METHODIST COLLEGE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE, New Delhi and Affiliated to OU, Hyderabad)

Abids, Hyderabad

ELECTRICAL MACHINES-II LABORATORY

(CODE: PC651EE)

STUDENT MANUAL

For

B.E VI Semester

(Department of Electrical and Electronics Engineering)

Name: …………………………………………………..

Roll. No: …………………………………………………

Academic Year: …………………………………………

CAUTION

1. Do not play with electricity.
2. Carelessness not only destroys the valuable equipment in the lab but also costs your life.
3. Mere conductivity of the experiment without a clear knowledge of the theory is of no value.
4. Before you close a switch, think of the consequences.
5. Do not close the switch until the faculty in charge checks the circuit.

'General Instructions to Students'

1. Students should report at the respective lab as per the time table schedule.
2. Students should come with thorough preparation for the experiment to be conducted.
3. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.
4. The group wise division made in the beginning should be adhered to, and no mix up of student among different groups will be permitted later.
5. Name plate details including the serial number of the machine used for the experiment should be invariably recorded.
6. Experiment should be started only after the staff-in-charge has checked the circuit diagram.
7. All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.
8. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.
9. Practical record should be neatly maintained.
10. They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.
11. Theory regarding each experiment should be written in the practical record before procedure in your own words.
12. Come prepared to the lab with relevant theory about the Experiment you are conducting.
13. While using Electrolytic capacitors, connect them in the right polarity.
14. Before doing the circuit connection, check the active components, equipment etc., for their good working condition.
15. Do not use the multimeter, if the battery indication is low.
16. Any damage of the experiment or burn out of the component due to negligence of student accordingly the penalty will be awarded.

Electrical Machines-II Lab

Instruction	02Periods per week
Duration of University Examination	02Hours
University Examination	50Marks
Sessional	25Marks

List of Experiments as per Syllabus

Sl. No	List of Experiments
1.	No-load test blocked rotor test and load test on 3-phase Induction motor.
2.	Performance characteristics of Single phase Induction motor.
3.	Voltage regulation of Alternator by A. Synchronous impedance method (EMF Method) B. Ampere-turn method (MMF Method) C. Z.P.F. Method (Potier Triangle Method)
4.	Speed control of three phase Induction motor by any three of the Following. A. Rotor impedance control B. Pole changing
5.	Retardation test / Dynamic Braking of DC Shunt motor.
6.	P.F Improvement of 3-Phase Induction motor using capacitors.
7.	Regulation of Alternator by slip test.
8.	Determination of V curves and inverted V curves of synchronous motor.
9.	Power angle characteristics of a synchronous motor.
10.	Dynamic Braking of 3-Phase Induction motor.
11.	Speed control of BLDC Motor.
12.	Load characteristics of Induction Generator
13.	Speed control of SRM motor

Note: At least 10 Experiments should be conducted in the semester.

INDEX PAGE

Sl. No	Name of the Experiment	Date			Manual Marks (Max . 20)	Record Marks (Max. 10)	Signature (Student)	Signature (Faculty)
		Conduction	Repetition	Submission of Record				
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
11.								
12.								
13.								
Average								

Signature of the lab In-charge Signature of the HOD

NO LOAD TEST AND BLOCKED ROTOR TEST AND LOAD TEST ON 3 - Ø INDUCTION MOTOR

AIM: A) To conduct No Load, Blocked rotor test on a Three Phase Induction motor and to find various parameters from circle diagram.

B) To conduct brake test on a 3- phase induction motor.

A) NO – LOAD, BLOCKED ROTOR TEST ON A 3-ϕ INDUCTION MOTOR

APPARATUS:

S.NO		Specification	Quantity
1	Watt Meter	(600V, 10A Dynamo)	2
2	Voltmeter	(0-600V, MI)	1
3	Ammeter	(0-10A, MI)	1
4	3 – Ø Variac	(0-440 V, 15A)	1

NAME PLATE DETAILS:

Parameter	Motor

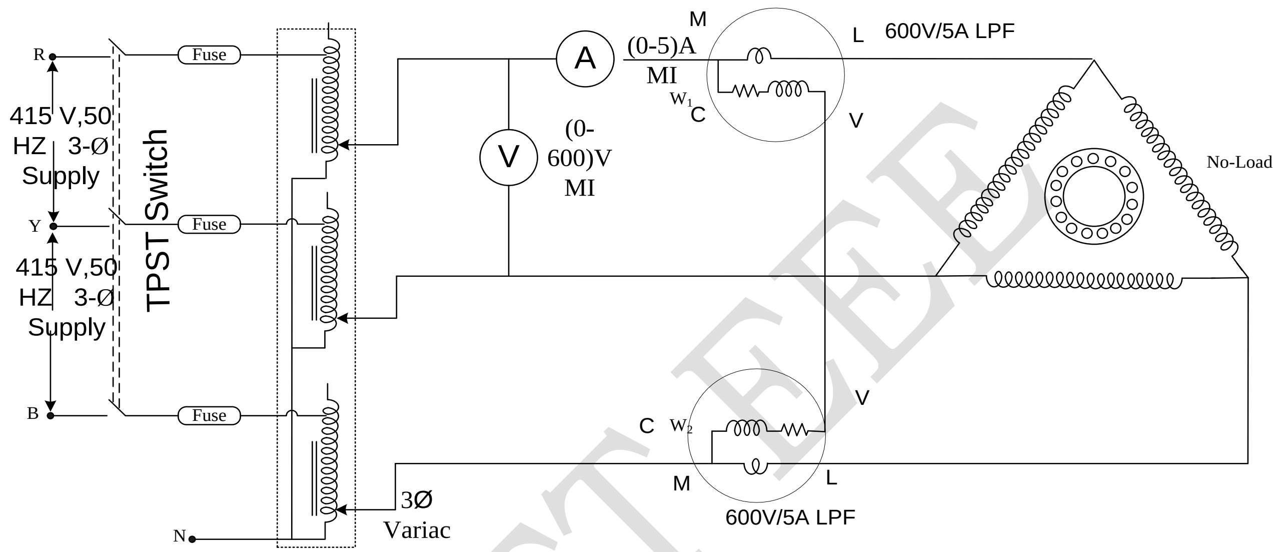
THEORY:

The induction motor is called as rotating transformer and the parameters of the equivalent circuit are determined through the tests called No load test and blocked rotor tests. These tests are similar to OC and SC tests of transformer. From the OC test on the transformer, the core resistance and reactance are determined and core losses are known and from the SC test, the winding resistance and reactance are determined and full load copper losses are known.

In the No load test, the induction motor is started on no load and rated voltage is applied and in blocked rotor test ,the rotor of the induction motor is mechanically locked or manually blocked from rotation and the motor is applied rated current through variac so that the stator current does not exceed the rated current. From these two tests the equivalent circuit of the induction motor is determined and performance parameters are predetermined through a circle diagram.

The circle diagram of an induction motor is used to find out the performance of given induction motor i.e. full load current, full load power factor, full load slip, efficiency, maximum power output and maximum torque. To obtain the circle diagram the no load and blocked rotor tests are performed.

CIRCUIT DIAGRAM:



Circuit Diagram for No-load Test of Induction Motor

PROCEDURE:

NO – LOAD TEST

1. Give the connections as per the Circuit Diagram.
2. Before starting of motor remove the load (by slackening the brake band).
3. Gradually apply the rated voltage i.e. 415 V to the motor with 3 Phase variac.
4. Tabulate the readings of different meters.

NOTE: At the no load the power factor of induction motor is less than 0.5 and one wattmeter shows negative readings hence either current coil or pressure coil of that meter should be reversed.

READINGS AND TABULAR FORM

Sl.No	V(volts)	I_o(Amps)	W_1(watts)	W_2(watts)	$W_o = W_1+W_2$

BLOCKED – ROTOR TEST

1. Block or hold the rotor by hand or tightening the brake belt.
2. Apply the low voltage and increase the voltage till full load current flows.
3. Tabulate the readings of all meters.

READINGS AND TABULAR FORM

Sl. No	V_s(volts)	I_s (Amps)	W_1 (watts)	W_2 (watts)	$W_s = W_1+W_2$

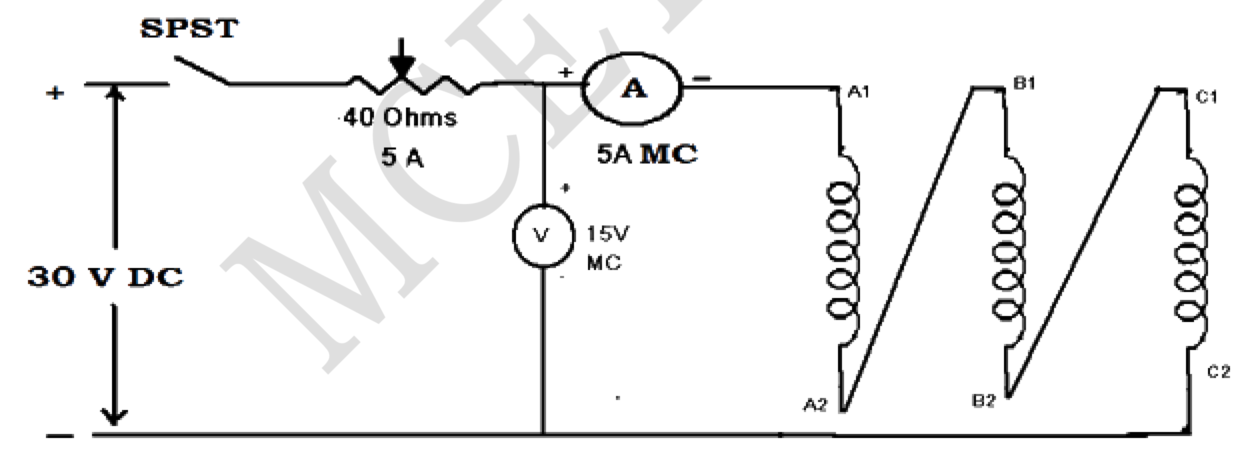
CALCULATIONS

Short circuit current at Normal voltage is $I_{sc} = I_s$ (V rated / V_{sc})

No load power factor $\cos\O_0 = W_o / (\sqrt{3}\ V*I_0)$ find $\O_0$

Short circuit P.F $\cos\O_{sc} = W_s / (\sqrt{3}\ V_s\ I_s)$ find $\O s$

MEASUREMENT OF STATOR RESISTANCE



1. Connect as per the Circuit Diagram given above.
2. Keep the 40 ohms resistance in maximum position.
3. Switch on the 30V DC supply and change the applied voltage by adjusting the rheostat. Note down the voltage and current readings.

READINGS AND TABULAR FORM

S. No	V	I	R_{dc}= V/3I

Stator resistance per phase Rs= 1.25 R_{dc}

PERFORMANCE COMPUTATION AND CIRCLE DIAGRAM:

Draw the circle diagram and find Efficiency, full load current and power factor of the given induction motor.

Construction of Circle Diagram

The data of No load test and blocked rotor test on the induction motor are used.

1. Find out the per phase values of no load current I_0, short circuit current I_{SC} and the corresponding phase angles Φ_0 and Φ_{SC}. $\varnothing_0 = \cos^{-1}(Woc/\sqrt{3}V_0 I_0)$.

$$\varnothing_{sc} = \cos^{-1}(Wsc/\sqrt{3}VscIsc).$$

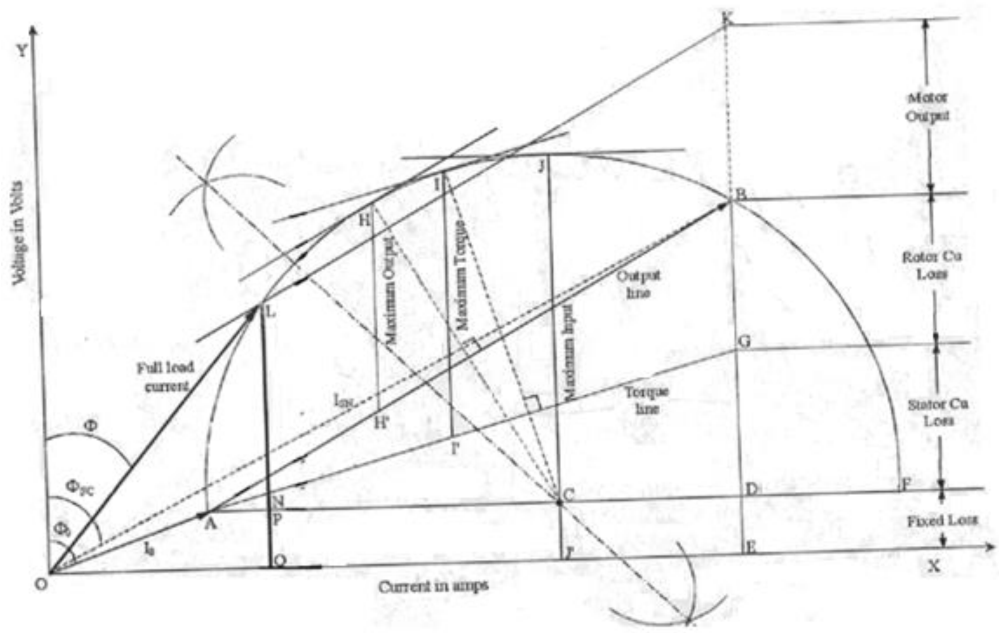
2. Find short circuit current I_{SN} corresponding to normal supply voltage.

$$I_{SN} = I_{SC}\,(Vrated / Vsc)$$

With this data, the circle diagram can be drawn as follows.

3. With suitable scale, raw vector OA with length corresponding to I0 at an angle Φ_0 from the vertical axis. Draw a horizontal line AB.
4. Draw OS equal to I_{SN} at an angle Φ_{SC} and join AS.
5. Draw the perpendicular bisector to AS to meet the horizontal line AB at C.
6. With C as centre, draw a portion of circle passing through A and S.
   This forms the circle diagram which is the locus of the input current.
7. From point S, draw a vertical line SL to meet the line AB.
8. Divide SL at point K so that SK: KL = rotor resistance: stator resistance.
9. For a given operating point P, draw a vertical line PEFGD as shown.
10. Then PE = output power, EF = rotor copper loss, FG = stator copper loss, GD=constant loss (iron loss + mechanical loss)
11. To find the operating points corresponding to maximum power and maximum torque, draw tangents to the circle diagram parallel to the output line and torque line respectively. The points at which these tangents touch the circle are respectively the maximum power point and maximum torque point

CIRCLE DIAGRAM FOR THREE PHASE SQUIRREL CAGE INDUCTION MOTOR



Efficiency line

12. The output line AS is extended backwards to meet the X-axis at O′.
13. From any convenient point on the extended output line, draw a horizontal line QT so as to meet the vertical from O′.
14. To find the efficiency corresponding to any operating point P, draw a line from O′ to the efficiency line through P to meet the efficiency line at T1. Now QT1 is the efficiency.

