METHODIST

Estd:2008

COLLEGE OF ENGINEERING AND TECHNOLOGY

(Affiliated to Osmania University & Approved by AICTE, New Delhi)

LABORATORY MANUAL

ELECTRICAL MACHINES –II LABORATORY

B.E, VI Semester: 2021-22

NAME: ____

ROLL NO:________________________________

BRANCH:________________________________

SEM:_____________________________

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Empowering youth- Architects of Future World

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COLLEGE OF ENGINEERING AND TECHNOLOGY

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VISION

To produce ethical, socially conscious and innovative professionals who would contribute to sustainable technological development of the society.

MISSION

To impart quality engineering education with latest technological developments and interdisciplinary skills to make students succeed in professional practice.

To encourage research culture among faculty and students by establishing state of art laboratories and exposing them to modern industrial and organizational practices.

To inculcate humane qualities like environmental consciousness, leadership, social values, professional ethics and engage in independent and lifelong learning for sustainable contribution to the society.

DEPARTMENT
OF
ELECTRICAL AND ELECTRONICS ENGINEERING

LABORATORY MANUAL

ELECTRICAL MACHINES –II LABORATORY

Prepared
By
Mr. G. Mohan Krishna,

Assistant Professor

Estd:2008

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COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION

To become a reputed centre for imparting quality education in Electrical and Electronics Engineering with human values, ethics and social responsibility.

MISSION

- To impart fundamental knowledge of Electrical, Electronics and Computational Technology.
- To develop professional skills through hands-on experience aligned to industry needs.
- To undertake research in sunrise areas of Electrical and Electronics Engineering.
- To motivate and facilitate individual and team activities to enhance personality skills.

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PROGRAM EDUCATIONAL OBJECTIVES

BE-Electrical Engineering graduates shall be able to:

- **PEO1**. Utilize domain knowledge required for analyzing and resolving practical Electrical Engineering problems.

- **PEO2**.Willing to undertake inter-disciplinary projects, demonstrate the professional skills and flair for investigation.
- **PEO3**. Imbibe the state of the art technologies in the ever transforming technical scenario.

- **PEO4**. Exhibit social and professional ethics for sustainable development of the society.

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PROGRAM OUTCOMES

Engineering Graduates will have ability to:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of electrical and electronics engineering problems.

- **PO2. Problem analysis:** Identify, formulate, review research literature, and analyze complex electrical and electronics engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- **PO3. Design/development of solutions:** Design solutions for complex electrical and electronics engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- **PO4. Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- **PO5. Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex electrical and electronics engineering activities with an understanding of the limitations.
- **PO6. The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional electrical and electronics engineering practice.
- **PO7. Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- **PO.8 Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the electrical and electronics engineering practice.
- **PO9. Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- **PO10. Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- **PO11. Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- **PO12. Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES

At the end of BE program Electrical and Electronics Engineering graduates will be able to:

- **PSO1.**Provide effective solutions in the fields of Power Electronics, Power Systems and Electrical Machines using MATLAB/MULTISIM.
- **PSO2.** Design and Develop various Electrical and Electronics Systems, particularly Renewable Energy Systems.
- **PSO3.** Demonstrate the overall knowledge and contribute for the betterment of the society.

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I. PREREQUISITE(S):

Level	Credits	Semester	Prerequisites
UG	1	1	Electrical machines-1&2

II. SCHEME OF INSTRUCTIONS

Lectures	Tutorials	Practicals	Credits
0	0	2	1

III. SCHEME OF EVALUATION & GRADING

S. No	Component	Duration	Maximum Marks
	Continuous Internal Evaluation (CIE)		
1.	Internal Examination – I and II	1 hour each	25
	CIE (Total)		**25**
2.	**Semester End Examination** (University Examination)	3 hours	**50**
		TOTAL	**75**

%Marks Range	>=90	80 to < 90	70 to < 80	60 to < 70	50 to < 60	40 to < 50	< 40	Absent
Grade	S	A	B	C	D	E	F	Ab
Grade Point	10	9	8	7	6	5	0	-

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COURSE OUTCOMES

After completing this course the student will be able to:

CO No.	Course Outcome	Taxonomy Level
C266.1	**Verify** the theory and working of electrical machines through laboratory experimental work.	**Understand**
C266.2	**Make** circuit diagram connections to perform experiments, measure, **analyze** the observed data to come to a conclusion.	**Evaluate**
C266.3	**Organize** reports based on performed experiments with effective demonstration of diagrams and characteristics/graphs.	**Analyze**
C266.4	**Determine** the different parameters of a three-phase alternator and its regulation	**Understand**
C266.5	**Determine** the different parameters of a three-phase synchronous motor as well as its ‘V’ and ‘inverted V’ curves	**Analyze**
C266.6	**Compare** the performance characteristics of different electrical machines.	**Create**

MAPPING OF COs WITH POs & PSOs

Correlation Level: High – 3; Medium – 2; Low – 1

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS0 1	PSO 2	PSO 3
C266.1	2	1	-	-	-	-	-	3	3	3	-	-	2	2	3
C266.2	3	3	-	-	-	-	-	3	3	3	-	-	2	2	3
C266.3	3	3	1	2	-	-	-	3	3	3	-	-	2	2	3
C266.4	2	1	-	-	-	-	-	3	3	3	-	-	2	2	3
C266.5	3	3	1	2	-	-	-	3	3	3	-	-	2	2	3
C266.6	3	3	3	3	-	-	-	3	3	3	-	-	2	2	3
C266	2.7	2.3	1.8	2.3	-	-	-	3	3	3	-	-	2	2	3

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LABORATORY CODE OF CONDUCT

1. Students should report to the labs concerned as per the scheduled time table.
2. Students, who report late to the labs will not be permitted to perform the experiment scheduled for the day.
3. Students to bring a 100 pages note book to enter the readings /observations while performing the experiment.
4. After completion of the experiment, certification of the staff in-charge concerned, in the observation book is necessary.
5. Staff member in-charge shall evaluate for 25 marks, each experiment, based on continuous evaluation which will be entered in the continuous internal evaluation sheet.
6. The record of observations, along with the detailed procedure of the experiment performed in the immediate previous session should be submitted for certification by the staff member in-charge.
7. Not more than three students in a group would be permitted to perform the experiment on the equipment-based lab set up. However only one student is permitted per computer system for computer-based labs.
8. The group-wise division made at the start of the semester should be adhered to, and no mix up with any other group would be allowed.
9. The components required, pertaining to the experiment should be collected from the stores in-charge, after duly filling in the requisition form / log register.
10. After the completion of the experiment, students should disconnect the setup made by them, and return all the components / instruments taken for the purpose, in order.
11. Any damage of the equipment or burn-out of components will be charged at cost as a penalty or the total group of students would be dismissed from the lab for the semester/year.
12. Students should be present in the lab for the total time duration, as scheduled.
13. Students are required to prepare thoroughly, before coming to Laboratory to perform the experiment.
14. Procedure sheets / data sheets provided to the students, if any, should be maintained neatly and returned after the completion of the experiment.

