

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

NETWORKS AND
ELECTRICAL TECHNOLOGY
LABORATORY
R16 REGULATIONS

SIR C.R.REDDY COLLEGE OF ENGINEERING:: ELURU-7
DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

ECE 217 NETWORKS LABORATORY
(2/4 ECE, I Semester)

- 1 Verification of ohm's law and Kirchhoff's laws
- 2 Verification of Superposition Theorem
- 3 Verification of Thevenin's Theorem
- 4 Verification of Maximum power Transfer Theorem
- 5 Verification of Reciprocity Theorem
- 6 Series R-L-C resonance & Parallel resonance
- 7 Two port networks
- 8 Time response of RL & RC circuits
- 9 Parameters of an Iron core Inductor
- 10 Calibration of Energy meter
- 11 Measurement of power in 3- Φ circuit
- 12 Series RLC vector diagram

Exp. No : 1

OHM'S LAW & KIRCHHOFF'S LAWS

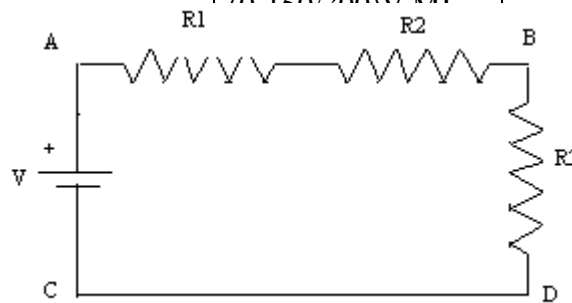
Aim:- To verify ohm's law and Kirchoff's voltage law and current law.

Apparatus:-

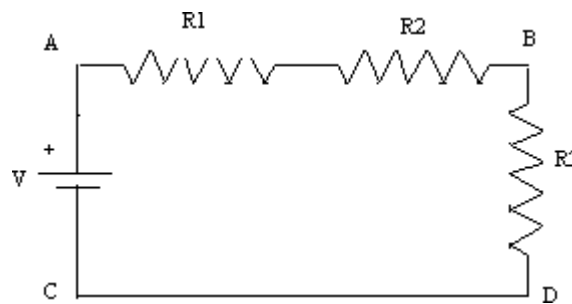
S.No	Description	Rating	Qty
1	1-Φ Dimmerstat	230/0-270V,8A	1
2	Incandescent lamp	25W	1
		40W	1
		60W	1
3	Ammeter	(0-1A)MI	3
		(0-3A)MI	1
4	Voltmeter	(0-150/200V)MI	4
5	Connecting wire		1
6	Connecting wire		-

Theory:-

a) Kirchoffs Voltage Law
According to this law, the algebraic sum of emfs acting in that circuit is equal to the algebraic sum of the IR drops.



Algebraic sum of emfs = Algebraic sum of IR drops in the circuit.



In mesh ABCD, $V=I(R_1+R_2+R_3)$

b) Kirchoff's Current Law:

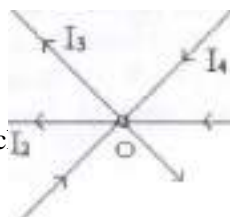
According to this law, in any network of wires carrying currents, the algebraic sum of all the currents meeting at a node is zero or the sum of all the incoming currents is equal to the sum of outgoing currents away from that node.

Let $I_1, I_2, I_3, I_4, I_5, I_6$ be the currents at node O. I_1, I_4, I_5 are the currents entering the node O and I_2, I_3, I_6 are the currents leaving the node O. Then according to Kirchoff's law,

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

i.e $I_1 + I_4 + I_5 = I_2 + I_3 + I_6$

c) Filament Lamp:-



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Ohm's Law:- At constant temperature the potential difference between two terminals of a conductor is proportional to the current flowing through the conductor.

V is proportional to I

$$V=I.R$$

Where R is the Resistance between those two terminals

$$R= V/I$$

The resistance of the filament lamp is determined by finding the current at different at voltages.

The filament lamp does not follow the ohms law because the lamp works at different temperatures.

The resistance at a temperature t°c

$$R_t=R_o[1+\alpha_0t]$$

Where R_o=Resistance at 0°c.

α_0 = temperature coefficient of resistance at 0°c

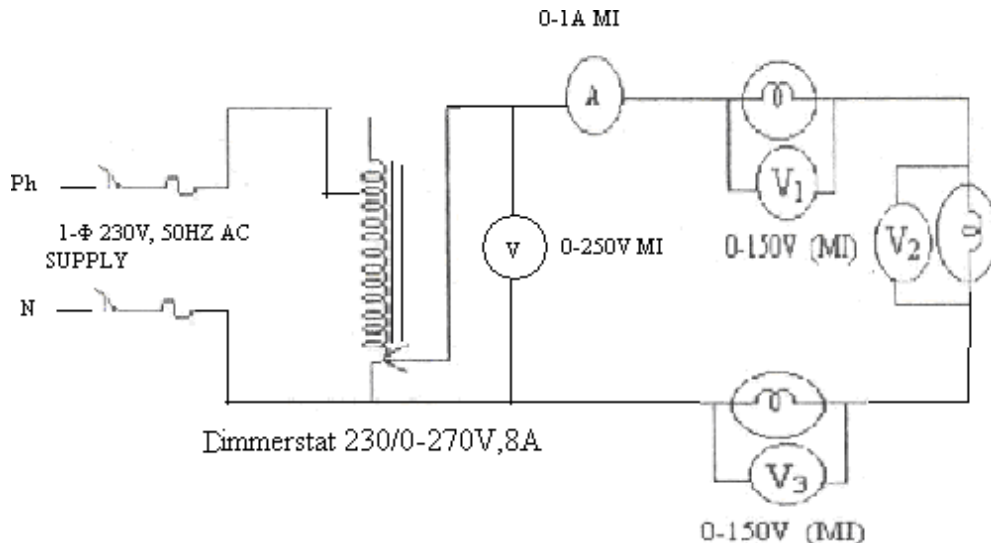
The graph between resistance and current is not linear.

The resistance of the filament lamp when the current flowing through the lamp is zero is called as cold resistance. i.e the resistance at room temperature.

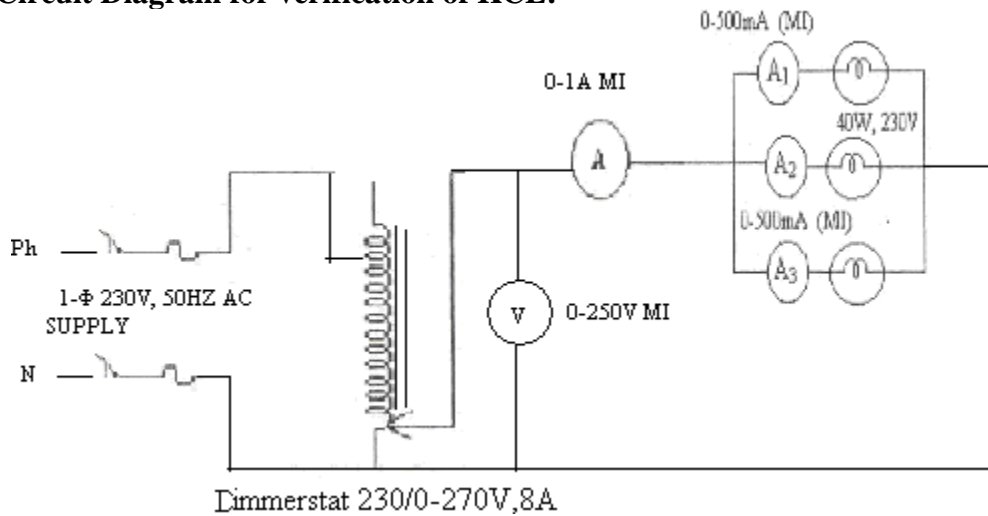
Graph:-



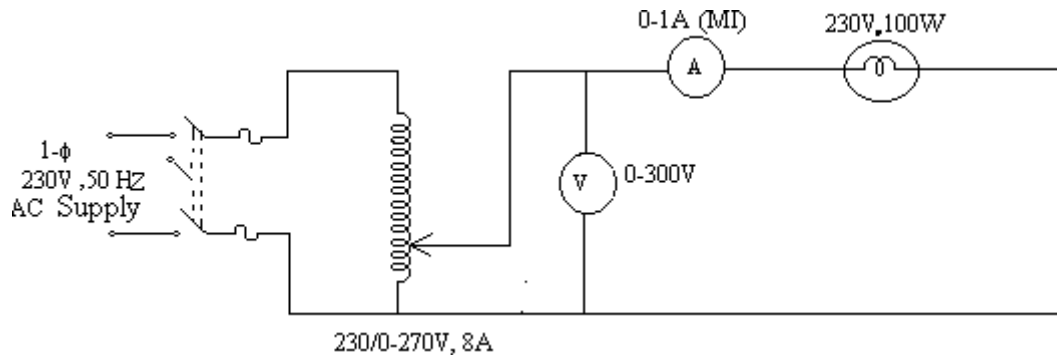
Circuit diagram for Verification of KVL:



Circuit Diagram for verification of KCL:-



Circuit diagram for measurement of resistance of a filament lamp



Procedure:-

a) Kirchhoff's Voltage Law:

1. The connections are made as shown in the circuit diagram.
2. With the dimmer stat at zero output the supply switch is closed.
3. The output of the dimmers tat is adjusted to the voltage in steps as given in the tabular column and the readings of V I, V 2, V 3 are noted for each step,
4. The dimmerstat is brought back to zero output and the supply switch is opened.

b) Kirchhoff's 's Current Law:

1. The connections are made as shown in the circuit diagram.
2. With the Dimmerstat at zero output the supply switch is closed.
3. The output of the dimmer stat is adjusted to the voltage in steps as given in the tabular column and all the ammeter readings are noted for each step.
4. The Dimmerstat is brought back to zero output and the supply switch is opened

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c) measurement of resistance of a filament lamp

1. The connections are made as shown in the circuit diagram.
2. With the Dimmerstat at zero output the supply switch is closed.
3. The Dimmerstat is varied in steps as given in the tabular column and the respective Ammeter readings are noted.
4. The Dimmerstat is brought back to zero output and the supply switch is opened

Tabular Column for Verification of KVL:

Sl.No	Applied voltage				$V = V_1 + V_2 + V_3$
	V in volts	V ₁ in volts	V ₂ in volts	V ₃ in volts	
1	50				
2	100				
3	150				
4	200				
5	230				

Tabular Column for Verification of KCL:

Sl.No	Applied voltage				$I = I_1 + I_2 + I_3$
	V in volts	I ₁ in Amps	I ₂ in Amps	I ₃ in Amps	
1	50				
2	100				
3	150				
4	200				
5	230				

Tabular column for measurement of resistance of a filament lamp:-

Sl.No.	V in Volts	I in Amps	R in Ohms	W in Watts
1.	50			
2.	100			
3.	150			
4.	200			
5.	230			

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Specimen calculations:-

KVL & KCL:-

$$V = V_1 + V_2 + V_3 \text{ (for KVL)}$$

$$I = I_1 + I_2 + I_3 \text{ (for KCL)}$$

Resistance of a filament lamp:-

$$R = \frac{V}{I} ; \quad W = I^2 R$$

Viva Questions:-

1. Why tungsten is used as filament in incandescent lamp ?
2. Melting point of a Tungsten -----
3. What are the types of filaments that are used in filament lamps?
4. Why gas is filled inside the filament lamp.
5. What is difference between AC and DC resistance
6. What is a linear circuit?
7. What is the heating effect of a electric current.
8. Define ohm 's law.
9. Define Kirchhoff's Voltage law.
10. Define Kirchhoff's Current law.
11. Filament of a lamp is made of -----
12. Give the Voltage Division Rule.
13. If one of the resistance in a parallel circuit is removed , what happence to the total resistance.
14. The series circuit consists of five equal resistances and dissipates 10 watts of power. Then power dissipated in each resistance?
15. The power dissipation in each of three parallel branches is 1W. What is the total Power dissipation of the circuit?
- 16.16.

Precautions:-

- 1) Do not touch bare conductors when supply is ON
- 2) Switch off all the measuring devices when NOT in USE.
- 3) Ensure that dimmerstat is in minimum position before switching ON the supply and before switching OFF the supply.
- 4) Ensure that there is no short circuit across the supply or any device, before switching ON the supply.
- 5) Check for prager polarity of meters.

Result:-

Exp. No : 2

VERIFICATION OF SUPERPOSITION THEOREM

Aim : To verify Superposition theorem.

Apparatus :

Sl.No.	Description	Rating	Qty.
1.	Dual DC power supply	0 - 30V, 2A	1
2.	Digital DC Milli ammeter	0 – 200mA	1
3.	Digital DC voltmeter	0 – 20V	1
4.	Superposition theorem circuit board	---	1
5.	Connecting wires	---	---

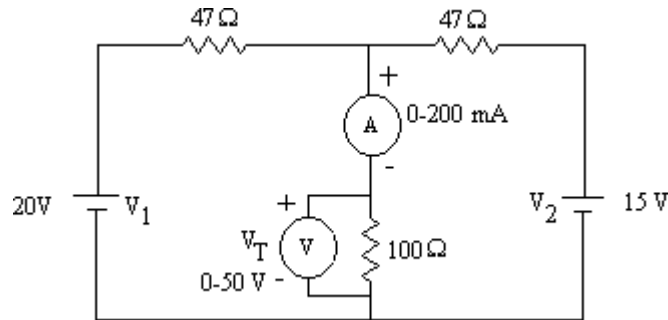
Theory:

Any linear network containing multiple sources, the response in any element is equal to the algebraic sum of responses due to individual sources.

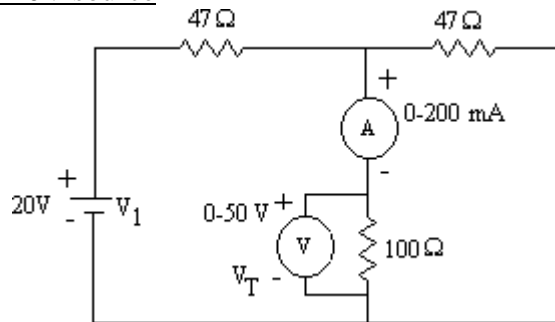
This theorem is applicable only in linear circuits, i.e., circuits consisting of resistance or impedance in which ohms law is valid. Superposition theorem can be applied to a circuit containing current sources and even to circuits containing both current and voltage sources. The above theorem is applied when the current in any particular branch of network containing number of voltage sources and current sources is to be determined.

Circuit diagram:

a) For the circuit with two sources

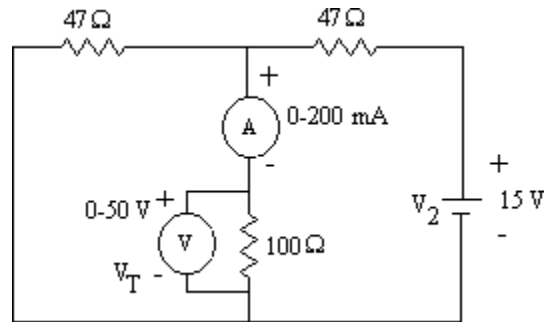


b) For the circuit with 20V source



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c) For the circuit with 15V source



Procedure :

a) For the circuit with two sources

1. The connections are made as shown in the circuit diagram - a.
2. With the voltage knobs of the Dual DC power supply at their minimum positions the power supply is switched ON.
3. The voltage V_1 is adjusted to 20V, the voltage V_2 is adjusted to 15V and the reading of the Milliammeter is noted.
4. The voltage knobs are brought back to their minimum positions and the power supply is switched OFF.

b) For the circuit with 20V source

1. The connections are made as shown in the circuit diagram - b.
2. With the voltage knobs of the Dual DC power supply at their minimum positions the power supply is switched ON.
3. The voltage V_1 is adjusted to 20V and the reading of the Milliammeter is noted.
4. The voltage knobs are brought back to their minimum positions and the power supply is switched OFF.

c) For the circuit with 15V source

1. The connections are made as shown in the circuit diagram - c.
2. With the voltage knobs of the Dual DC power supply at their minimum positions the power supply is switched ON.
3. The voltage V_2 is adjusted to 15V and the reading of the Milliammeter is noted.
4. The voltage knobs are brought back to their minimum positions and the power supply is switched OFF.

Tabular Column :

Sl.No.	Condition of the circuit	V ₁ <i>in</i> Volts	V ₂ in Volts	V _T in Volts	I <i>in</i> mA
1.	With Two voltage sources				
2.	With 20 V source only				
3.	With 15 V source only				

Theoretical Calculations:

Applying mesh analysis for circuit diagram – a, we get,

$$147I_1 - 100I_2 = 20$$

$$-100I_1 + 147I_2 = 15$$

Solving for I₁ and I₂, we get,

$$I_1 = 0.12404 \text{ A} ; \quad I_2 = -0.0176 \text{ A} ;$$

The current in the 100Ω branch is

$$I_1 - I_2 = 0.1417 \text{ A}$$

Applying mesh analysis for circuit diagram - b, we get,

$$147I_1 - 100I_2 = 20$$

$$-100I_1 + 147I_2 = 0$$

Solving for I₁ and I₂, we get

$$I_1 = 0.2533 \text{ A} ; \quad I_2 = 0.1723 \text{ A} ;$$

The current I_x in the 100Ω branch is I₁ - I₂ = 0.081 A

Applying mesh analysis for circuit diagram - c, we get,

$$147I_1 - 100I_2 = 0$$

$$-100I_1 + 147I_2 = 15$$

Solving for I₁ and I₂, we get,

$$I_1 = 0.1292 \text{ A} ; \quad I_2 = 0.1899 \text{ A} ;$$

The current I_y in the 100Ω branch is -I₁ + I₂ = 0.0607 A

Finally I_x + I_y = 0.1417 A = The current due to the two sources.

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Viva Questions:

1. Super position theorem is valid for -----
2. When applying super position theorem to any circuit ideal voltage source is replaced by --- and ideal current source is replaced by -----
3. Give the statement of superposition theorem.
4. Give the limitations of super position theorem.
5. When the superposition theorem is applied to the circuits consisting of dependent sources, how the dependent sources act
6. Superposition theorem is essentially based on the concept of?

Precautions:

1. Don't touch bare conductors when supply is ON
2. Wear shoes in laboratory to avoid shocks
3. Switch off the all the measuring devices when NOT in USE.
4. Ensure that there is no short circuit across the supply or any device, before switching on the supply.
5. Ensure that the current knob of the dc power supply is in maximum position before switching on the supply.

Expt.3

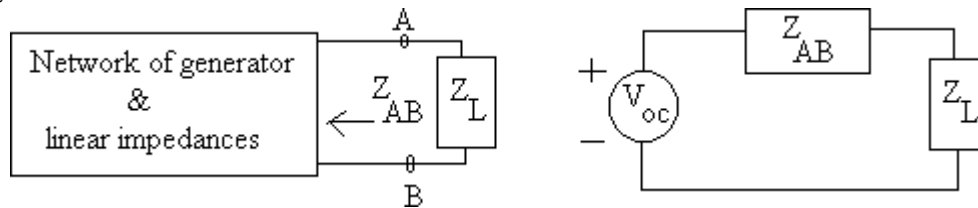
THEVENIN'S THEOREM

Aim: To verify Thevenin's Theorem.

Apparatus :

Sl.No.	Description	Range	Qty.
1.	DC power supply	0-30V, 2A	1
2.	Digital DC Milliammeter	0-200mA	1
3.	Digital DC Voltmeter	0-20V	1
4.	Thevenin's theorem circuit board	---	1
5.	Potentiometer	500 Ω	1
6.	Connecting wires	---	---

Theory :

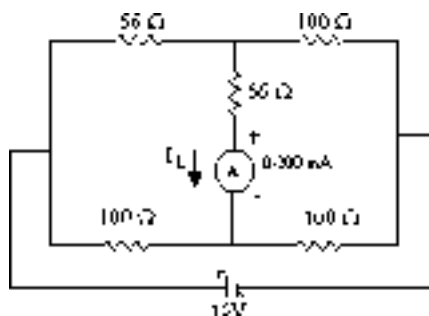


Consider a generator network consisting of generator & linear impedances as shown in figure. Z_L is the load impedance connected across terminals A & B. According to Thevenin's theorem this network can be replaced by an emf V_{oc} in series with an impedance Z_{AB} as shown in figure. V_{oc} is the open circuit voltage i.e, the voltage measured at terminals A & B when Z_L is removed.

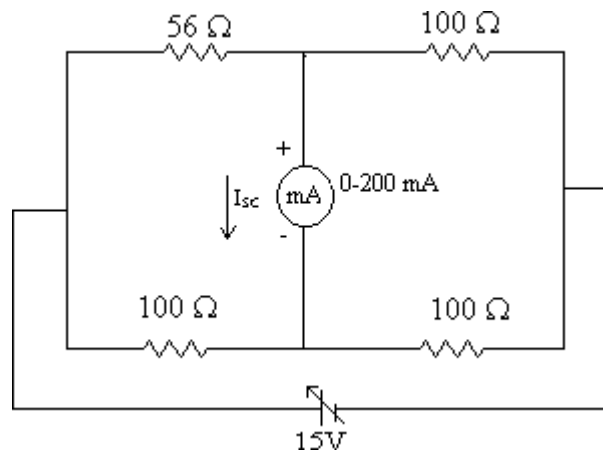
Z_{AB} is the impedance looking into terminals A & B with load Z_C removed with all generators replaced by their internal impedances. The only restriction on this theorem is that network is not magnetically coupled to external circuits.

Circuit diagram :

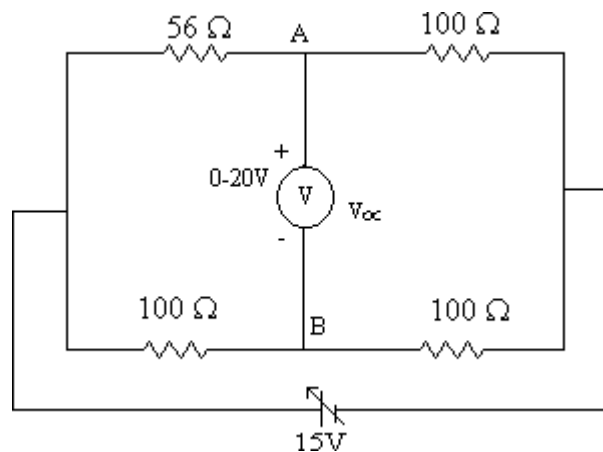
a) For measurement of Load current



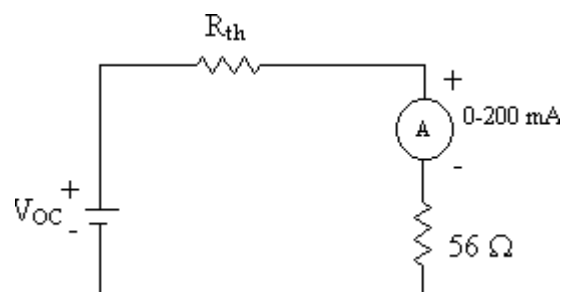
b) For measurement of Short circuit current



c) For measurement of Open circuit voltage



d) For verification of Thevenin's Theorem



Procedure :**a) For measurement of Load current**

1. **The connections are made as shown in the circuit diagram - a.**
2. With the voltage knobs of the DC power supply at their minimum positions the power supply is switched ON.
3. The voltage knobs are varied gradually such that the output voltage is adjusted to 15 Volts and the ammeter reading is noted.
4. The voltage knobs are brought back to their minimum positions and the DC power supply is switched OFF.

b) For measurement of Short circuit current

1. The connections are made as shown in the circuit diagram - b.
2. Step No's 2 to 4 of part – a, are repeated.

c) For measurement of Open circuit voltage

1. The connections are made as shown in the circuit diagram - c.
2. With the voltage knobs of the DC power supply at their minimum positions the power supply is switched ON.
3. The voltage knobs are varied gradually such that the output voltage is adjusted to 15 Volts and the voltmeter reading is noted.
4. The voltage knobs are brought back to their minimum positions and the DC power supply is switched OFF.

d) For verification of Thevenin's Theorem

1. The value of R_{Th} which is calculated from the above readings is fixed using a potentiometer and connected into the circuit as shown in the circuit diagram - d.
2. The output of DC power supply is adjusted to the measured value of V_{OC} from the earlier setup and the ammeter reading is noted.
3. The voltage knobs are brought back to their minimum positions and the DC power supply is switched OFF.

