAGRAM:



5. PROCEDURE:

(i) Connect the circuit as shown in circuit diagram.
ii) Start the motor with maximum resistance in the armature circuit and minimum resistance in the field circuit.
iii) Bring the motor to the rated speed, first by decreasing the resistance in the armature circuit and then by increasing the resistance in the field circuit.
iv) Vary the resistance in the field circuit and take readings of speed and field current, keeping the armature voltage constant at a particular value.
v) Change armature voltage to another value and repeat the procedure given in – (iv)
vi) Then change the resistance in the armature circuit and take reading of speed and armature voltage, keeping the field current constant at a particular value.
vii) Change the field current to another value, repeat the procedure given in (vi).
viii) Take three sets of readings for each method of variation.

6. OBSERVATION TABLE:

Table I: Variation of speed with field excitation.

Sl. No.	Field current(A)	Speed(rpm)	Constant Armature Voltage (V)

Table II : Variation of speed with armature voltage.

Sl. No.	Armature voltage (V)	Speed(rpm)	Constant field Current (A)

7. CALCULATION:

8. RESULT AND DISCUSSIONS:

1. With the increase in resistance in the field circuit, the field current decreases so speed increases.

2. With the increase in resistance in the armature circuit, voltage drop in armature increases i.e. back emf E_b decreases and, therefore, speed decreases.

3. Plot speed against field current for different sets of constant armature voltage on a graph paper.

4. Plot speed against armature voltage for different sets of constant field current on another graph paper.

9. PRECAUTIONS:

1. All connections should be tight.
2. Don't touch live terminals.
3. Don't insert the resistance in field winding, when motor begins to start.
4. Reading should be obtained carefully.

10. PRE EXPERIMENT QUESTIONS:

1. What is the function of DC motor?
2. What is working principle of DC motor?
3. What is Back EMF ?

11. POST EXPERIMENT QUESTIONS:

1. What are the methods for speed control of DC shunt motors?
2. In order to increase the speed above rated speed, which method of speed control is used in DC shunt motor?
3. In order to decrease the speed below rated speed, which method of speed control is used in DC shunt motor?

EXPERIMENT 9

Determinations of efficiency of a dc shunt motor by load test.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostat	1250Ω, 0.8A	Wire Wound	1
4	Tachometer	(0-1500) rpm	Digital	1
5	Connecting Wires	2.5sq.mm.	Copper	Few

PRECAUTIONS:

1. DC shunt motor should be started and stopped under no load condition.
2. Field rheostat should be kept in the minimum position.
3. Brake drum should be cooled with water when it is under load.

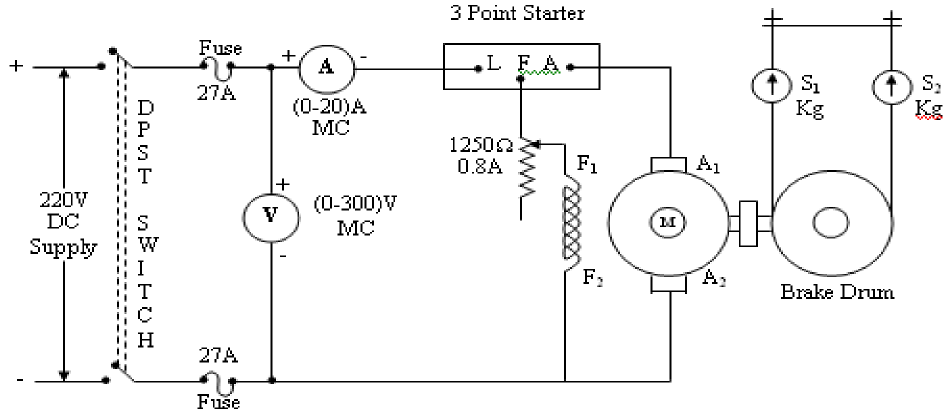
PROCEDURE:

1. Connections are made as per the circuit diagram.
2. After checking the no load condition, and minimum field rheostat position, DPST switch is closed and starter resistance is gradually removed.
3. The motor is brought to its rated speed by adjusting the field rheostat.
4. Ammeter, Voltmeter readings, speed and spring balance readings are noted under no load condition.

5. The load is then added to the motor gradually and for each load, voltmeter, ammeter, spring balance readings and speed of the motor are noted.