Slip Line

15. Draw line QR parallel to the torque line, meeting the vertical through A at R.
16. To find the slip corresponding to any operating point P, draw a line from A to the
17. Slip line through P to meet the slip line at R1.
18. Now RR1 is the slip

Power Factor Curve

19. Draw a quadrant of a circle with O as centre and any convenient radius.
20. To find power factor corresponding to P, extend the line OP to meet the power factor
21. Curve at C′. Draw a horizontal line C′C1 to meet the vertical axis at C1. Now OC1 Represents power factor.

FORMULAE:

1. Fixed losses(constant loss) = DE X Power scale(watts)
2. Stator copper loss =DG X Power scale(watts)
3. Rotor copper loss =GB X Power scale(watts)

4. Maximum torque =[HH' X Power scale(watts)] / (2∏N / 60) N-m
5. Maximum output power = II' X Power scale(watts)
6. Maximum input power = JJ' X Power scale(watts)
7. Maximum efficiency = Maximum output power / Maximum input power
8. Full load current = OL X Current scale(amps)
9. Full load power factor = Cos(angle between OL and Y-axis)
10. Full load torque = [LN X Power scale(watts) / (2∏N / 60) N-m
11. Full load output power = LM X Power scale(watts)
12. Full load input power = LQ X Power scale(watts)
13. Full load efficiency = Full load output power / full load input power
14. Full load stator copper losses = NP X Power scale(watts)
15. Full load Rotor copper losses = MN X Power scale(watts)

RESULT:

DISCUSSION:

1. How can the maximum torque and maximum power to be determined from the circle diagram.
2. Show the motoring, generating and braking regions for an induction machine on its circle diagram.
3. How the equivalent circuit of an induction motor is found from the no load and blocked rotor tests.
4. Draw the circle diagram of a double cage induction motor.
5. Why does an Induction motor always operate at lagging pf only?
6. How can we separate friction and wind age loss from no load loss?

OUTCOMES:

The student is able to

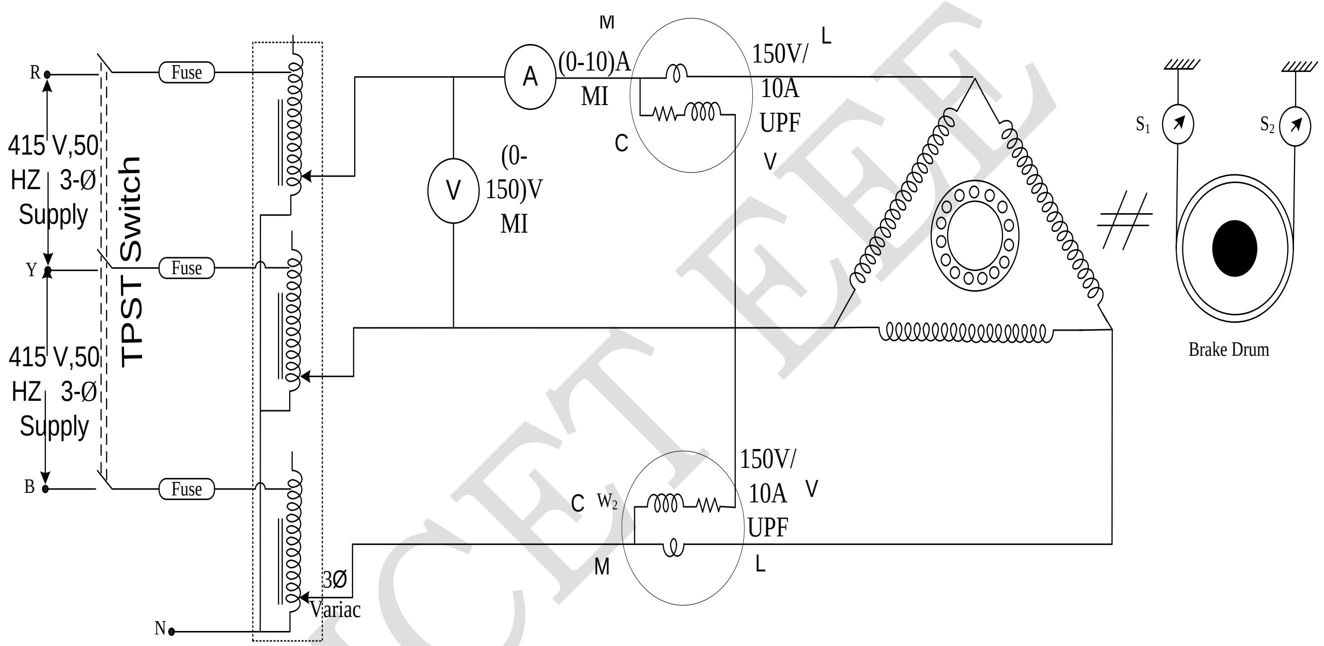
- Construct Circle diagram.
- Estimate the operating point at a given load and asses the slip, various losses and efficiency.
- Find the performance of given induction Machine.

B) **LOAD TEST ON A 3- PHASE INDUCTION MOTOR:**

THEORY:

The efficiency of small induction motors can be found directly by loading the machine by means of a brake drum. The induction motor is mechanically loaded and the input and the output powers are measured at different loads. The efficiency with load and reaches a maximum when the variable loss (copper loss) equals the constant loss (Friction and windage loss+ Iron loss) and then decreases with further increase in load.

CIRCUIT DIAGRAM:



PROCEDURE:

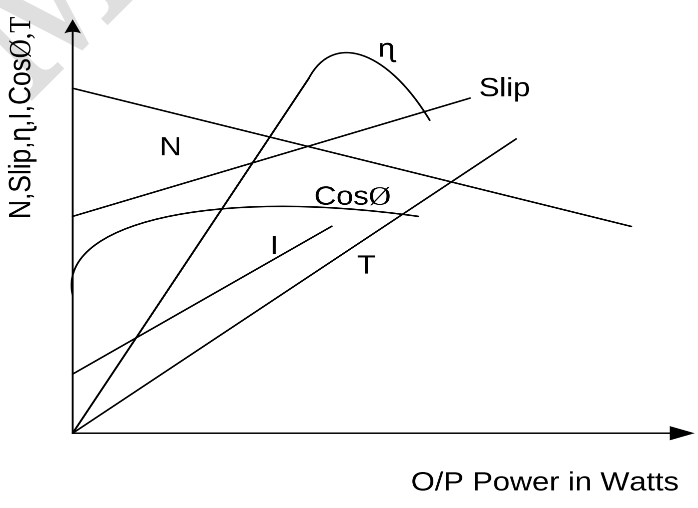
1. Give the connections as per the Circuit Diagram.
2. By using Variac, gradually apply the rated voltage i.e 415 V to the motor.
3. Take no – load readings of current and power.
4. Now by increasing loads on the motor note down the corresponding current and power readings.
5. Gradually increase the load until rated current flows.
6. Take at least six readings.
7. Calculate the efficiency at different loads.

READINGS AND TABULAR FORM:

Sl.No	V (V)	I (A)	W_1(watts)	W_2 (watts)	W = (S1-S2) Kgs	N(rpm)	T=9.81 *W * r (N- M)	O/P=2πNT/60	I/P = (W1+W)/2 (watts)	η = (OP/IP)x100

SAMPLE CALCULATIONS:

SAMPLE GRAPHS:



RESULT:

DISCUSSIONS:

1. Why does an induction motor have poor Power factor at no-load?
2. Compare the Power factors of a high speed induction motor and a low speed Induction motor.
3. What is cogging and crawling?
4. Show the stable and unstable regions on the torque-slip curve of an induction Motor.
5. How can an induction motor be made to operate as a generator?

OUTCOMES:

The student is able to

- Differentiate the direct and indirect load tests.
- Draw various characteristics of Induction motor.

PERFORMANCE CHARACTERISTICS OF SINGLE PHASE INDUCTION MOTOR

AIM: To obtain the characteristics of a single phase Induction motor by conducting brake test.

APPARATUS:

S.NO	EQUIPMENT	SPECIFICATION	QUANTITY
1	Voltmeter	(0-300V, MI)	1
2	Ammeter	(0-10 A, MI)	1
3	Wattmeter	(10A, 300V)	1
4	1 - Ø Variac	(0-270V, 15A)	1
5	Tachometer	(0-9999rpm)	1

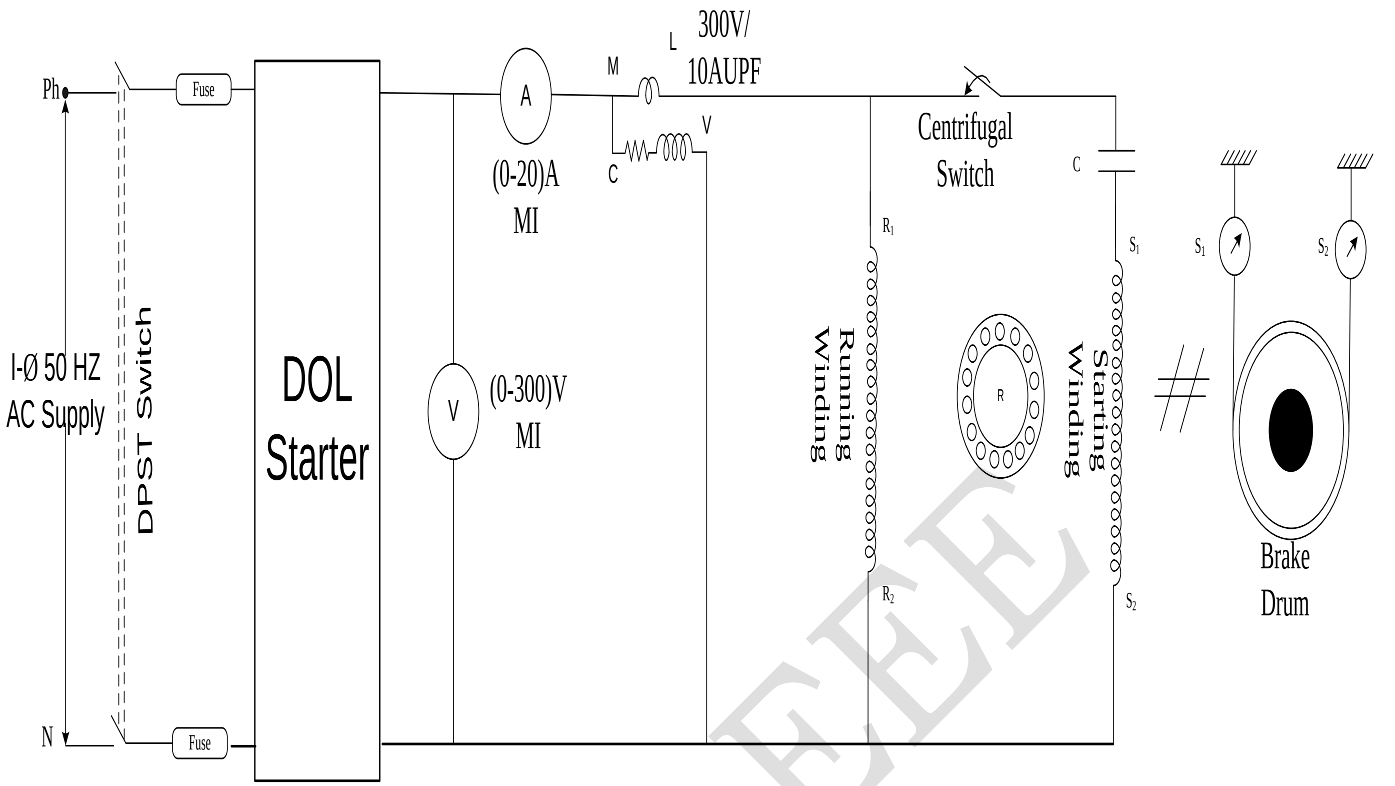
NAME PLATE DETAILS:

Parameter	Motor

THEORY:

A single phase induction motor is made to start by using an auxiliary winding (Starting winding) which is connected in series with a capacitor. The main and auxiliary windings produce two fluxes displaced in both space and time by 90 degree electrical. This creates a rotating magnetic field in the air gap thus producing a torque on the rotor. Single phase motors are noisier and produce a lesser torque than a corresponding three phase motor and have a higher frame size for the same power output.

CIRCUIT DIAGRAM:



PROCEDURE:

1.Give the connections as per the Circuit Diagram.

2.Before starting of the motor remove the load by adjusting the brake drum,

3.By using the variac gradually apply rated voltage.

4.Take the no load readings of the current and power.

5.Now by increasing the load (i.e. by tightening the brake band) on the motor.

6.Gradually increase the load in steps of 0.5 A.

7.Calculate the efficiency at different loads.

8.Plot the graphs (η Vs output and η Vs load current).

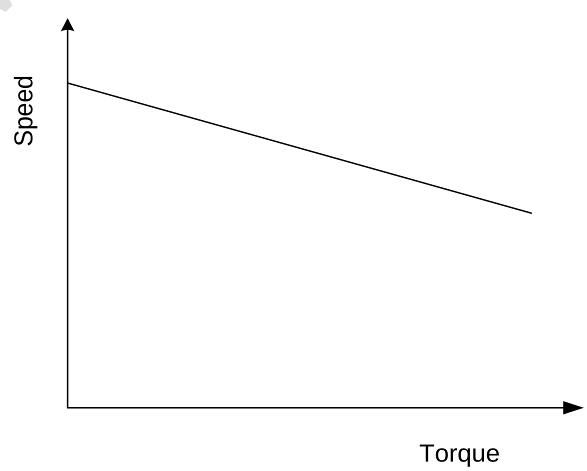
READINGS AND TABULAR FORM:

'r' is the radius of the brake drum; w_1 is the reading of the wattmeter

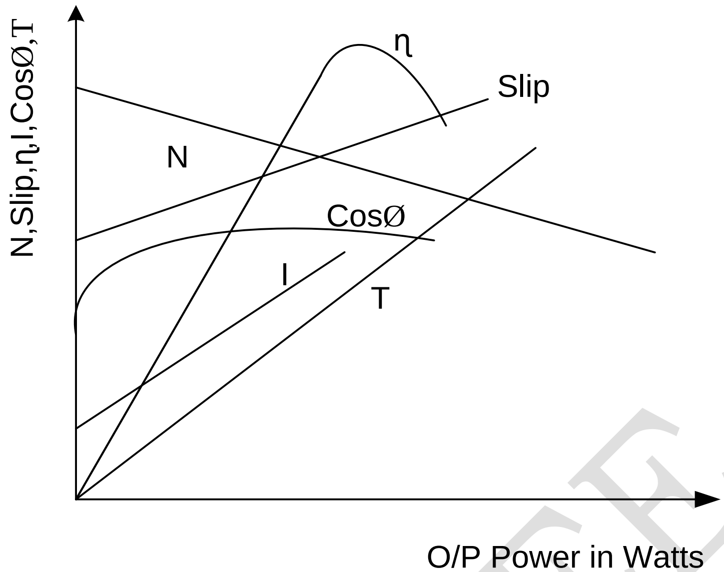
Sl.No	V (V)	I_L (A)	Speed (rpm)	LOAD		W = S_1-S_2 (Kg)	T=9.81×W×r (Nm)	Output = $\frac{2\pi NT}{60}$ (W)	Input = w_1 (W)watts	% η = (output / Input) * 100
				S_1 Kg	S_2 Kg					
1										
2										
3										
4										
5										
6										
7										
8										

SAMPLE GRAPHS:

Mechanical characteristic



Electrical characteristics



RESULTS:

DISCUSSION:

1. Mention the application of single phase induction motors.
2. What are the different types of single phase induction motors?
3. Why is a single phase induction motor noisier than a three phase motor?
4. What are the typical values of the capacitor for starting and for running? How will you determine these values?
5. What are the other types of single phase motors?