Tabular Column :

Sl.No.	Circuit diagram	Quantity to be measured	Meter Reading
1.	A	Load current	$I_L =$ Amps
2.	B	Short circuit current	$I_{sc} =$ Amps
3.	C	Open circuit voltage	$V_{OC} =$ Volts
4.	D	Load current	$I_L =$ Amps

Theoretical Calculations :

a) For circuit (a):

Applying KVL for Circuit(a),

$$\begin{aligned}212I_1 - 56I_2 - 100I_3 &= 0 \\-56I_1 + 256I_2 - 100I_3 &= 0 \\-100I_1 - 100I_2 + 200I_3 &= 15\end{aligned}$$

Solving I_1, I_2, I_3 We get,

$$I_1 = 0.1057 \text{ A}; I_2 = 0.0908 \text{ A};$$

The current I through 56Ω resistor is,

$$I_L = I_1 - I_2 = 0.1057 - 0.0908 = 0.0149 \text{ A};$$

b) For circuit (b):

$$\begin{aligned}\text{Equivalent resistance } R_e &= \frac{56 \times 100}{(100 + 56)} + \frac{100 \times 100}{(100 + 200)} \\ &= 85.89 \Omega\end{aligned}$$

$$\text{Therefore } I = \frac{15}{85.89} = 0.1746 \text{ A}$$

$$\text{Current through } 56 \Omega \text{ resistance is } I_{56} = \frac{0.1746 \times 100}{156} = 0.11194 \text{ A}.$$

$$\text{Current through } 100 \Omega \text{ resistance is } I_{100} = \frac{0.1746 \times 100}{200} = 0.0873 \text{ A}.$$

$$\text{Therefore } I_{sc} = I_{56} - I_{100} = 0.11196 - 0.0873 = 0.02464 \text{ A}$$

c) For Circuit (c)

$$V_A = 15 - \frac{15}{156} \times 100 = 9.615 \text{ V}$$

$$V_B = 15 - \frac{15}{200} \times 100 = 7.5 \text{ V}$$

$$V_{OC} = V_A - V_B = 2.115 \text{ V}$$

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d) For circuit(d)

$$R_{TH} = \frac{V_{OC}}{I_{SC}} = \frac{2.115}{0.02464} = 85.85\Omega$$

$$I_L = \frac{V_{TH}}{R_{TH} + R_L} = \frac{2.115}{85.85 + 56} = 0.0149A$$

Viva Questions:

- 1) While applying thevenin's theorem, thevenin's voltage is equal to-----
- 2) Thevenin's impedance is -----
- 3) Norton's equivalent form in any complex impedance circuit consists of ----
- 4) What is the main application of thevenin's theorem?

Precautions:

1. Don't touch bare conductors when supply is ON
2. Wear shoes in laboratory to avoid shocks
3. Switch off the all the measuring devices when NOT in USE.
4. Ensure that there is no short circuit across the supply or any device, before switching on the supply.
5. Ensure that the current knob of the dc power supply is in maximum position before switching on the supply.
6. Check for proper polarity of meters.

Expt.4

MAXIMUM POWER TRANSFER THEOREM

Aim : To verify Maximum power transfer theorem.

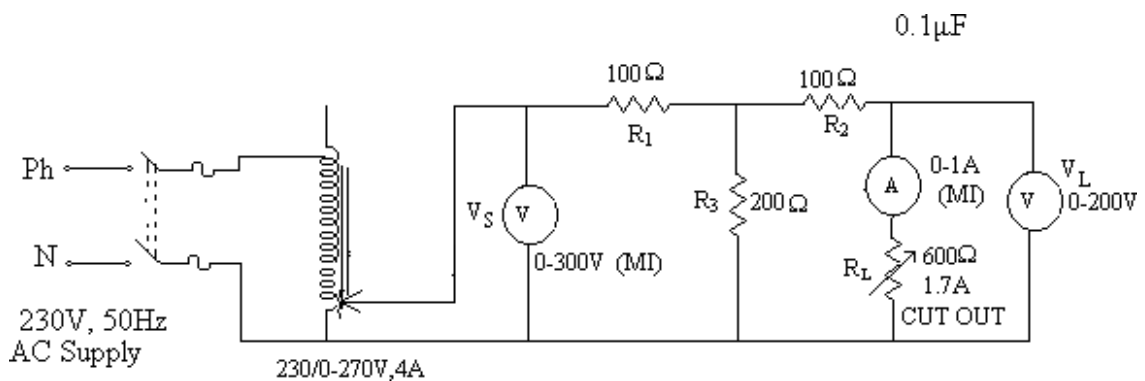
Apparatus :

Sl.No.	Description	Range	Qty.
1.	1- ϕ Dimmerstat	230/0-270V, 8A	1
2.	Rheostat	600 Ω , 1.7A	4
3.	Ammeter	0-1A (MI)	1
4.	Multimeter	---	2
5.	Connecting wires	---	---

Theory :

Many circuits basically consist of sources, supplying voltage, current and power to the load; for example, a radio speaker system, or a microphone supplying the input signals to voltage pre-amplifiers. Sometime it is necessary to transfer maximum voltage, current or power from source to the load. The Maximum Power Transfer Theorem states that maximum power is delivered from a source to load when the load resistance is equal to the source resistance. This theorem can also be applied to complex impedance circuits. If source impedance is complex then maximum power is transferred from source to load when load impedance is equal to complex conjugate of source impedance.

Circuit diagram :



Procedure :

1. The connections are made as shown in the circuit diagram.
2. With the dimmerstat at zero output and the rheostat R_L in CUTOUT position the supply switch is closed.
3. The output of the dimmerstat is adjusted such that V_s reads 220V.
4. The rheostat R_L is gradually CUTIN in steps such that the current is decreased in steps of 0.05A and the voltmeter reading V_L is noted.
5. The dimmerstat is brought back to zero output and the supply switch is opened.

Tabular column :

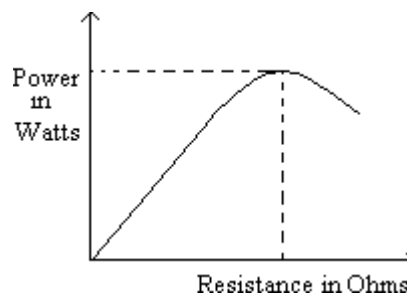
Sl.No.	V _s in Volts	I _L <i>in Amps</i>	V _L in Volts	R _L <i>in Ohms</i>	W <i>in Watts</i>

Specimen Calculation :

$$R_L = \frac{V_L}{I_L}$$

$$W = I_L^2 R_L$$

Nature of Graph :



Theoretical Calculations:

The equivalent resistance as seen from the load end of the circuit when the AC supply is short-circuited is: -

$$R_s = \frac{R_1 R_3}{R_1 + R_3} + R_2 ; \quad R_s = \frac{100 \times 200}{300} + 100 ; \quad R_s = 166.67 \Omega$$

The open circuit voltage V_{oc} is found by keeping the output open circuited (i.e., R_L is disconnected)

$$V_{oc} = \frac{V_s \times R_3}{R_1 + R_3} ; \quad V_{oc} = \frac{220 \times 200}{300} ; \quad V_{oc} = 146.67 \text{ V}$$

$$\text{The maximum power } P = \frac{V_{oc}^2}{4R_L} ; \quad P = \frac{(146.67)^2}{4 \times 166.67} = 32.267 \text{ W}$$

Viva Questions:

- 1 Condition for Maximum power transferred to a load in a DC circuit ----
2. In a complex impedance circuit, the maximum power transfer occurs when the load impedance is equal to-----
3. Maximum power transfer occurs at what % of its efficiency?
4. Applications of maximum power transfer theorem.
5. What is the value of maximum power transferred to the load (R_L). When E is generator EMF and R_i is internal resistance.

Precautions:

- 1 Do not touch bare conductors when supply is ON
- 2 Switch off the all the measuring devices when NOT in USE.
- 3 Ensure that dimmerstat is in minimum position before switching ON the supply and before switching OFF the supply.
- 4 Ensure that there is no short circuit across the supply or any device, before switching ON the supply.
- 5 Check for proper polarity of meters.

Expt.5

RECIPROCALITY THEOREM

Aim : To verify reciprocity theorem.

Apparatus :

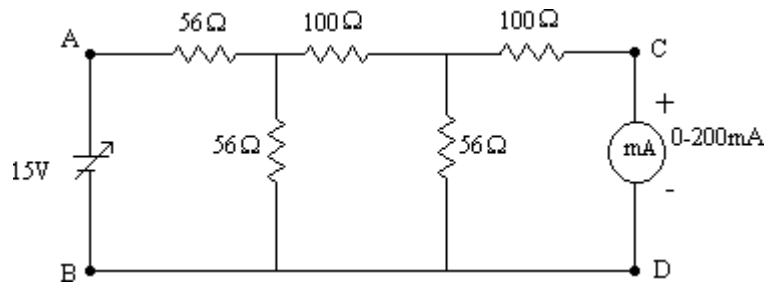
Sl.No.	Description	Rating	Qty.
1.	DC power supply	0-30V, 2A	1
2.	Digital DC Milliammeter	0-200mA	1
3.	Reciprocity theorem circuit board	---	1
4.	Connecting wires	---	---

Theory:

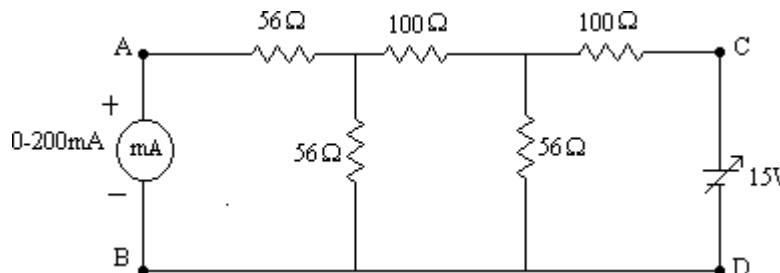
According to this theorem if we apply input to a circuit, which consist of resistors, inductors, capacitors and transformers, including coupled circuits, the ratio of response in any element to the input is constant even when the position of input and output are interchanged.

Circuit diagram :

a) With source across AB



b) With source across CD



Procedure :

1. The connections are made as shown in the circuit diagram - a.
2. With the voltage knobs of the DC power supply at minimum positions the power supply is switched ON.
3. The voltage knobs are varied, the output is adjusted to 15 V and the Milliammeter reading is noted.
4. The voltage knobs are brought back to their minimum positions and the power supply is switched OFF.
5. Step No's - 1 to 4 are repeated for circuit diagram - b also.

Tabular Column :

Sl.No.	Condition of the Circuit	V in Volts	I in mA	Ratio in Ohms
1.	Source across AB	15		
		20		
		30		
2.	Source across CD	15		
		20		
		30		

Specimen Calculation :

$$\text{Ratio} = \frac{V}{I}$$

Theoretical Calculations :

The mesh equations for Circuit diagram – a, are :

$$\begin{aligned} 112I_1 - 56I_2 &= 15 \\ -56I_1 + 212I_2 - 56I_3 &= 0 \\ -56I_2 + 156I_3 &= 0 \end{aligned}$$

Solving the above equations for the value of I_3 ,

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We get,

$$I_3 = 0.0164 \text{ A.}$$

The mesh equations for Circuit diagram – b, are :

$$112I_1 - 56I_2 = 0$$

$$-56I_1 + 212I_2 - 56I_3 = 0$$

$$-56I_2 + 156I_3 = 15$$

Solving the above equations for the value of I_1 ,

We get,

$$I_1 = 0.0164 \text{ A.}$$

Viva Questions:

- 1) Reciprocity theorem is applicable to -----
- 2) Condition for a reciprocal network in terms of ABCD parameters.
- 3) Condition for a reciprocal network in terms of Z parameters.
- 4) Give the Statement of Reciprocity theorem.

Precautions:

- 1 Don't touch bare conductors when supply is ON
- 2 Wear shoes in laboratory to avoid shocks
- 3 Switch off the all the measuring devices when NOT in USE.
- 4 Ensure that there is no short circuit across the supply or any device, before switching on the supply.
- 5 Ensure that the current knob of the dc power supply is in maximum position before switching on the supply.
- 6 Check for proper polarity of meters.

Expt.6

**R-L-C SERIES RESONANCE & R-L-C
PARALLEL RESONANCE**

Aim : To plot a resonance curve and calculate the resonant frequency.

Apparatus :

Sl.No.	Description	Range	Qty
1.	Inductor (DIB)	---	1
2.	Capacitor (DCB)	0.1 μ f	1
3.	Resistance (DRB)	1k Ω	1
4.	Ammeter	0-50 mA (MI)	1
5.	Multimeter	---	1
6.	Function generator	---	1
7.	C.R.O	---	1
8.	Connecting wires	---	---

Theory :

An a.c voltage of rms value V when applied to an R-L-C circuit establishes an rms current I given by

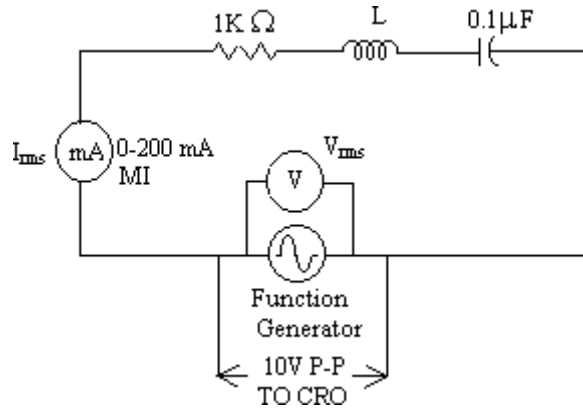
$I = V / Z$ where $Z = \sqrt{R^2 + (X_C - X_L)^2}$. In this experiment $X_C > X_L$ the effect of $X_C > X_L$ is a leading power factor, since the current I leads V by an angle ϕ ,

where $\phi = \tan^{-1} \left(\frac{X_C - X_L}{R} \right)$. In an inductor copper loss takes place due to the resistance of its coil and core loss takes place in the magnetic core (in case of iron core inductor). In the capacitor losses takes place in di-electric media used for making it. The losses taking place in the magnetic core of the inductor or di-electric media of the capacitor are usually known. The copper losses are taken into account when the resistance of the coil is connected in series with inductance. The importance of R in the R-L-C series circuit is

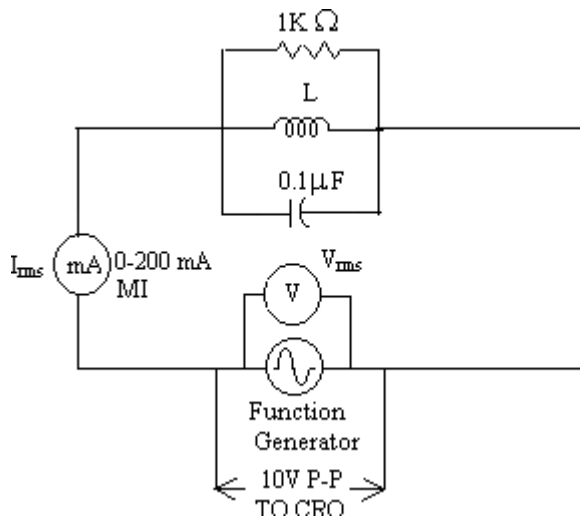
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that, when $X_L = X_C$ due to the variable inductor or variable capacitor or due to varying frequency the current is limited only by R.

Circuit diagram for R-L-C series resonance :



Circuit diagram for R-L-C parallel resonance :



Procedure :

1. The connections are made as shown in the circuit diagram.
2. With the amplitude knob of the Function generator at minimum position, frequency at 100 Hz, the Function generator is switched ON.
3. The frequency is varied in steps as given in the tabular column and for each step by maintaining the output voltage constant at 10V peak to peak the voltmeter and Milliammeter readings are noted for each step.
4. The frequency is brought back to 100 Hz the amplitude knob is brought back to its minimum position and the Function generator is switched OFF.

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Tabular Column for series resonance :

Sl.No.	Frequency in Hz	V(peak-peak) in Volts	V(rms) In volts	I in mA	Z in Ohms

Tabular Column for parallel resonance:

Sl.No.	Frequency in Hz	V(peak-peak) in Volts	V(rms) In volts	I in mA	Z in Ohms

Specimen Calculation :

For series resonance:-

We have in an R L C circuit
$$I = \frac{V}{R + j \left(\omega_L - \frac{1}{\omega_C} \right)} ; Z = \frac{V}{I},$$

At resonance as, $X_L = X_C$, We have, $Z = R$, Then, $I = \frac{V}{R}$

For parallel resonance:-

Current $I = V \times Y$

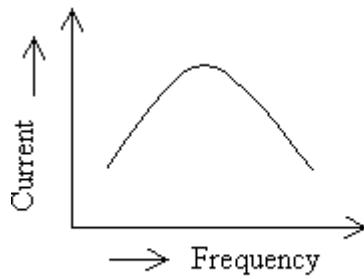
Admittance $Y = G + j(B_L - B_C)$

At resonance $B_L = B_C$

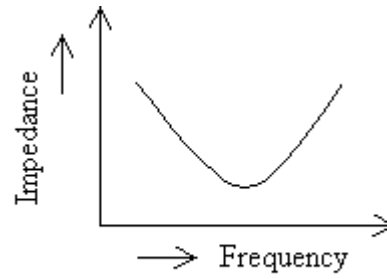
Current $I = V \times G$

Nature of graph :

For series resonance:

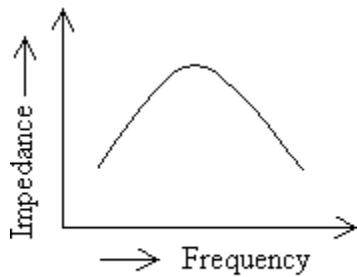


Frequency VS Current

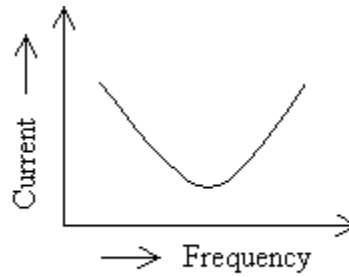


Frequency VS Impedance

For parallel resonance:



Frequency VS Impedance



Frequency VS Current

Viva Questions :

1. Give the dynamic impedance in parallel resonant RLC circuit
2. What is the condition for series resonance?
3. Give the formula for Resonant frequency of RLC series circuit.
4. At resonance RLC series circuit act as a----
5. Below resonance frequency RLC series circuit act as a----
6. Above resonance frequency RLC series circuit act as a----
7. What is band width?
8. What is the power factor of the circuit at resonance-----
9. Why current is maximum at resonance in RLC series circuit?
10. Why impedance is minimum at resonance in RLC series circuit.
11. At resonance voltage drop across inductor is equal to voltage drop across capacitor why?
12. What is current value at lower and upper cut off frequency in RLC series circuit in terms of maximum value?
13. If $X_L > X_C$, RLC series circuit act as a----
14. If $X_L < X_C$ RLC circuit act as a----
15. Define Q -factor
16. What is the power factor of a parallel resonant circuit?
17. Series and parallel resonant circuits magnifies-----
18. What is the relation between apparent power(S), true power (P) & reactive power (Q).

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19. What is the phase angle between line voltage and phase voltage in a balanced star connected system
20. what is the power factor of RLC series circuit at lower cut off and upper cut off frequency
21. What are the units for susceptance
22. Insulation for all electrical equipment is designed for----- value.
23. The form factor for DC supply voltage is always-----
24. In a series resonant circuit the impedance above and below resonant frequency is--- &---
25. Give the expression for quality factor in series RLC circuit
26. What is meant by selectivity?
27. Give the relation between bandwidth & quality factor
28. What is meant by magnification?
29. Give the other name for parallel resonant circuit

Precautions :

- 1) Don't touch bare conductors when supply is ON
- 2) Wear shoes in laboratory to avoid Electric shocks
- 3) Switch off the all the measuring devices when NOT in USE.
- 4) Check for proper polarity of meters.
- 5) Ensure that there is no short circuit across the supply or any device, before switching on the supply.

Expt.7

TWO PORT NETWORK

Aim:- To find out Z-parameters, Y parameters, A B C D parameters and h parameters

Apparatus :-

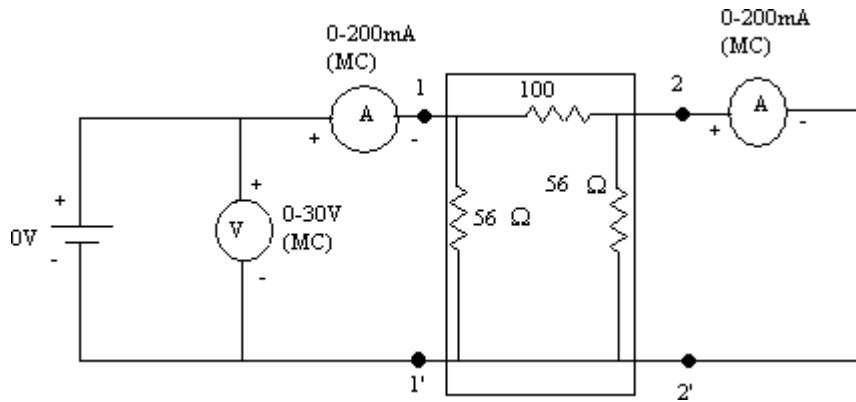
Sl.No	Description	Rating	Qty
1	DC power supply	0-30V, 2A	1
2	Digital DC milli ammeter	0-200 mA	2
3	Digital DC voltmeter	0-20V	2
4	Two port N/W circuit board	-----	1
5	Connecting wires	-----	-

Theory:- A part is normally referred to a pair of terminals of a network through which we can have access to network either for connecting a sources or for measuring, an O/P the network having only two pairs of terminals, through which it is accessible is called a two port network. The port at which the response is calculated in designated as O/P terminals of the another terminal pair at which excitation is calculated is designated as I/P terminals. The voltage of current at I/P terminals i.e port are V_1 & I_1 . out of the 4 variables V_1, V_2, I_1, I_2 only two are independent of the other two are expressed in terms of these independent variables in terms of network parameters. The various network parameters are Z, Y, A, B, C, D, h.