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DOS AND DON'TS IN THE LABORATORY

Dos

- All bags most be left at the indicated place.
- Shoes and apron must be worn at all times.
- Be as neat as possible. Keep the work area and workbench clear of items not used in the experiment.
- Always check to see that the power switch is OFF before plugging into the outlet. Also, turn instrument or equipment OFF before unplugging from the outlet.
- The lab timetable must be followed strictly.
- Be PUNCTUAL for your laboratory session.
- Experiment must be completed within the given time.
- Noise must be kept to a minimum.
- Handle all apparatus with care.

Don'ts

- No ungrounded electrical or electronic apparatus is to be used in the laboratory unless it is double insulated or battery operated.
- When unplugging a power cord, pull on the plug, not on the cable.
- Students are strictly PROHIBITED from taking out any items from the laboratory.

Before Leaving Lab:

- Place the stools under the lab bench.
- Turn off the power to all instruments.
- Return all the equipment to lab assistant.
- Turn off the main power switch to the lab bench.
- Please check the laboratory notice board regularly for updates.

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CONTENTS

Sl.No.	List of Experiments
1.	No-load test and blocked rotor 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 (Poitier Triangle Method)
4.	Speed control of three phase Induction motor by 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.
	Additional Experiments
11.	Measurement of negative and zero sequence impedance of Alternator.
12.	Load test on 3-phase induction motor.

Expt. No.1.NO LOAD TEST AND BLOCKED ROTOR TEST ON 3 - Ø INDUCTION MOTOR

Aim:

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

Apparatus:

S.NO	Equipment	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

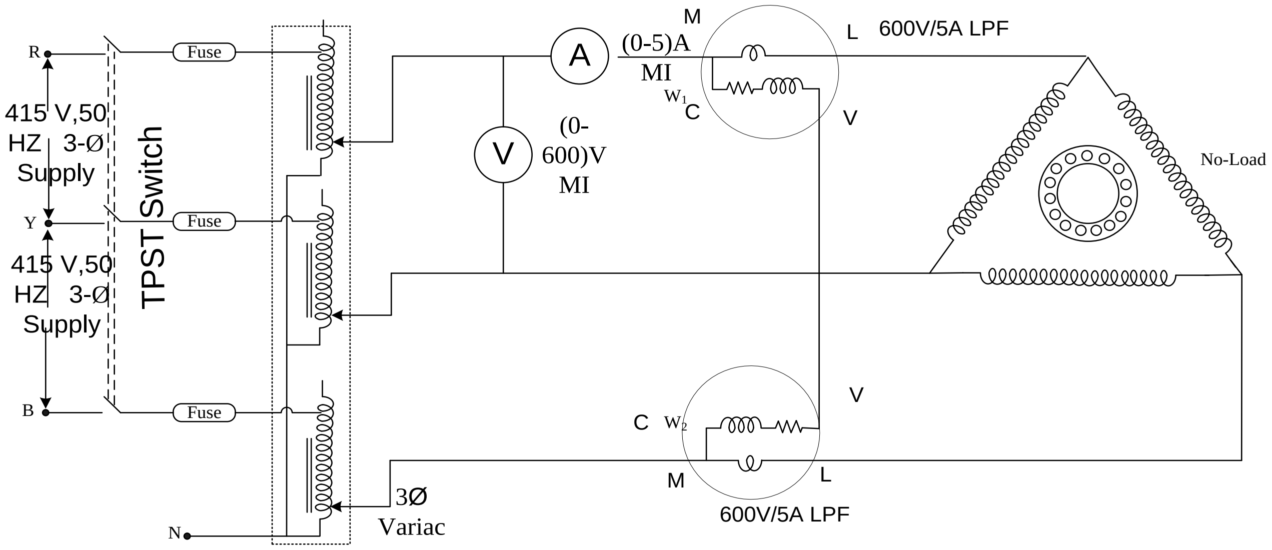
Theory:

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, core losses are known and from the SC test, the winding resistance and reactance are determined, 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 a 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 helpful in finding the performance details i.e. full load current, full load power factor, full load slip, efficiency, maximum power output and maximum torque through the no load and blocked rotor tests which are performed.

Circuit Diagram:



Procedure:

No – load test

1. Make 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 when one of the wattmeter shows negative readings 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 it 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)	$W_s= W_1+W_2$

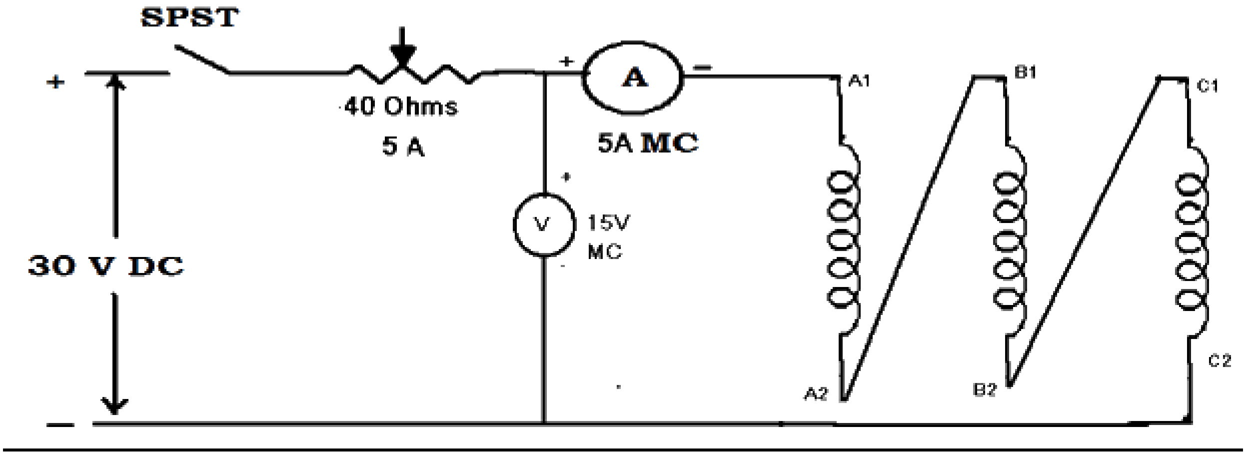
Calculations:

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

No load power factor $\cos Ø_0 = W_o / (\sqrt{3}\, V{*}I_0)$ find $Ø_0$

Short circuit P.F $\cos Ø_{sc} = W_s / (\sqrt{3}\, V_s I_s)$ find $Ø_s$

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	$R_{dc} = V/3I$

AC Stator resistance per phase **$R_s = 1.5\, R_{dc}$**

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. DrawhorizontalaxisOXandverticalaxisOY.Heretheverticalaxisrepresentsthevoltage reference.
2. With suitable scale, draw phasor OA with length corresponding to I_0at anangle Φ_0 from the vertical axis .Draw a horizontal line AB. $Ø_0$= Cos^{-1} (Woc/ √3V_0I_0).
   $Ø_{sc}$ = Cos^{-1} (Wsc/ √3VscIsc).
3. Draw OS equal to I_{SN} at an angle Φ_{SC} and join AS.
4. Draw the perpendicular bisector to AS to meet the horizontal line AB at C.
5. With C as centre, draw a semi-circle passing through A and S. This forms the circle diagram which is the locus of the input current.
6. From point S, draw a vertical line SL to meet the line AB.
7. Fix the point K as below.