OUTCOMES:

The student is able to

- Discriminate the no load and brake tests.
- Understand the principle and operation of single phase induction motor.

Understand the function of capacitor.

REGULATION OF 3–PHASE ALTERNATOR BY EMF AND MMF METHODS

AIM: To predetermine the regulation of 3-phase alternator by EMF and MMF methods and also draw the vector diagrams.

APPARATURS REQUIRED:

SL.NO	Name of the Apparatus	Type	Range	Quantity
1	Ammeter	MC	0 – 1/2 A	1
2	Ammeter	MI	0 – 5/10 A	1
3	Voltmeter	MC	0 – 300 V	1
4	Voltmeter	MI	0 – 600 V	1
5	Rheostat	Wire wound	290 Ω, 1.2A	1
6	Rheostat	Wire wound	350Ω, 1.4A	1
7	Tachometer	Digital	---	1
8	TPST knife switch	--	--	1

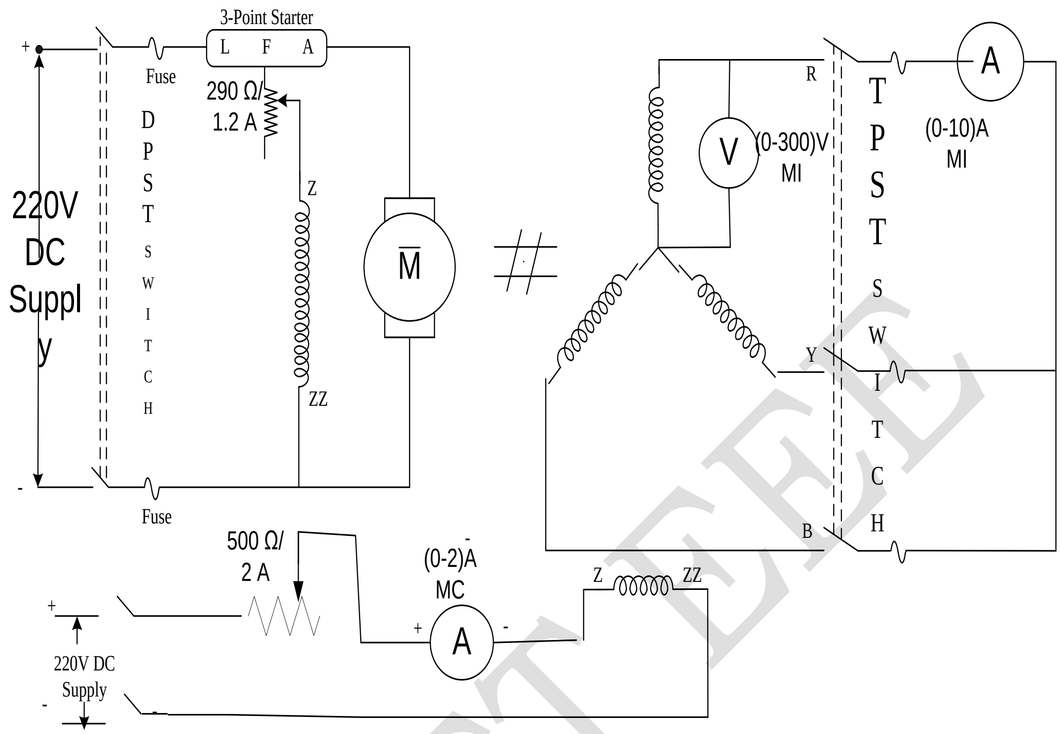
NAME PLATE DETAILS:

TYPE	DC SHUNT MOTOR	ALTERNATOR
VOLTAGE		
CURRENT		
SPEED		
POWER		

THEORY:

The regulation of a 3-phase alternator may be predetermined by conducting the Open Circuit (OC) and the Sort Circuit (SC) tests. The methods employed for determination of regulation are EMF or synchronous impedance method, MMF or Ampere Turns method and the ZPF or Potier triangle method. In this experiment, the EMF and MMF methods are used. The OC and SC graphs are plotted from the two tests. The synchronous impedance is found from the OC test. The regulation is then determined at different power factors by calculations using vector diagrams. The EMF method is also called pessimistic method as the value of regulation obtained is much more than the actual value. The MMF method is also called optimistic method as the value of regulation obtained is much less than the actual value. In the MMF method the armature leakage reactance is treated as an additional armature reaction. In both methods the OC and SC test data are utilized.

Circuit Diagram for OCC and SCC Characteristics



PROCEDURE: (FOR BOTH EMF AND MMF METHODS)

1. Note down the name plate details of the motor and alternator.
2. Connections are made as per the circuit diagram.
3. Switch ON the supply by closing the DPST switch.
4. Using the Three point starter, start the motor to run at the synchronous speed by adjusting the motor field rheostat.
5. Conduct Open Circuit test by varying the potential divider for various values of field current and tabulate the corresponding Open Circuit Voltage readings.
6. Conduct Short Circuit test by closing the TPST switch and adjust the potential divider to set the rated armature current and tabulate the corresponding field current.
7. The Stator resistance per phase is determined by connecting any one phase stator winding of the alternator as per the circuit diagram using MC voltmeter and ammeter of suitable ranges.

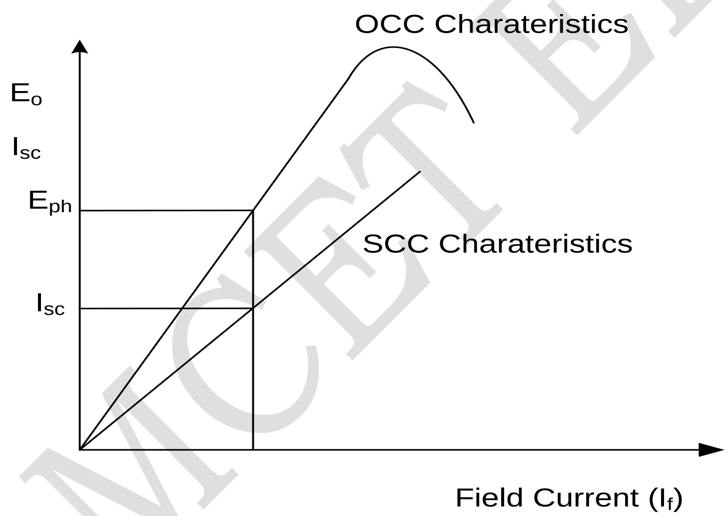
PROCEDURE TO DRAW GRAPH FOR EMF METHOD:

1. Draw the Open Circuit Characteristic curve (Generated Voltage per phase VS Field current).
2. Draw the Short Circuit Characteristics curve (Short circuit current VS Field current)
3. From the graph find the open circuit voltage per phase (E1 (ph) for the rated short circuit current (Isc).
4. By using respective formulae find the Zs, Xs, Eo and percentage regulation.

PRECAUTIONS:

1. The motor field rheostat should be kept in the minimum resistance position.
2. The alternator field potential divider should be kept in the minimum voltage position.
3. Initially all switches are in open position.

Model graph for EMF method:



TABULAR COLUMNS

OPEN CIRCUIT TEST:

Sl.No	FIELD CURRENT (A)	OC VOLTAGE (V)
1.		
2.		
3.		
4.		
5.		
6.		

7.		
8.		
9.		
10.		

SHORT CIRCUIT TEST:

SC CURRENT (A)	FIELD CURRENT (A)

TABULAR COLUMNS

SYNCHRONOUS METHOD

Sl.No	POWER FACTOR		VOLTAGE REGULATION	
	LAG	LEAD	LAG	LEAD
1	0.8	0.8		
2	0.6	0.6		
3	0.4	0.4		
4	0.2	0.2		
5	1	1		

CALCULATION FOR EMF METHOD

FORMULAE:

Synchronous Impedance Zs = O.C. voltage / S.C. current

Synchronous Reactance $Xs = \sqrt{Zs2 - Ra2}$

Open circuit voltage for lagging p.f = $\sqrt{(V\cos\Phi + IaRa)^2 + (V\sin\Phi + IaXs)^2}$

Open circuit voltage for leading p.f. = $\sqrt{}(V\cos\Phi + IaRa)2 + (V\sin\Phi - IaXs)2$

Open circuit voltage for unity p.f = $\sqrt{(V + IaRa)^2 + (IaXs)^2}$

Percentage regulation $= \frac{EO - V}{V} * 100$

Zs = Voc(rated)/Isc = OC voltage at Isc/4.1 = 58.1

Eo = √(VcosΦ + IaRa)2 + (VsinΦ – IaXs)2

V =

Ia =

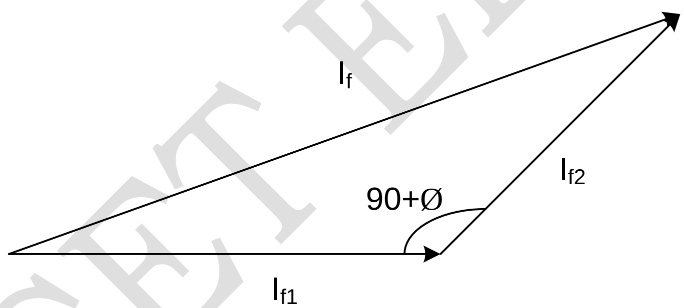
$Xs = \sqrt{Zs^2 - Ra^2}$

PF = cosΦ =, sinΦ =

PROCEDURE TO DRAW GRAPH FOR MMF METHOD:

1. Determine value of (V+IaRacosØ) and thisis projected in to OCC to Find If1 Short Circuit Corresponding Field Current taken as If2

Lagging P.F.:

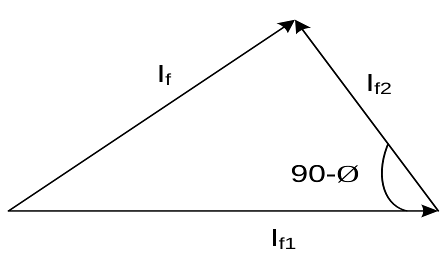


For Lagging P.F Resultant Field Current is $I_f = \sqrt{I_{f1}^2 + I_{f2}^2 + 2I_{f1}I_{f2}Cos(180-(90+\phi))}$

This resultant field current is projected in to OCC to determine no load EMF(Eo)

$$\text{Percentage regulation} = \frac{E_o - V}{V} X100$$

Leading P.F.:

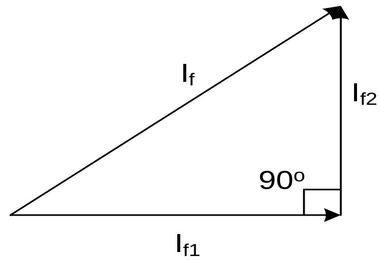


For Leading P.F Resultant Field Current is $I_f = \sqrt{I_{f1}^2 + I_{f2}^2 + 2I_{f1}I_{f2}Cos(180-(90-\phi))}$

This resultant field current is projected in to OCC to determine no load EMF(Eo)

$$\text{Percentage regulation} = \frac{E_o - V}{V} X100$$

Unity P.F.:



For Unity P.F Resultant Field Current is $I_f = \sqrt{I_{f1}^2 + I_{f2}^2}$

This resultant field current is projected in to OCC to determine no load EMF(Eo)

$$\text{Percentage regulation} = \frac{E_o - V}{V} X100$$

RESULT:

REGULATION OF 3–PHASE ALTERNATOR BY ZPF METHOD

AIM: To determine the regulation of a 3-phase alternator by ZPF Method.

APPARATUS:

Sl.No.	Meter	Range	Type	Quantity
1.	Voltmeter	0-600V	MI	1
2.	Ammeter	0-10A	MI	1
3.	Ammeter	0-2A	MC	1
4.	3-Φ Inductive Load			1

NAME PLATE DETAILS:

Motor **Alternator**

THEORY:

a) **Potier Triangle(or ZPF) Method**:

The two main factors contributing towards regulation of an alternator, viz. the leakage reactance voltage drop and armature reaction magneto motive force are separated in this method. (In case of synchronous impedance method, the two effects were taken into consideration together in terms of a reactance Xs or a voltage IXs).A is a point on the zero power factor curve corresponding to rated voltage at the terminals. AB'is drawn equal to OB and parallel to X-axis as shown in figure. From B', a line parallel to air-gap line and intersecting the open circuit characteristic at P is drawn. PB'A is the pointer triangle for this alternator. PC is perpendicular on AB'. On the voltage scale, PC represents the leakage reactance drop at full-load. (PC/Ir1) is defined as potier reactance Xl, and is very nearly equal to the leakage reactance X1. On the excitation or field current scale, CA represents the armature reaction m.m.f. corresponding to full-load current.