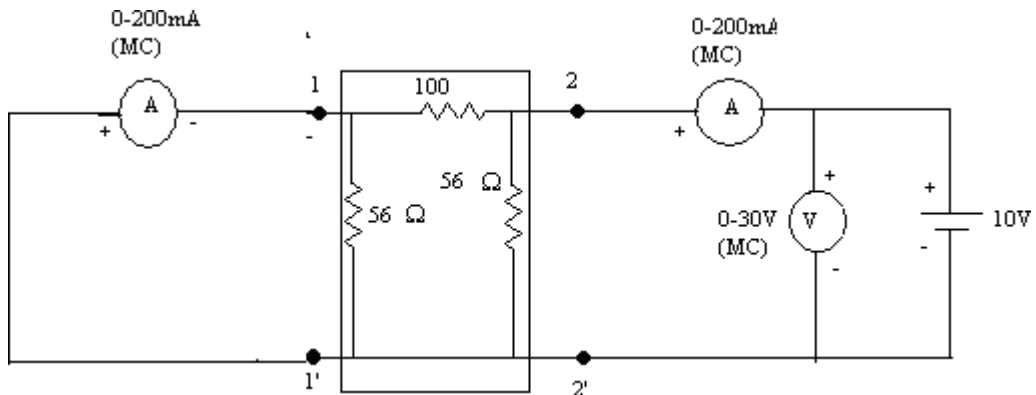
Procedure:-

1. The connections are made as shown in circuit diagram (a)
2. With the voltage knobs of the DC power supply at their minimum position the power supply is switched ON.
3. The voltage knobs are varied such that the output of the power supply will be 10V and all the meter readings are noted.
4. The voltage knob are brought back to their minimum positions and the power supply is switched OFF
5. Step no's 1 to 4 are repeated for circuit diagram (b) and also for circuit diagram (c)

Circuit diagram:



Fig(a) port 2-2' short circuited



Fig(b) port 1-1' short circuited

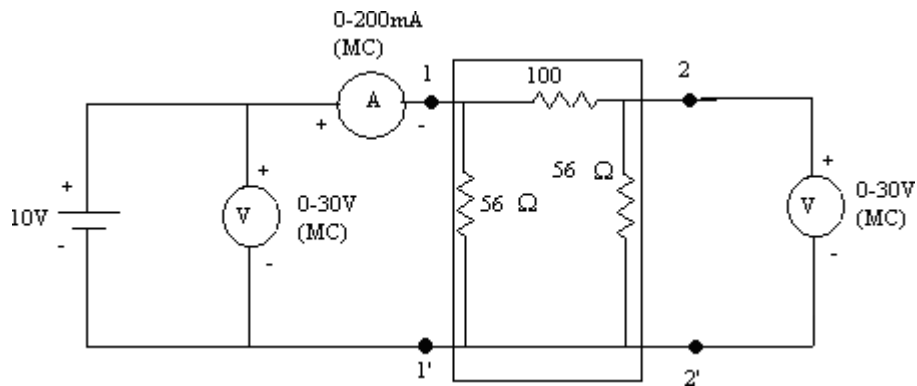
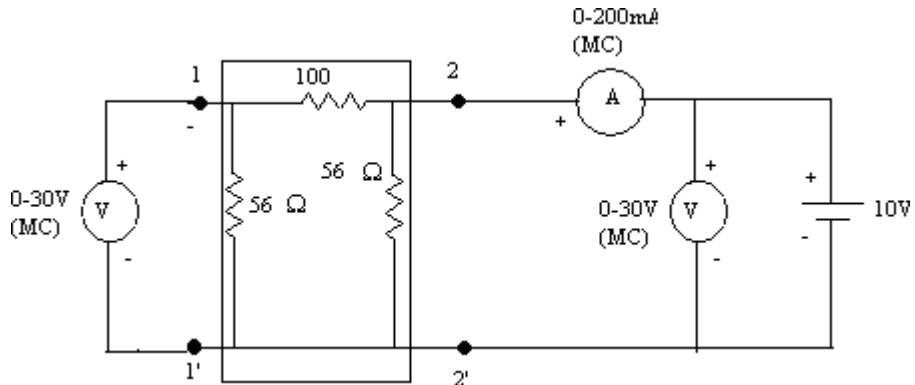


Fig (c) when port 2-2' open circuited



Fig(d) when port 1-1' open circuited

Tabular column:-

S.No	Name	V ₁ in Volts	I ₁ in Amps	V ₂ in volts	I ₂ in Amps
1	Port 2-2' shortcircuited				
2	Port 1-1' shortcircuited				
3	Port 2-2' opencircuited				
4	Port 1-1' opencircuited				

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Specimen calculations;-

Z-parameters:-

$$V_1 = Z_{11}I_1 + Z_{12}I_2;$$

$$V_2 = Z_{21}I_1 + Z_{22}I_2;$$

When port 2-2' open circuited:

$$Z_{11} = \frac{V_1}{I_1} \Big|_{I_2=0}; \quad Z_{21} = \frac{V_2}{I_1} \Big|_{I_2=0}$$

When port 1-1' open circuited:

$$Z_{12} = \frac{V_1}{I_2} \Big|_{I_1=0}; \quad Z_{22} = \frac{V_2}{I_2} \Big|_{I_1=0}$$

Y-parameters:-

$$I_1 = Y_{11}V_1 + Y_{12}V_2$$

$$I_2 = Y_{21}V_1 + Y_{22}V_2$$

When port 2-2' short circuited:

$$Y_{11} = \frac{I_1}{V_2} \Big|_{V_2=0}; \quad Y_{21} = \frac{I_2}{V_1} \Big|_{V_2=0}$$

When port 1-1' short circuited:

$$Y_{12} = \frac{I_1}{V_2} \Big|_{V_1=0}; \quad Y_{22} = \frac{I_2}{V_2} \Big|_{V_1=0}$$

A B C D Parameters:

$$V_1 = AV_2 - BI_2$$

$$I_1 = CV_2 - DI_2$$

When port 2-2' open circuited

$$A = \frac{V_1}{V_2} \Big|_{I_2=0}; \quad C = \frac{I_1}{V_2} \Big|_{I_2=0}$$

When port 2-2' short circuited:

$$B = \frac{-V_1}{I_2} \Big|_{V_2=0}; \quad D = \frac{-I_1}{I_2} \Big|_{V_2=0}$$

A,D are dimension less quantities

h-Parameters:-

$$V_1 = h_{11}I_1 + h_{12}V_2$$

$$I_2 = h_{21}I_1 + h_{22}V_2$$

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When port 2-2' short circuited:

$$h_{11} = \frac{V_1}{I_1} \Big|_{V_2 = 0} \qquad h_{21} = \frac{I_2}{I_1} \Big|_{V_2 = 0}$$

When port 1-1' open circuited:

$$h_{12} = \frac{V_1}{V_2} \Big|_{I_1 = 0}; \qquad h_{22} = \frac{I_2}{V_2} \Big|_{I_1 = 0}$$

Viva questions:-

1. Give an example for lumped element & distributed element
2. Give an example for bilateral element
3. Define electric network
4. Give the classification of Network elements
5. Define active element
6. Define passive element
7. What are unilateral elements?
8. What are bilateral elements
9. Give examples of active elements
10. Give examples of passive elements
11. Give examples of unilateral elements
12. Give examples of bilateral elements
13. What are linear elements?
14. What are non-linear elements
15. What are lumped elements?
16. What are distributed elements?
17. Give examples for LUMPED parameters.
18. Give examples for Distributed parameters.

Precautions:-

- 1) Don't touch bare conductors when supply is ON
- 2) Wear shoes in laboratory to avoid Electric shocks
- 3) Switch off the all the measuring devices when NOT in USE.
- 4) Check for proper polarity of meters.
- 5) Ensure that there is no short circuit across the supply or any device, before switching on the supply.

Result:- The Z, Y, A B C D & h parameters are calculated.

Expt.8

TIME RESPONSE OF RL & RC CIRCUITS

Aim:- To find the time constant series RL & RC circuits

Apparatus :-

Sl.No	Description	Rating	Qty
1	Resistors	1KΩ	1
		100Ω	1
2	Capacitor	0.1μf	1
3	Inductor	10mH	1
4	CRO		1
5	Function generator		1
6	Connecting wires		

Theory:-

In a network containing energy storage elements with change in excitation, the currents & voltages change from one stable to other is called transient state. The storage elements deliver their energy to the resistances, hence the response change with time gets saturated after some time, and is referred to as the transient response.

Consider a circuit consisting of resistance and inductance as shown in fig. the inductor in the circuit is initially unchanged, and is in series with a resistor. When the switch is closed we find the complete solution for the current, the solution of the circuit is

$$i = \frac{V}{R} [1 - e^{-RT/2}]$$

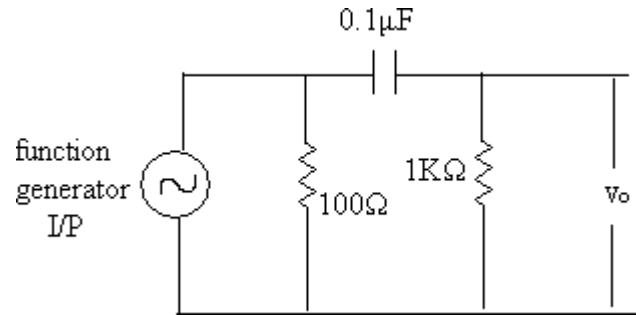
Consider a circuit consisting of resistance and capacitor as shown in fig. the capacitor in the circuit is initially unchanged, and is in series with a resistor. When the switch is closed we find the complete solution for the current. The solution of the circuit

$$i = \frac{V}{R} e^{-t/RC}$$

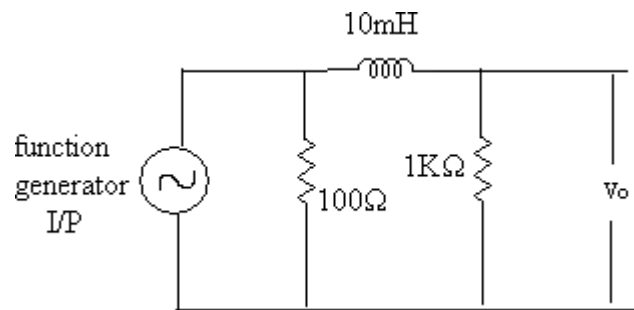
Tabular column:-

R ₁ (Ω)	R ₂ (Ω)	C in f	L in H	Theoretical time constant	Practical time constant

Circuit diagram:-



Series RC circuit



Series RL circuit

Procedure:-

1. Connect the circuit as shown in fig
2. Apply 1KHZ, 1V peak to peak square wave signal as I/P
3. connect the I/P signal to channel 1 and the O/P to channel 2 of CRO value.

Specimen calculations:-

$t=L/R, L=$

$t=RC, C=$

Viva Questions:-

- 1) What is transient?
- 2) Why transients occur in electric circuits?
- 3) What is free and forced response?
- 4) Define time constant of RL circuit?
- 5) Define time constant of RC circuit?
- 6) The time duration from the instant of switching till the attainment of steady state is called.....?
- 7) The response of a circuit due to-----alone is called natural response
- 8) In circuits excited by DC source at steady state----- behave as short circuit----- And-----behave as open circuit?
- 9) In electrical circuits transient currents are associated with
- 10) In transient circuit analysis, complementary function gives----- response.

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Precautions:-

- 1) Don't touch bare conductors when supply is ON
- 2) Wear shoes in laboratory to avoid Electric shocks
- 3) Switch off the all the measuring devices when NOT in USE.
- 4) Check for proper polarity of meters.
- 5) Ensure that there is no short circuit across the supply or any device, before switching on the supply.

Expt.9

PARAMETERS OF AN IRON CORE INDUCTOR

Aim : To determine the resistance and inductance of an iron-core inductor.

Apparatus :

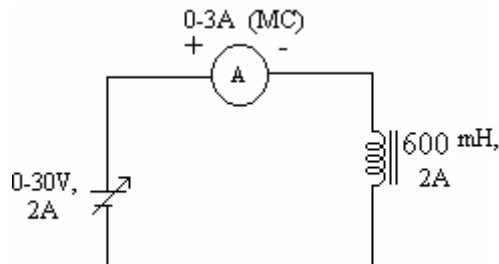
Sl.No.	Description	Rating	Qty.
1.	Iron core inductor	250 mH, 2A	1
2.	1- ϕ Dimmerstat	230/0-270V, 4A	1
3.	D.C power supply	0-30V, 2A	1
4.	Ammeter	0-3A (MC) 0-3A (MI)	1 1
5.	Voltmeter	0-250V (MI)	1
6.	Wattmeter	1/2A, 300V, 60W, LPF	1
7.	Connecting wires	---	---

Theory:-

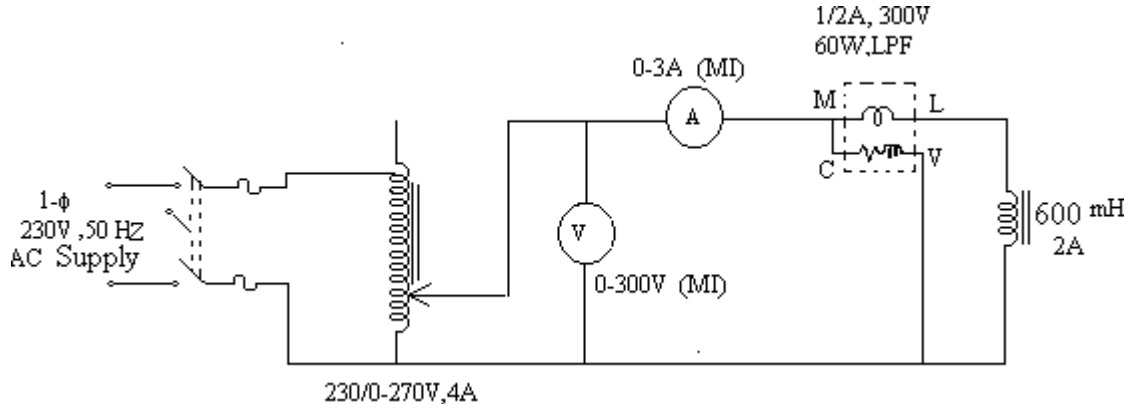
The property of a substance which opposes the flow of current through it is called resistance. The parameters of an iron core are resistance and inductance. In order to find the resistance, choke coil is connected to the DC supply. The choke coil consists of resistance and inductance. Resistance can be calculated and it can be measured in this experiment resistance can only be calculated. The units of resistance is ohms. The impedance can be determined by connecting it to the AC supply inductance also can be calculated. By knowing about resistance and impedance we can determine the value of inductive reactance. From its value we can calculate the value of impedance of given frequency. Resistance, impedance, reactance has same units ohms. Because these all have same characteristics i.e opposition of flow of current it. Reactance cannot be measured. In case of impedance as it is a combination of reactance and resistance it can apply only be calculated, but not be measured.

Circuit diagram :

a) For calculating DC resistance



b) For calculating all the parameters of the Inductor



Procedure :

a) For calculating DC resistance

1. The connections are made as shown in the circuit diagram - a.
2. With the voltage knobs of the D.C. Power supply at minimum positions the power supply is switched ON.
3. The voltage is varied in steps as given in the tabular column and the respective currents are noted.
4. The voltage knobs are brought back to their minimum positions and the power supply is switched OFF.

b) For calculating all the parameters of the Inductor

1. The connections are made as shown in the circuit diagram - b.
2. With the Dimmerstat at zero output the supply switch is closed.
3. The Dimmerstat is varied in steps such that the output voltage is adjusted to the values given in the tabular column and for each step the readings of all the meters are noted.
4. The Dimmerstat is brought back to zero output and the supply switch is opened.

Tabular column (1):

Sl.No.	V	I	R
	<i>in Volts</i>	<i>in Amps</i>	<i>in Ohms</i>
1.	2		
2.	4		
3.	6		
4.	8		

Tabular column (2):

Sl.No.	V <i>in Volts</i>	I <i>in Amps</i>	W <i>in Watts</i>	Z <i>in Ohms</i>	R <i>in Ohms</i>	X _L <i>in Ohms</i>	L <i>in Henry</i>	p.f
1	50							
2	100							
3	150							
4	200							
5	230							

Specimen calculation :

$$Z = \frac{V}{I} ; \quad R = \frac{W}{I^2} ; \quad X_L = \sqrt{Z^2 - R^2} ; \quad L = \frac{X_L}{2\pi f} ; \quad \text{Cos}\phi = \frac{R}{Z} ;$$

Viva Questions :

1. What is meant by true power?
2. What is apparent power?
3. What is power factor?
4. What is the power factor of pure resistive circuit?
5. Power factor of '0' indicates what?
6. In RC circuit power dissipation is due to which component.
7. R.M.S value of sine wave indicates what?
8. Define R.M.S value?
9. Give the relation between R.M.S value and peak value of a sinusoidal waveform
10. Define peak factor?
11. Give the peak factor of the sinusoidal wave form?
12. Define form factor of sinusoidal wave form?
13. Define impedance?
14. Give phase relation in a pure inductor?
15. Give phase relation in a pure capacitor?
16. What is the impedance of pure capacitor?
17. What is the average value of a sine wave over a full cycle?
18. A sine wave voltage is applied across a capacitor, when the frequency of 'v' is

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increased?

19. A sine wave voltage is applied across a inductor, when the frequency of 'v' is increased?
20. For the same peak value, which wave will have highest RMS value?
21. The form factor of D.C voltage is?
22. The power consumed in a circuit element will be least when the phase difference between V&I is?
23. Give the importance of impedance diagram?
24. What are compound circuits?
25. When the resistance of an RC circuit is greater than X_c , Φ between applied voltage and the total current is closer to?
27. When frequency of applied voltage in a series RC circuit is increases, what happens to X_c ?
28. Give the phasor diagram of series RL circuit?
29. Give the phasor diagram of series RC circuit?
30. What is the phase angle between capacitor current and the applied voltage in a parallel RC circuit

Precautions :

- 1) Don't touch bare conductors when supply is ON
- 2) Wear shoes in laboratory to avoid Electric shocks
- 3) Switch off the all the measuring devices when NOT in USE.
- 4) Check for proper polarity of meters.
- 5) Ensure that there is no short circuit across the supply or any device, before switching on the supply.

Expt.10

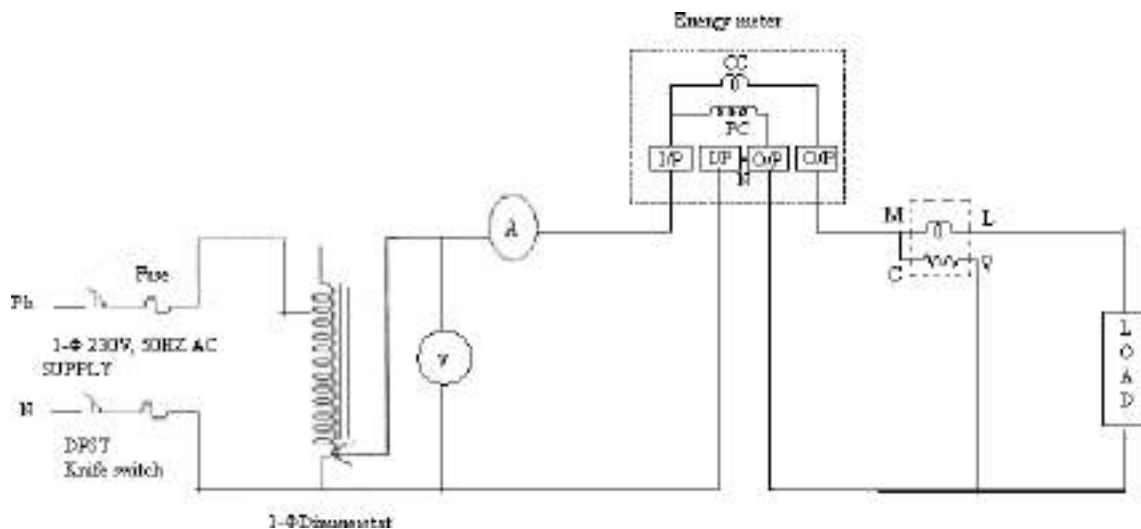
ENERGY METER CALIBRATION

Aim:- To calibrate the given single phase energy meter

Apparatus:-

S.no	Name	Range	Qty
1	Voltmeter	0-250-MI	1
2	Ammeter	0-10A	1
3	Single phase energy meter	230V,10A, 50HZ	1
4	Wattmeter	300V/10A	1
5	Stopwatch		1

Circuit Diagram:-



Procedure:-

1. Connect the circuit as shown in the circuit diagram.
2. Apply the rated voltage of 230 V.
3. Vary the load such that $\frac{1}{4}$ of its rated current flows in the ammeter.
4. Note down the readings of Voltmeter, Ammeter and Wattmeter.
5. Note down the time required for 5 revolutions in the Energy meter.
6. Vary the load to $\frac{2}{3}$, full load current.
7. For every load note down the Voltmeter, Ammeter and Wattmeter readings; and note down time required for 5 revolutions.

Tabular column:-

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S.no	Load	Voltage	Current	Power	$\text{Cos}\Phi = \frac{W}{VI}$	Time in sec for 5 revolutions(t)

Specimen calculations:-

Meter constant = 1200 rev/1Kwh

No.of units consumed for 5 rev. $E_r = \frac{1}{1200} \times 5 \text{ kwh}$

No.of units consumed actually for 5 rev. $E_a = \frac{w}{1000} \times \frac{\text{time}(t)}{60 \times 60}$

% error = $\frac{E_r - E_a}{E_a} \times 100$

Viva Questions:

- 1) What is the functioning of shading band in energy meter?
- 2) In energy meter driving torque is produced due to?
- 3) What is formula for braking torque in energy meter?
- 4) What is the condition for steady state speed of energy meter disc?
- 5) What is ment by creeping?
- 6) How do you prevent the creeping?
- 7) What are the units for power?
- 8) What are the units for energy?

Precautions:

1. Don't touch bare conductors when supply is ON
2. Don't Switch on the supply unless the circuit is approved by any Staffmember.
3. Wear shoes in laboratory to avoid Electric shocks
4. Switch off the all the measuring devices when NOT in USE.
5. Check for proper polarity of meters.
6. Ensure that there is no short circuit across the supply or any device, before switching on the supply.

Expt.11

**POWER MEASUREMENT IN A 3-Φ BALANCED A.C CIRCUIT
USING TWO WATT METER METHOD**

AIM:

To measure the 3-Φ power using two watt meter method in a balanced A.C circuit.

APPARATUS REQUIRED:

S.NO	APPARATUS REQUIRED	RANGE	QUANTITY
1.	Ammeter	(0 – 10) A (M.I)	1
2.	Volt meter	(0 – 600) V (M.I)	1
3.	Watt meter	600V/10A (UPF)	2
4.	3-Φ load	-	-
5.	Connecting wires	-	-

THEORY:

The connections of the two current coils in series with the load in the two phases and the two pressure coils are connected between two phases and third phase respectively. If the current coil carrier I_R and I_B and the pressure coil are V_{YR} and V_{YB} .

In terms of instantaneous currents i_R, i_Y, i_B and instantaneous voltages v_R, v_Y, v_B .

The instantaneous total power is given by

$$P = V_R I_R + V_Y I_Y + V_B I_B \quad \text{--- (1)}$$

In case of y connected without neutral, we have

$$I_R + I_Y + I_B = 0$$

$$I_Y = - (I_R + I_B) \quad \text{--- (2)}$$

Substitute equation (2) in equation (1)

$$P = V_R I_R + V_Y (-I_R - I_B) + V_B I_B$$

$$= V_R I_R - V_Y I_R - V_Y I_B + V_B I_B$$

$$= I_R (V_R - V_Y) + I_B (V_B - V_Y)$$

$$P = V_{YR} I_R + V_{YB} I_B$$

NOTE: The watt meters read only the average power.

Wattmeter number 1: i.e.

$$W_1 \text{--- Current coil carries } I_R$$

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___ Pressure coil carries V_{YR}

Wattmeter number 2: i.e.

W_1 ___ Current coil carries I_B

___ Pressure coil carries V_{YB}

Therefore, $P = W_1 + W_2$

$$P = V_{YR} I_R \cos\Phi_1 + V_{YB} I_B \cos\Phi_2 \quad \text{---} \quad \textcircled{3}$$

Thus, the total average power for a 3- Φ circuit is obtained by adding two reading of watt meter W_1 and W_2 .

In equation $\textcircled{3}$ $\cos\Phi_1$ and $\cos\Phi_2$ are the phase angles between V_{YR} and I_R and between V_{YB} and I_B .

In terms of instantaneous currents I_R, I_Y, I_B and instantaneous voltages V_R, V_Y, V_B .

The instantaneous total power is given by

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Close the supply (TPST) switch.
3. The load is applied in steps and for each step meter readings are noted.
4. Repeat step 3 until the rated current of load is reached.
5. Load is removed in steps and switch is opened.
6. Calculate and verify the total power.

TABULAR COLUMN:

S.NO	V_1 (Volts)	W_1 (Watts)	W_2 (Watts)	W_1+W_2	I_L (Amps)	$\sqrt{3} V_L I_L \cos\Phi$

MODEL CALCULATIONS:

Voltage across load (V_L) = V

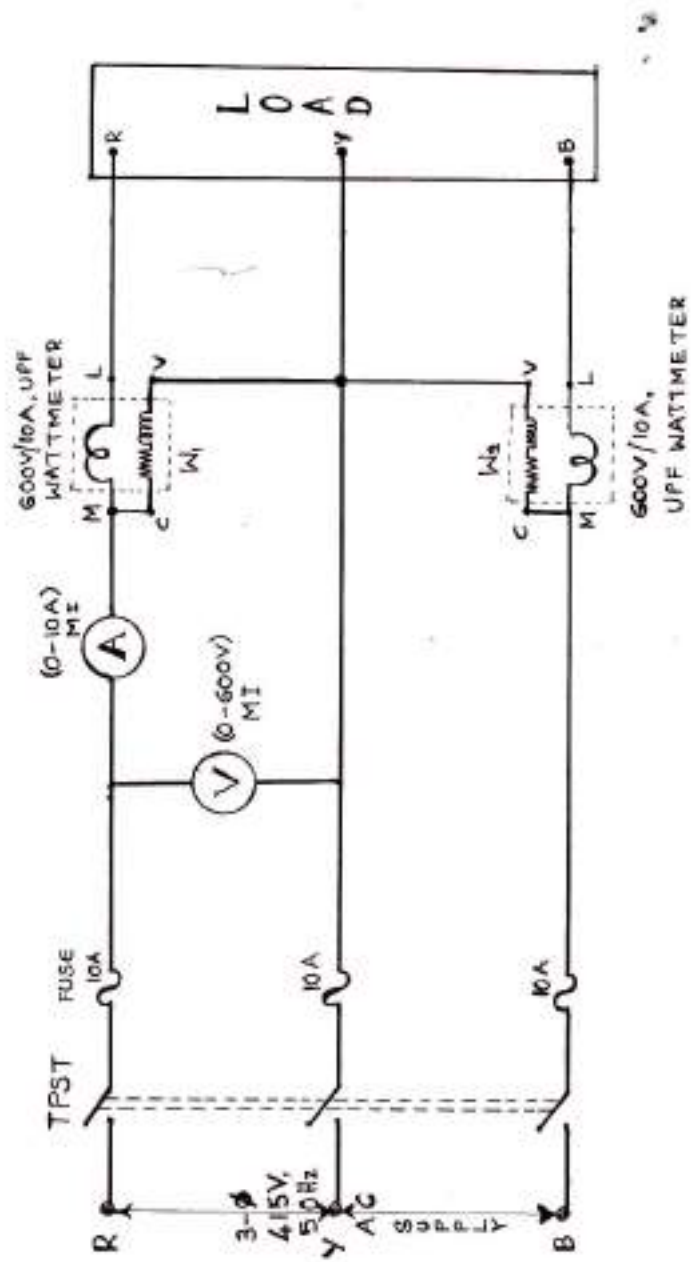
Load current (I_L) = A

Watt meter reading W_1 = Watts

W_2 = Watts

W_1+W_2 = Watts

Total power = $\sqrt{3} V_L I_L \cos\Phi$ Watts



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Viva Voce Questions:-

- 1) Can wattmeter measures the reactive power?
- 2) What are the different methods for finding three phase power?
- 3) What type of load is used in this experiment?
- 4) Define Active power?
- 5) Define reactive power?
- 6) Define apparent power?
- 7) Define Form factor?
- 8) Define Peak factor?
- 9) What is the relation between voltage and current in a pure resistor?
- 10) What is the relation between voltage and current in a pure Inductor?
- 11) What is the relation between voltage and current in a pure capacitor?
- 12) Define frequency?
- 13) What is electric power?
- 14) Why we are using (0-600V) voltmeter in this experiment?
- 15) What type of wattmeter is used in this experiment?