   For wound rotor machines where equivalent rotor resistance R_2' can be found out:
   Divide SL at point K so that SK: KL= equivalent rotor resistance: stator resistance.

   For squirrel cage rotor machines:
   Find Stator copper loss using I_{SN} and stator winding resistance R_1.
   Rotor copper loss=total copper loss– stator copper loss.
   Divide SL at point K so that SK: KL=rotor copper loss: stator copper loss.

   Note:If data for separating stator copper loss and rotor copper loss is not available then assume that stator copper loss is equal to rotor copper loss .So divide SL at point K so that SK=KL

8. Fora given operating point P, draw a vertical line PE FG D as shown.

   Then,

   PD=input power,

   PE=output power,

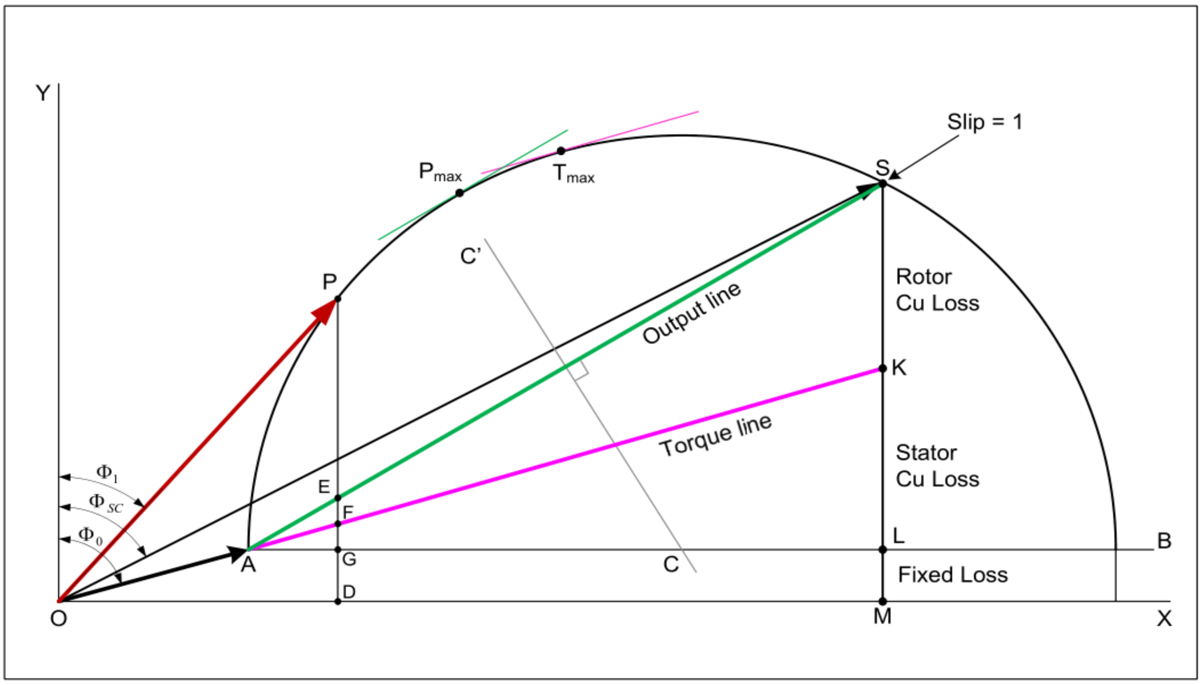
   EF=rotor copper loss,

   FG=stator copper loss,

   GD=constant loss(iron loss+ mechanical loss)

9. Efficiency of the machine at the operating point P,$\eta = \frac{PE}{PD}$
10. Power factor of the machine at operating point P=cos Φ_1
11. Slip of the machine at the operating point P,$S = \frac{EF}{PF}$
12. Starting to r queat rated voltage(in syn. watts)=SK

13. 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 the set angents touch the circle are respectively the maximum power point(T_{max}) and maximum torque point(P_{max})



Result:

Discussion:

- How can the maximum torque and maximum power be determined from the circle diagram?
- Show the motoring, generating and braking regions for an induction machine on its circle diagram.
- How can the equivalent circuit of an induction motor be found from the no load and blocked rotor tests.

Expt. No.2.PERFORMANCE CHARACTERISTICS OF SINGLE PHASE INDUCTION MOTOR

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

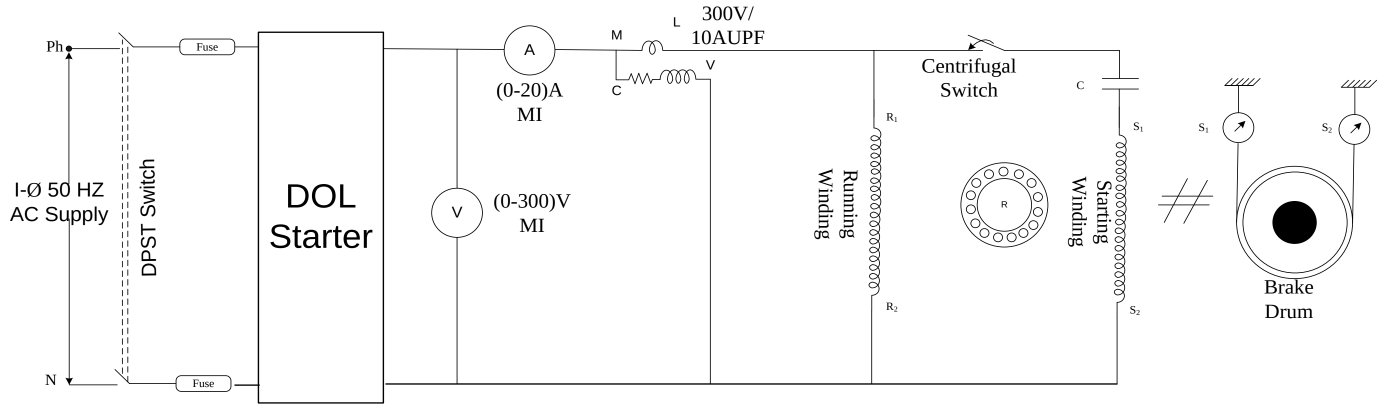
Apparatus:

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

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 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 note down the corresponding current and power readings.
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).