TO OBTAIN THE OPEN-CIRCUIT VOLTAGE, PROCEED AS FOLLOWS:

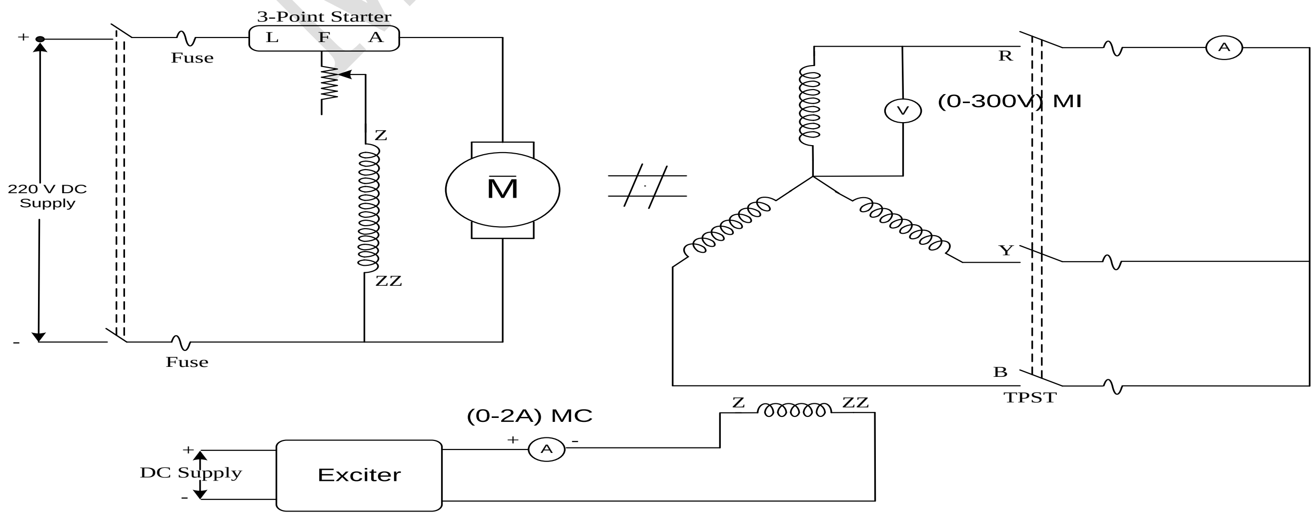
To V add resistance drop I*Ra and leakage reactance drop I*Xp for full load current. The resultant Eg is the voltage actually induced in the machine. FR is the excitation corresponding to the voltage Eg and is obtained from the O.C.C. From Fg subtract vector ally AC, which is the armature reaction m.m.f at full-load and is denoted as FA in figure. FA is in phase with the armature current I and Fg loads Eq by 900. The resultant, FR – FA = FM. Corresponding to FM, obtain, the open-circuit voltage Voc from O.C.C. The regulation at full-load at a p.f. Cos φ is then given by $\frac{V_{oc} - V}{V} X100$ percent,

PROCEDURE: -

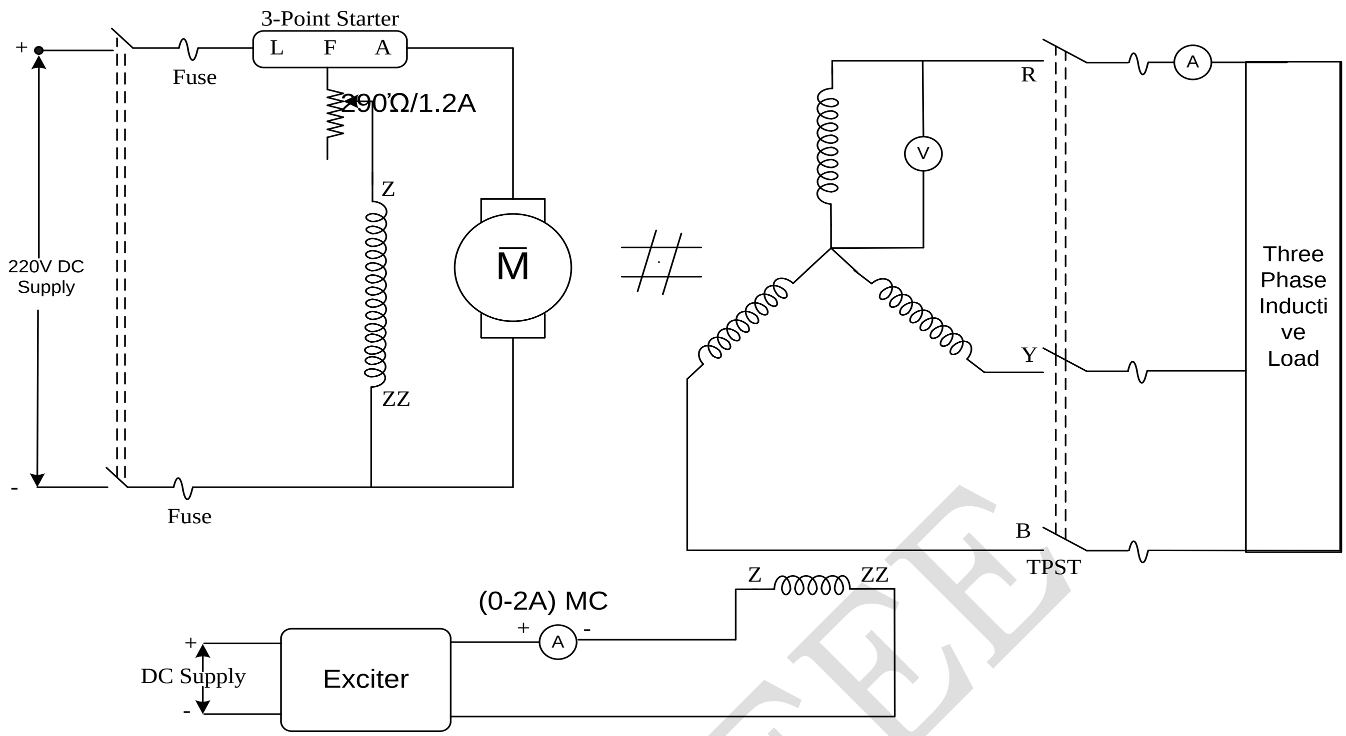
1. Connect the circuit for OCC as per Circuit Diagram
2. Start the Induction Motor using DOL Starter.
3. Increase the excitation of the alternator in steps.
4. Note down the field current and OC voltage.
5. Now connect the 3-Φ inductive load across the Armature terminals and increase the
6. Field current until full load armature current flows.
7. Vary the load in steps in turn varying the filed current such that full load current is maintained in each step.
8. Note down the values of If& V.
9. Connect the circuit for SCC shorted with ammeter.
10. Increase the field excitation current until full load armature current flows and note down the reading.
11. Draw graphs for OCC and ZPF Curves.
12. Calculate XL from the graph.

    The regulation of alternator is then calculated by the formulae.

Circuit Diagram for OCC and SCC Characteristics



Circuit Diagram for ZPF Characteristics



OBSERVATION: -

OPEN CIRCUIT TEST:

Sl.NO	FIELD CURRENT (A)	OC VOLTAGE (V)
1.		
2.		
3.		
4.		
5.		
6.		
7.		

SC CHARACTERISTICS

SC CURRENT(A)	FIELD CURRENT(A)

ZPF TEST

VOLTAGE	PHASE CURRENT	FIELD CURRENT

OBSERVATION TABLE

PF		VOLTAGE REG	
LAG	LEAD	LAG	LEAD

PROCEDURE:

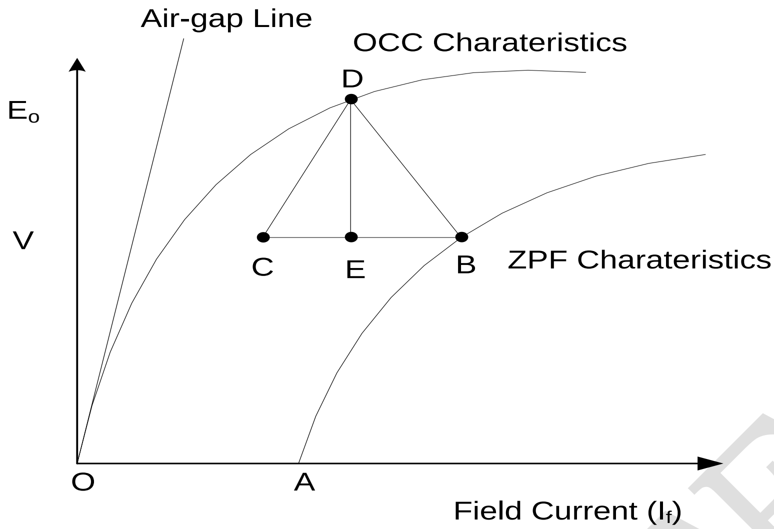
1. Note down the name plate details of the motor and alternator.
2. Connections are made as per the circuit diagram.
3. Switch ON the supply by closing the DPST switch.
4. Using the Three point starter, start the motor to run at the synchronous speed by adjusting the motor field rheostat.
5. Conduct Open Circuit test by varying the potential divider for various values of field current and tabulate the corresponding Open Circuit Voltage readings.
6. Conduct Short Circuit test by closing the TPST switch and adjust the potential divider to set the rated armature current and tabulate the corresponding field current.
7. Conduct Zero Power Factor test by closing the TPST switch and adjust the potential divider to set the rated armature current and tabulate the corresponding field current and terminal Load Voltage.
8. The Stator resistance per phase is determined by connecting any one phase stator winding of the alternator as per the circuit diagram using MC voltmeter and ammeter of suitable ranges.

PROCEDURE TO DRAW THE POTIER TRIANGLE (ZPF METHOD):

(All the quantities are in per phase value)

1. Draw the Open Circuit Characteristics (Generated Voltage per phase VS Field Current)
2. Mark the point A at X-axis, which is obtained from short circuit test with full load armature current.
3. From the ZPF test, mark the point B for the field current to the corresponding rated armature current and the rated voltage.
4. Draw the ZPF curve which passing through the point A and B in such a way parallel to the open circuit characteristics curve.
5. Draw the tangent for the OCC curve from the origin (i.e.) air gap line.
6. Draw the line BC from B towards Y-axis, which is parallel and equal to OA.
7. Draw the parallel line for the tangent from C to the OCC curve

MODEL GRAPHS: -



Join the points B and D also drop the perpendicular line DE to BC, where the line DE represents armature leakage reactance drop (IXL)

BE represents armature reaction excitation (Ifa or If2).

Air Gap EMF(Er) for lagging p.f = $\sqrt{(V\,Cos\Phi + IaRa)^2 + (V\,Sin\Phi + IaXL)^2}$

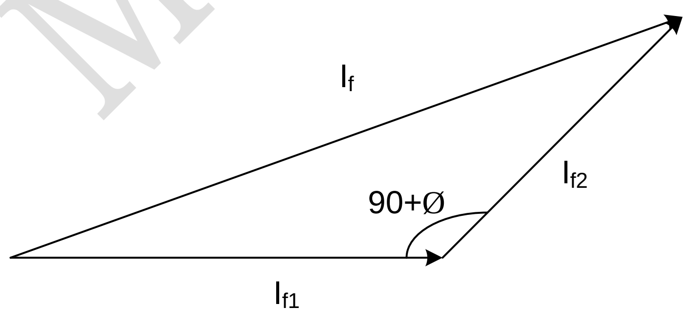
Air Gap EMF(Er) for leading p.f = $\sqrt{(V\,Cos\Phi + IaRa)^2 + (V\,Sin\Phi - IaXL)^2}$

Air Gap EMF(Er) for unity p.f = $\sqrt{(V+ IaRa)^2 + (IaXL)^2}$

Air Gap EMF(Er) is projected in to OCC is considered as If1

armature reaction excitation is considered as If2

Lagging P.F.:

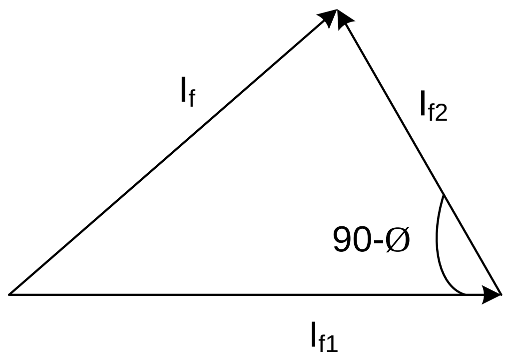


For Lagging P.F Resultant Field Current is $I_f = \sqrt{I_{f1}^2 + I_{f2}^2 + 2I_{f1}I_{f2}Cos(180-(90+\phi))}$

This resultant field current is projected in to OCC to determine no load EMF(Eo)

Percentage regulation = $\frac{E_o - V}{V} X100$

Leading P.F.:

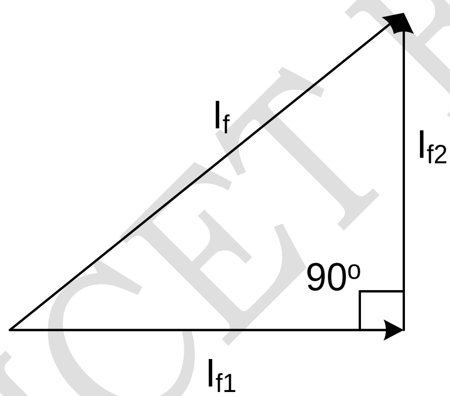


For Leading P.F Resultant Field Current is $I_f = \sqrt{I_{f1}^2 + I_{f2}^2 + 2I_{f1}I_{f2}Cos(180-(90-\phi))}$

This resultant field current is projected in to OCC to determine no load EMF(Eo)

$$\text{Percentage regulation} = \frac{E_o - V}{V} X100$$

Unity P.F.:



For Unity P.F Resultant Field Current is $I_f = \sqrt{I_{f1}^2 + I_{f2}^2}$

This resultant field current is projected in to OCC to determine no load EMF(Eo)

$$\text{Percentage regulation} = \frac{E_o - V}{V} X100$$

RESULT:

DISCUSSION:

1. What are the methods for finding the regulation of an alternator?
2. Why is it necessary to find the regulation of an alternator?
3. Explain why each method gives different values for the regulation?
4. What are the quantities that can be obtained from the Potier triangle?
5. What is the nature of armature reaction for leading, lagging and unity power factor loads?

OUTCOMES:

The student is able to

- Understand the regulation methods to determine regulation.
- Understand synchronous reactance, impedance.
- Understand the difference between Synchronous impedance method and ZPF method.
- Understand Potier triangle.

Understand effect of power factor on armature reaction.

SPEED CONTROL OF THREE PHASE INDUCTIONMOTOR

AIM: To control the speed of Three Phase slip ring Induction motor by

A) Rotor resistance method.