Precautions:

1. Don't touch bare conductors when supply is ON
2. Don't Switch on the supply unless the circuit is approved by any Staffmember.
3. Wear shoes in laboratory to avoid Electric shocks
4. Switch off the all the measuring devices when NOT in USE.
5. Check for proper polarity of meters.
6. Ensure that there is no short circuit across the supply or any device, before switching on the supply

Expt.12

SERIES RLC VECTOR DIAGRAM

Aim:- To draw the vector diagram of a series RLC circuit.

Apparatus:-

S.no	Description	Range	Qty
1	Rheostat	200Ω, 1.7A	1
2	Inductor	600mH, 2A	1
3	Capacitor	100μF, 350V	1
4	1-Φ dimmerstat	230/0-270V, 8A	1
5	Ammeter	0-1A (MI)	1
6	Multimeter	-	1
7	Connecting wires	-	-

Theory:-

An ac voltage of rms value V when applied to an RLC series circuit establishes an rms current I given by

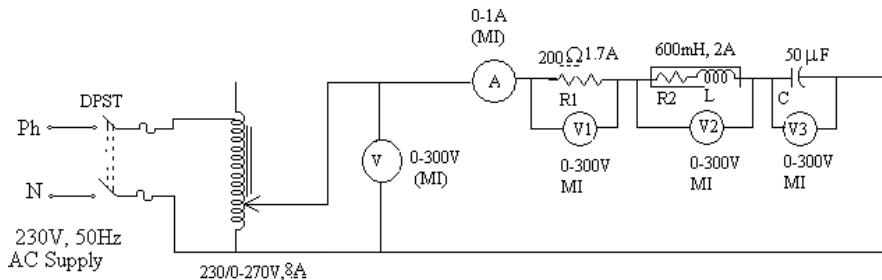
$$I=V/Z \text{ Where } Z= \frac{V}{\sqrt{R^2 + (X_C - X_L)^2}} \cdot \Phi = \tan^{-1} \left(\frac{X_C - X_L}{R} \right)$$

Where Φ is the angle between voltage and current i.e phase angle. When $X_L > X_C$ the circuit behaves as inductive and the current lags the voltage by an angle Φ. When $X_C > X_L$ the circuit behaves as capacitive the current leads the voltage by an angle Φ.

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With the dimmerstat at zero output the supply switch is closed.
3. The dimmerstat is varied in steps such that the output voltage is adjusted to the values given in the tabular column and for each step the voltage across R, voltage across L and Voltage across C as well as current are noted.
4. The dimmerstat is brought back to zero output and the supply switch is opened.

Circuit diagram:-



Tabular column:-

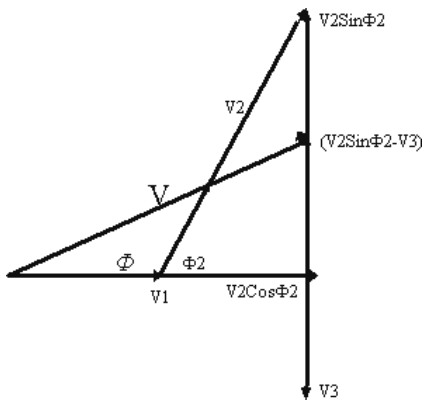
S.No	V in Volts	I in Amps	V ₁ in Volts	V ₂ in Volts	V ₃ in Volts	V ₃ -V ₂ in Volts	Calculated V in Volts	Φ in Degrees	CosΦ

Specimen calculations:-

$$V = \sqrt{(V_1 + \frac{V_2 \cos \Phi_2}{X_L})^2 + (V_2 \sin \Phi_2 - V_3)^2} \cdot \Phi$$

$$\Phi_2 = \tan^{-1} \left| \frac{X_L}{R_2} \right| \qquad \text{Phase angle } \Phi = \tan^{-1} \left| \frac{X_L - X_C}{R_1 + R_2} \right| = \tan^{-1} \left| \frac{V_2 \sin \Phi_2 - V_3}{(V_1 + \frac{V_2 \cos \Phi_2}{X_L})} \right|$$

Vector diagram:-



Viva Questions:-

1. The power consumed in a circuit element will be least when the phase difference between V&I is?
2. When frequency of applied voltage in a series RC circuit is increases, what happens to X[c]?
3. Give the phasor diagram of series RL circuit?
4. Give the phasor diagram of series RC circuit?
5. What is the phase angle between capacitor current and the applied voltage in a parallel RC circuit

Precautions:

1. Don't touch bare conductors when supply is ON
2. Don't Switch on the supply unless the circuit is approved by any Staffmember.
3. Wear shoes in laboratory to avoid Electric shocks

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4. Switch off the all the measuring devices when NOT in USE.
5. Check for proper

switching on the supply

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DEPARTMENT OF ELECTRICAL & ELECTRONICS
ENGINEERING**

MACHINES LABORATORY

Experiment Name

- 1. Swinburnes Test on D.C Shunt Motor**
- 2. Speed control of D.C Shunt Motor**
- 3. Load Test on D.C Shunt Motor**
- 4. D.C. Shunt Generator Characteristics**
- 5. O.C.C. of D.C. Separately excited Generator**
- 6. Hopkinson's Test on D.C Machines**
- 7. D.C. Series Generator Characteristics.**
- 8. D.C. Compound Generator Characteristics.**
- 9. V & Λ Curves of Synchronous Motor.**
- 10. Regulation of alternator by EMF Methods**
- 11. Load Test on a 3- ϕ Squirrel cage Induction Motor**
- 12. Load Test on a 1- ϕ Induction Motor**
- 13. O.C & S.C Test on a 1- ϕ Transformer**
- 14. Equivalent circuit of a 3- ϕ Slip-ring Induction Motor**

Exp. No : 1

SWINBURNE'S TEST ON D.C. SHUNT MOTOR

Aim:- To conduct the no load test on the DC shunt machine and determine its efficiency at different loads when operating as a) Motor & b) Generator

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 3 A	1
2	Ammeter	(M.C)	0 – 1.5 A	1
3	Voltmeter	(M.C)	0 – 250 V	1
4	Rheostat	Wire Wound	500 Ω , 1.2 A	2
5	Tachometer	Digital	0-9999 R.P.M	1
6	DC shunt motor		-	1
7	Connecting wires	PVC insulated	-	-

Theory:- Swinburne's test is a simple indirect method to calculate the efficiency of constant flux DC machines. In this method constant losses are calculated at no-load and from this efficiency at any desired load can be pre-determined in advance. In this method the machine is run as a motor at no-load, at its rated voltage & rated speed (adjusted by using shunt field Rh)

Limitations

- Applicable to constant flux machines i.e shunt & compound machines

Advantages:

- It is economical because power required to test the machine is very small i.e no load input power.
- The efficiency can be pre-determined at any desired load.

Disadvantages:

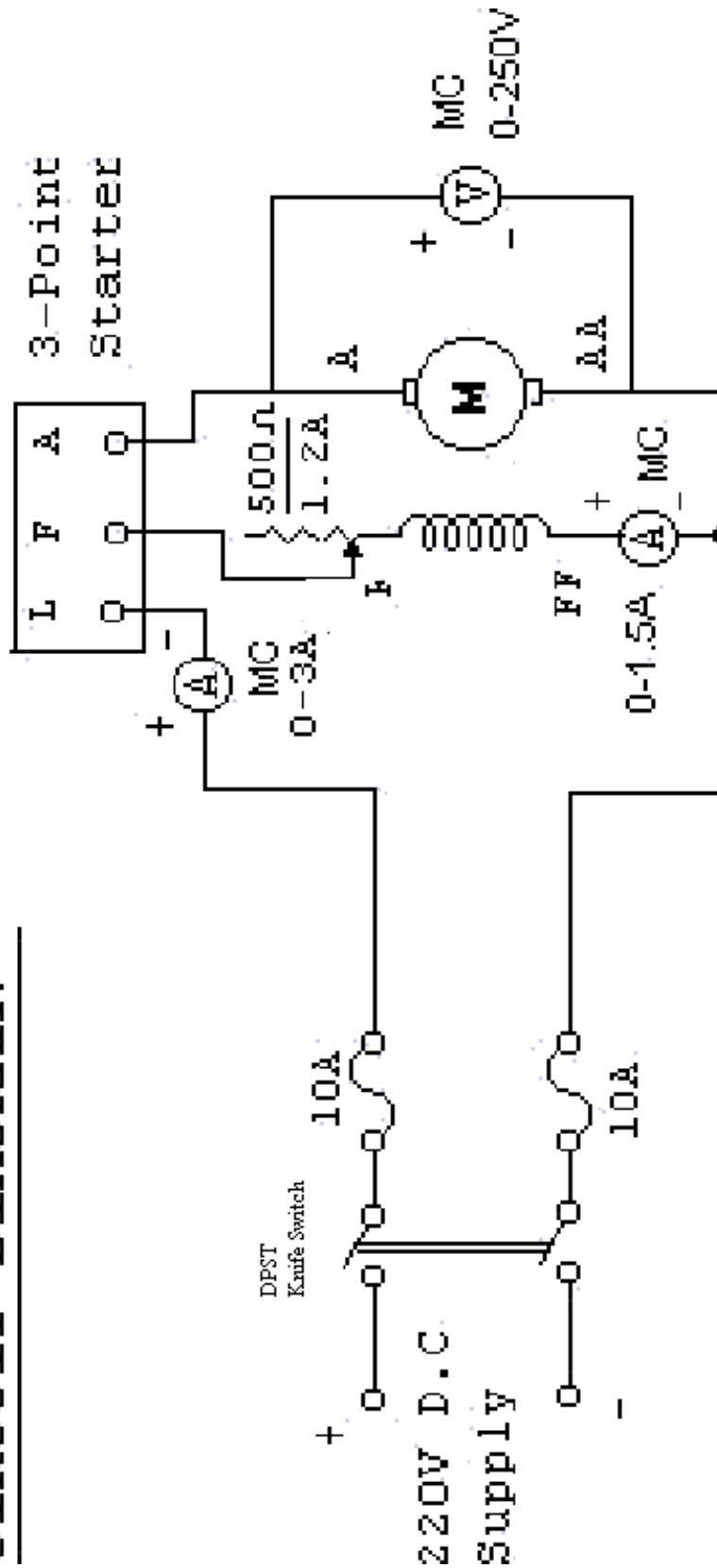
- At full load due to armature reaction, flux is destroyed which increases the iron losses. No account is taken for this change in iron losses.
- As the test is on no-load, it is impossible to know whether commutation would be satisfactory at full load and whether the temp. rise would be within the specified limits.

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With the motor field rheostat in CUTOFF position, 3-point starter handle at its initial position, the supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in the motor armature circuit so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat.
5. All the meter readings are noted into the tabular column.

6. The motor field rheostat is brought back to cut out position and the supply switch is opened.

CIRCUIT DIAGRAM: -



Tabular column:-

Sl.No	I_o In Amps	I_{sh} In Amps	V In volts

Specimen calculations:-

- No load armature current = $I_{ao} = I_o - I_{sh}$ amps
where I_o - is the no-load input current of the D.C motor
 I_{sh} - is the shunt field current
- Armature copper loss = $I_{ao}^2 R_a$ watts
where R_a - is the armature resistance of the D.C.Machine
it can be determined by Volt-Amp method.
- Total input power = $P_i = V I_o$ watts
- Constant power loss = $P_c = V I_o - I_{ao}^2 R_a$ watts
- Calculation of Efficiency

when running as motor : If I_L = Full Load current in amps

	<u>At full Load</u>	<u>At Half Full Load</u>
a. Armature current	= $I_a = I_L - I_{sh}$ amps	$I_a = \frac{I_L}{2} - I_{sh}$ amps
b. Armature cu. Loss	= $w_c = I_a^2 R_a$ watts	$w_c = I_a^2 R_a$ watts
c. Motor input	= $P_i = V I_L$ watts	$P_o = \frac{1}{2} V I_L$ watts
d. Constant losses	= P_c watts	
e. Total losses	= $P_t = P_c + w_c$ watts	

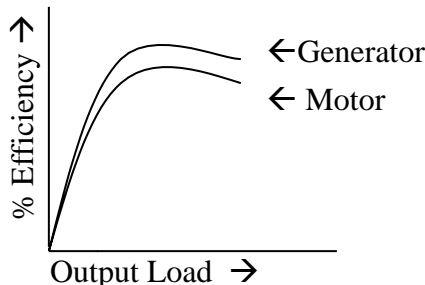
$$\therefore \% \text{ efficiency of motor} = \frac{P_i - P_t}{P_i} \times 100$$

when running as generator:

	<u>At Full Load</u>	<u>At Half Full Load</u>
a. Armature current	= $I_a = I_L + I_{sh}$ amps	$I_a = \frac{I_L}{2} + I_{sh}$ amps
b. Armature cu. Loss	= $w_c = I_a^2 R_a$ watts	$w_c = I_a^2 R_a$ watts
c. Generator output	= $P_o = V I_L$ watts	$P_o = \frac{1}{2} V I_L$ watts
d. Constant losses	= P_c watts	
e. Total losses	= $P_t = P_c + w_c$ watts	

$$\therefore \% \text{ efficiency of generator} = \frac{P_o}{P_o + P_t} \times 100$$

Nature of Graph :-



Viva – Voce Questions:

1. Do you require a startor for a dc motor under the running condition, why?
2. Can you use the dc motor as a dc generator? If so, what is to be done.
3. What are the losses taking place in a dc machine.?
4. What is the power o/p & efficievcy during swinburns test?
5. What is the fuse rating for conducting swinburns test on a dc machine of 18A?
6. What is the principle of operation of dc motor?
7. What happens to dc shunt motor if source polarity reversed?
8. A dc shunt motor refuses to start when switched on what could be the possible reasons and remedies?
9. What happens to motor if field circuit is suddenly opened?
10. What are the advantages and disadvantages of Swinburns test over the other tests?
11. When will you get the maximum efficiency for a dc machine?

Exp. No : 2

SPEED CONTROL OF D.C. SHUNT MOTOR

Aim:- To control the speed of a D.C. shunt motor by Armature control method and field control method.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 3 A	1
2	Voltmeter	(M.C)	0 – 250 V	1
3	Rheostat	Wire wound	500 Ω, 1.2 A	1
4	Rheostat	Wire Wound	38 Ω, 10 A	1
4	Tachometer	Digital	0 – 9999 rpm	1
6	D.C. shunt motor		3HP, 220 V, 12 A	1
7	Connecting wires	PVC insulated	-	-

Theory:-

The speed of a dc shunt motor can be controlled by varying

- i) Flux/pole (Flux control method)
- ii) Resistance of armature circuit (rheostat control method)
- iii) Applied voltage (Voltage control method)

Speed of a motor is given by the relation:

$$N \propto \frac{E_b}{\phi} \quad \text{-- (1)}$$

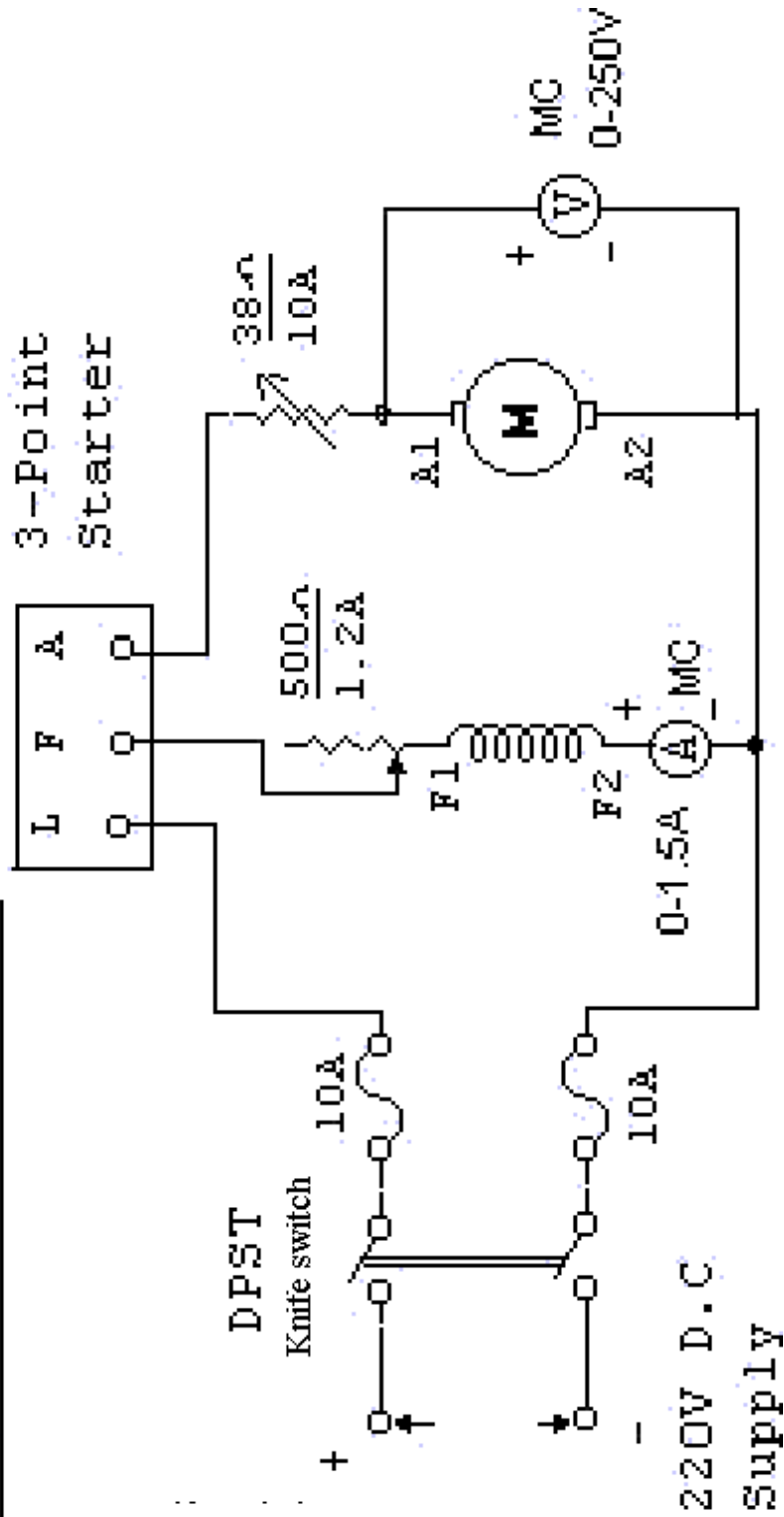
i) Flux control method:- This method is used when speeds above normal speeds are required. In the above equation (1) by decreasing the flux, the speed can be increased and vice versa. The flux of a dc motor can be changed by changing I_{sh} with the help of a shunt field rheostat. The current in shunt field rheostat is less. I^2R loss is small, so that rheostat is small in size.

ii) Armature or rheostat control method:- This method is used when speeds below the no-load speeds are required. In this method the voltage across the armature is varied by increasing a variable rheostat in series with the armature circuit, as resistance is increased, potential difference across the armature is decreased, there by decreasing the armature speed. This method is expensive (Cu loss more) and unsuitable for rapidly changing loads because for a given value of R_t , the speed will change with load.

iii) Voltage control method:- This method is also used to control the speeds below the no-load speeds. In this method the shunt field of the motor is connected across the fixed supply and then by supplying different voltage to the armature different speeds are obtained. The control voltage is

obtained from potential dividers, solid state rectifier and Ward-Leonard system.

CIRCUIT DIAGRAM: -



Procedure:-

a) For Armature voltage control method:-

1. The connections are made as shown in the circuit diagram.
2. With the armature rheostat is CUTIN position, the field rheostat in CUTOOUT position and the 3-point starter handle at its initial position, the D.C. supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in armature circuit so that the motor starts and runs at some speed.
4. The armature rheostat is brought to cut out position so that rated voltage is applied across the armature.
5. The field current is adjusted to a certain value by varying the field rheostat such that the motor runs at nearly rated speed.
6. The armature rheostat is CUTIN gradually so that the armature voltage is varied in steps and the corresponding speeds are noted in the tabular column.
7. Step no. 5 is repeated until the armature rheostat is completely CUTIN.
8. The field rheostat is brought back to CUTOOUT position, the armature rheostat to CUTIN position and the D.C. supply switch is opened.

b) For field control method:-

1. Step nos. 1, 2 & 3 of armature voltage control method are repeated.
2. The armature rheostat is varied such that the rated voltage is applied across the armature terminals.
3. The field rheostat is gradually cut in steps so that the field current is varied in steps of 0.05A and the corresponding value of speeds are noted.
4. Step no. 3 is repeated until the field rheostat is completely CUT IN.
5. Step no. 3 and 4 are repeated for an armature voltage of 200V.
6. The field rheostat is brought back to CUT OUT, the armature rheostat to CUT IN position and the supply switch is opened.

Tabular column:-

a) Armature voltage control

Field current =

Sl.No	Armature voltage In Volts	Speed In rpm

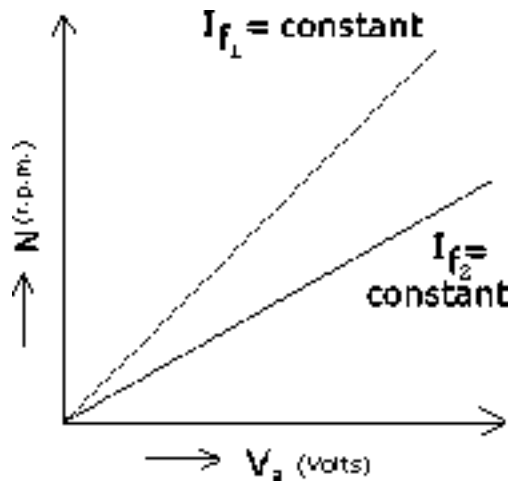
b) Field control method

Armature voltage =

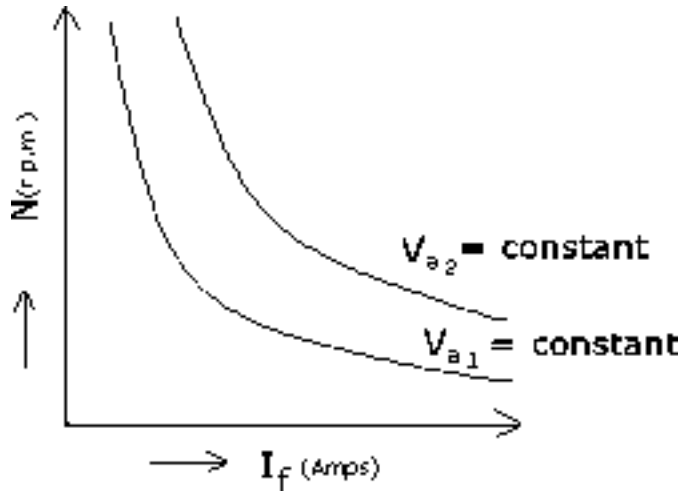
Sl.No	Field current In Volts	Speed In rpm

Nature of graph:

a) Armature Voltage Control



b) Field Control



Viva – Voce Questions:-

1. Speed of a dc shunt motor is directly proportional to field current (true or false)?
2. A dc shunt motor rated speed as 1500 rpm. How do you get speed below and above 1500 rpm?
3. Give the equation of the back EMF induced in a dc motor. What is the other equation by which it can be calculated?
4. What is the difference between arm voltage control and arm series resistance control in case of dc shunt motor? Which one is preferable?
5. Define speed regulation of a dc motor? How much percent will it be usually for a shunt motor?