Tabular Form:

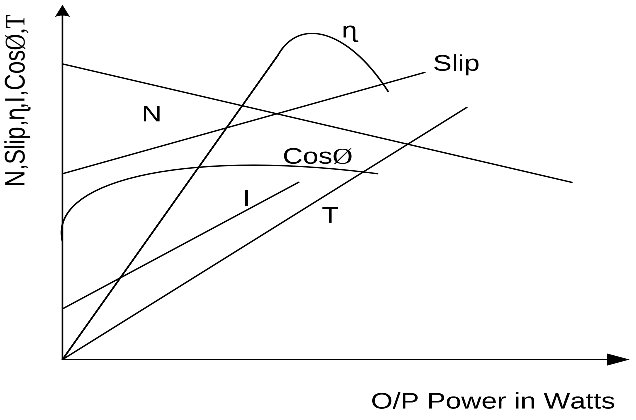
‘**r**’ is the radius of the brake drum; ‘**w_1**’is the reading of the wattmeter.

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										

Model Graphs:

Mechanical characteristic

Electrical characteristics



Results:

Viva Questions:

- Mention the application of single phase induction motors.
- What are the different types of single phase induction motors and their methods of starting?
- Why is a single phase induction motor noisier than a three phase motor?
- What are the typical values of the capacitor for starting and for running, how are they determined?

Expt. No.3 (A). 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.

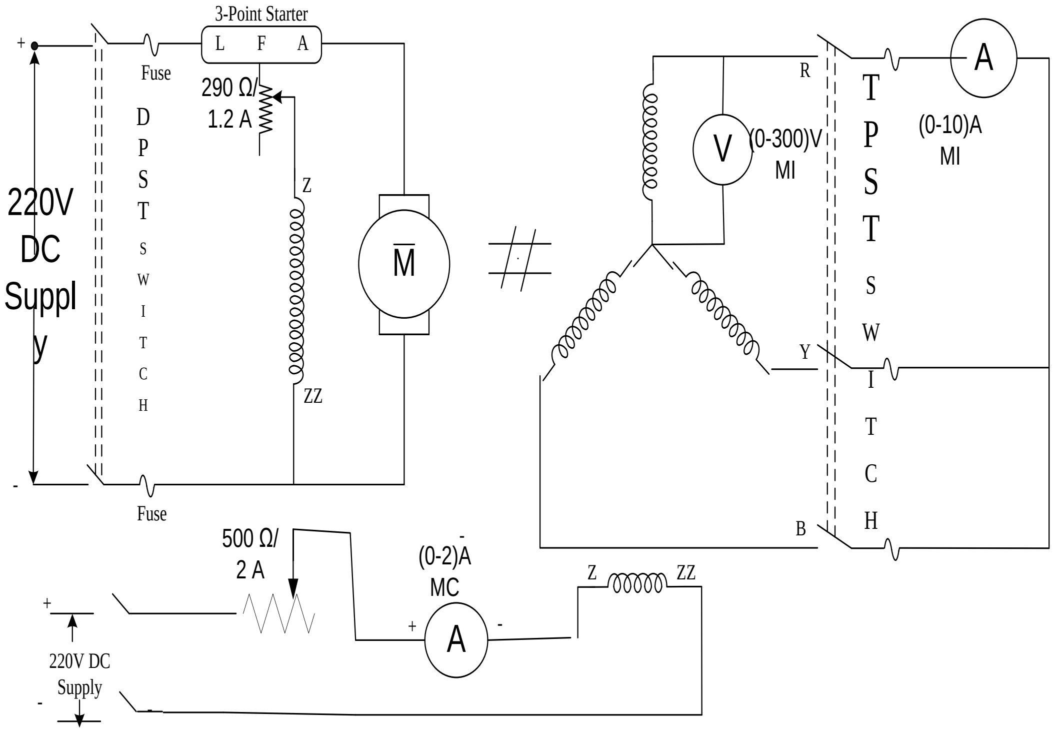
Apparatus:

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	500Ω, 2A	1
7	Tachometer	Digital	---	1
8	TPST knife switch	--	--	1

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 Poitier 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:



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.

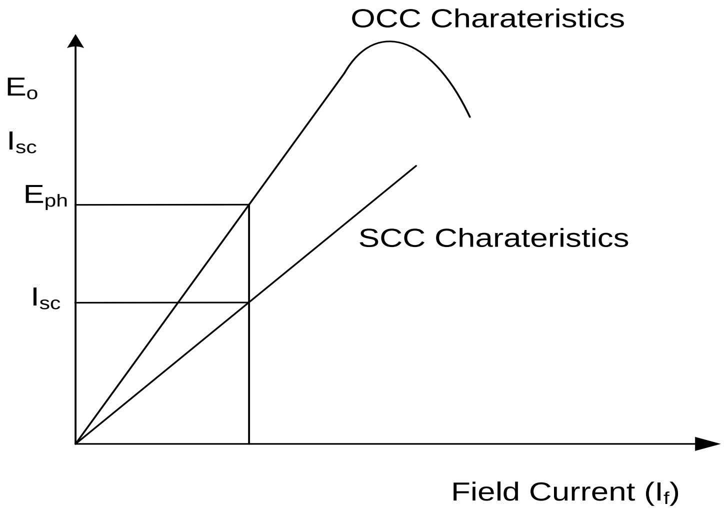
Tabular Form:

Open circuit test		
Sl.No	FIELD CURRENT (A)	O.C VOLTAGE (V)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Short circuit test	
S.C CURRENT (A)	FIELD CURRENT (A)

Model Graphs:

EMF method



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/ =

Eo = $\sqrt{(V\cos\Phi + IaRa)^2 + (V\sin\Phi - IaXs)^2}$

V =

Ia =

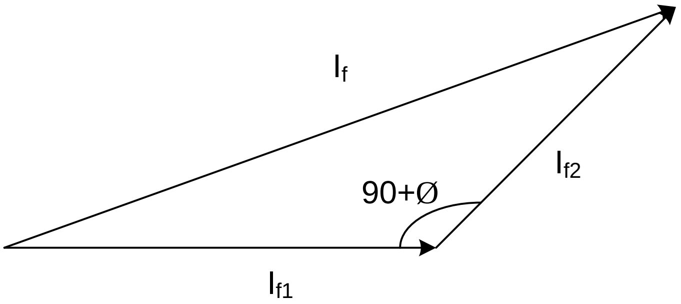
Xs = $\sqrt{Zs^2 - Ra^2}$

PF = cosΦ =, sinΦ =

Procedure to draw graph for MMF method:

1. Determine value of (V+ Ia*Ra * cosØ) and this is projected in to OCC to Find If1
   Short Circuit Corresponding Field Current taken as If2

   Lagging P.F.:

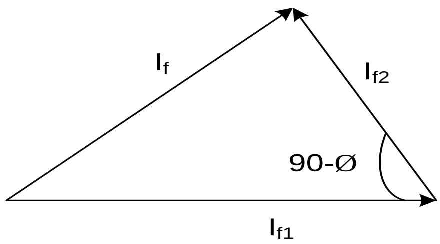


For Lagging P.F Resultant Field Current is $I_f = \sqrt{I_{f1}^2 + I_{f2}^2 + 2I_{f1}I_{f2}Cos(180-(90+\phi))}$