B) Stator voltage control

APPARATUS:

S.NO	Equipment	Specification	Quantity
1	Voltmeter	(0-600V, MI)	1
2	Voltmeter	(0-15 V, MC)	1
3	Ammeter	(0-5A, MC)	1
4	Rotor Rheostat		1
5	Tachometer	(0-9999rpm)	1
6	Rheostat	(40Ω, 5A)	1
7	3 – Ø Variac	(0-440 V, 15A)	1

NAME PLATE DETAILS:

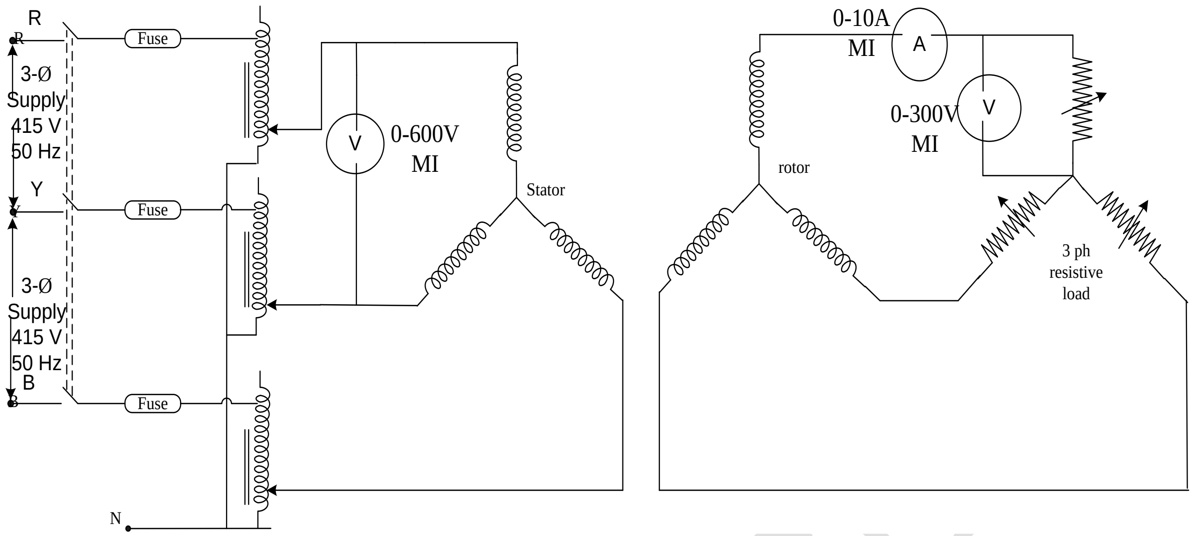
Parameter	**Motor**

THEORY:

The speed of a 3-phase induction motor can be changed by changing the applied frequency, the numbers of poles and slip. The slip can be changed by changing the applied stator voltage and by changing the external resistance in the rotor circuit (slip ring motors only). The speed range obtained is small for the rotor resistance method and stator voltage control method.

A) <u>ROTOR RESISTANCE METHOD:</u>

CIRCUIT DIAGRAM:



PROCEDURE:

Rotor resistance control method:

1. Keep the rotor resistance in maximum position.
2. Apply the rated voltage to the stator of motor.
3. Note down the speed.
4. Decrease the motor resistance in steps and note down the corresponding speed.
5. Measure the value of external rotor resistance per phase for each step of controller.
6. Draw the rotor resistance Vs speed curve.

READINGS AND TABULAR FORM:

Ns – Synchronous speed = $\frac{120\,f}{P}$

Slip S_o = $\underline{Ns - Nr}$

Ns

No = Speed of motor without external resistance at rated voltage

S_1 = $\underline{Ns - N_1}$

Ns

N_1 = Speed with rotor resistance in position No "1".

$\underline{S_o}$= $\underline{r_{20}*S_2}$= $\underline{r_{22}}$ where r_{20} = Rotor resistance per phase

S_1 r_{21} S_1 r_{21}

r_{21} r_{22}, r_{23} ….. Stand for the total rotor circuit resistance when the external variable resistance is kept in position 1, 2, 3 and so on.

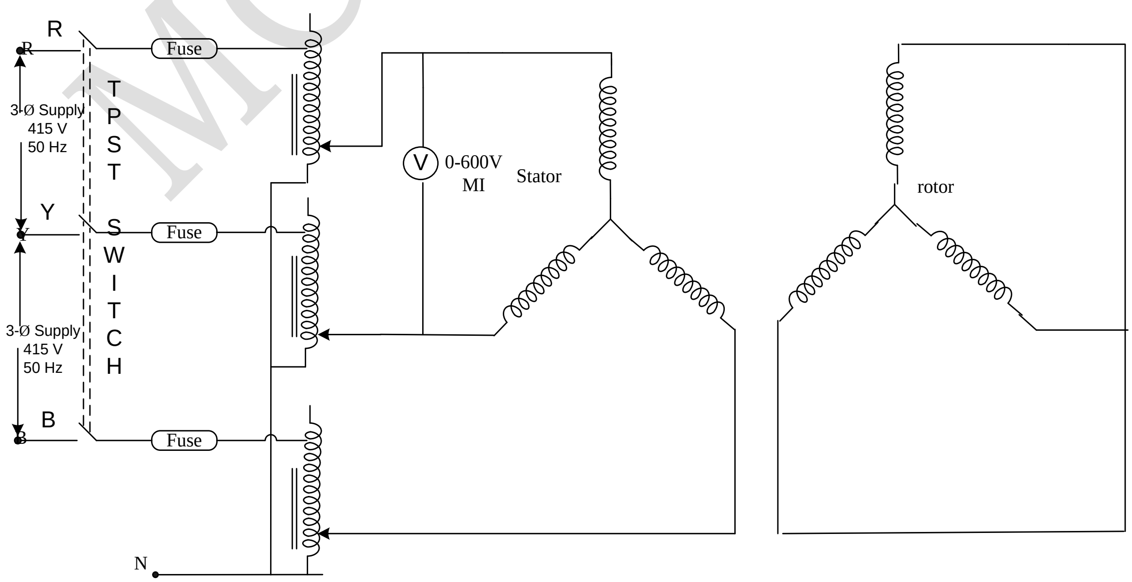
To calculate Rotor Resistance

S.No	**V_{ph}(v)**	**I_L(A)**	**N(rpm)**	**R=V/I**

Rotor Resistance / Phase $R_{20} = R_2$ (D.C Resistance of rotor winding /phase) × 1.25

B) <u>STATOR VOLTGE CONTROL:</u>

CIRCUIT DIAGRAM:



<u>PROCEDURE:</u>

Stator voltage control method:

1. Do the connection as shown in the circuit diagram.
2. Apply rated voltage gradually to the motor with the help of three phase transformer.
3. Note down the voltmeter reading and speed of the motor.
4. Gradually decrease the voltage to the corresponding voltmeter readings &speed.
5. Draw motor voltage Vs speed curve.

TABULAR COLUMN:

Sl.No	Voltage	speed

SAMPLE CALCULATIONS:

RESULT:

DISCUSSIONS:

1. Is it possible to control the speed of squirrel cage induction motor by same method?
2. Is there any similarity between transformer and induction motor?
3. What are the applications of 3 – Phase Slip ring induction motor?
4. What are the other speed control methods?
5. What is Vector control of Induction Motor?

OUTCOMES:

The student is able to

- Control the speed of induction motor by various methods.
- Understand the merits and demerits of various methods.

RETARDATION TEST, DYNAMIC BRAKING OF D.C SHUNT MOTOR

A) RETARDATION TEST

AIM : To conduct the retardation test in DC Shunt motor

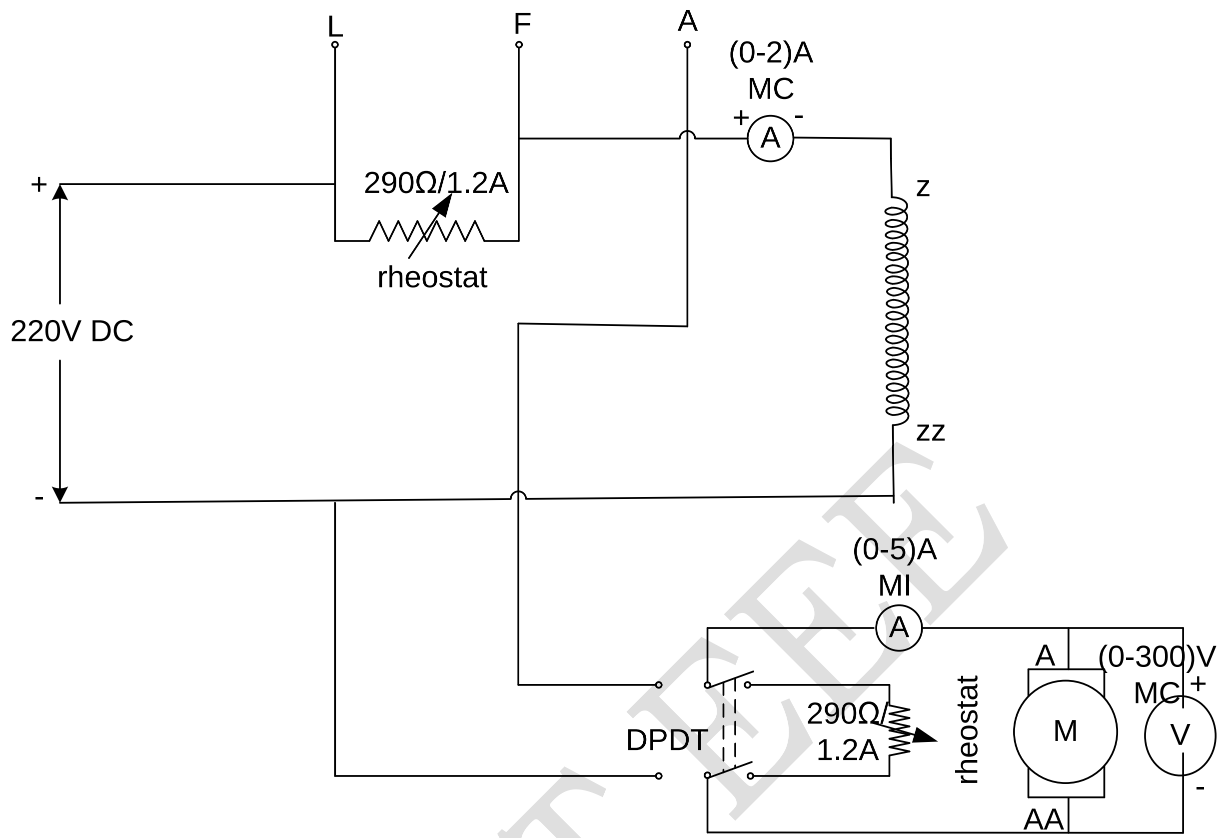
APPARATUS REQUIRED

Sl.No	Name of the Apparatus	Type	Range	Quantity
1	Ammeter	MC	0 – 1/2 A	1
2	Ammeter	MI	0 – 5/10 A	1
3	Voltmeter	MC	0 – 300 V	1
5	Rheostat	Wire wound	290 Ω, 1.1A	1
6	Rheostat	Wire wound	500Ω, 2A	1
7	Tachometer	Digital	---	1
8	TPST knife switch	--	--	1

NAME PLATE DETAILS

TYPE	DC SHUNT MOTOR
VOLTAGE	
CURRENT	
SPEED	
POWER	

CIRCUIT DIAGRAM:



THEORY:

This method is applicable for shunt motor and is used for finding stray losses. Then knowing the armature shunt cu losses at given load current efficiency can be calculated. The machine under test is speeded up slightly beyond its normal speed and then supply is cut off from the (armature while keeping) shuts down and its kinetic energy is used to meet the rotational losses i.e friction winding and iron losses

Kinetic energy of the armature = $\frac{1}{2} I\omega^2$

I = moment of inertia of armature

ω= angular velocity

Rotational losses Ps= rate of loss of kinetic energy

$$Ps = \frac{d}{dt}\left(\frac{1}{2} I\omega 2\right)$$

$$= I\omega \frac{d\omega}{dt}$$

Two quantities are required:

(i) Moment of inertia of the armature

(ii) $\frac{d\omega}{dt}$or $\frac{dN}{dt}$

1. **Finding $\frac{d\omega}{dt}$**

A voltmeter V is connected across the armature and carefully monitored because when the supply is cut off the armature speed and hence voltmeter reading falls. By noting different amount of time a curve is drawn between time and speed.

$$Ps = 0.011\ I_N \frac{dN}{dt}$$

2. **Finding moment of inertia (I):**

In this method time taken to slow down say by 5% is noted with armature alone. Next a retardation torque is applied to the armature and given time is noted. The double throw switch S while cutting of the armature from supply automatically joins it to a non-inductive resistance R. The power drawn by this resistance acts as a retarding torque on the armature. Here by making it slow down comparatively quickly the losses is $Ia^2(R + Ra)$, V Ia

Let Ps' be this power

$$Ps + Ps' = \left(\frac{2\pi}{60}\right)^2 I_N \frac{dN}{dt} = 0.112\ I_N \frac{dN}{dt_2}$$

$$Ps = Ps'[\frac{\frac{dN}{dt_1}}{\frac{dN}{dt_1} - \frac{dN}{dt_2}}]$$

PROCEDURE :

1. Connect the circuit as per diagram and switch on.
2. Allow the motor to attain rated speed by varying field rheostat.
3. Now the supply to armature terminals of DC shunt motor is cut off.
4. Note down the corresponding values of time taken by the motor speed to reduce to 1250, 1000, 750,500,250 and 0 rpm respectively.
5. Draw the speed Vs time graph and find the slope dN/dt_1
6. Again start the motor and allow the motor to attain rated speed by varying field rheostat.
7. Now the supply to armature terminals is cut offand an additional load is applied by throwing the double throw switch to position 1-2
8. Note down the values of load current and voltage across load and time as the speed

reduces.