6. The motor is then brought to no load condition and field rheostat to minimum position, then DPST switch is opened.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 21}{100} = 26.25A$$

NAME PLATE DETAILS:

Rated Voltage : 220V
Rated Current : 21A
Rated Power : 3.5KW
Rated Speed : 1500 RPM

S.No.	Voltage V (Volts)	Current I (Amps)	Spring Balance Reading		$(S_1 \sim S_2)$Kg	Speed N (rpm)	Torque T (Nm)	Output Power Pm (Watts)	Input Power P_i (Watts)	Efficiency η%
			S_1(Kg)	S_2(Kg)						

TABULAR COLUMN:

FORMULAE:

Circumference of the Brake drum = cm.

$$R = \frac{\text{Circumference}}{100 \times 2\pi} \text{ m}$$

Torque $T = (S_1 \sim S_2) \times R \times 9.81$ Nm

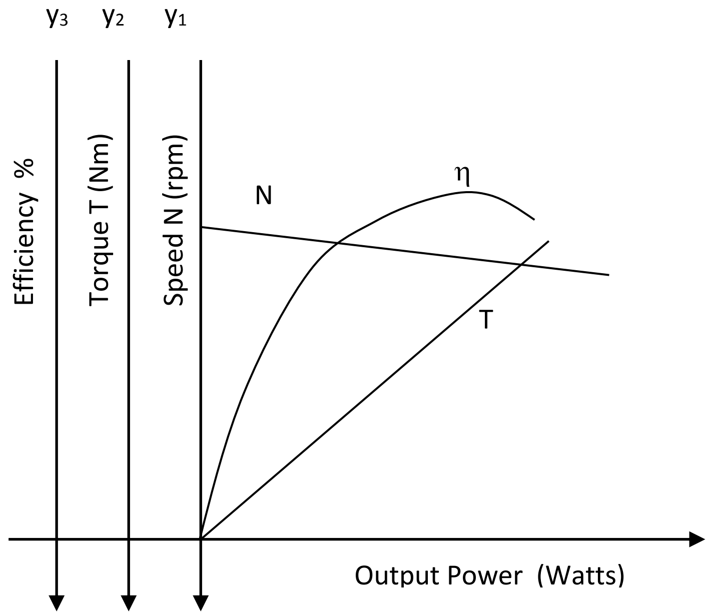
Input Power $P_i = VI$ Watts

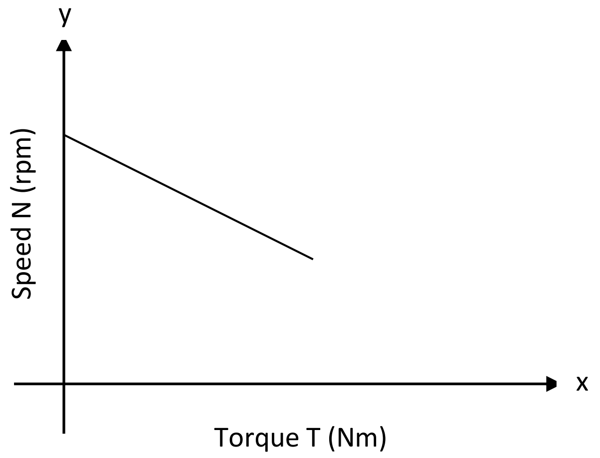
Output Power $P_m = \dfrac{2\pi NT}{\quad}$ Watts

60

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

MODEL GRAPHS:





RESULT:

Thus load test on DC shunt motor is conducted and its efficiency is determined.

EXPERIMENT 10

1. OBJECTIVE:

TO STUDY RUNNING AND SPEED REVERSAL OF A 3-PHASE INDUCTION MOTOR AND RECORD SPEED IN BOTH CONDITIONS.