Exp. No : 3

LOAD TEST ON D.C. SHUNT MOTOR

Aim:- To conduct the brake load test on D.C. shunt motor and determine its performance characteristics.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 10 A	1
2	Ammeter	(M.C)	0 – 1 A	1
3	Voltmeter	(M.C)	0 – 250 V	1
4	Rheostat	Wire wound	500 Ω , 1.2 A	1
5	Tachometer	Digital	0-9999 rpm	1
6	D.C. shunt motor with loading arrangement		-	1
7	Connecting wires	PVC insulated	-	-

Theory:- This is a direct method of testing dc machine. This test is conducted on low Horse power machines the machine is run as a motor and a brake frictional load is applied to the moving shaft. The moment of the brake drum is restricted with a braking arrangement. The braking arrangement consists of

- a) Water cooled brake drum b) belt c) Spring balances to measure the tension on the brake belt and d) tension adjusting mechanism. The friction between brake drum and belt acts as a mechanical load. By adjusting the tension of the belt the load on the motor can be adjusted. Due to brake friction terrible heat is produced. To keep the brake drum with in the working temperature or to remove the heat due to friction the brake drum is filled with water for cooling.

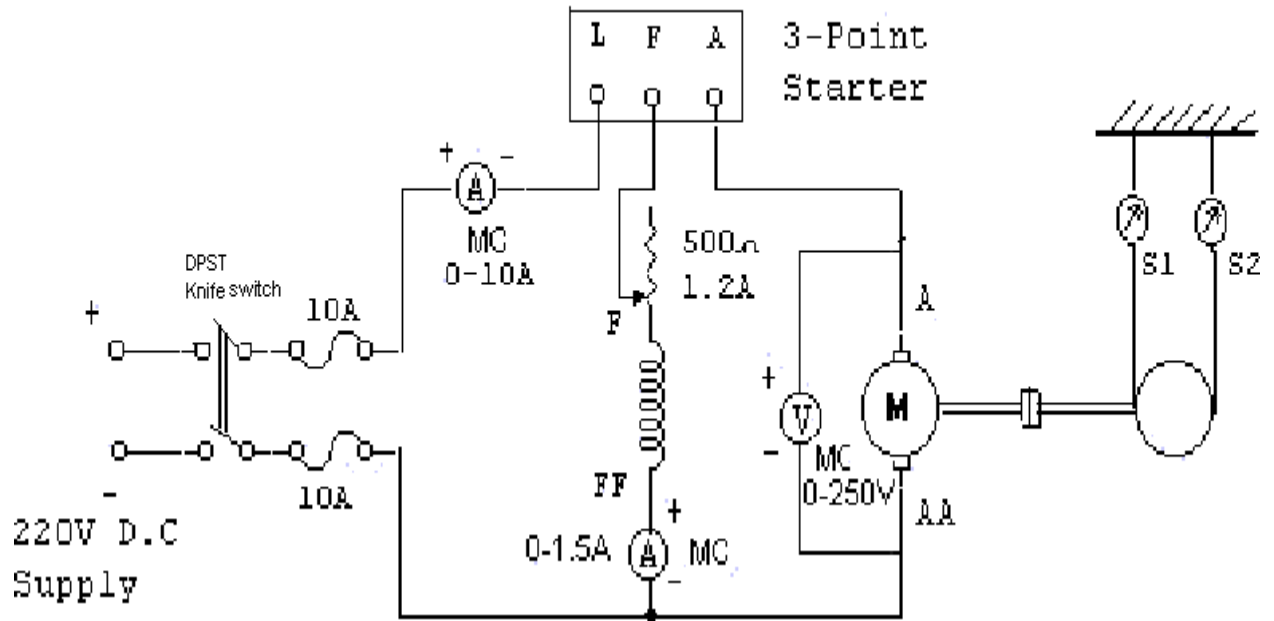
Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With the motor field rheostat in cutout position, the 3 point starter handle in initial position and ensuring that the belt over the brake drum is totally loosened, the supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in the motor armature circuit so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat and all the meter readings as well as speed are noted.
5. The load is applied in steps and for each step all the meter readings, spring balance readings as well as speed are noted.
6. Step no. 5 is repeated until the rated current of the motor is nearly reached.

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- The load is removed in steps, the motor field rheostat is brought back to cut out position and the supply switch is opened.

CIRCUIT DIAGRAM: -



Tabular column:-

Sl. No	V In Volts	I _l In Amps	I _{sh} In Amps	S ₁ In Kgs	S ₂ In Kgs	T In N - m	N In rpm	I _a In Amps	Input In Watts	Output In watts	% Efficiency

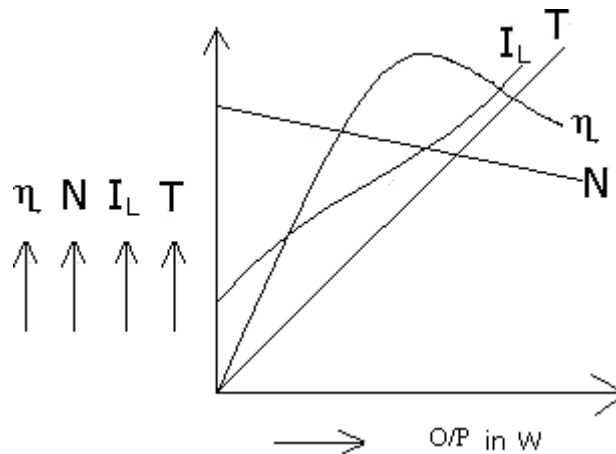
Specimen calculations:-

1. Torque $T = (S_1 \sim S_2) \times r \times 9.81 \text{ N - m}$
2. Armature current $I_a = I_L - I_{sh} \text{ amps}$
3. Motor input power $P_i = V \cdot I_L \text{ watts}$

4. Motor output power $P_o = \frac{2\pi NT}{60} \text{ watts}$

5. % efficiency $\eta = \frac{\text{output power}}{\text{input power}} \times 100$

Nature of the graph:-



Viva – Voce Questions:-

1. What is the condition for maximum output in a dc motor?
2. What happens if the field circuit of a dc motor is opened under running condition?
3. Write down the torque equation of a dc motor?
4. Draw the characteristics & performance curves of a dc shunt motor?
5. The lost torque in a dc motor is proportional to which loss?
6. What is meant by critical speed?
7. What are the usual ranges of field winding resistance armature resistance in case of a dc shunt motor?

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8. Can we use 3-point starter for the speed control of dc motor using field rheostat method? Why?
9. What are the different speed control methods used for dc series motor?

Exp. No : 4

DC SHUNT GENERATOR CHARACTERISTICS

Aim:- To conduct the no-load and load test on a D.C. shunt generator and draw its O.C.C, internal and external characteristics.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.C)	0 – 250 V	1
2	Ammeter	(M.C)	0 – 10 A	1
3	Ammeter	(M.C)	0 – 2 A	1
4	Rheostat	Wire Wound	500 Ω, 1.2 A	2
5	Tachometer	Digital	0 – 9999 rpm	1
6	Load box	Resistive	230 V/ 10 A	1
7	D.C. shunt generator coupled D.C. motor		-	-
8	Connecting wires	PVC insulated	-	-

Theory:-

External characteristic curve (ECC):- This is drawn under load condition. It is the curve drawn between load current or line current and load voltage or terminal voltage taking current on X axis induced emf on Y axis.

Internal characteristic curve (ICC). It is also called as total characteristic curve. It is drawn between armature current and generated voltage. Taking armature current on X axis, induced emf on Y axis

Relation between terminal voltage and induced emf:-The voltage measured at the terminals is known as terminal voltage and that induced in the generator is known as induced emf which is represented by E.

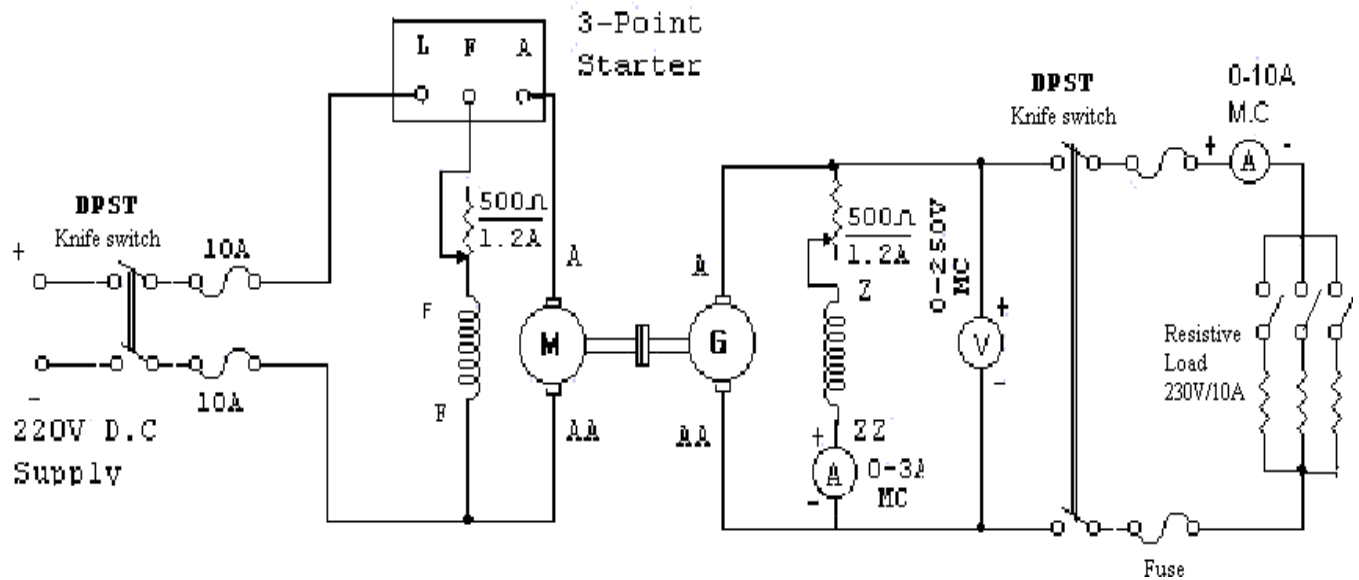
Procedure:-

1. The connections are made as shown in the circuit diagram.
2. Ensuring that the motor field rheostat is in CUTOFF position, generator field rheostat is in CUTIN position, 3-point starter handle is in initial position and the load switch is in off position and the supply switch (DPST) is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in the motor armature circuit, so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat.
5. The generator field rheostat is varied in steps and the readings of field current and terminal voltage are noted.
6. Step No 5 is repeated until the generator voltage reaches to its rated value.

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7. The load switch (DPST) is closed to connect the load to the generator and all the meter readings are noted in the tabular column.
8. The load is varied in steps and all the meter readings are noted in the tabular column.
9. Step no.8 is repeated until the rated current of the generator is reached.
10. The load is reduced in steps, the load switch is opened, the generator field rheostat is brought back to CUTIN position, the motor field rheostat to CUTOFF position and the supply switch is opened.

CIRCUIT DIAGRAM:-



Tabular Column:-

Open circuit characteristic

Sl.no	I _f In Amps	E In Volts

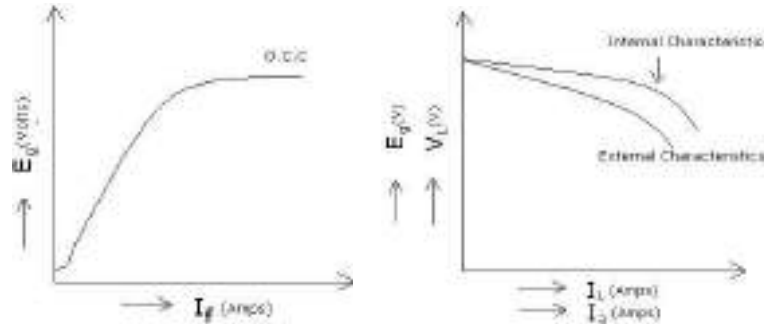
Internal and external characteristic

Sl.no	I _f In Amps	I _L In Amps	V In volts	I _a In Amps	I _a R _a In Volts	E In volts

Specimen calculations:-

Induced voltage under load = $E = V + I_a R_a$

Nature of graph:-



Fig(a) : Open Circuit Characteristic Fig (b) : Internal (E_g Vs I_a) and External (V_L Vs I_L) Characteristics

Viva – Voce Questions:-

1. What are the conditions to be fulfilled for the shunt generator to build up voltage?
2. What is meant by the term “critical field resistance” related to the dc shunt generator?
3. What is meant by the term “critical load resistance” in case of a dc shunt generator?
4. What is the type of voltage induced in the armature of a dc generator.
5. Can you measure the “Induced voltage” under load condition for a dc generator? Why?
6. Represent the armature reaction drop in the load characteristics of a dc shunt generator?
7. What is the purpose of the commutator in a dc machine?
8. What is meant by “critical speed N_0 ” in case of a dc shunt generator?
9. What is the principle of operation of dc generator?
10. List out the factors affecting the voltage fall in a dc shunt generator?
11. What will happen if you given ac supply to the field of a dc generator?
12. A properly connected generator is showing a zero terminal voltage when it is run by a prime mover. What is the reason?

Exp. No : 5

OPEN CIRCUIT CHARACTERISTICS OF A D.C. GENERATOR

Aim:- To plot the open circuit characteristics of a separately excited D.C. generator.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.C)	0 – 250 V	1
2	Ammeter	(M.C)	0 – 1 A	1
3	Rheostat	Wire Wound	500 Ω , 1.2 A	2
4	Tachometer	Digital	0-9999 R.P.M	1
5	DC Motor coupled to D.C Generator		-	-
6	Connecting wires	PVC insulated	-	-

Theory:- The field current I_f is obtained from an external independent DC source. It can be varied from zero upwards by a potentiometer and its value is read by Ammeter connected in the field circuit.

Voltage equation of a DC generator is $E_g = \phi ZNP/60A$

Hence if speed is constant, the above relation becomes $E = K\phi$

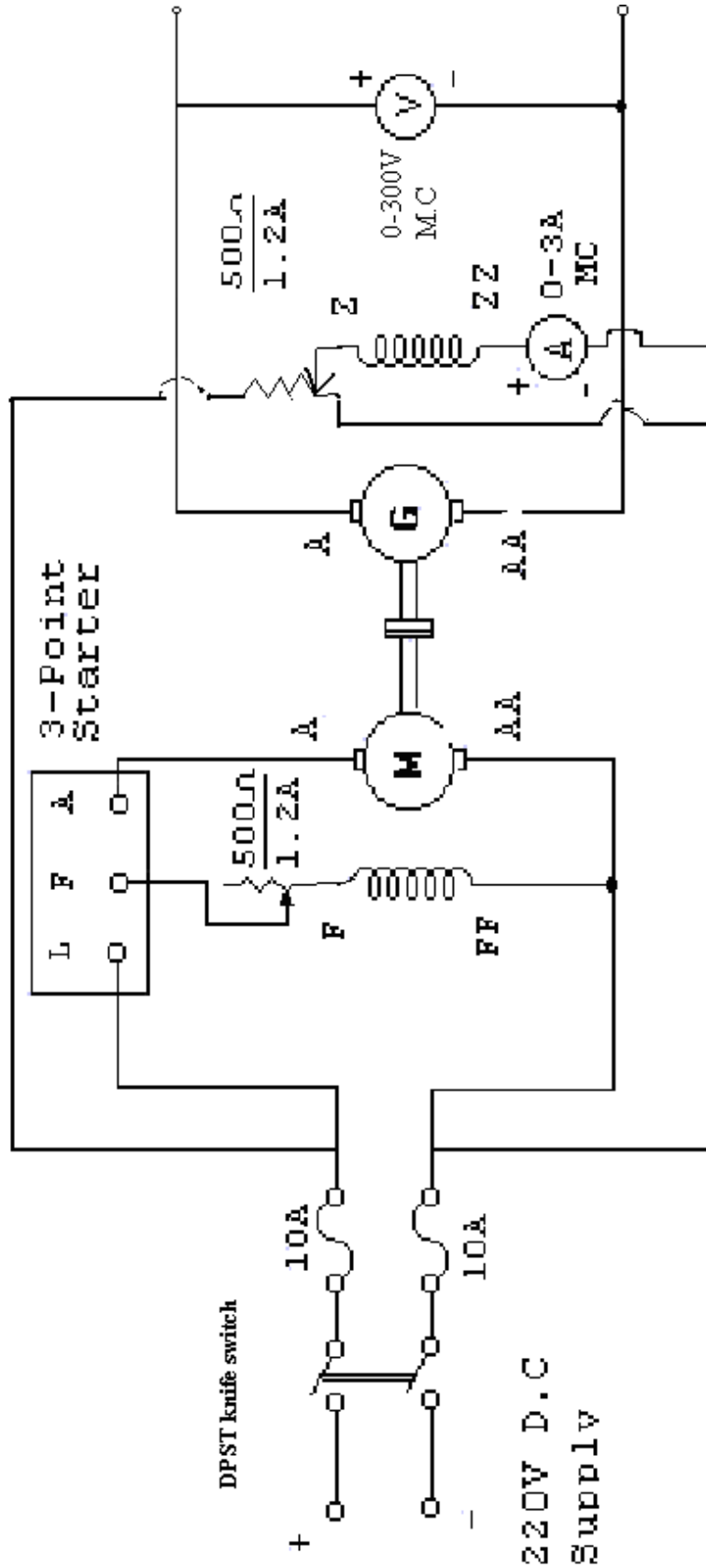
It is obvious that when I_f is increased from its initial small value, the flux ϕ and hence generated emf increases as current while the poles are unsaturated. But as the flux density increases, the poles become saturated so a generator in I_f is requires to produce a given increase in voltage than as the lower part of the curve.

The curve showing relation between the terminal voltage 'V' and field current I_f when the generator is on no-load

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With the motor field rheostat in CUTOOUT position, the generator field rheostat in CUTIN position and the motor 3-point starter handle at its initial position, the DC supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in the motor armature circuit so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat.
5. The generator field is excited by gradually varying the resistance of the generator field rheostat in steps and for each step the corresponding field current and the no load voltage are noted.
6. Step no. 5 is repeated until the rated voltage of the generator is reached and all the meter readings are noted for each step.
7. The generator field rheostat is brought back to CUTIN position, the motor field rheostat to CUTOOUT position and the supply switch is opened.

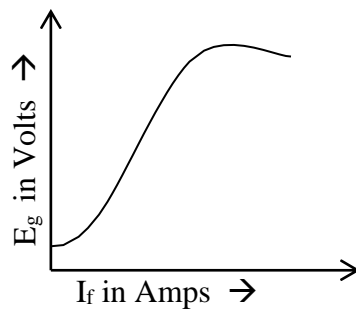
CIRCUIT DIAGRAM: -



Tabular column:-

Sl.No	I _f In Amps	E _g In volts

Nature of graph:-



Viva – Voce Questions:-

1. Identify the locations of field and armature windings for different machines.
2. What do you mean by rated values of a machine
3. What is to be done if the residual flux is not present in a dc generator?
4. Write down the EMF equation of a dc genertor?
5. To found OCC of a self excited shunt generator it has to be connected as a separately excited generator when it is (true or false).
6. Expand OCC what is the other name for it? Where does OCC of dc generator lies at speed N_1 with respect to that of OCC at N_2 if $N_1 < N_2$.
7. Commutator works as a _____ in dc generator and as a _____ in a dc motor.
8. Large dc generators will have _____winding and high voltage, small generator will have _____windings.
9. Interpoles will be placed between _____ in a dc generator.
10. A dc shunt motor can be started using 4 point starter (True or False) ?

Exp. No : 6

HOPKINSON'S TEST ON D.C. MACHINES

Aim:- To conduct Hopkinson's test on two identical DC shunt machine and determine the efficiency of each M/C at various loads.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.C)	0 – 250 V	2
2	Ammeter	(M.C)	0 – 10 A	3
3	Ammeter	(M.C)	0 – 2 A	2
4	Tachometer	Digital	0 – 9999 rpm	1
5	Rheostat	Wire wound	500 Ω , 1.2 A	2
6	D.C. shunt motor coupled generator			
7	Connecting wires	PVC insulated		

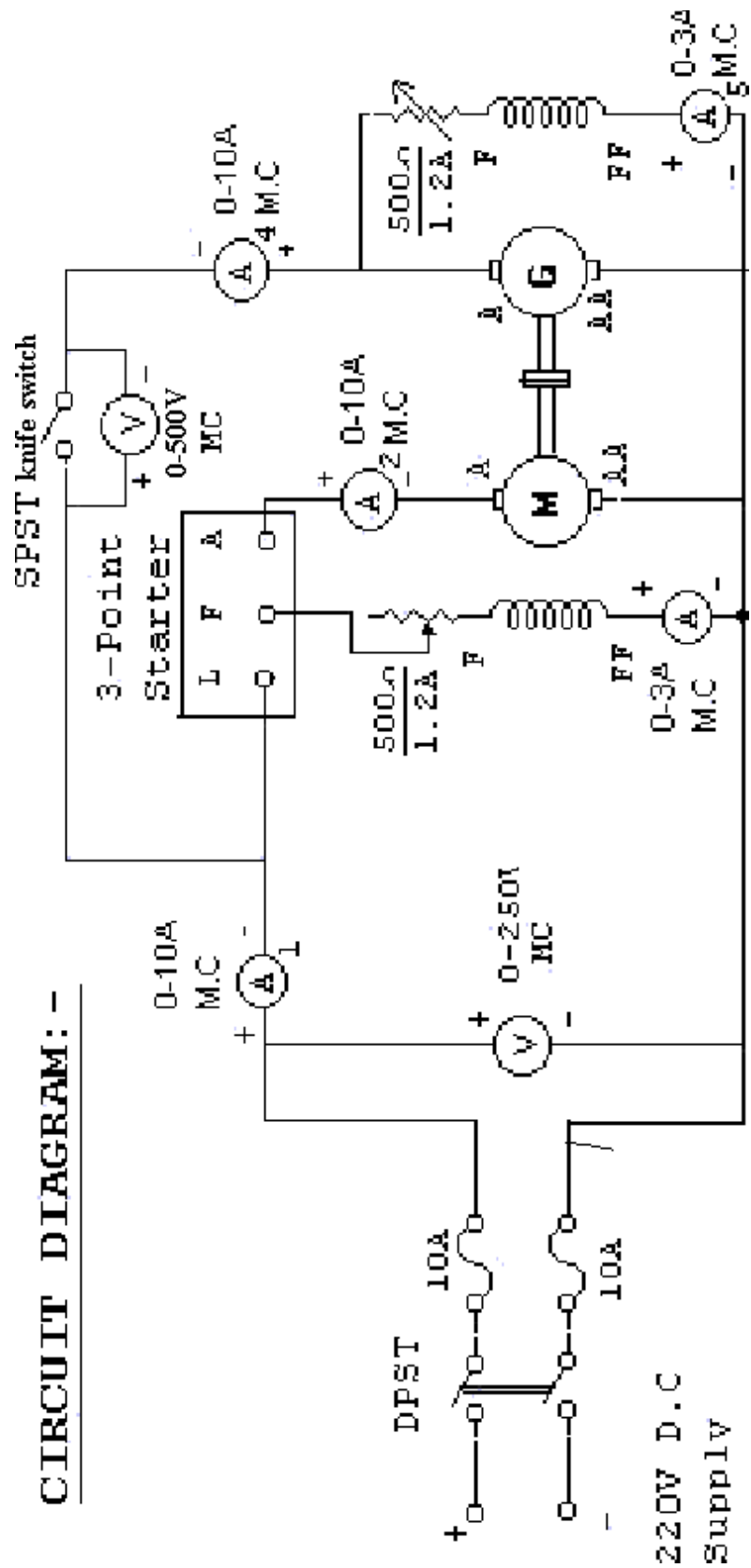
Theory:- By this method full load test can be carried out on two shunt machines, preferably identical ones, without wasting their outputs. The two m/c are mechanically coupled and are adjusted electrically that one of them runs as a motor and the other as a generator. The mechanical o/p of the motor drives the generator and the electrical o/p of generator is used in supplying the greater part of input to motor. If there were no losses in the m/ces they would have run without any external supply. But due to these losses gen o/p is not sufficient to drive the motor and vice versa. The losses are supplied either by an extra motor which is belt connected to the MG set or by supply mains electrically born the supply mains

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With motor field rheostat in cutout position, generator field rheostat in cut in position, ensuring that 3-point starter handle at its initial position and with the S.P.S.T. switch open, the supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in the motor armature circuit, so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat.
5. The generator field rheostat is varied such that the generator terminal voltage is same as supply voltage so that the voltmeter across the SPST switch reads zero value and the SPST switch is closed.
6. The meter readings are noted in the tabular column.
7. The field rheostat of generator is varied in steps such that the field current is also varied in steps of 0.1 A and all the meter readings are noted in the tabular column for each step upto I_4 reads generator rated current.