9. Draw the speed Vs time graph and find the slope dN/dt_2
10. Calculate Ps using the formula

TABULAR FORMS

1. with no load

Sl.No	Voltage	Speed	Time
1			
2			
3			
4			
5			
6			

2. with load

Sl.No	Voltage	Current	Time	Speed

CALCULATIONS

$dN/dt_1 = OB_1/OA_1$

$dN/dt_2 = OB_2/OA_2$

$$Ps = Ps'\left[\frac{\frac{dN}{dt_1}}{\frac{dN}{dt_1} - \frac{dN}{dt_2}}\right]$$

Where $Ps' = V_{avg} * I_{avg}$

B) DC SHUNT MOTOR BREAKING

AIM: To study the dynamic braking in DC Shunt motor

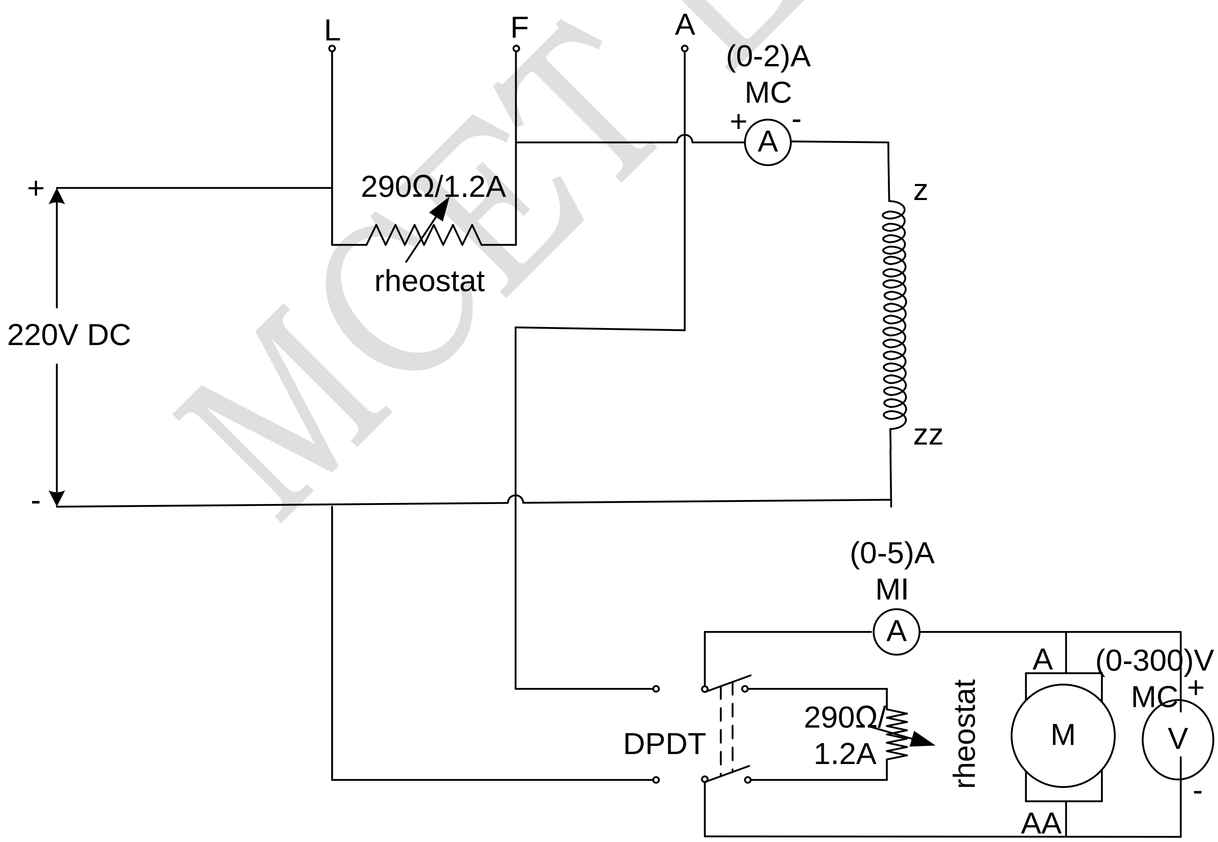
APPARATUS REQUIRED

Sl.No	Name of the Apparatus	Type	Range	Quantity
1	Ammeter	MC	0 – 1/2 A	1
2	Ammeter	MI	0 – 5/10 A	1
3	Voltmeter	MC	0 – 300 V	1
5	Rheostat	Wire wound	290 Ω, 1.1A	1
6	Rheostat	Wire wound	500Ω, 2A	1
7	Tachometer	Digital	---	1
8	TPST knife switch	--	--	1

NAME PLATE DETAILS

TYPE	DC SHUNT MOTOR
VOLTAGE	
CURRENT	
SPEED	
POWER	

CIRCUIT DIAGRAM



THEORY

Braking in any electrical machine is accomplished mainly by three methods:

1. Regenerative braking
2. Dynamic braking
3. Plugging or reverse current braking.

Regenerative braking allows feeding back of the stored energy in the m/c back to the supply and hence it is the most energy efficient method of braking. In dynamic braking, the generated power in the machine is dissipated in an external resistance. In plugging, the stored kinetic energy in the machine as well as the energy supplied from the source – both are wasted in the form of heat in the external resistance.

In this experiment, two methods of braking namely dynamic braking and plugging are to be implemented and tested for the given DC motor. The plugging is to be done at a reduced voltage so that the current through the machine is limited to its Full-Load value. The computer simulation of plugging operation is also to be carried out using a dynamic model for the DC machine.

PROCEDURE:

1. Connections are given as per the circuit diagram. As there is no starter provided for the given DC shunt machine, an external rheostat has to be used in series with the armature so that the starting current is within the set limit.
2. Keep rheostat in maximum resistance position and switch on the DC supply to the motor by closing the DPDT in 11' position. As the m/c picks up the speed external resistance can be cut down.
3. When the machine has gone up to its rated speed, throw the switch in position 22', so that the dynamic braking takes effect. Note down the time taken by the machine to stop completely after dynamic braking is initiated.
4. Plugging voltage should be varied from 25 to 50V and the time taken by the m/c to stop should be recorded.

OBSERVATIONS:

Sl. No.	Reverse Voltage	Resistance in the circuit	Braking Time
1			
2			
3			
4			
5			
6			

NOTE: Field to be separately excited during braking.

RESULT

POWER FACTOR IMPROVEMENT USING CAPACITORS

AIM: To improve the system power factor of an induction motor load resulting using capacitor.

APPARATUS:

Sl.No	Name	Type	Range	Quantity
1.	Voltmeter	M.I	0-600V	1
2.	Ammeter	M.I	0-10A	3
3.	Wattmeter	Dynamometer	3Ø,600V,10A	1
4.	3Φ Capacitor load		3 kw	1
5.	TPST	Knife switch	400V,2KVAR	1

NAME PLATE DETAILS:

Rated speed =

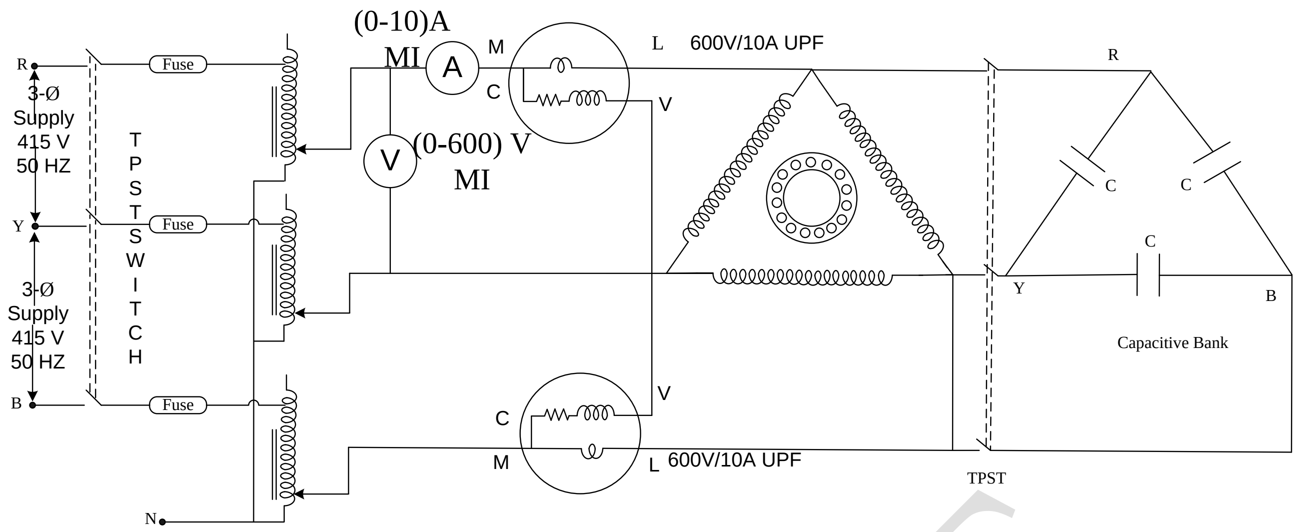
Rated voltage =

Rated current =

THYORY:

Constructional wise the stator of an induction motor is the same as that of a synchronous motor or generator. It is an outer stationary, hollow cylindrical structure made of laminations of steel having slots on the inner periphery. The two essential parts of three phase induction motor, as mentioned earlier are stationary part known as stator, rotating part known as rotor. The 3 phase winding is fed from 3 phase supply, rotating magnetic field of constant magnitude and rotating at synchronous speed is produced. Consider the instant the rotor is stationary the relative motion of the rotor with respect to the stator is anti-clock wise by applying the Flemings right hand rule the direction of the induced emf in the rotor is found to be towards the observer or outwards.

CIRCUIT DIAGRAM



PROCEDURE :

1. Do the connections as per the circuit diagram.
2. Apply rated voltage to the motor with the help of 3phase variac.
3. Take all the meter readings under no load.
4. Gradually apply load in steps and the corresponding meter readings & spring balance reading with & without capacitor for each load.
5. Calculation of power factor of system for both combinations i.e, with or without capacitor.
6. Draw Po Vs P.F in both cases.

FORMULAE:

Torque $T = (s_1 - s_2) * 9.81 * r$

Where r = radius of brake drum =----------

S_1, S_2 are spring balance reading.

Power i/p, $P_{in} = W_1 + W_2$

Power o/p , $P_{out} = 2\pi NT / 60$

$P_{in} = W_1 + W_2$

Efficiency $\eta = P_{out} / P_{in}$

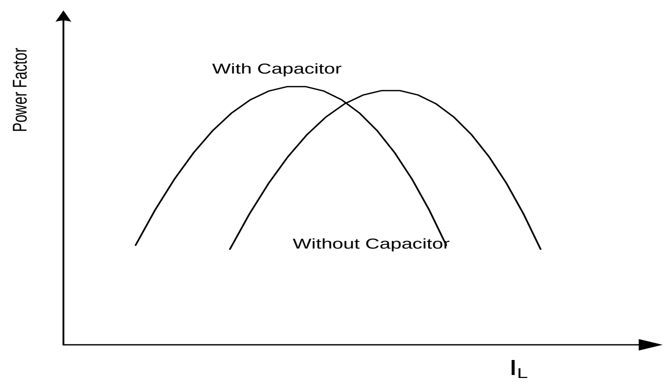
Power factor , $p.f = P_{in} / \sqrt{3} V I_L$

TABULAR COLUMN

V=415V

Sl.No		V	I_L(A)	W1	W_2	S1	S2	T	P.F	N	P_{in}	P_{out}	η
1	WITH OUT CAPACITOR												
	WITH CAPACITIVE LOAD												
2	WITH OUT CAPACITOR												
	WITH CAPACITIVE LOAD												
3	WITH OUT CAPACITOR												
	WITH CAPACITIVE LOAD												
4	WITH OUT CAPACITOR												
	WITH CAPACITIVE LOAD												
5	WITH OUT CAPACITOR												
	WITH CAPACITIVE LOAD												

EXPECTED GRAPH:



RESULT:

DETERMINATION OF X_d AND X_q OF A SALIENT POLE SYNCHRONOUS MACHINE

AIM: To determine direct and quadrature axis synchronous reactance of a synchronous machine.

APPARATUS:

Sl.No	Meter	Range	Type	Quantity
1.	Voltmeter	0-600V	MI	1
2.	Ammeter	0-5A	MI	1
3.	Tachometer	0-10000 RPM	Analog	1
4.	Variac	3- Φ, 415 V /15 A		1

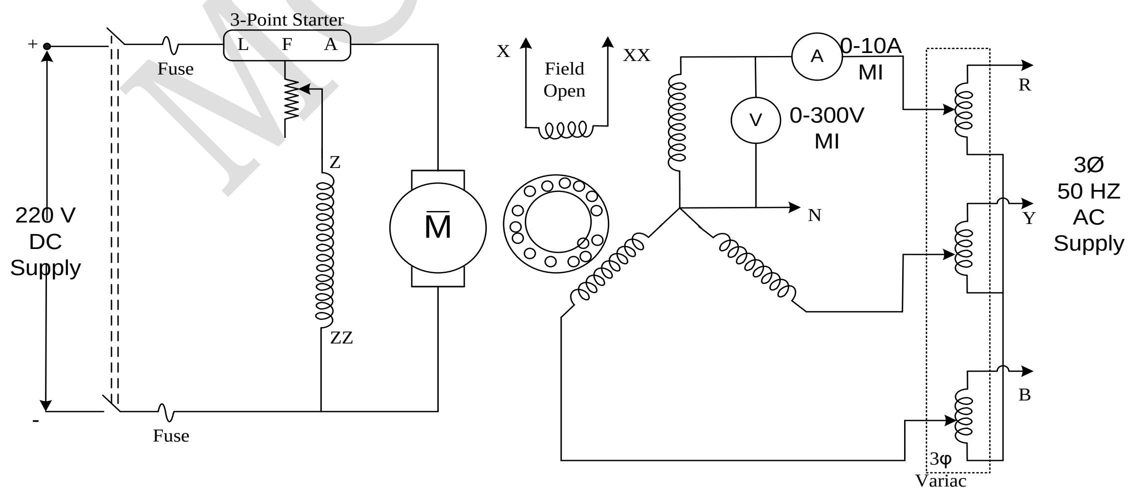
Name Plate Details:	
Alternator	Motor
KVA : Volts : Amps : Rpm : Phase :	KVA : Volts : Amps : Rpm : Phase :

THEORY:

The values of X_d and X_q are determined by applying a balanced reduced external voltage (say, V volts) to an unexcited machine at a speed a little less than the synchronous speed (the slip being less than 1%). Connection diagram is shown in circuit diagram. Applied voltage to the armature, armature current and the voltage induced in the field winding are measured by oscillo-graphs. Due to voltage V applied to the stator terminal a current I will flow causing a stator mmf. This stator mmf moves slowly relative to the poles and induced an emf in the field circuit in a similar fashion to that of rotor in an induction motor at slip frequency. The effect will be that the stator mmf will moves slowly relative to the poles. The physical poles and the armature-reaction mmf are alternately in phase and out, the change occurring at slip frequency. When the axis of the pole and the axis of the armature reaction mmf wave coincide, the armature mmf acts through the field magnetic circuit. The voltage applied to the armature is then equal to drop caused by the direct component of armature reaction and leakage reactance. When the armature reaction mmf is in quadrature with the field poles, the applied voltage is equal to the leakage reactance drop plus the equivalent voltage drop of the cross magnetizing field component. From oscillograph record.

$$X_d = \frac{\text{Maximum voltage}}{\text{Minimum current}} \quad ; \qquad X_q = \frac{\text{Minimum voltage}}{\text{Maximum current}}$$

CIRCUIT DIAGRAM



PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Check Phase Sequence of Alternator and Start synchronous machine
3. Drive the synchronous machine using prime mover (DC shunt motor) at a speed slightly less than synchronous speed.
4. With the field of the alternator open circuited apply 25% of the balanced three phase rated voltage and rated frequency across the armature terminals.
5. Note down the maximum and minimum readings of voltmeter & ammeter.
6. Calculate X_d and X_q and plot a graph with armature current on X-axis and X_d and X_q on Y – axis.