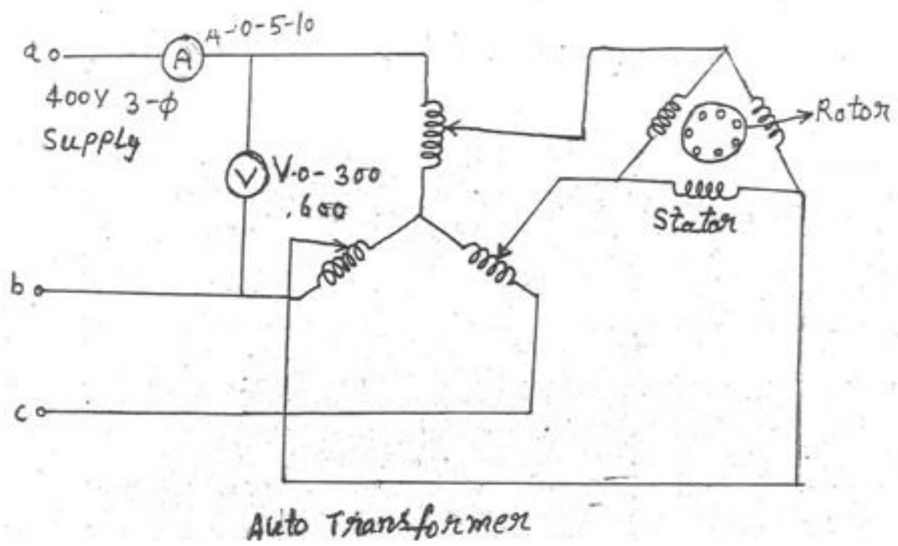
2. APPARATUS REQUIRED:

Serial No.	Equipment	Specification	Quantity	Remark
1	3-phase induction motor		1	
2	Star-delta Starter		1	
3	TPIC switch		1	
4	Speedometer		1	
5	Connecting leads			

3. THEORY:

When a 3-Φ supply is provided to a three- phase wound stator of an induction motor, a rotating magnetic field is established, rotating at synchronous speed. At start, stationary rotor conductors cut across the revolving magnetic field and emf is induced in them by the electromagnetic phenomenon. Current flows through the rotor conductors, as they form a closed path, and so rotor field is developed. By interaction of stator magnetic field and rotor field, torque develops and causes the rotation of rotor in the same direction as that of revolving magnetic field. Motor is connected to the 3-phase ac supply mains through star-delta starter and TPIC switch. The direction of rotation of a 3-phase induction motor can be reversed by interchanging any two terminals at the TPIC switch and speed can be measured by Speedometer.

4. CIRCUIT DIAGRAM:



5. PROCEDURE:

1. The connections of a 3-phase induction motor are made to the star-delta starter and to the TPIC switch, as shown in figure.
2. The TPIC switch is closed and the motor is started by taking the lever of the starter to the start (star) position and then with a jerk to the run (delta) position. The direction of the rotation of the motor is observed. Say, it is in clockwise direction.
3. Speed of the motor is measured by a speedometer.
4. Now the motor is stopped by pushing the stop button and supply to the motor is removed by opening the TPIC switch.
5. The two leads of the motor are interchanged to the TPIC switch.
6. TPIC switch is closed and the motor is started again.
7. The direction of rotation of the motor is observed. Speed of motor is again measured by a speedometer.
8. The push button is pushed and the TPIC switch is made off.

6. OBSERVATIONS:

1. The direction of rotation of the motor in second case is found opposite to that in first case.
2. The speed of the motor is same in both cases.

7. CALCULATION:

8. RESULT AND DISCUSSION: The direction of rotation of 3-phase induction motor changes by interchanging the any two terminal connections of stator winding.

9. PRECAUTIONS:

(i) All connections should be tight.
(ii) Never touch the live terminals.
(iii) Before changing the connections switch off the power supply..
(iv) Increase the load slowly.
(v) Don’t wear loose dress during the experiment, it may be dangerous.
(vi) Care must be taken to put lever of the starter at star position at the time of starting.

10. PRE EXPERIMENT QUESTIONS:

1. What is meant by an induction motor?
2. What are the types of 3-phase induction motors?
3. What is rotating magnetic field?
4. What is Slip?

11. POST EXPERIMENT QUESTIONS:

1. How can the direction of rotation of the 3-phase induction motor be reversed?
2. Which type of induction motor is generally preferred?
3. How to reverse the direction of rotating of 3-phase induction motor?
4. What will happen if we interchange the connections of all three phases?