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8. The field rheostat of generator is brought back to cut in position, so that the generator current is zero, the motor field rheostat is brought back to cut out position and the supply switch is opened



Tabular column:-

Sl.No	Voltage In Volts	I ₁ In Amps	I ₂ In Amps	I ₃ In Amps	I ₄ In Amps	I ₅ In Amps	Generator O/P in watts	Motor O/P in watts	Efficiency of Generator in %	Efficiency of Motor in %

Specimen calculations:-

Armature cu losses of generator = $(I_4 + I_5)^2 R_a$

Armature cu losses of motor = $I_2^2 R_a$

Shunt field cu losses in generator $\equiv V I_5$

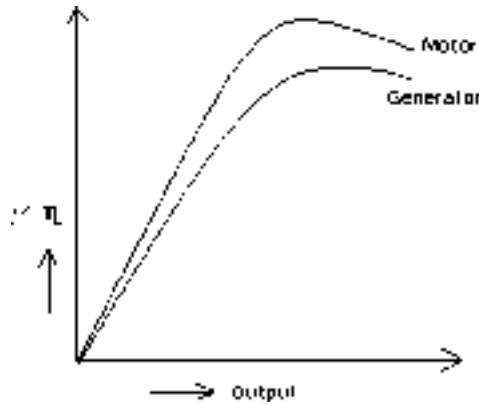
Shunt field cu losses in motor $\equiv V I_3$

Total stray losses $\rho_s = VI_1 - [(I_4 + I_5)^2 R_a + I_2^2 R_a + VI_5 + VI_3]$

∴ Efficiency of Generator $\eta_g = \frac{VI_4 - \rho_s - \frac{VI_4^2}{2I_4} - \frac{VI_5}{I_4}}{VI_4} \times 100$

∴ Efficiency of Motor $\eta_m = \frac{V(I_1 + I_4) - I_2^2 R_a - VI_3 - \frac{\rho_s}{2}}{V(I_1 + I_4)} \times 100$

Nature of graph :-



Viva – Voce Questions:-

1. Stray loss in a dc machine depends on what quantities?
2. Draw the circuit diagram to measure the armature resistance of a dc machine?
3. What is the difference between the Swinburns test and Hopkinsons test?
4. Which loss is obtained from the Hopkinsons test?
5. Is the stray loss obtained from the Hopkinsons test really same for both the machines? Why?
6. Which part of the stray loss is not equal both the machines during Hopkinsons test? Why?
7. Which loss comes under rotational losses in case of a dc shunt machine?
8. For a dc shunt machine the efficiency obtained from the Swinburns test is more than the one obtained from the Hopkinsons test justify?

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Exp. No : 7

D.C SERIES GENERATOR CHARACTERISTICS

Aim:- To draw the internal and external characteristics of DC series generator by conducting load test.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.C)	0 – 250 V	1
2	Ammeter	(M.C)	0 – 10 A	1
3	Rheostat	Wire Wound	500 Ω , 1.2 A	1
4	Tachometer	Digital	0 – 9999 rpm	1
5	Load box	Resistive	230 V/ 10 A	1
6	D.C. series generator coupled to DC motor		-	-
7	Connecting wires	PVC insulated	-	-

Theory:- In series generator the field winding is connected in series with the armature winding.

ECC: External characteristic curve . it is the curve drawn between the load current and terminal voltage. Taking load current (I_L) on X axis and terminal voltage on Y-axis

ICC: Internal characteristic curve. It is the curve drawn between armature current and generated voltage. Taking armature current I_a on X axis and generated voltage on Y axis

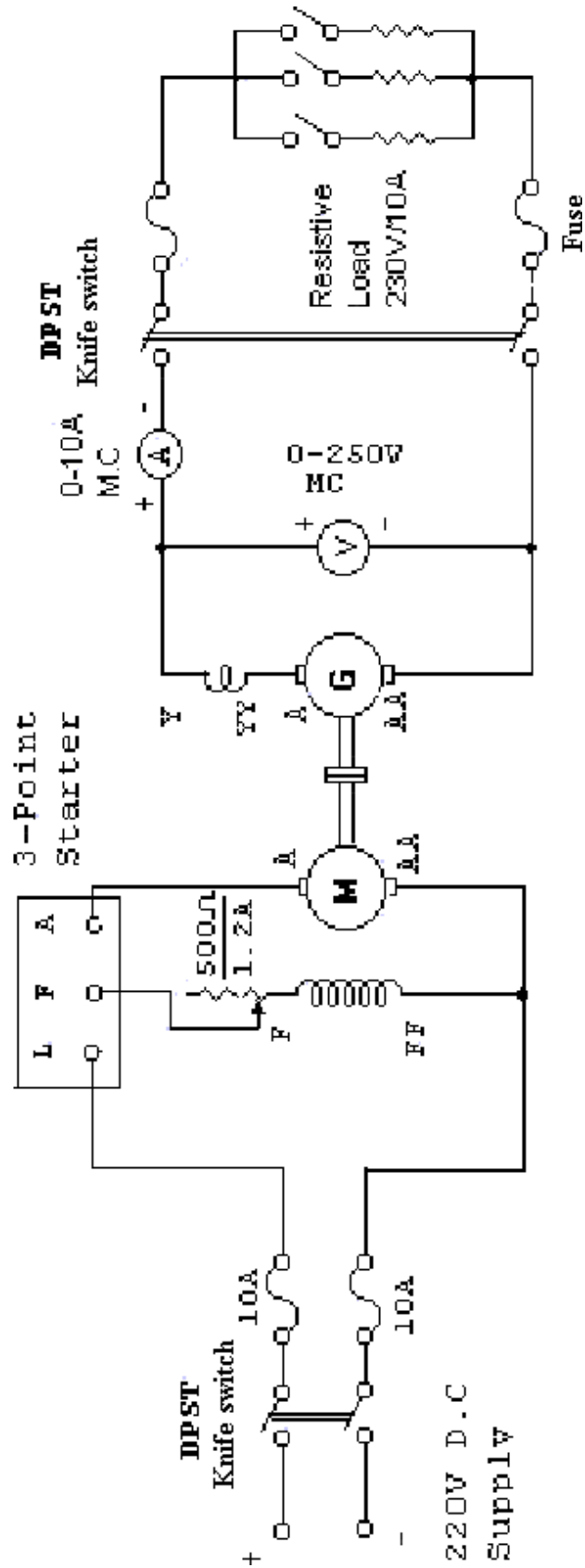
In series generator

Armature current = field current = load current

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. Ensuring that the motor field rheostat is in CUTOUT position, the 3-point starter handle is in initial position, the generator load switch in open position the supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the motor armature circuit resistance, so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat. And the voltmeter reading is noted (indicates residual voltage)
5. The load switch of the generator is closed.
6. The load is varied in steps and all the meter readings are noted in the tabular column.
7. Step No 6 is repeated until the rated current of the generator is reached.
8. The load is removed in steps, the load switch of the generator is opened the motor field rheostat is brought back to CUTOUT position and the supply switch is opened.

CIRCUIT DIAGRAM: -



Tabular Column :-

Sl. no	I _L In Amps	V _L In volts	I _a R _a Drop In Volts	Induced E.M.F In volts

Specimen calculations :-

$$\text{Induced E.M.F} = E = V + I_a (R_a + R_{sc})$$

Nature of graph :-

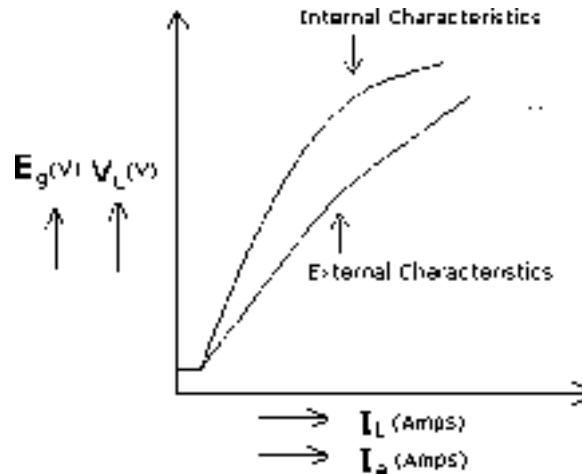


Fig: Internal (E_g Vs I_a) and External (V_L Vs I_L) Characteristics

Viva – Voce Questions:-

1. Draw the load characteristics of a dc series generator.
2. Can a dc series generator. Excite on no load, why? What is meant by critical load resistance of the above machine.
3. What is the usual range of field winding resistance in case of a dc series machine.
4. Series generator has _____ characteristics of series generator.

Exp. No : 8**D.C COMPOUND GENERATOR CHARACTERISTICS**

Aim:- To draw the internal and external characteristics of DC short shunt compound generator by conducting load test (Both cumulative & differential)

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.C)	0 – 250 V	1
2	Ammeter	(M.C)	0 – 10 A	1
3	Ammeter	(M.C)	0 – 2 A	1
4	Rheostat	Wire Wound	500 Ω , 1.2 A	2
5	Tachometer	Digital	0 – 9999 rpm	1
6	Load box	Resistive	230 V/ 10 A	1
7	D.C. compound generator coupled to DC shunt motor		-	-
8	Connecting wires	PVC insulated	-	-

Theory:- **The method of adding the series field flux with the shunt field flux is known as compounding. According to method of compounding the compound generators are classified into two categories.**

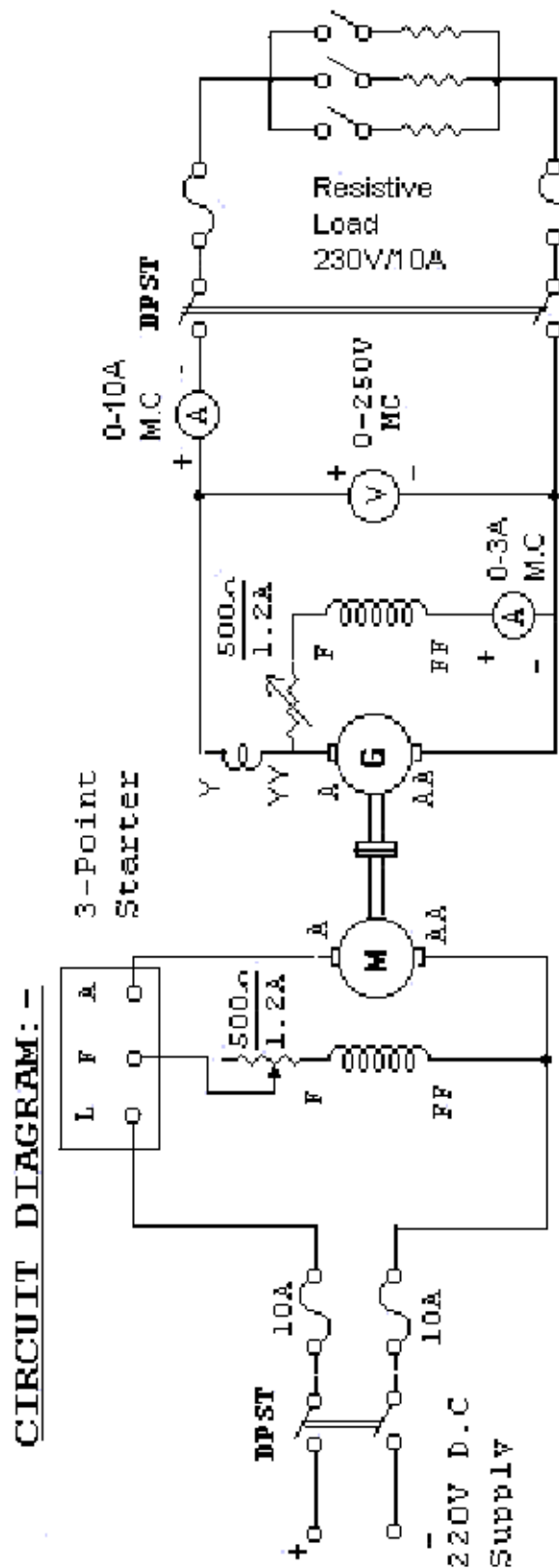
- i) Cumulatively compounding generator.
- ii) Differential compounding generator.

In cumulative compounding generator the flux produced by the series field winding must be right direction with the shunt field flux. ie the series field flux inphase with the shunt field flux. but in the case of differential compounding generator the flux produced by the series field winding is in such a direction that it should opposes the shunt field flux. there by the resultant flux decreases.

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With motor field rheostat is in CUTOOUT position, generator field rheostat in CUTIN position, ensuring that the 3-point starter handle is in initial position, and load switch in off position the supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually, so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat.
5. The generator field rheostat is varied gradually so that the generator voltage is built up to its rated value.
6. The load switch of the generator is closed
7. The load is applied in steps and for each step all the meter readings are noted.
8. Step No.(7) is repeated until the rated current of the generator is reached
9. The load is removed in steps, the load switch of the generator is opened the generator field rheostat is brought back to CUTIN position the motor field rheostat to CUTOOUT position and the supply switch is opened.
10. The series field winding terminals of the generator are interchanged and the above procedure is repeated to get another type of compounding.

Note: If the first one is cumulative compound, second one will be differential compounding.



Tabular Column:-

a) Cumulative Compounding:

Sl.no	I _L In Amps	V _L In volts	I _f In Amps	I _a In Amps	E _g In volts

b) Differential Compounding:

Sl.no	I _L In Amps	V _L In volts	I _f In Amps	I _a In Amps	E _g In volts

Specimen calculations:-

The Induced E.M.F $E_g = V_L + I_a R_a + I_L R_{sc}$

Nature of graph:-

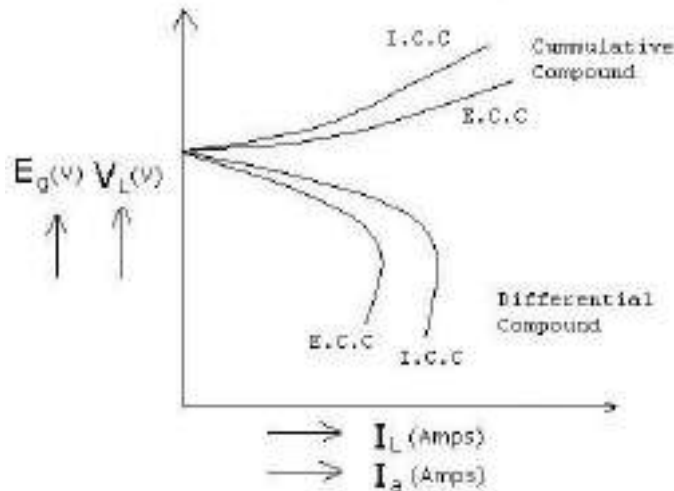


Fig: Internal (E_g Vs I_a) and External (V_L Vs I_L) Characteristics

Viva – Voce Questions:-

1. Mention the difference between cumulative and differential compound dc generator.
2. Sketch load characteristics of compound generators
3. How can you identify the machine whether it is cumulative, differential compounded machine?
4. When do you load the generator?
5. A generator will be loaded by a mechanical load (true or false).

Exp. No. 9

‘V’ AND ‘Λ’ CURVES OF A SYNCHRONOUS MOTOR

Aim:- To draw ‘V’ and ‘Λ’ curves of an auto induction start synchronous motor at no load and at different loads.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 3 A	1
2	Ammeter	(M.I)	0 – 10 A	1
3	Voltmeter	(M.I)	0 – 600 V	1
4	3- ϕ , 2 –element Power factor meter	Dynamometer	500 V / 10 A	1
5	Rheostat	Wire Wound	500 Ω / 1.2A	1
5	3- ϕ Dimmer stat	Core type	415/0-470V, 10 A	1
6	Synchronous motor		3 HP, 415V, 3.5A	1
7	Connecting wires	PVC insulated		

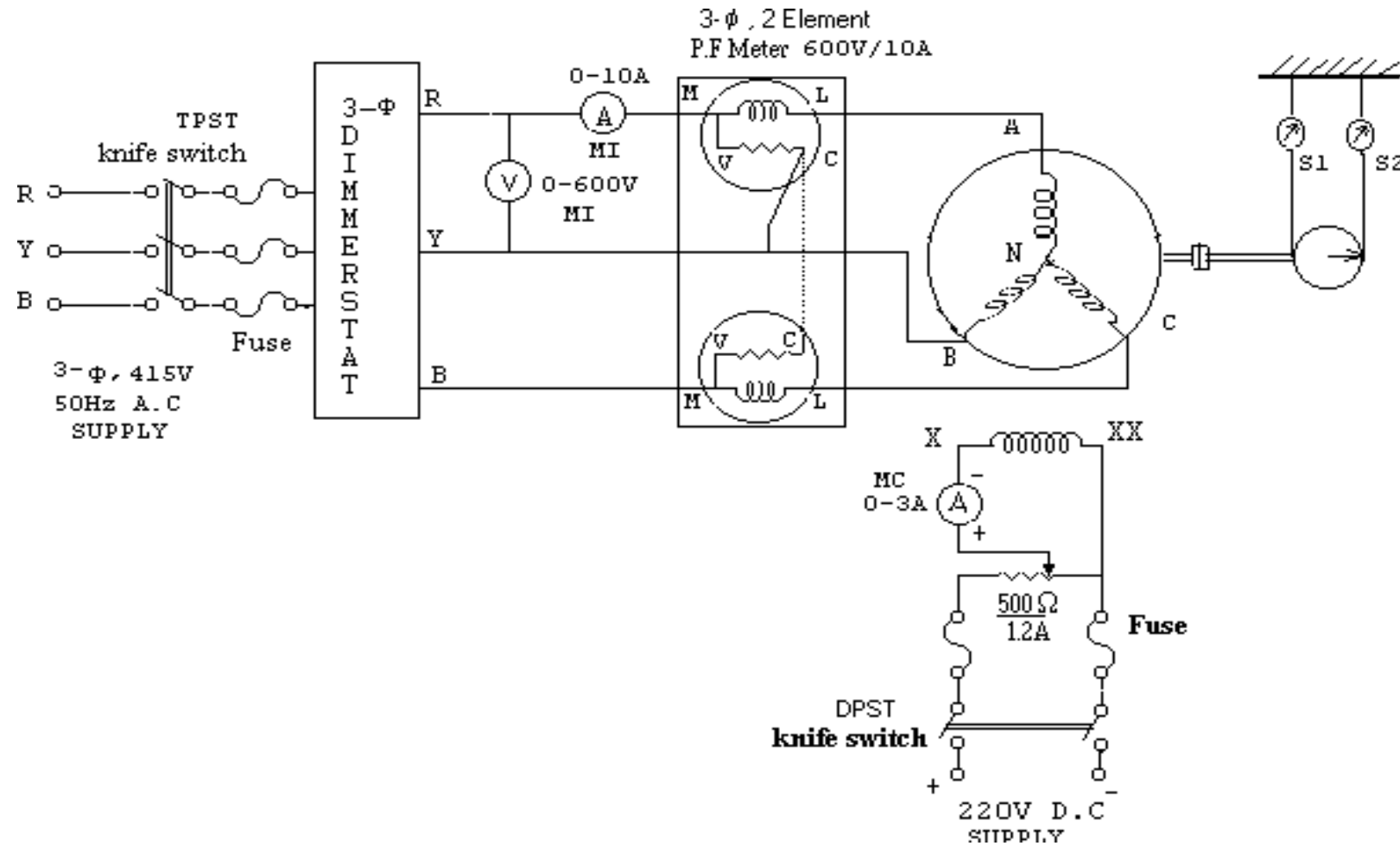
Theory:-

When the field current of a synchronous motor is reduced, a lagging armature current is produced and that exceeds the minimum current at unity power factor at normal excitation. Similarly, when the motor is over excited the armature current also rises and exceeds the current required at normal excitation to develop to necessary torque at any given load. By applying a given constant load to the shaft of a synchronous motor and varying the field current from under excitation to over excitation and recording the armature current at each step, we can obtain the ‘V’ curves. The armature phase current is plotted against the DC field current both for no-load and load.

The power factor is plotted against the DC field current for no-load and load also note that both sets of curves show that a slightly increased field current is required to produce normal excitation as the load is increased, at no-load, the armature current at unity power factor is zero. But some small value of armature current is necessary to produce the torque to counter balance notational losses. As load is applied not only does the armature current lose, but also it is also necessary to increase the excitation to bring the armature current back in phase with the bus phase voltage.

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Circuit Diagram:-



Procedure:-

1. The connections are made as shown in the circuit diagram.
2. Ensuring that the dimmer stat is at zero out put, the belt over the brake drum is loose , the 3- ϕ ac supply switch is closed.
3. The dimmer stat is gradually varied so that rated voltage is applied and the motor runs as an induction motor closed to the synchronous speed.
4. With the alternator field rheostat in cut in position the DC supply switch is closed. Due to the excitation of the field, the machine starts operating as a synchronous motor.
5. The field current is varied in steps from min value to max value using the rheostat all the meter readings are noted for each step.
6. The load is applied in steps to the motor by tightening the belt on the brake drum and step no 5 is repeated for each step of load.
7. The load is removed in steps by loosing the belt on the brake drum, the field rheostat is brought back to cutin position, the dc supply switch is opened and the ac supply switch is also opened.

Tabular column:-

No-load

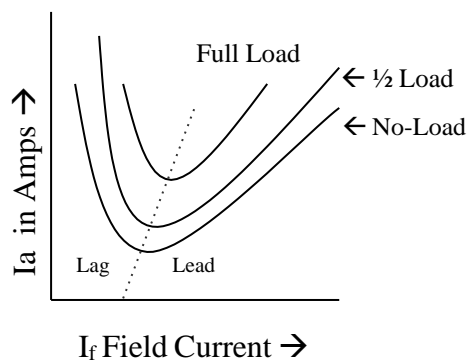
S.No	I _f In Amps	I _a In Amps	p.f

With Load:

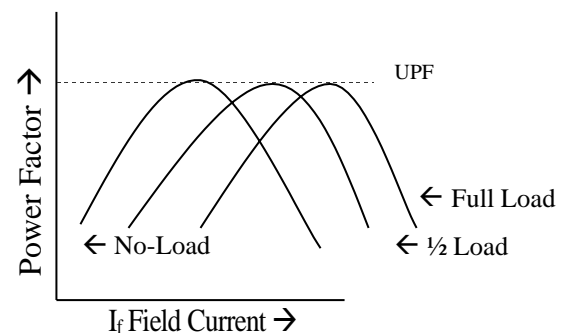
S.No	I _f In Amps	I _a In Amps	p.f

Nature Of Graph:-

'V' - Curves



Inverted 'V' - Curves



Viva Questions:-

1. What is meant by V curve of synchronous motor?
2. What is meant by inverted V of synchronous motor?
3. How the synchronous motor does behave, when it is under excited?
4. How the synchronous motor does behave, when it is over excited?
5. What is the nature of the power factor, when the motor is operated at over excited?
6. What is the nature of the power factor, when the motor is operated at no-load and under excited?
7. How does the synchronous motor behaves, when it is normal excited?
8. Where we use over excited synchronous motor?
9. At which power factor the motor will draw minimum armature current?
5. In which applications the synchronous motor can be used when it operated at over excited?
11. Application of synchronous motor
12. Whether the synchronous motor is self excited or not why?
13. What is under excitation?
14. What is over excitation?
15. What is normal excitation?

Exp. No. 10

REGULATION OF AN ALTERNATOR BY EMF METHOD

Aim:- To conduct open circuit and short circuit test on a 3- ϕ alternator and determine the full load regulation curve with E.M.F method.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 1.5 A	1
2	Ammeter	(M.I)	0 – 10 A	1
3	Voltmeter	(M.I)	0 – 300 V	1
5	Rheostat	Wire Wound	500 Ω / 1.2 A	2
8	Tachometer	(digital)	0.99999 rpm	1
9	Motor alternator set		-	1
10	Connecting wires	PVC insulated	-	-

Theory:-

The voltage regulation of an alternator is defined as the increase in the terminal voltage when the load is through off, produced that the field excitation and the speed are constant.

$$\% \text{ regulation} = \frac{E - V}{V} \times 100$$

Where E – is the no-load voltage

V – is the load voltage

The variation in terminal voltage ‘V’ is due to the following reasons.