TABULAR COLUMN:

Sl.No	V_{MIN} (Volts)	V_{MAX} (Volts)	I_{MIN} (Amps)	I_{MAX} (Amps)	X_d (Ohms)	X_q (Ohms)
1						

CALCULATION:

$$X_d = \frac{V_{MAX}}{I_{MIN}} ; X_q = \frac{V_{MIN}}{I_{MAX}}$$

Cos $Ø_0$ = .8 $Ø_0$ =36.86

I_a = rated current

R_{adc} = ohm $R_{a\,ac}$=1.6* R_{adc} = ohm

V=

$$Tan\Psi = (V\sin\Phi + I_a X_q)/(V\cos\Phi + I_a R_a)$$

$$I_d = I_a Sin\Phi$$

$$I_q = I_a Cos\Phi$$

Lagging P.F $\Psi = \delta + \phi$

$$E_o = VCos\delta + I_q R_a + I_d X_d$$

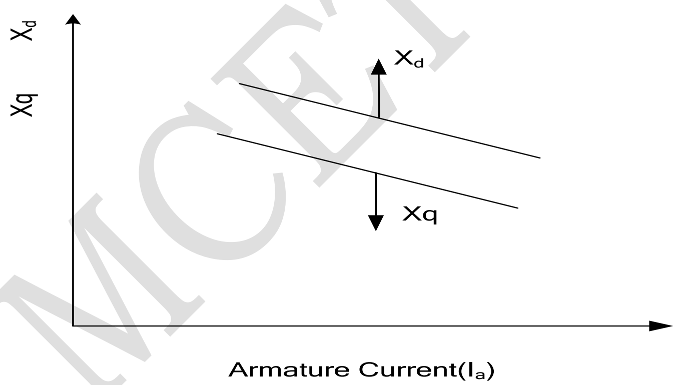
%Regulation $\%R = \frac{(E_o - V)}{V} X100$

Leading P.F $\Psi = -\delta + \phi$

$$E_o = VCos\delta + I_q R_a + I_d X_d$$

%Regulation $\%R = \frac{(E_o - V)}{V} X100$

MODEL GRAPH:



PRECAUTIONS:

1. Note down the readings without parallax errors.
2. Speed of the alternator must be slightly less than synchronous speed.

RESULT:

DISCUSSIONS:

1. Why is a salient pole machine said to be 'stiffer' than a cylindrical machine?
2. Give in detail the construction of a salient pole machine.
3. For which type of prime mover is a salient pole machine suitable?
4. Sketch the power angle characteristics of a salient pole machine.
5. What is reluctance power?

V – CURVES AND INVERTED 'V' CURVESOF A SYNCHRONOUS MOTOR

AIM: To draw the V and inverted V curves of a 3 phase Synchronous Motor

APPARATUS REQUIRED:

Sl.No	Name of the apparatus	Type	range	Quantity
1.	Wattmeter	UPF	10A,600V	2
2.	Ammeter	MI	(0-10)A	1
3.	Ammeter	MC	(0-2)A	1
4.	Voltmeter	MI	(0-600V)	1

NAME PLATE DETAILS:

3ØSYNCHRONOUS MOTOR

DC EXCITATION

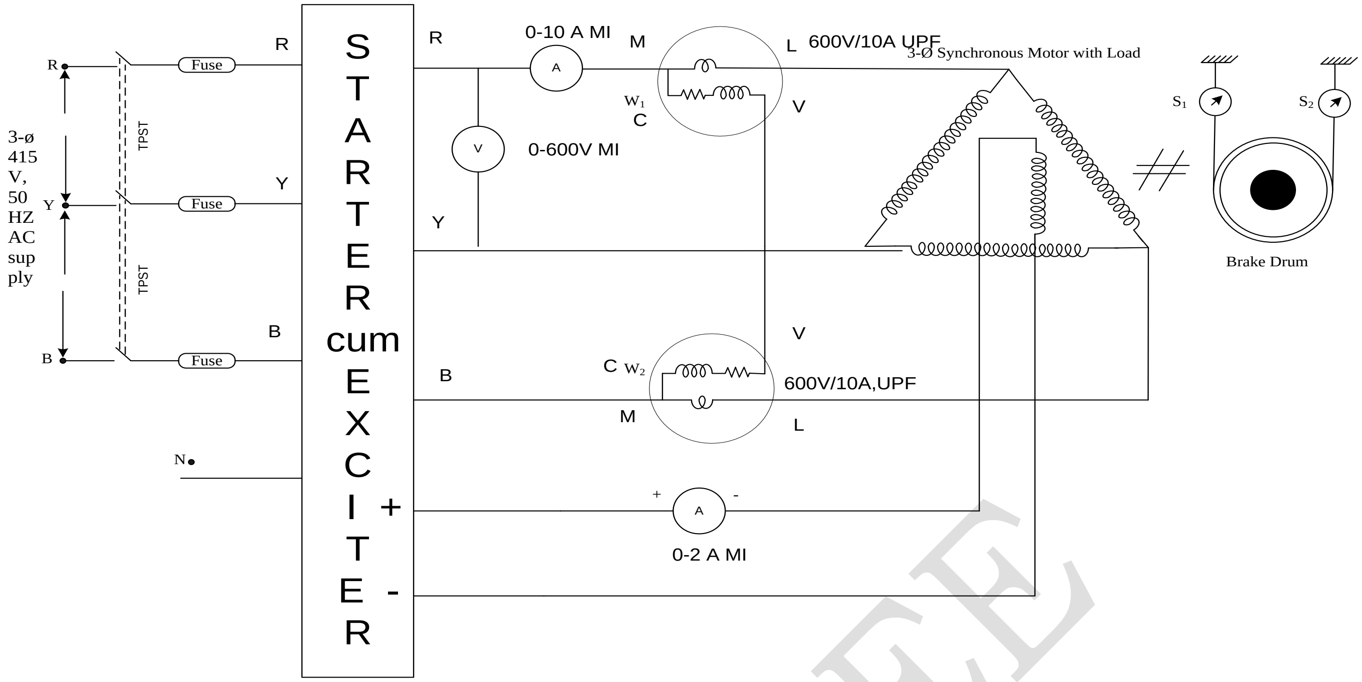
FUSE RATING:

125% of rated current (full load current)

For DC excitation:

For synchronous motor:

CIRCUIT DIAGRAM:



THEORY:

If excitation is varied from very low (under excitation) to very high (over excitation) value, then current Ia decreases, becomes minimum at unity p.f. and then again increases. The initial lagging current becomes unity and then becomes leading in nature.

Excitation can be increased by increasing the field current passing through the field winding of synchronous motor. If graph of armature current drawn by the motor (Ia) against field current (If) is plotted, then its shape looks like an English alphabet V. If such graph are obtained at various load conditions we get family of curves, all looking like V. such curves are called V curves of synchronous motor.

As against this, if the power factor (cosØ) is plotted against field current(If), then the shape of the graph looks like an inverted V. such curves obtained by plotted p.f against If, at various load condition are called inverted V curves of synchronous motor.

PRECAUTION:

(1) The motor should be started without load.

(2) Initially TPST switch is in open position.

PROCEDURE:

(1) Note down the name plate details of the motor.

(2) Connections are made as pr the circuit diagram.

(3) Close the TPST switch.

(4) By keeping exciter cum starter in ‘1’ position (starter position) the motor is started. The motor starts as an induction motor.

(5) In order to give the excitation to the field for making it to run as the synchronous motor, change the position of exciter cum starter in’2’ position.

(6) By varying excitation note down the excitation current, armature current, voltage and the power for various values of excitation. Calculate the power factor.

(7) The same process has to be repeated for loaded condition.

(8) Later the motor is switched off and the graph is drawn.

TABULATION:

NO LOAD **V_L = ……..**

Sl.No	Field Current I_f(A)	Armature Current I_a(A)	W1	W2	Power (P) = W1+W2	Power Factor = ($P / \sqrt{3} V_L I_a$)
1.						
2.						
3.						
4.						
5.						
6.						

LOAD **V_L = ……..**

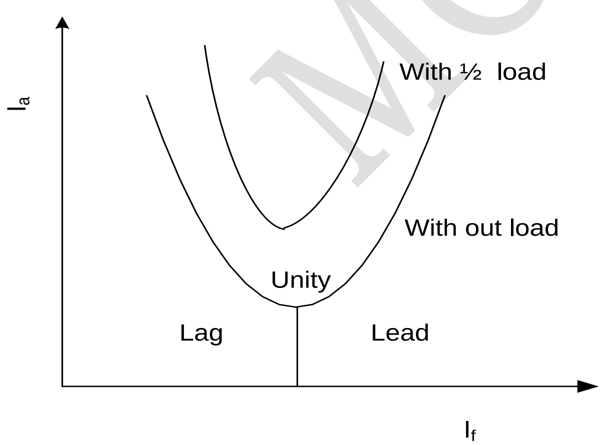
Sl.No	Field Current I_f(A)	Armature Current I_a(A)	W1	W2	Power (P) = W1+W2	Power Factor = (P /√3 V_L I_a)
1.						
2.						
3.						
4.						
5.						
6.						

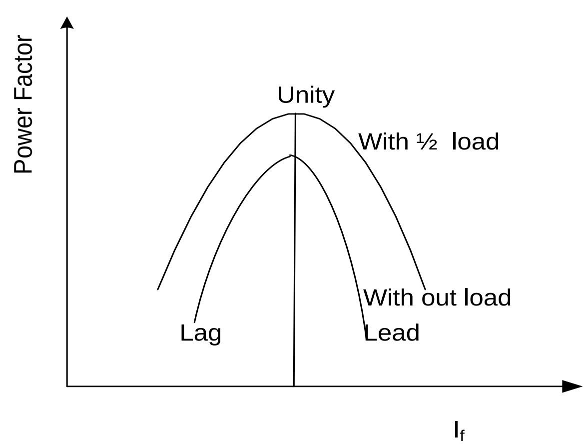
GRAPH:

The graph is drawn for-

(1) Armature current Vs Excitation current.

(2) Power factor Vs Excitation current.





RESULT:

DISCUSSION:

1. How can the power factor of a load be improved?
2. Which type of rotor is preferred for a synchronous motor?
3. Why does the synchronous motor change the armature current in the form of V-curves?
4. How do you obtain the minimum excitation for stable running of the motor?
5. Define stability for synchronous machine.

OUTCOMES:

The student is able to

Understand the variation of armature current with field current.

DISCUSSION:

1. What are the starting methods of synchronous motors?
2. How can a synchronous motor be used for improving the power factor of a given load.
3. A salient pole motor develops a small amount of power even with no excitation Explain.
4. Explain why armature current of a synchronous motor decreases and then increases with field current?
5. Explain the working of a synchronous machine connected to infinite bus.

OUTCOMES:

The student is able to

- Understand the effect of excitation on power factor and armature current
- Understand the principle of Synchronous condenser.

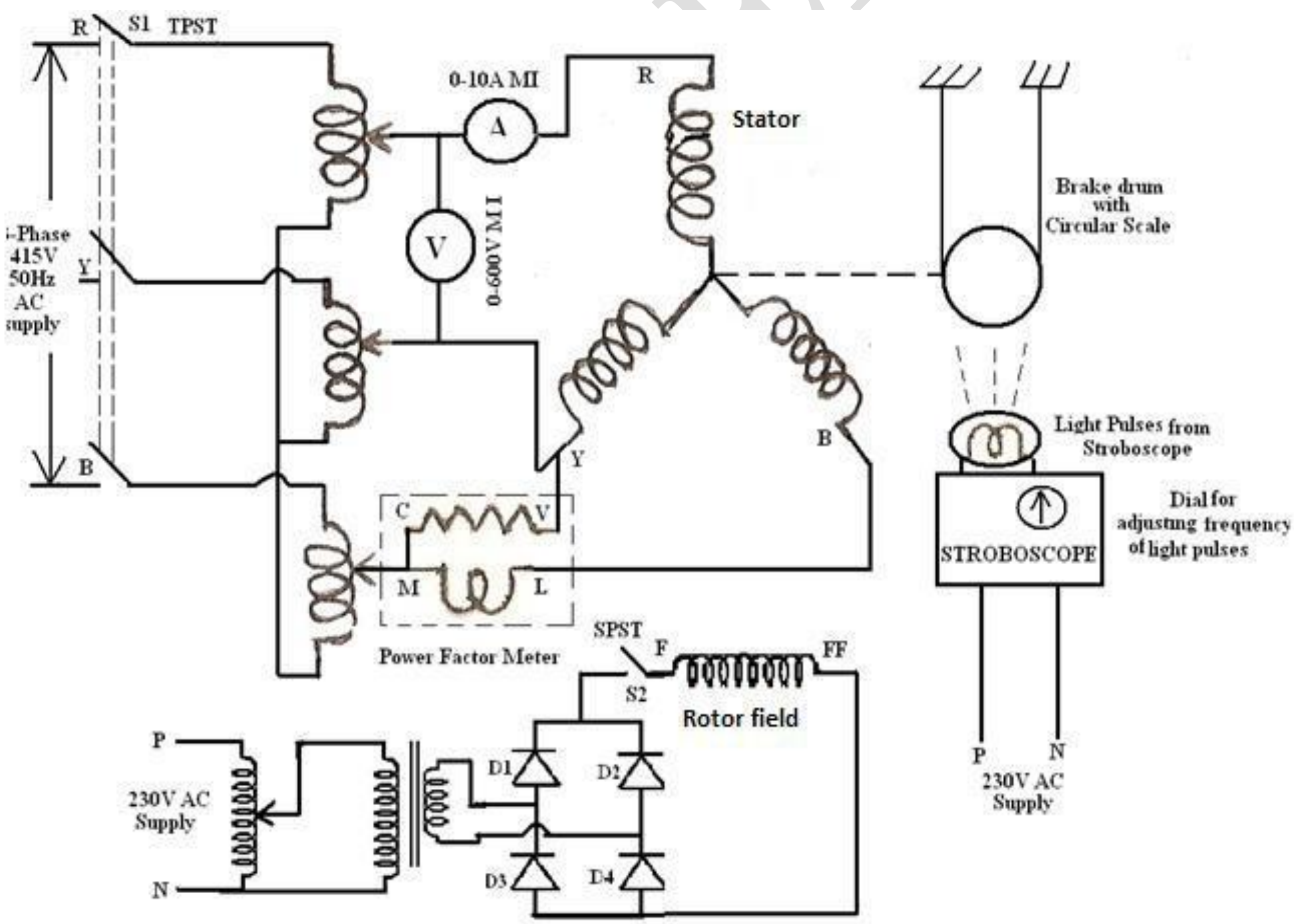
POWER ANGLE CHARACTERISTICS OF SYNCHRONOUS MOTOR

AIM: To obtain the power and torque angle characteristics of a synchronous motor.