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

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

Leading P.F.:

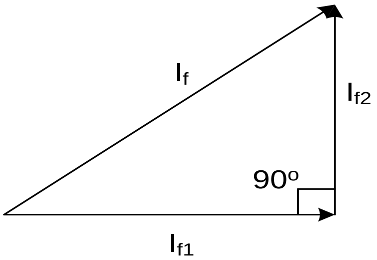


For Leading P.F Resultant Field Current is $I_f = \sqrt{I_{f1}^2 + I_{f2}^2 + 2I_{f1}I_{f2}Cos(180-(90-\phi))}$

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

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)

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

Result:

Expt. No. 3 (B). 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.	Rheostat	290ohms/1.2A	Wire-wound	1
5.	3-Φ Inductive Load	--	--	1

Theory:

Poitier 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 Poitier 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:

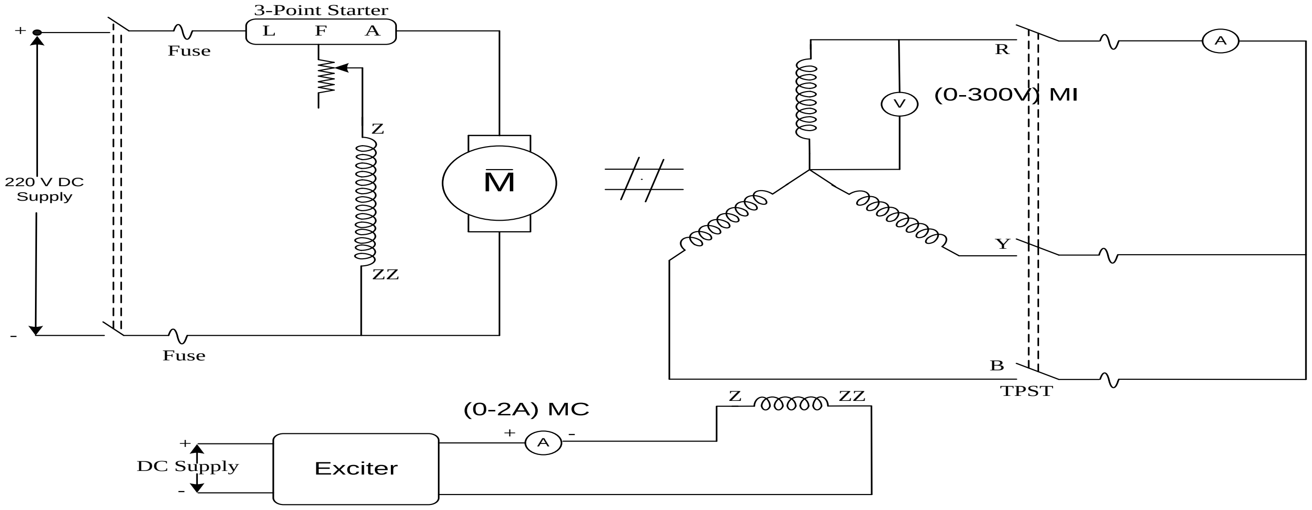
To V add resistance drop I*Ra and leakage reactance drop I*Xp for full load current. The resultant Eg is the voltage actually induced in the machine. FR is the excitation corresponding to the voltage Eg and is obtained from the O.C.C. From Fg subtract vector ally AC, which is the armature reaction m.m.f 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:

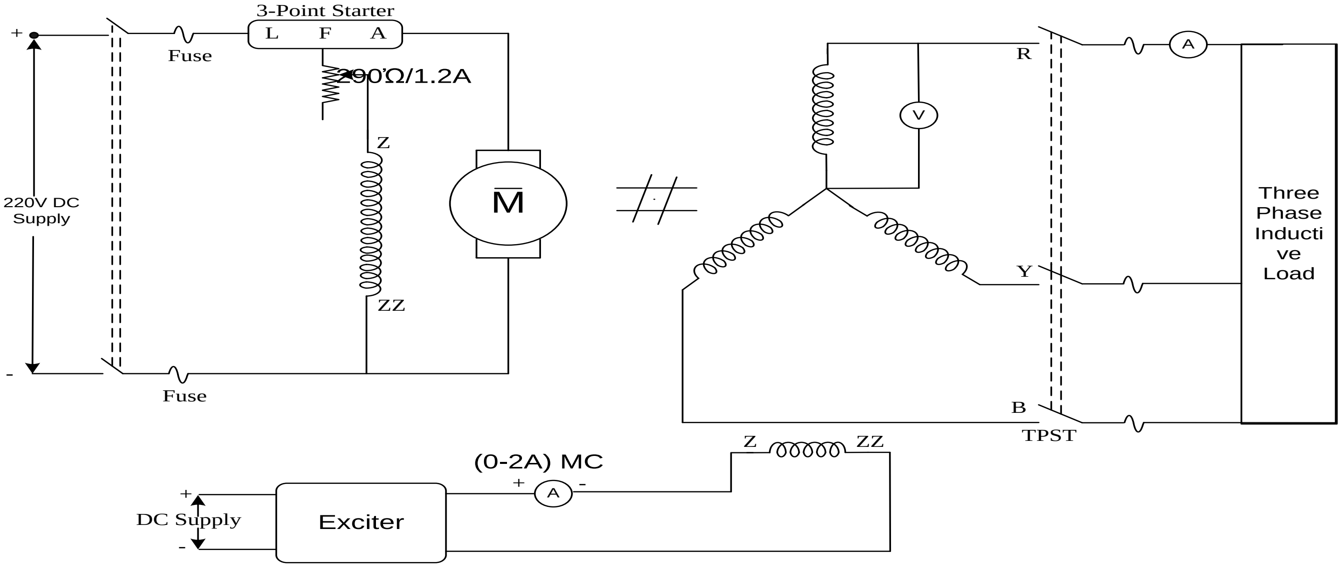
1. Connect the circuit for OCC as per Circuit Diagram
2. Start the Induction Motor using DOL Starter.
3. Increase the excitation of the alternator in steps.
4. Note down the field current and OC voltage.
5. Now connect the 3-Φ inductive load across the Armature terminals and increase theField current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

    The regulation of alternator is then calculated by the formulae.

Circuit Diagram :



Circuit Diagram for ZPF Characteristics



Procedure:

Note down the name plate details of the motor and alternator.