1. Voltage drop due to armature resistance Ra.
2. Voltage drop due to armature leakage reactance.
3. Voltage drop due to armature reaction.

Regulation of an alternator can be determined by measuring the voltage of the alternator, i.e. ‘V’ when loaded and ‘E’ when the load is taken off. In actual practice it will be difficult to load a big alternator in the testing laboratory as the laboratory may not have such heavy loads. More over, during the testing period a considerable amount of electrical energy will be wasted as losses in the machine and in the load. This is why regulation of large alternators are not generally determined by direct loading method.

Regulation of an alternator can be determined from the results of the following two tests.

- a. Open circuit test.
- b. Short circuit test.

Open circuit test:-This test is carried out with the alternator running no-load and at rated speed. The field current and corresponding terminal voltage is recorded up to about 120% of rated terminal voltage. The characteristic shows

the relationship between field current and terminal voltage on no-load is called the open circuit characteristic.

Short circuit test:-This test is performed when the alternator is running at rated speed. The armature terminals are short circuited with a very low excitation current and the field current corresponding to rated armature current is noted and a plot of field current versus armature current is called short circuited characteristic.

From these curves synchronous impedance can be calculated and then synchronous reactance can be separated as $X_s = \sqrt{Z_s^2 - R_a^2}$

Procedure:-

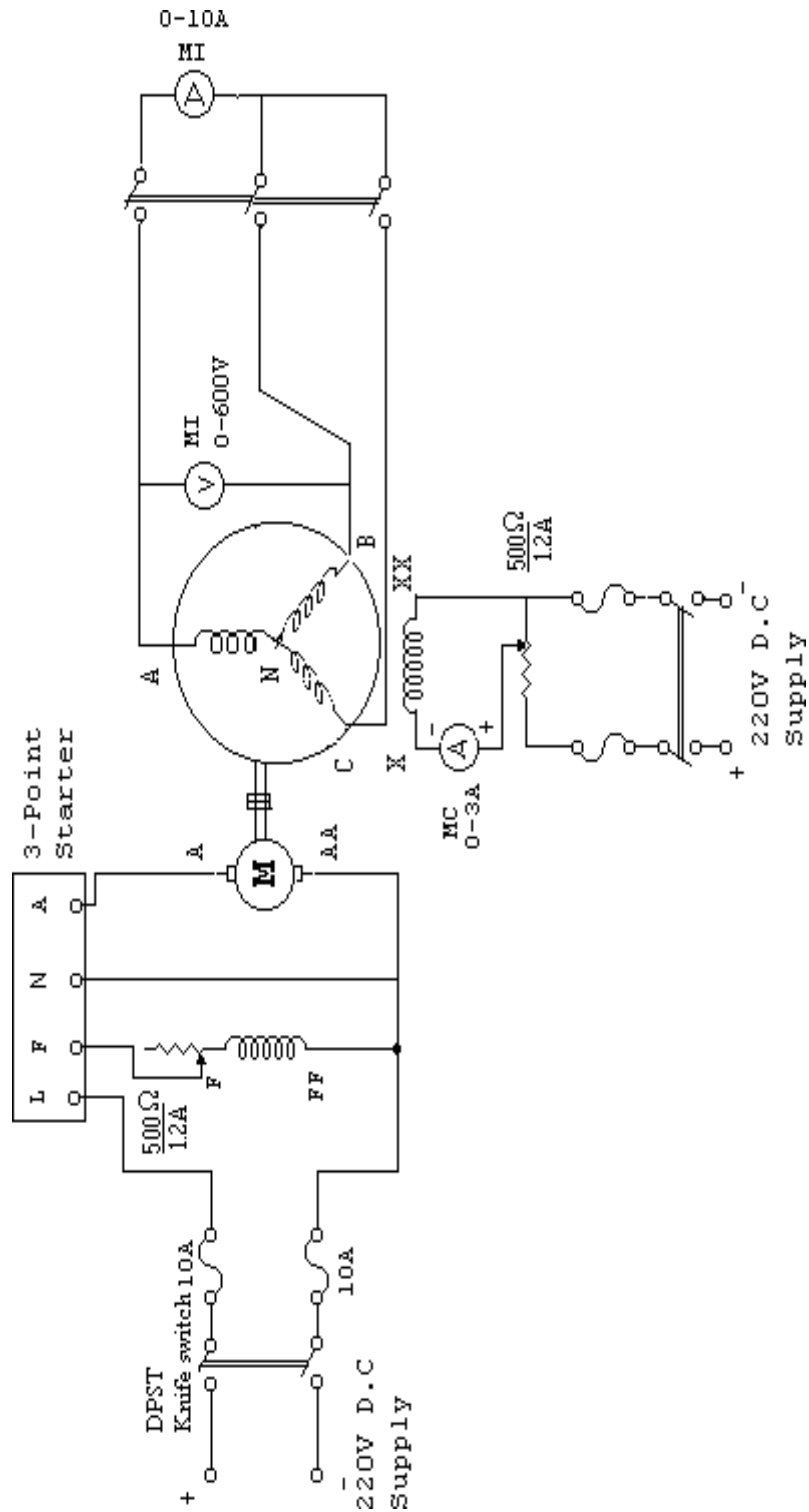
Open circuit characteristic Test

1. The connections are made as shown in the circuit diagram.
2. With the motor field rheostat in cut out position, the alternator field rheostat is cut in position, the 4-point starter handle is in initial position and the TPST opened, the supply switch is closed.
3. The 4-point starter handle is moved slowly in the clockwise direction to cut out the resistance in the motor armature circuit so the motor starts.
4. The motor is brought to its rated speed, which is the rated speed of the alternator also by adjusting the motor field rheostat.
5. The dc supply switch of the alternator field is closed, the field current of the alternator is varied in steps and for each step the alternator voltage along with the field current are noted.
6. Step 5 is repeated until the alternator voltage reaches about 120% of its rated value.
7. The alternator field rheostat is brought back to cut in position, the alternator field dc supply switch is opened, dc motor field rheostat is brought back to cut out position and the supply switch is opened.

Short circuit test:

1. Step nos 1, 2, 3 and 4 of o.c.c. test are repeated.
2. The TPST switch is closed, so that the alternator terminals are short circuited.
3. The dc supply switch of the alternator field is closed and the alternator field rheostat is varied such that the ammeter reads the rated current of the alternator and the corresponding field current is noted.
4. The TPST switch is opened, the alternator field rheostat is brought back to cut in position, the alternator field dc supply switch is opened, the motor field rheostat is brought back to cut out position and the dc supply switch is opened.

Circuit diagram:-



Tabular column:-

O.C test:

Sl.No	I _f In Amps	E ₀ In volts

S.C test:

Sl.No	I _f In amps	I _a In amps

Specimen calculations:-

D.C armature resistance per phase = R_{DC}

AC cumulative resistance per phase = 1.2 to 1.6 × R_{DC}

E.M.F. method (or) synchronous impedance method:

The synchronous impedance per phase $Z_s = \frac{E_0}{I_a}$ / at constant field current

$$\therefore Z_s = \frac{\text{AC in volts}}{\text{AB in amps}} \quad \& \quad \text{Synchronous reactance} \quad X_s = \sqrt{Z_s^2 - R_a^2}$$

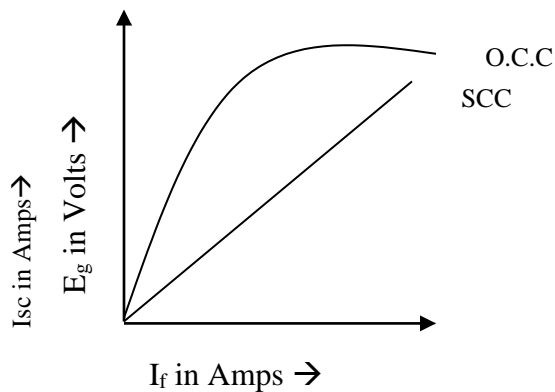
$$\% \text{ Regulation} = \frac{E_0 - V}{V} \times 100$$

Where V – is the rated terminal voltage/phase

$$E_0 = \sqrt{(V \cos\phi + I_a R_a)^2 + (V \sin\phi \pm I_a X_s)^2}$$

(+) → for lagging power factor (-) → for leading power factor
for different power factors the regulation is calculated and tabulated

Nature of graph:-



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Viva Questions:-

1. Why is it important to pre-determine the value of regulation of alternator?
2. What are the basic parameters on which regulation of alternator depends
3. What are the various indirect methods for finding out the regulation of alternator?
4. Which method gives fairly reliable value for regulation of alternator?
5. Why ZPF method is most reliable and accurate to find out the regulation of alternator?
6. Which of the method of finding out regulation is optimistic method?
7. Which of the method of finding out regulation is pessimistic method?
8. What is short circuit ratio (SCR)?
9. Can a dc generator be converted into alternator?
10. What is skin effect?
11. Why regulation up is considered in case of alternator?
12. What are the different excitation systems for synchronous machines?
11. How the alternators are classified
14. What is meant by hunting?
15. What is the difference between salient rotor and smooth cylindrical rotor?

Exp. No.11

LOAD TEST ON THREE PHASE INDUCTION MOTOR

Aim:- To conduct load test on three phase squirrel cage Induction motor and obtain the performance Characteristics.

Apparatus:-

Sl.	Apparatus	Type	Range	Qty
1.	Ammeter	(M.I)	0 – 10A	1
2.	Voltmeter	(M.I)	0 – 600V	1
3.	Wattmeter U.P.F.	Dynamometer	10A/600V	1
4.	Tachometer	Digital	0-10,000 rpm	1
5.	3-φ Dimmer stat	Core type	415V/0-470V, 10A	
6.	3-φ Squirrel cage Induction motor with loading arrangements		Belt driven type Load	1
7.	Connecting wires	PVC insulated	-	-

Theory:-

The load test on induction motor is performed to compute its complete performance i.e. torque, slip, efficiency, power factor etc. during this test, the motor is operated at rated voltage and frequency and normally loaded mechanically by brake and pulley arrangement from the observed data, the performance can be calculated, following the steps given below.

Slip: The speed of the rotor, N_n droops slightly as load on the motor is increased.

$$\text{Synchronous speed, } N_s = \frac{120f}{P} \text{ r.p.m.}$$

$f \rightarrow$ frequency
 $P \rightarrow$ No. of poles

$$\text{Then, slip } S = \frac{N_s - N_r}{N_s} \times 100\%$$

Normally, the range of slip at full load is from 2 to 5 percent.

Torque: A brake drum is coupled to the shaft of the motor and the load is applied by tightening the belt, provided on the brake drum.

$$\text{Net force exerted, } \omega = (S_1 - S_2) \text{ kg}$$

$$\begin{aligned} \text{Then, load torque, } T &= \omega \times \frac{d}{2} \text{ kg-m} \\ &= \omega \times \frac{d}{2} \times 9.81 \text{ N}\omega - \text{m} \end{aligned}$$

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Where, d is-effective diameter of the brake drum in meters.

Output power: The output power in watts developed by the motor is given by

$$\text{Output power, } P_0 = \frac{2\pi NT}{60} \text{ watt}$$

Where N is the speed of the motor in r.p.m

Power factor: If ϕ is the power factor angle, then $\cos\phi = \frac{\omega}{\sqrt{3}VI}$

Where ω is the input power.

Efficiency: Percentage efficiency of the motor, $\eta = \frac{\text{output power}}{\text{input power}} \times 100$

Full load efficiency of 3-phase induction motor lies in the range of 82% (For small motor) to 92% (For very large motors)

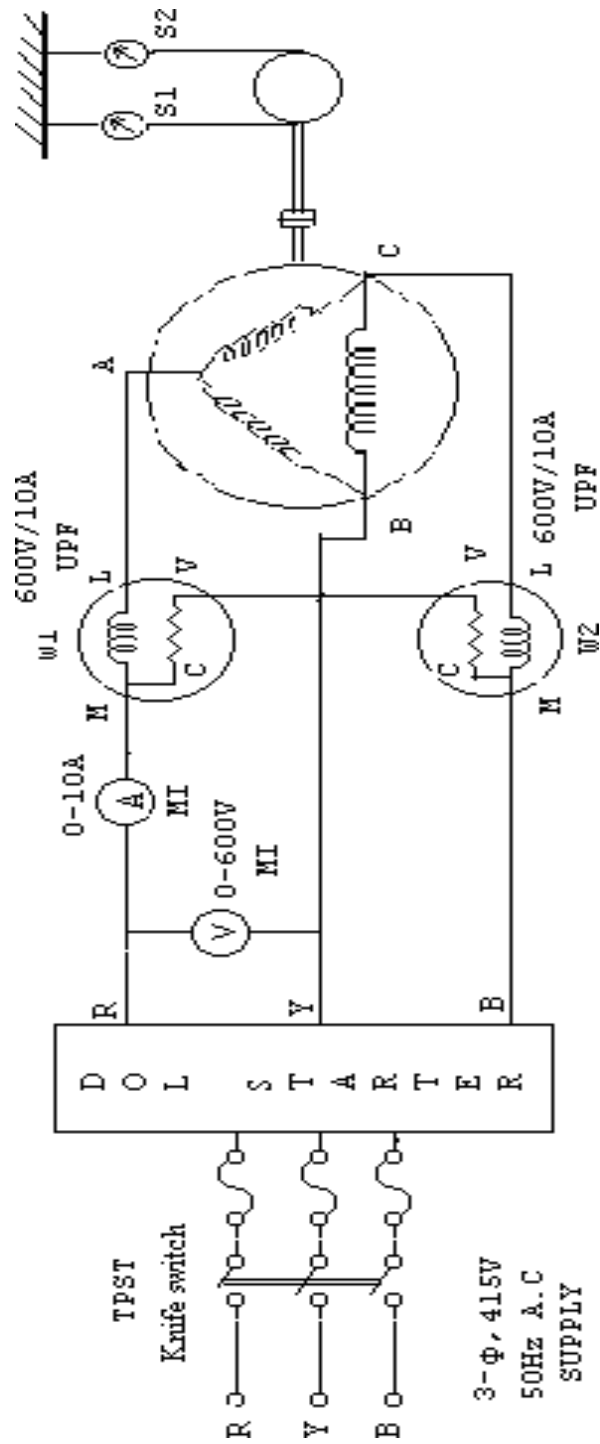
Procedure:-

- 1) The connections are made as shown in the circuit diagram.
- 2) Ensuring that the dimmerstat is at zero output and the belt over the brake drum is totally loosened, the supply switch (TPST) is closed
- 3) The dimmerstat is gradually varied so that the motor is brought to its rated speed and all the meter readings as well as speed are noted.
- 4) The load is applied in steps and for each step all the meter readings, spring balance readings as well as speed are noted.
- 5) Step no.4 is repeated until the rated current of the motor is reached.
- 6) The load is removed in steps, the Dimmerstat is brought back to zero output and the supply switch is opened.

Tabular column:-

S.I No	V _L in volts	I _L in Amps	W ₁ in Watts	W ₂ in Watts	S ₁ In kgs	S ₂ In kgs	W _T in Watts	Speed in rpm	Torque in N-m	Output In Watts	η in %	Power Factor cos φ	Slip in %

Circuit diagram:-



Specimen calculations: -

$$\text{Wattmeter constant} = \frac{\text{voltage range of } W \times \text{current range of } W}{\text{Maximum Wattmeter scale reading}}$$

$$1. \text{ Input Power} = (W_1 \pm W_2) \text{ watts}$$

$$2. \text{ Torque} = (S_1 - S_2) \cdot R \cdot 9.81 \text{ N-m}$$

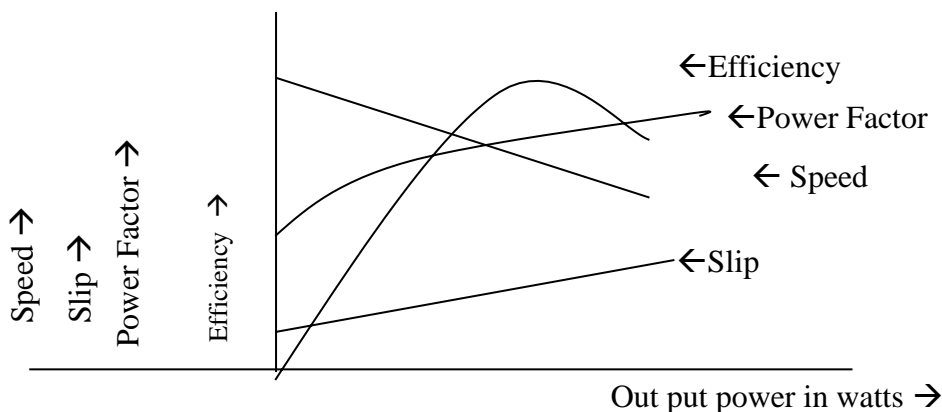
$$3. \text{ Output Power} = \frac{2\pi NT}{60} \text{ watts}$$

$$4. \% \text{ Efficiency} = \frac{\text{Output power}}{\text{Input power}} \times 100$$

$$5. \text{ Power Factor} = \cos \phi = \cos \left\{ \tan^{-1} \sqrt{3} \frac{(w_1 - w_2)}{(w_1 + w_2)} \right\}$$

$$6. \% \text{ Slip} = \frac{N_s - N}{N_s} \times 100 \quad \text{where } N_s = \frac{120f}{P} \text{ r.p.m}$$

Nature of graph:-



Viva Questions:-

1. What are various types of three phase induction motor as per rotor construction?
2. What is the basic operation of a three phase induction motor?
3. How the starting torque can be increased in squirrel cage motors?
4. How does the slip vary with load?
5. What is the percentage slip at full load (approx)?
6. What is meant by cogging (magnetic locking)?
7. What is meant by crawling?
8. How much is approx the starting current drawn by three phase induction motor, when started at rated voltage in terms of full load current?
9. What happens to the induction motor when it rotates at synchronous speed?

Exp. No.12

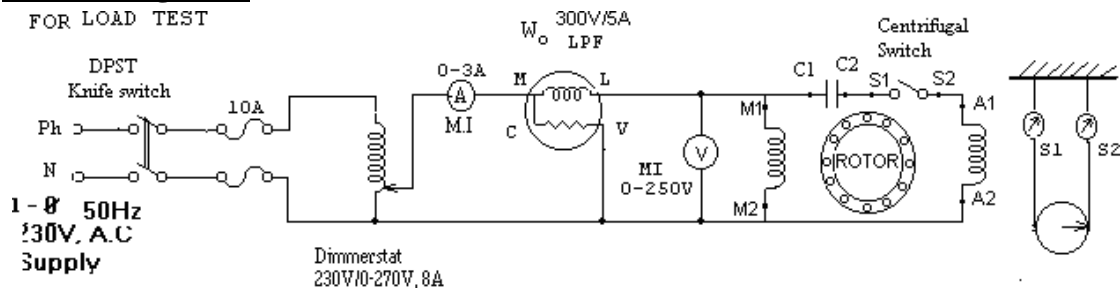
LOAD TEST ON 1- ϕ CAPACITOR START INDUCTION MOTOR.

Aim:- To conduct the load test on 1- ϕ induction motor and determine its performance characteristics.

Apparatus:-

S. No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.I)	0 – 250 V	1
4	Ammeter	(M.I)	0 – 10 A	1
6	Wattmeter (U.P.F.)	Dynamometer	300V/10A	1
7	Dimmer stat	Core type	230 V / 0-270 V	1
8	1- ϕ Capacitor start Induction motor		230V, 5A	-
9	Connecting wires	PVC insulated	-	-

Circuit Diagram:-



Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With the dimmer stat at zero out put the supply switch is closed.
3. The dimmer stat is varied such that the rated voltage is applied to the motor and all the meter readings are noted in the tabular column.
4. The load is applied in steps and for each step all the meter readings, spring balance readings as well as speed are noted.
5. Step no.4 is repeated until the rated current of the motor is reached.
6. The load is removed in steps, the dimmer stat is brought back to zero out put and the supply switch is opened.

Tabular column:-

Sl. No	V_L in Volts	I_L in Amps	W_T in watts	S_1 in Kgs	S_2 in Kgs	W_T in watts	Speed in RPM
Torque n N-M		Output in Watts		η in %		Power factor Cosϕ	

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Specimen calculations: -

$$\text{Wattmeter constant} = \frac{\text{voltage range of } W \times \text{current range of } W}{\text{Maximum Wattmeter scale reading}}$$

$$1. \text{ Input Power} = (W_1) \text{ watts}$$

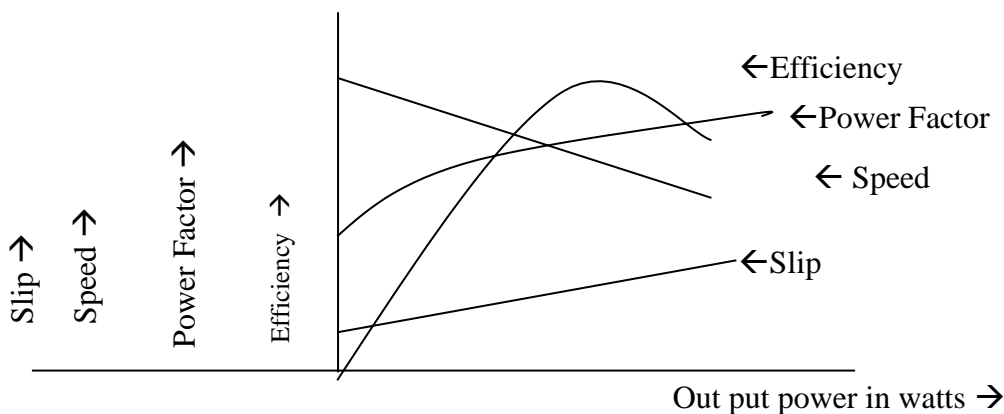
$$2. \text{ Torque} = (S_1 - S_2) \times R \times 9.81 \text{ N-m}$$

$$3. \text{ Out put Power} = \frac{2\pi NT}{60} \text{ watts}$$

$$4. \% \text{ Efficiency} = \frac{\text{Output power}}{\text{Input power}} \times 100$$

$$5. \text{ Power Factor} = \cos \phi = P/VI$$

Nature of graph:-



Viva Questions:-

1. Which theory is commonly used for the analysis of 1- Φ induction motor?
2. What is the slip of forward and backward rotor?
3. How many winding are provided on the stator of split-phase induction motor?
4. What is the phase displacement in space between the two winding?
5. How these two windings connected at the time of starting the motor?
6. How much is the phase splitting between these two windings?
7. How the phase splitting between two windings can be increased?
8. At what speed of the motor ,starting winding is disconnected from the circuit of main winding?
9. How the auxiliary winding is disconnected from the circuit of the main winding?
10. What will happen, if the starting winding is not disconnected during the normal running conditions of the motor?
11. Why 1- Φ induction motor is not self starting?
12. What is the necessity of connecting capacitor in series with the starting winding?
13. What are the advantages of connecting a capacitor?

14. How do you reverse the direction of rotation of the capacitor start induction motor?
15. What is the difference between capacitor start and capacitor run induction motor?

Exp. No.13

OPEN CIRCUIT AND SHORT CIRCUIT TESTS ON 1- ϕ TRANSFORMER

Aim: -Conduct the open circuit and short circuit test on 1- ϕ transformer and determine the efficiency and regulation at different loads.

Apparatus: -

Sl.N	Apparatus	Type	Range	Qty
1.	Ammeter	(M.I)	0 - 3A	1
2.	Ammeter	(M.I)	0 – 10A	1
3.	Voltmeter	(M.I)	0 – 30V	1
4.	Voltmeter	(M.I)	0 – 115V	1
5.	Wattmeter L.P.F	Dynamometer	2.5A/150V	1
6.	Wattmeter U.P.F.	Dynamometer	10A/75V	1
7.	Variac	Core type	230V/0-270V, 8A	1
8.	1- ϕ Transformer	Core type	230V/115V 2kVA	1
9.	Connecting wires	P.V.C Insulated	-	-

Theory:-

By conducting O.C. and S.C. tests on a given transformers we can predict the efficiency, regulation and equivalent circuit without actually loading it. The purpose of this test is to determine no-load loss (or) core loss and no-load current, which is helpful in finding x_0 and R_0 .

In O.C test one winding of the transformer usually high voltage winding is left open and the other is connected to its supply of normal voltage and frequency. A wattmeter w , voltmeter V , and an ammeter A are connected in L.V. winding, with the normal voltage is applied to the primary, normal flux will be setup in the core hence normal iron losses will occur which are recorded by the wattmeter. The no-load current is small so copper loss is negligibly small. Hence the wattmeter reading represents practically the core loss.