APPARATUS:

Apparatus	Range	Qty
Synchronous motor with brake drum and circular scale		1 No
Voltmeter	(0-600V, MI)	1 No
Ammeter	(0-10A, MI)	1 No
Power factor meter	(0-10A, 600V, 0.5lag,1,0.5lead)	1 No
Stroboscope		1 No
Tachometer	(0-9999rpm)	1 No
3 – Phase Variac	(0-440 V, 15A)	1 No

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect the synchronous motor to the three phase power supply through the autotransformer as per the circuit diagram shown in figure.
2. Switch on the three phase AC supply by closing the Triple Pole Single Throw switch(TPST) S_1 And gradually increase the output voltage of the auto transformer to the rated line voltage of the synchronous motor. Switch on the supply to the field. Adjust the excitation till the pf meter reads unity. Keep the pf at unity throughout the experiment now switch on the power supply to the stroboscope and let the light fall on the circular scale attached to the brake drum.
3. Adjust the number of light pulses falling on the circular scale by slowly rotating the dial on the stroboscope till the scale appears steady. Note the reading as shown by the index mark. Let this be Q_1. Note the reading on the dial of the strobe scope, this gives the synchronous speed of the motor. The speed of the motor can also be measured by a tachometer.
4. Apply some load on the motor shaft by means of the brake drum and note the new reading on the circular scale.
5. Repeat the previous step for other increasing loads on the motor.
6. After noting the observations ,switch off the stroboscope and unload the motor shaft
7. Reduce the output voltage from the auto transformer to zero and switch off the power supply.

PRECAUTIONS:

1. Pour some water into the brake drum after the motor starts and runs at a steady speed
2. If the reading taken in step 3) above is disturbed, then steps 3) and 4) must be repeated
3. Before starting the motor, field circuit must be open.

Note: *When using the stroboscope it is not necessary to maintain the same value for Q1 for different loads applied on the motor. But the initial and final values of the readings from the circular scale taken at successive loads must be taken when the readings appear steady, as shown by the index mark.*

READINGS AND TABULAR FORM:

Sl.No	Reading on circular scale	Difference ΔQ (degrees)	Speed N (r.p.m).	W1 (kg)	W2 (kg)	Torque (T)= 9.81(W1-W2)r Nm	Power(P) 2πNT/60 Watts	Input power Watts √3VIcosΦ

SAMPLE CALCULATIONS:

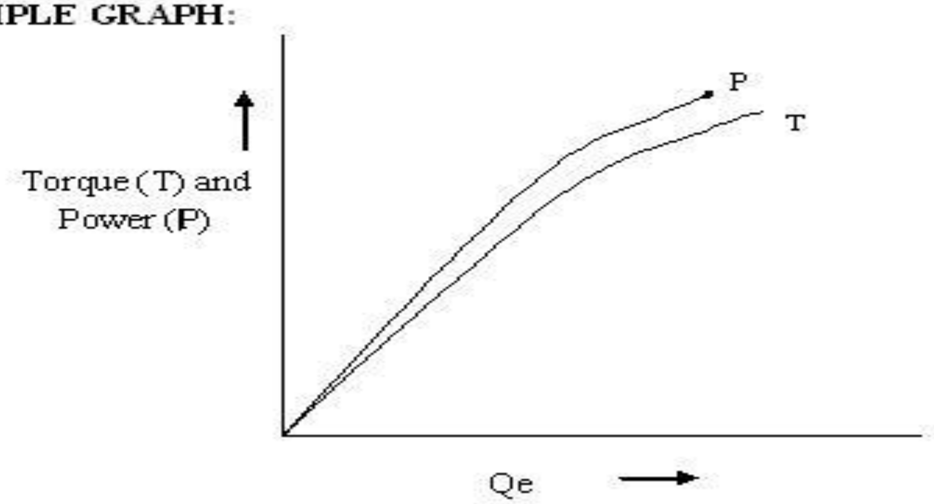
In space Qe= (2/P)Qm

Where

Qe= torque angle in electrical degrees,

Qm=torque angle in mechanical degrees and given by the stroboscope and circular scale, P= number of poles of the synchronous motor.

SAMPLE GRAPH:



61

RESULT:

DISCUSSIONS:

1. What is the steady state, dynamic and transient stability limits for synchronous machines?
2. How do the synchronous machines behave when stable running is lost?
3. Find the steady state stability limit for the machine on which this experiment is performed
4. Why does the synchronous motor not develop any starting torque when the rotor and stator power supplies are switched on?

BRAKE TEST ON A 3- PHASE INDUCTION MOTOR

AIM: To know the performance of 3-phase induction motor by conducting brake test.

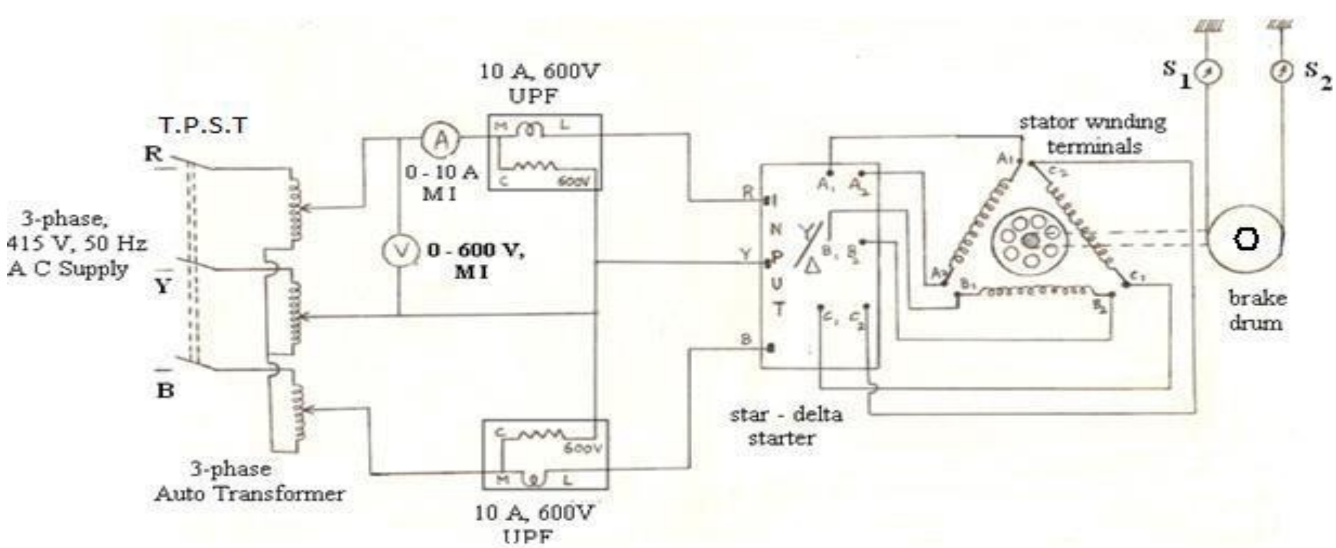
APPARATUS:

Sl.No	Apparatus	Type	Range	Qty
1.	Ammeter	MI	(0-10)A	1
2.	Voltmeter	MI	(0-600)V	1
3.	Wattmeter	UPF	10A-20A, 600V	2
4.	Tachometer	Digital	0-9999rpm	1
5.	3–Ø Variac	-	440V, 15A	1

THEORY:

Induction motor performance can be evaluated by i) direct load test ii) indirect load test. In direct load test, motor is loaded by a frictional arrangement using brake drum and belt. This method is applicable to small capacity induction motors only. As the load torque is increased gradually the motor torque increases, slip increases, speed of the motor decreases.

CIRCUIT DIAGRAM:



PROCEDURE:

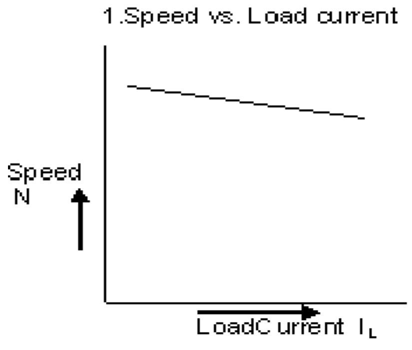
1. Give the connections as per the circuit diagram.
2. By using variac, gradually apply the rated voltage i.e 415 V to the motor.
3. Take no–load readings of current and power.
4. Now by increasing load on the motor, note down the corresponding current and power readings.
5. Increase the load gradually until rated current flows.
6. Take at least six readings.
7. Calculate the efficiency at different loads.

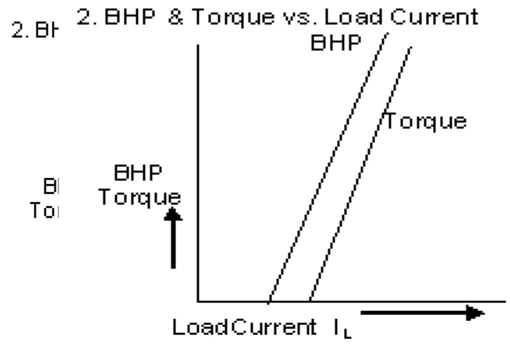
READINGS AND TABULAR FORM:

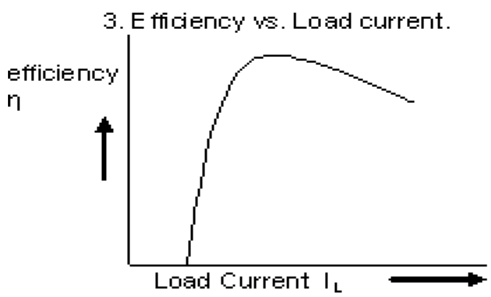
Sl.NO	V (V)	I (A)	W_1 (watts)	W_2 (watts)	W = S_1-S_2 Kgs	T = 9.81*W*r N-M	O/P = 2πNT/60 (watts)	I/P = W1 + W2 (watts)	η = (OP/IP)x100
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									

SAMPLE CALCULATIONS:

SAMPLE GRAPHS:







RESULT:

DISCUSSIONS:

1. Why does an induction motor have poor Power factor at no-load?
2. Compare the Power factors of a high speed induction motor and a low speed Induction motor.
3. What is cogging and crawling?
4. Show the stable and unstable regions on the torque-slip curve of an induction Motor.
5. How can an induction motor be made to operate as a generator?
6. Compare the line currents and starting torque of induction motor when started by Autotransformer and by stator impedance.

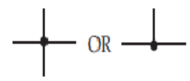
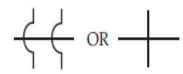
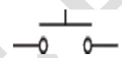
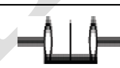
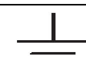
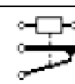
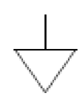
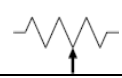
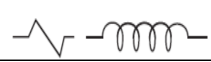
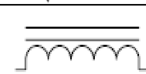
Outcomes:

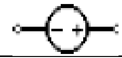
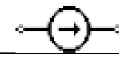
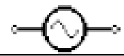
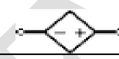
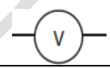
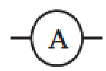
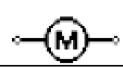
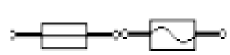
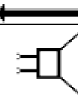
After performing the experiment the student will be able to

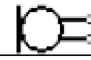
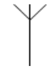
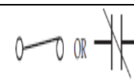
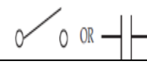
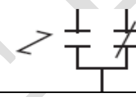
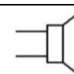
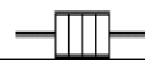
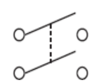
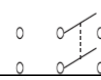
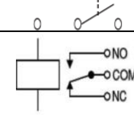
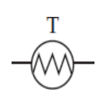
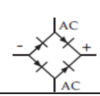
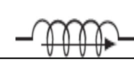
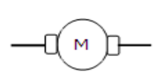
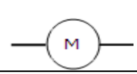
- Differentiate the direct and indirect load tests.
- Draw various characteristics of induction motor.

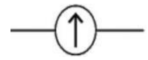
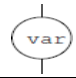
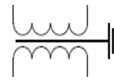
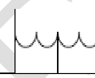
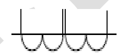
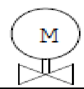
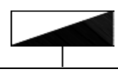
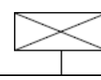
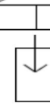
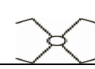
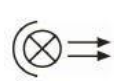
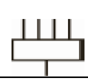
Appendix

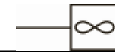
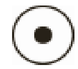
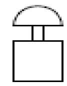
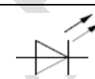
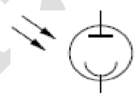
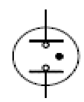
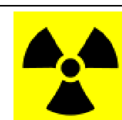
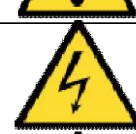
STUDY OF ELECTRICAL SYMBOLS

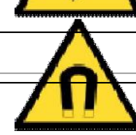
Sl. No.	Particulars	Symbol
1	Electrical wire	
2	Connected wires	
3	Not connected wires	
4	SPST Toggle switch	
5	SPDT Toggle switch	
6	Pushbutton Switch (N.O)	
7	Pushbutton Switch (N.C)	
8	Earth Ground	
9	Chassis ground	
10	SPST Relay	
11	SPDT Relay	
12	Digital Grounding	
13	Resistor	
14	Potentiometer	
15	Variable Resistor	
16	Polarized Capacitor	
17	Inductor	
18	Iron-core Inductor	
19	Variable Inductor	

20	DC Voltage Source	
21	Current Source	
22	AC Current Source	
23	Generator	
24	Battery Cell	
25	Battery	
26	Controlled Voltage Source- DC	
27	Controlled Current source	
28	Voltmeter	
29	Ammeter	
30	Ohm meter	
31	Wattmeter	
32	Lamp/Light/Bulb	
33	Motor	
34	Transformer	
35	Fuse	
36	Electrical Bell	
37	Buzzer	
38	Bus	
39	Loudspeaker	

40	Microphone	
41	Arial Antenna	
42	Circuit Breaker	
43	Contacts Closed – NC	
44	Contacts Open - NO	
45	AC Generator	
46	DC Generator	
47	Relay with Transfer Contacts	
48	Current Transformer	
49	Loud Speaker	
50	Heater	
51	DPST	
52	DPDT	
53	Relay with Contacts	
54	Thermistor	
55	Full wave, Bridge Type Rectifier	
56	Inductor Solenoid / Coil	
57	DC Motor	
		

58	AC Motor	
59	Galvanometer	
60	VAR Meter	
61	Power-Factor Meter	
62	Isolation Transformer	
63	Variable Voltage Transformer	
64	Auto Transformer	
65	Current Transformer with Two Secondary Windings On One Core	
66	Motor Operated Valve	
67	Electrical Distribution Panel	
68	Junction Box	
69	Instrument Panel or Box	
70	Lightning Arrestor	
71	Lightning Rod	
72	Choke	
73	One-way switch	
74	Two-way switch	
75	Intermediate switch	
76	Spot light	
77	Distribution Board	

78	Fan	
79	Joint Box	
80	Short circuit device	
81	Emergency push button	
82	Lighting outlet position	
83	Lighting outlet on wall	
84	Connector	
85	Light Emitting Diode	
86	Photo Cell	
87	Voltage Indicator capacitive	
88	General caution	
89	Poisonous sign	
90	Radio Activity sign	
91	Ionizing radiation sign	
92	Non-ionizing radiation sign	
93	Biohazard sign	
94	Warning sign	
95	High voltage sign	



96	Magnetic field symbol	
97	Chemical weapon symbol	
98	Laser hazard sign	
99	First Aid	
100	Fire Extinguisher