EXPERIMENT 11

1. OBJECTIVE: TO MEASURE ENERGY BY A SINGLE PHASE ENERGY METER AND DETERMINE ERROR.

2. APPARATUS REQUIRED:

Serial No.	Equipment	Specification	Quantity	Remark
1	Energy Meter	5 A,240 V	1	
2	MI voltmeter	0-300V	1	
3	MI ammeter	0-5 A	1	
4	Dynamometer Type wattmeter	5 A,240 V	1	
5	Auto-transformer or Variac	0- 300 V	1	
6	Lamp load			
7	Spot watch			
8	DPIC switch		1	
9	Connecting leads			

3. BRIEF THEORY:

Energy meter is an integrating instrument which is used to record the energy consumed by the load during a given time period. 1- Phase Induction type energy meter, as shown in figure 1, is the most common form of AC KWH meters used every day in domestic and industrial installations. These meters measure electrical energy in Kilo-watt hours. The principle of this meter is practically the same as that of the induction wattmeter.

There are four parts of the energy meter:

(i) **Driving System:**
The driving system of the energy meter consists of two silicon steel laminated electromagnet M1 & M2.M1 is called as a series magnet and M2 is called as a shunt magnet. M1 is called current coil connected in series with the circuit. M2 is called as a voltage coil and is connected across the supply.
Short-circuited copper shading bands are provided on the lower part of the central limb of the shunt magnet. These loops are called power factor compensators. by adjusting the position of these poles the shunt magnet flux can be made to lag behind the voltage by 90 degree, the function of upper band is to provide fractional compensation.

(ii) **Moving System:**
This system consists of a thin alumilium disc mounted on a spindle. The disc is placed in the air gap between the series & shunt magnets so that it cuts the fluxes of both the magnets. A deflecting torque is produced by the flux of earth magnet with eddy current induced in the disc by the flux of other magnet.

(iii) Braking System:

It consists of a permanent magnet known as brake magnet. it is placed near the edger of the aluminum disc. When the disc rotates in the field of the brake magnet, eddy currents react with the flux and exert a braking or retarding torque and this is proportional to the speed of the disc. The amount of this torque can be adjusted by adjusting the position of the brake magnet. In some brake magnets are placed diagonally.

(iv) Registering System:

The disc spindle is connected through a set of gears to a counting mechanism and records a number, which is proportional to the number of revolutions of the disc and indicates the energy consumed directly in KWh.

The data mentioned on the name plate of the energy meter are as follows:

No of phases: single

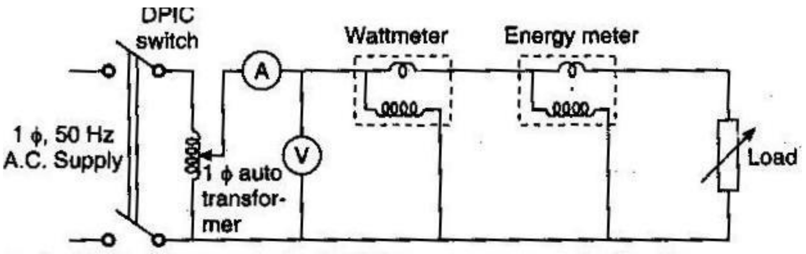
Volts: 230/240/250 V

Frequency: 50 Hz

Current rating: 5/10/25 A

Energy meter constant: ……revolution/kWh

4. CIRCUIT DIAGRAM:



5. PROCEDURE:

1. Connect the circuit according to circuit diagram.
2. Apply the rated voltage by auto transformer at no load.
3. The current coil of energy meter is connected in series with load, while the pressure coils across the supply.
4. Connect the variable resistor or lamp load between phase and neutral. Note the readings of all meters.
5. Note down the time for particular revolution of disc of energy meter.

6. OBSERVATION TABLE:

Sr. No.	Voltage	Current	Power	No. of revolution	Time	Energy E_t (power *Time)	Energy(E_S

7. CALCULATION

E_t=Power*time (KWh)

E_S= No. of revolution/Meter constant

%Error= (E_S - E_t)*100/ E_S

8. RESULT AND DISCUSSIONS:

% error is …..%, the meter is FAST (if + ve) or SLOW (if –ve).

9. PRECAUTIONS:

(vii) All connections should be tight.

(viii) Never touch the live terminals.

(ix) Before changing the connections switch off the power supply..

(x) Increase the load slowly.

(xi) Don’t wear loose dress during the experiment, it may be dangerous.

10. PRE EXPERIMENT QUESTIONS:

1. What is difference between energy and power?

2. What is energy meter constant?

11. POST EXPERIMENT QUESTIONS:

1. Explain the construction of 1-phase induction type energy meter.

2. Measure the energy consumed in five days for your household electrical appliances.