In S.C. test one winding, normally L.V. winding is short-circuited and meters are connected in H.V. side. Very low voltage is applied on H.V. side and it is increased slowly until full load current is flowing in the winding. Under these conditions wattmeter reading represents the full load copper loss. There is also a small amount of core loss, which is negligible compared to the copper loss.

Procedure:-

For O.C Test:-

- 7) The connections are made as shown in the circuit diagram .
- 8) With the dimmer stat at zero output, the supply switch (DPST) is closed.
- 9) The output of the dimmer stat is adjusted such that the voltmeter reads the rated voltage at the L.V winding of the transformer and all the meter readings are noted in the tabular column.
- 10) The dimmer stat is brought back to zero output and the supply switch (DPST) is opened

For S.C Test:-

- 1) The connections are made as shown in the circuit diagram .
- 2) With the dimmer stat at zero output, the supply switch is closed.
- 3) The output of the dimmer stat is adjusted such that the ammeter reads the rated current at the H.V winding of the transformer and all the meter readings are noted in the tabular column.
- 4) The dimmer stat is brought back to zero output and the supply switch is opened

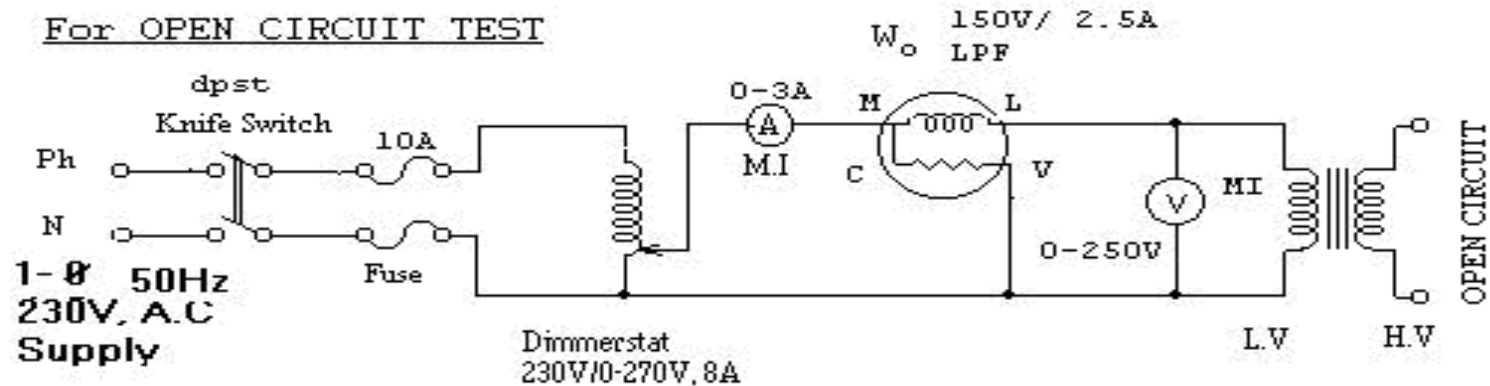
Tabular Column:-

	Open circuit test			Short circuit Test		
S.I No	V_o in volts	I_o in Amps	W_o in Watts	V_{sc} in volts	I_{sc} in Amps	W_{sc} In Watts

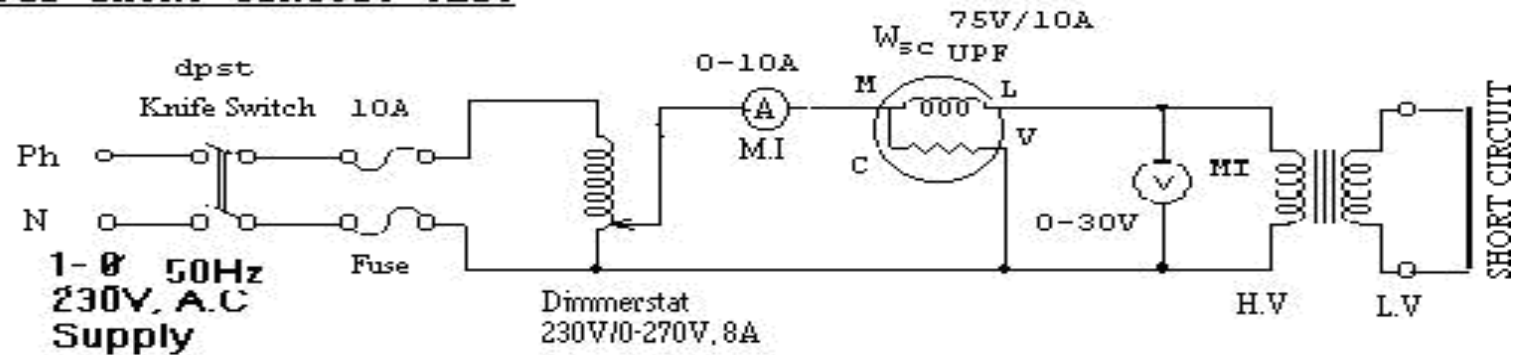
S.I No	$\cos \phi_o$	I_w in Amps	I_m in Amps	R_o in Ω	X_m in Ω	$\cos \phi_{sc}$	R_{eq} in Ω	X_{eq} in Ω	W_{sc} In Watts

Circuit Diagram:-

For OPEN CIRCUIT TEST



For SHORT CIRCUIT TEST



Specimen calculations:-

Rated current of transformer = $\frac{\text{KVA rating of transformer}}{\text{Supply voltage}}$

Wattmeter Multiplication factor = $\frac{\text{Voltage Range} \times \text{Current Range}}{\text{Maximum wattmeter scale reading}} \times \text{Power factor}$

Input Power = Wattmeter reading X Wattmeter Multiplication factor

1. $\cos\phi_0 = \frac{W_0}{V_0 I_0}$ 2. $I_w = I_0 \cos\phi_0$ 3. $I_m = I_0 \sin\phi_0$ 4. $R_o = \frac{V_o}{I_w}$
 5. $X_m = \frac{V_o}{I_m}$ 6. $R_{eq} = \frac{W_{sc}}{I_{sc}^2}$ 7. $Z_{eq} = \frac{V_{sc}}{I_{sc}}$ 8.
 $X_{eq} = \sqrt{Z_{eq}^2 - R_{eq}^2}$

% Efficiency at full load = $\frac{\text{FullloadVA} \times \cos\phi}{\text{FullloadVA} \times \cos\phi + W_o + W_{sc}} \times 100$

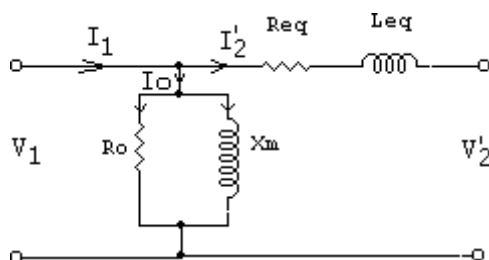
Efficiency at any load X*F.L, where X = 1/4 or X = 1/2 or X = 3/4

% Efficiency at X.* F.L = $\frac{X \cdot \text{FullloadVA} \times \cos\phi}{X \cdot \text{FullloadVA} \times \cos\phi + W_o + X^2 W_{sc}} \times 100$

% Regulation = $\frac{R_{eq} \cos\phi \pm X_{eq} \sin\phi}{V_{rated}} \times 100$

where + is for Lagging P.F
 - is for Leading P.F

Equivalent Circuit:-



R_o, X_m – are referred to L.V Side

R_{eq}^1, X_{eq}^1 Referred to H.V Side

These values referred L.V Side are

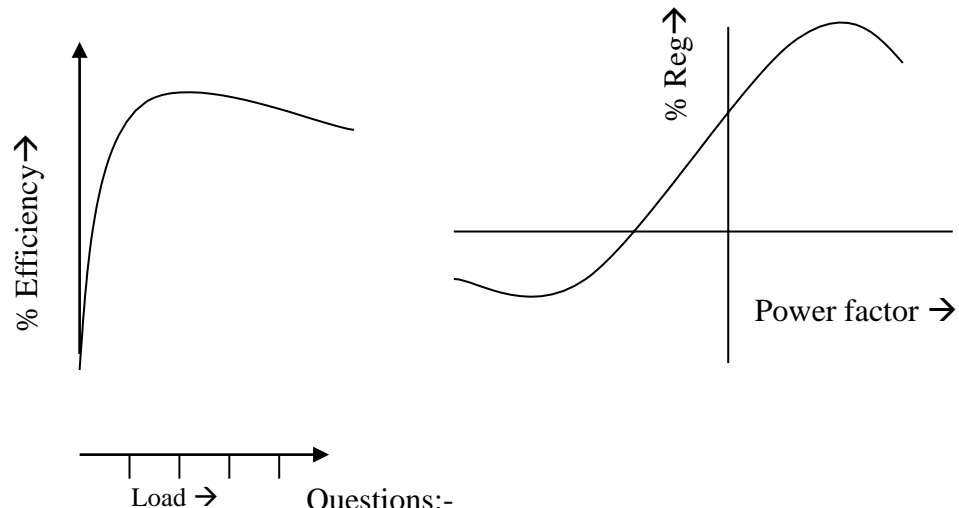
$R_{eq} = \frac{R_{eq}^1}{k^2}$
 $X_{eq} = \frac{X_{eq}^1}{k^2}$

$$\text{where } k = \frac{N_{21}}{N_1} = \frac{E_2}{E_1}$$

Nature of graph:-

a) % Efficiency Vs Load

b) % Regulation Vs Power Factor



Viva – Voce

Questions:-

1. What is the working principle of a transformer?
2. Name the different types of transformers?
3. Write the EMF equation of the transformer.
4. What is an ideal transformer?
5. What are the losses takes place in a transformer?
6. Define step-up and step-down transformers?
7. Why the transformer rating in KVA?
8. From Open Circuit Test which losses are determined?
9. From Short Circuit Test which losses are determined?
10. A single phase, 2 KVA, 230/115V transformer is connected to OC test. Calculate the rated primary current and why the ammeter rating is fixed as (0-3)A?
11. A single phase, 2 KVA, 230/115V transformer is connected to SC test. Calculate the rated primary current and why the voltmeter rating is fixed as (0-30) volts?
12. What is the condition for maximum efficiency in a transformer?
13. Define the Efficiency of a transformer?
14. For a particular voltage constant, if the frequency is increases, what are the changes takes place in a transformer?
15. Define regulation?
16. Define All-Day efficiency?
17. In this experiment we got the Maximum efficiency at ½ full loads, why?

Exp. No.14

PARAMETERS AND EQUIVALENT CIRCUIT OF 3- ϕ SLIP RING INDUCTION MOTOR

Aim: To conduct no-load and blocked rotor tests on 3- ϕ slip ring induction motor and determine the equivalent circuit parameters

Apparatus:

S.No	Apparatus	Type	Range	Quantity
1	Ammeter	M.I	0-5A	1
			0-10A	1
2	Voltmeter	M.I	0-600V	1
			0-300V	1
3	Wattmeter LPF	Dynamometer	500V/5A	1
4	Wattmeter UPF	Dynamometer	250V/10A	1

Procedure:

No-load test:

1. The connections are made as in the circuit diagram
2. Ensuring that the dimmerstat is at zero output, the belt over the brake drum is totally loosened and the rotor resistance is at maximum value, the TPST switch is closed
3. The dimmerstat is gradually varied so that the motor is brought to its rated speed by applying rated voltage and the rotor resistance is cutout gradually and all the meter readings are noted in the tabular column
4. The rotor resistance is brought back to maximum value, the dimmerstat to zero output position and the TPST supply switch is opened.

Blocked rotor test:

1. The connections are made as in the circuit diagram
2. Ensuring that the dimmerstat is at zero output, the belt over the brake drum is tightened so that the rotor is blocked and the TPST switch is closed
3. The dimmerstat is gradually varied so that the rated current of the motor is passed and all the meter readings are noted in the tabular column
4. The dimmerstat is brought back to zero output position and the TPST supply switch is opened and the belt over the brake drum is totally loosened.

Tabular column:

No-load test:

S.No	V _o Volt	I _o Amps	W _o Watts	Cos ϕ _o

Blocked rotor test:

S.No	V _{BR} Volt	I _{BR} Amps	W _{BR} Watts	Cosφ _{BR}

Specimen Calculations:

From No-load test:

Stator resistance/Ph $R_1 = \underline{\hspace{4cm}}$ ohms

No-load power factor $\text{Cos}\phi = \frac{W_o}{\sqrt{3}V_o I_o}$

Where $V_o =$ no load voltage (line to line)

$I_o =$ no load current

$W_o =$ no load input power

Magnetizing current $I_\mu = I_o \sin\phi_o$

Core loss current component $I_w = I_o \cos\phi_o$

No load resistance $R_o = \frac{V_o / \sqrt{3}}{I_w}$

Magnetizing reactance $X_m = \frac{V_o / \sqrt{3}}{I_\mu}$

From Blocked rotor test:

Equivalent impedance per phase $Z_{01} = \frac{V_{BR} / \sqrt{3}}{I_{BR}}$

Equivalent resistance $R_{01} = \frac{W_{BR}}{3I_{BR}^2}$

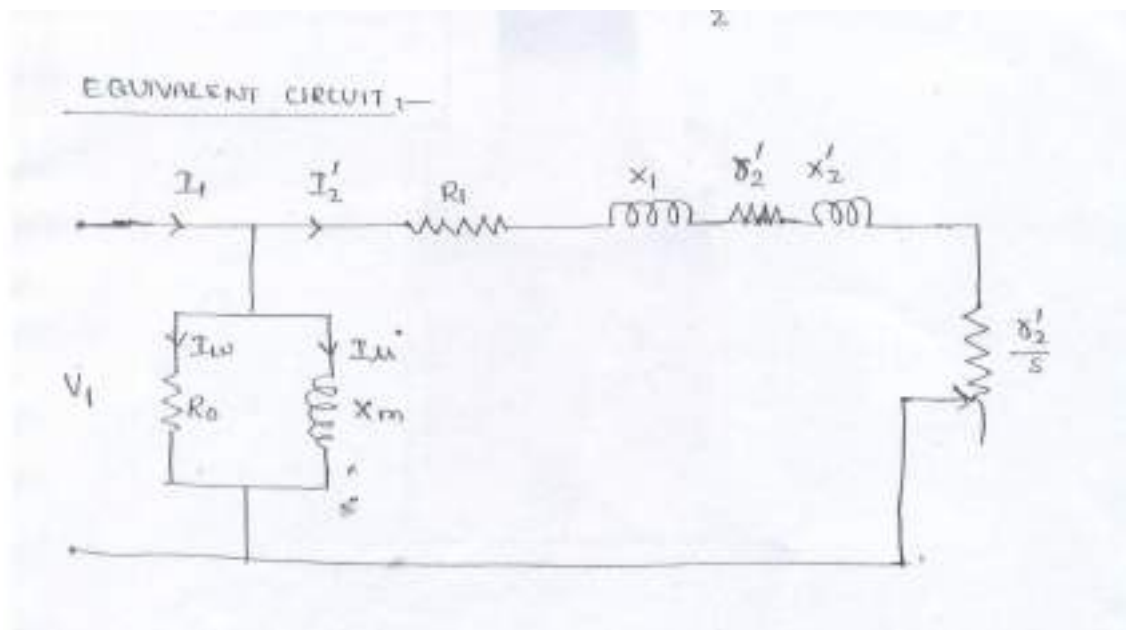
Equivalent reactance $X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$

Stator resistance per phase $R_1 = \underline{\hspace{4cm}}$ ohms

Rotor resistance per phase referred to stator, $R_2^1 = R_{01} - R_1$

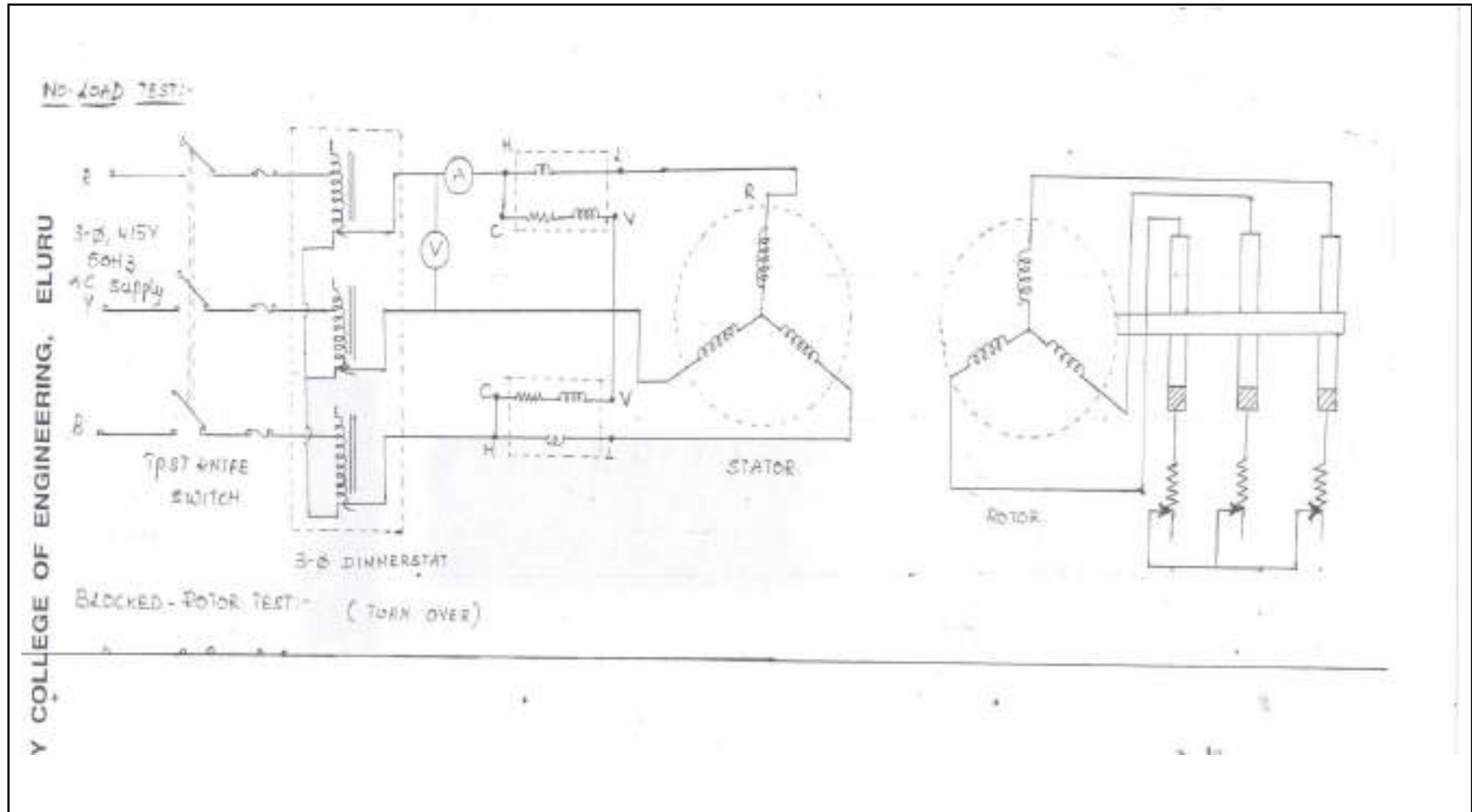
Assume that ; Stator reactance = rotor reactance referred to stator

i.e $X_1 = X_2^1 = \frac{X_{01}}{2}$



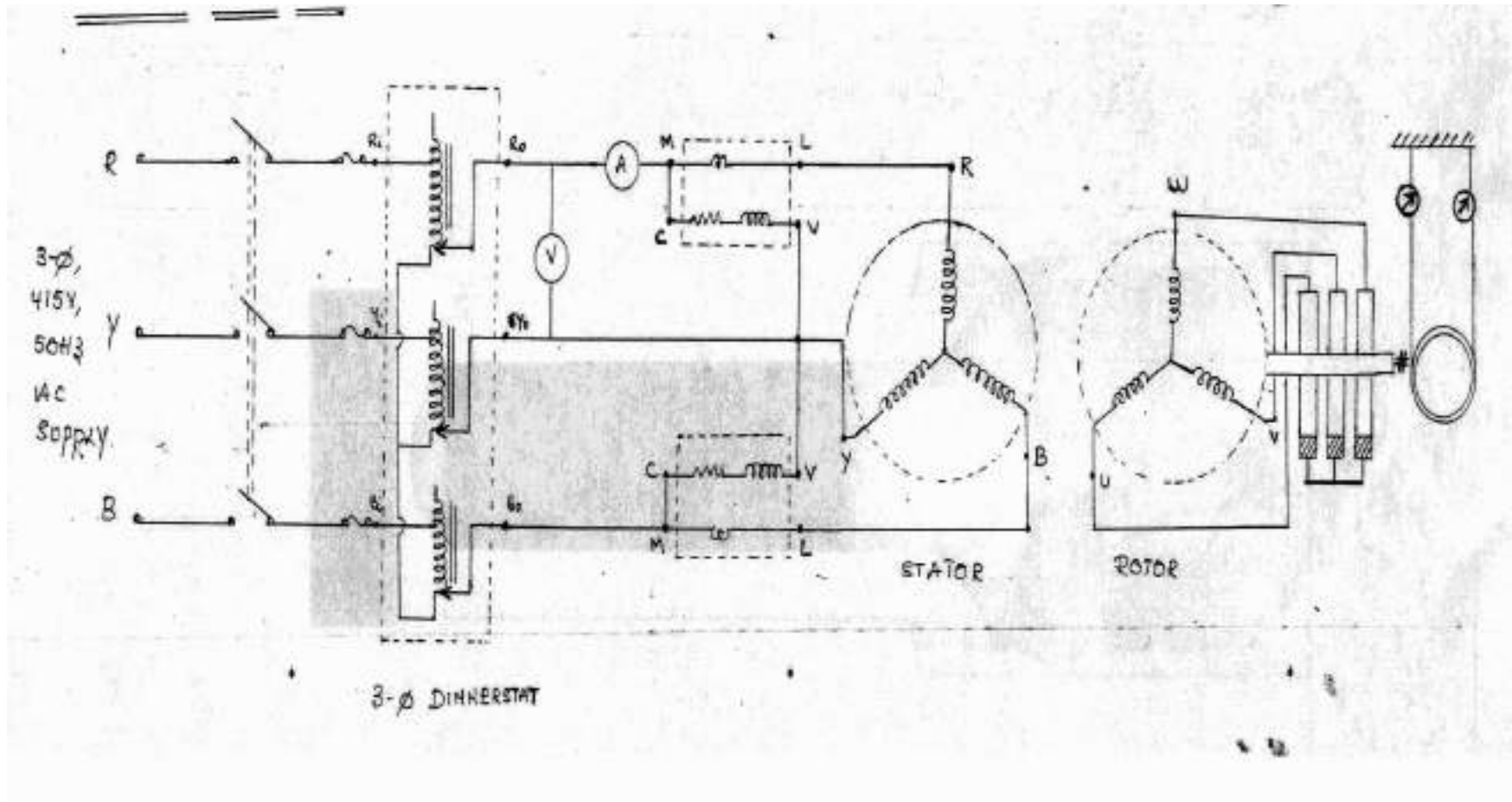
Result:

No-Load Test:



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Blocked Rotor Test:



Viva Questions:-

1. In which type of induction motor, considerably high starting torque can be achieved?
2. How high starting torques are obtained in slip ring induction motors?
3. Why the rotor of an induction motor cannot run at synchronous speed, if it did so then what happens?
4. Why 3-phase induction motor is running at half full load. If the fuse in one of the phases burn, what happens to the motor?
5. In a 3-phase induction motor the electrical representation of the variable mechanical load is
6. Why core losses are neglected in blocked rotor test and copper losses are neglected in no load test?
7. Why we multiply DC resistance to AC with a value of 1.2 to 1.6?
8. Why we are using LPF wattmeters incase of no load test?
9. what precautions we have to take before switching on the supply in case of no-load test and blocked rotor test.
10. If two induction motors are identical in all aspects. if motor A has lesser air gap then motor B.Explain which of the motor will have a) poor no load power factor b) better full load power factor
11. Enumerate the possible reasons if 3-phase induction motor fails to start?
12. What is meant by single phasing?
13. Can a 3-phase induction motor run at 1-phase supply?
14. Can slip ring induction motor be reversed by transposing any two leads from sling rings?
15. What is the material used to make slip rings?