1. Connections are made as per the circuit diagram.
2. Switch ON the supply by closing the DPST switch.
3. Using the Three point starter, start the motor to run at the synchronous speed by adjusting the motor field rheostat.
4. Conduct Open Circuit test by varying the potential divider for various values of field current and tabulate the corresponding Open Circuit Voltage readings.
5. 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.
6. 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.
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 the Poitier 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

Tabular form:

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)

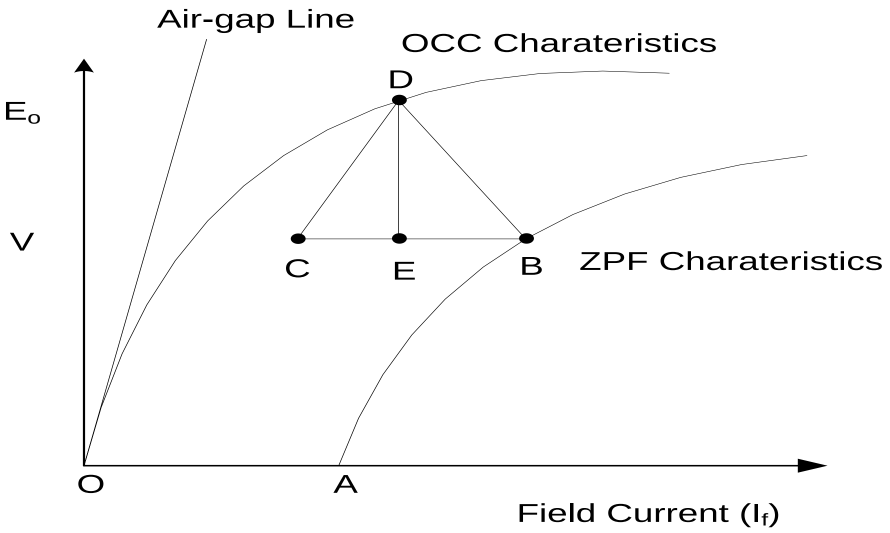
ZPF TEST

VOLTAGE	PHASE CURRENT	FIELD CURRENT

Observation table:

PF		VOLTAGE REG	
LAG	LEAD	LAG	LEAD

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 = $\sqrt{(V\,\mathrm{Cos}\Phi + IaRa)^2 + (V\,\mathrm{Sin}\Phi + IaXL)^2}$

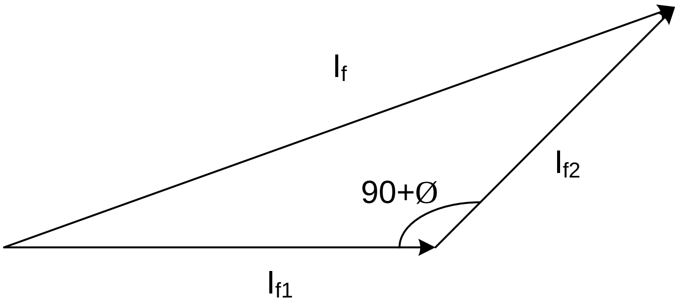
Air Gap EMF(Er) for leading p.f = $\sqrt{(V\,\mathrm{Cos}\Phi + IaRa)^2 + (V\,\mathrm{Sin}\Phi - IaXL)^2}$

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.:

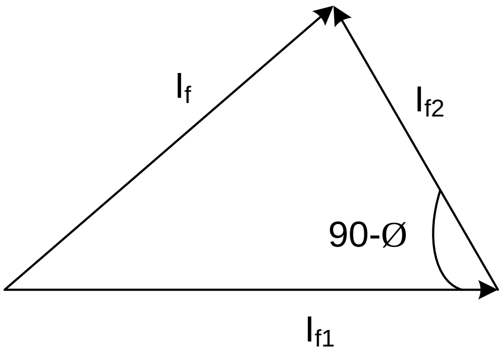


For Lagging P.F Resultant Field Current is $I_f = \sqrt{I_{f1}^2 + I_{f2}^2 + 2I_{f1}I_{f2}Cos(180-(90+\phi))}$

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

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

Leading P.F.:

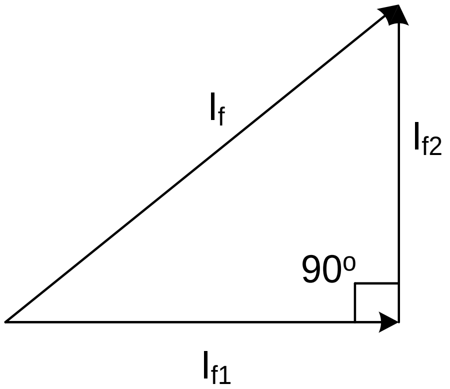


For Leading P.F Resultant Field Current is $I_f = \sqrt{I_{f1}^2 + I_{f2}^2 + 2I_{f1}I_{f2}Cos(180-(90-\phi))}$

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

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)

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

Result:

Expt. No.4.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:

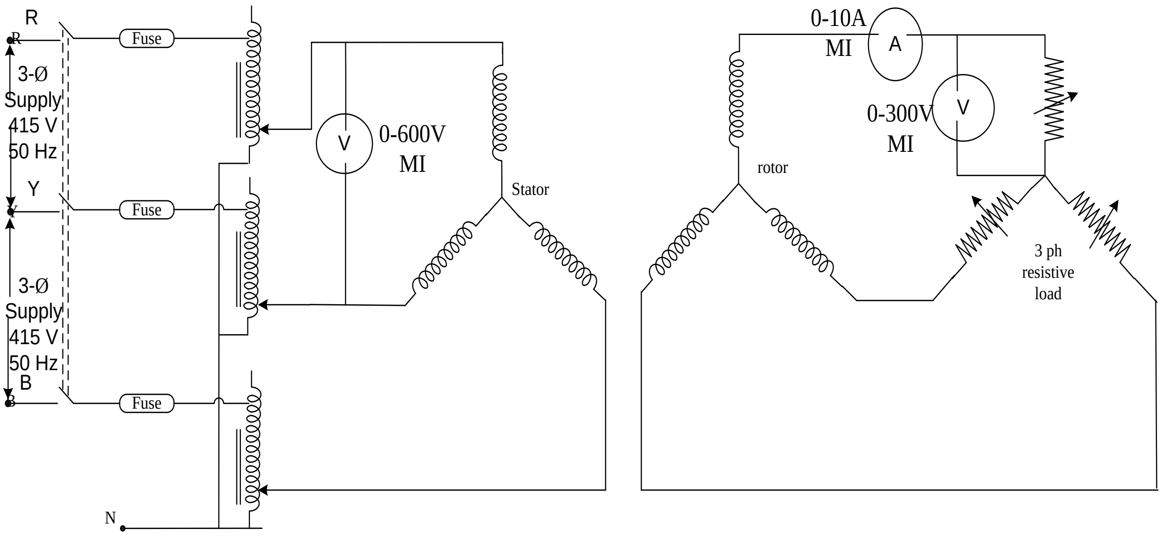
S.NO	Equipment	Specification	Quantity
1	Voltmeter	(0-600V, MI)	1
4	Rotor Rheostat	--	1
5	Tachometer	(0-9999rpm)	1
6	Rheostat	(40Ω, 5A)	1
7	3 – Ø Variac	(0-440 V, 15A)	1

Theory:

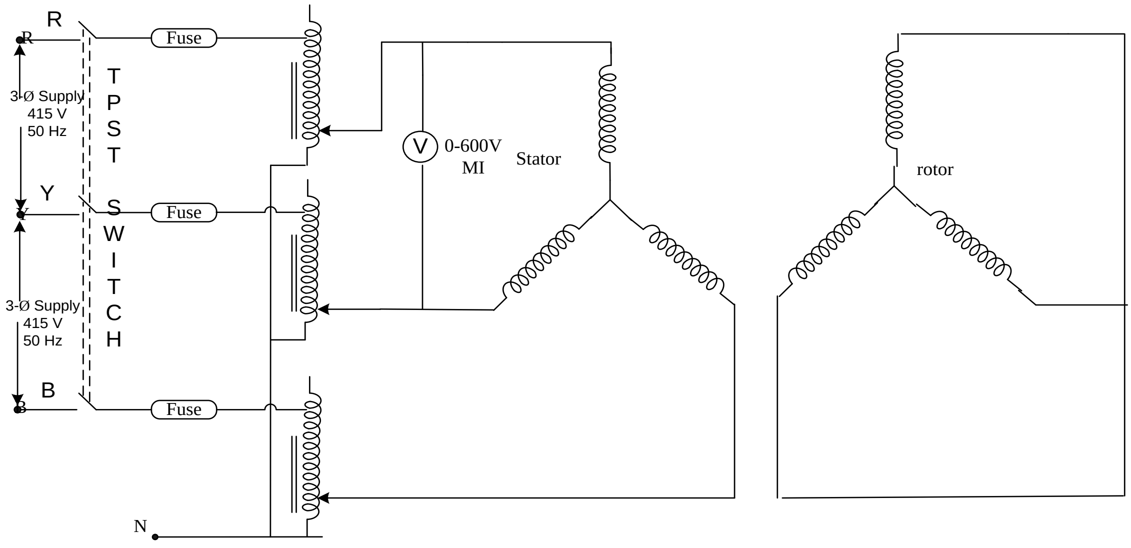
The speed of a 3-phase induction motor can be changed by changing the applied frequency, the numbers of poles and slip. The slip can be changed by changing the applied stator voltage and by changing the external resistance in the rotor circuit (slip ring motors only). The speed range obtained is small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

Circuit Diagram:

ROTOR RESISTANCE METHOD



STATOR VOLTGE CONTROL



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.

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 Form:

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

Stator voltage control method		
Sl.No	**Voltage**	**speed**

Result:

Expt. No.5.RETARDATION TEST, DYNAMIC BRAKING OF D.C SHUNT MOTOR

Aim: To conduct the retardation test on a DC Shunt motor.

Apparatus:

Sl.No	Name of the Apparatus	Type	Range	Quantity
1	Ammeter	MC	0 – 1/2 A	1
2	Ammeter	MC	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

Theory:

This method is applicable for shunt motor and is used for finding stray losses. By 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. The armature keeping running even though power is shut down and its kinetic energy is used to meet the rotational losses i.e friction winding and iron losses. Gradually the armature stops.

Kinetic energy of the armature = ½ $I\omega^2$

I = moment of inertia of armature

ω= angular velocity

Rotational losses Ps= rate of loss of kinetic energy

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

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

Two quantities are required:

Moment of inertia of the armature

$\frac{d\omega}{dt}$Or$\frac{dN}{dt}$

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 readings of speed and voltmeter at different times, a curve is drawn between time and speed.

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

Finding moment of inertia (I):

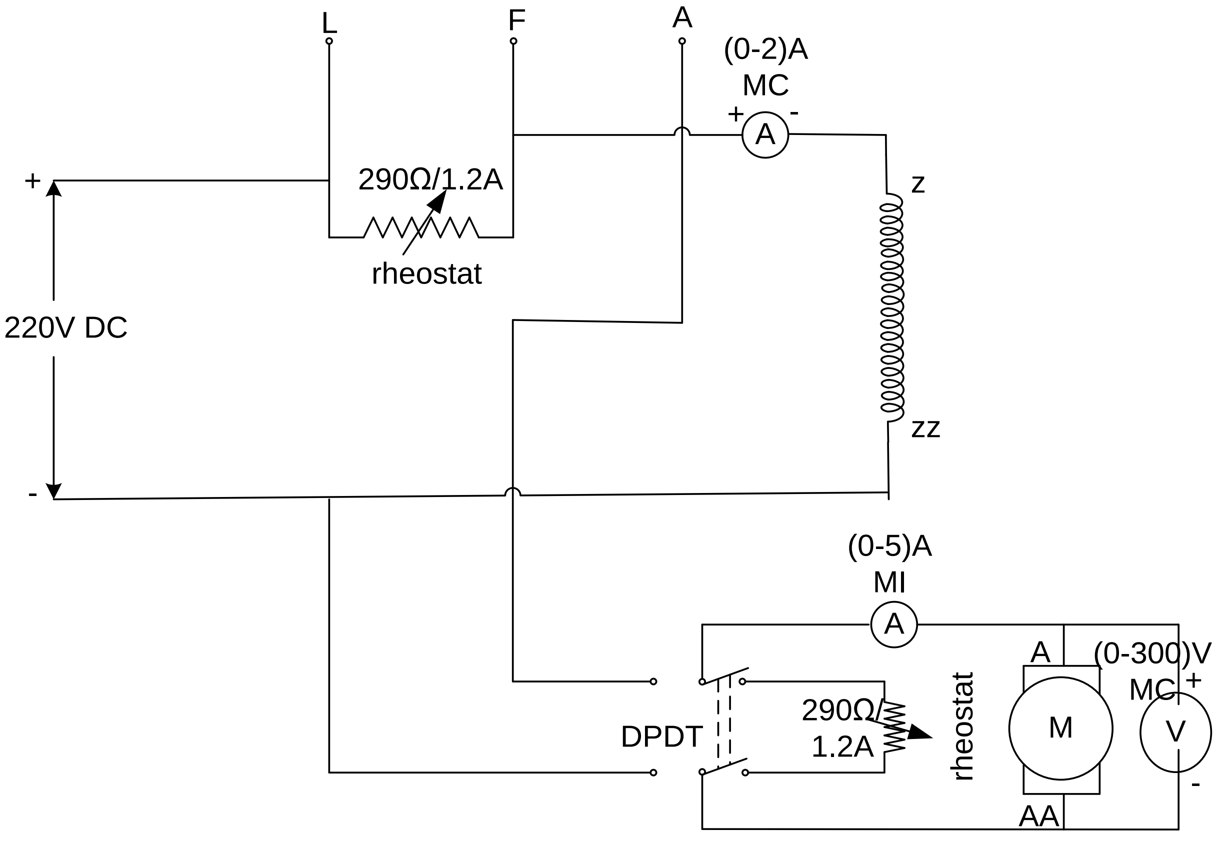
In this method time taken to slow down say by 5% is noted with armature alone. Next a retardation torque is applied to the armature and given time is noted. The double throw switch S while cutting of the armature from supply automatically joins it to a non-inductive resistance R. The power drawn by this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

Let Ps' be this power

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

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

Circuit Diagram:



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 Form:

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

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

Result:

EXPT.NO.5. (B) DC SHUNT MOTOR BRAKING

Aim: To study the dynamic braking in DC Shunt motor

Apparatus:

Sl.No	Name of the Apparatus	Type	Range	Quantity
1	Ammeter	MC	0 – 1/2 A	1
2	Ammeter	MC	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 switches	--	--	1

Theory:

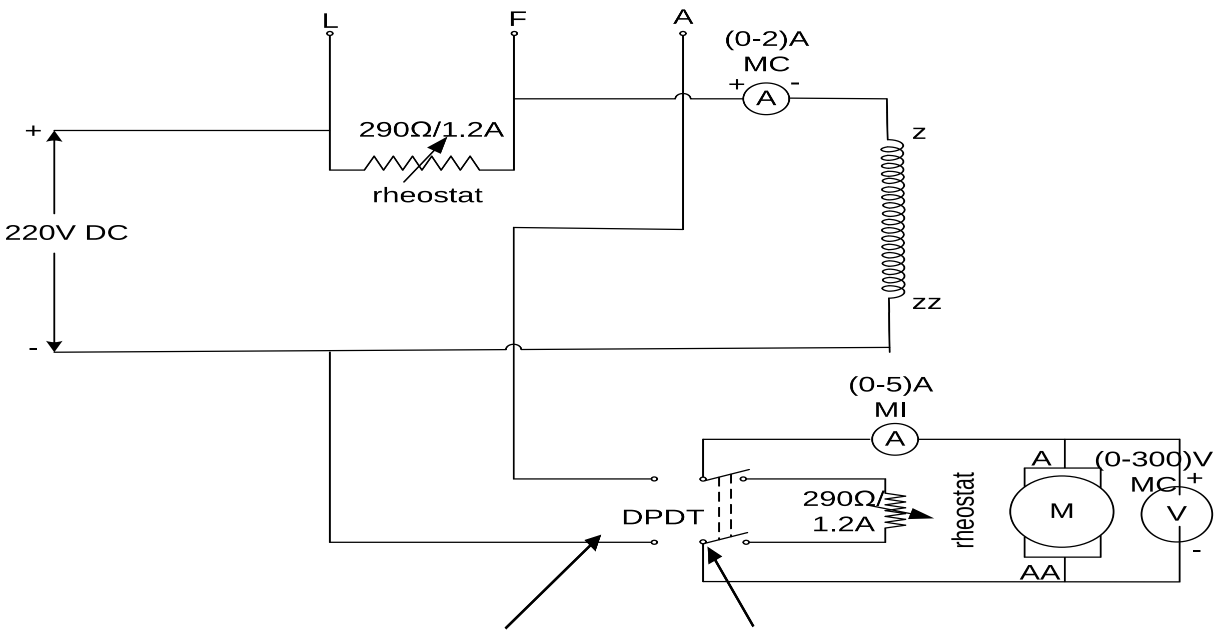
Braking in any electrical machine is accomplished mainly by three methods:

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

Regenerative braking allows the stored energy in the m/c to be fed 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 implemented and tested for the given DC motor. The plugging is 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 carried out using a dynamic model for the DC machine.

Circuit Diagram:



Procedure: **11' position 2 2" position**

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.

Plugging voltage should be varied from 25 to 50V and the time taken by the m/c to stop should be recorded.

Note: Field to be separately excited during braking.

Tabular form:

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

Result:

Expt. No.6.POWER FACTOR IMPROVEMENT USING CAPACITORS

Aim:

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

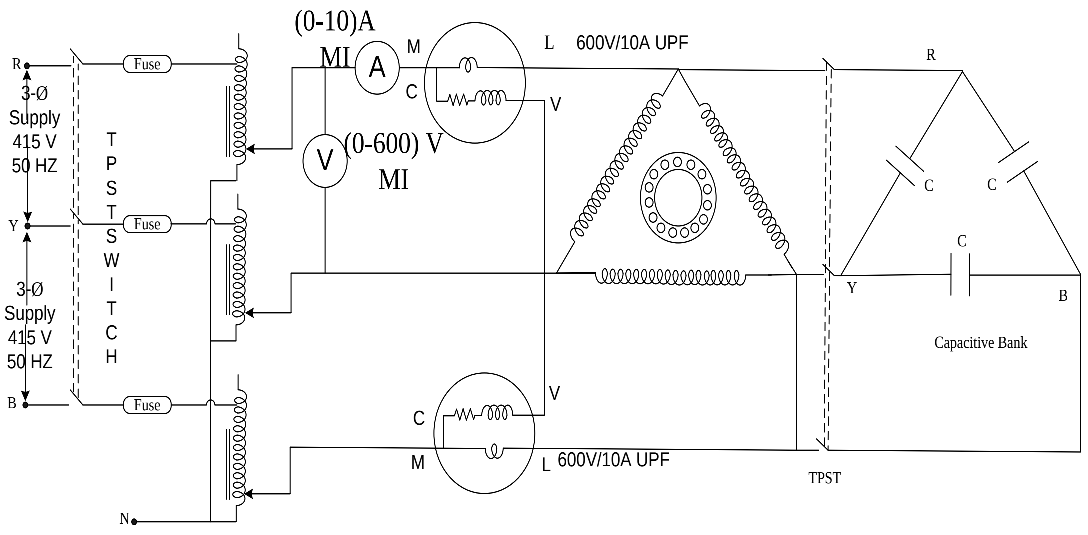
Apparatus:

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		400V,2KVAR	1
5.	TPST	Knife switch	-	1

Theory:

The power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit.More the inductive the circuit nature is, more energy losses and less power factor. Less the inductive the circuit nature is, less energy losses and less power factor. Less the Capacitive the circuit nature is, more energy losses and less power factor. More the Capacitive the circuit nature is, less energy losses and less power factor.

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

$P_{in} = W_1 + W_2$

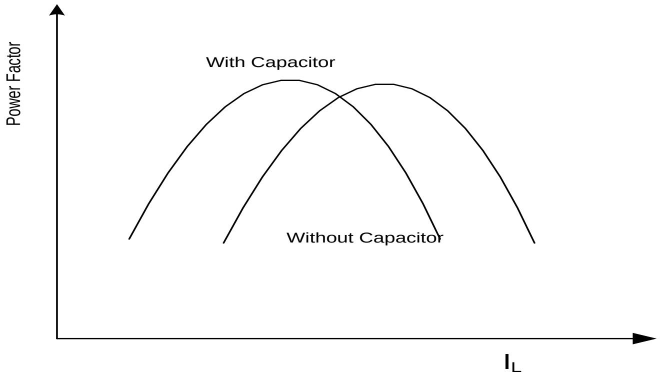
Efficiency $\eta = P_{out} / P_{in}$

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

Tabular Form:

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:

Viva:

1) What is the range of power factor improvement, one can expect, when 2, 3 and 5 KVAR capacitors per phase are provided?

2) Draw the phasor diagram of the load, with and without capacitors.

Expt. No.7.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:

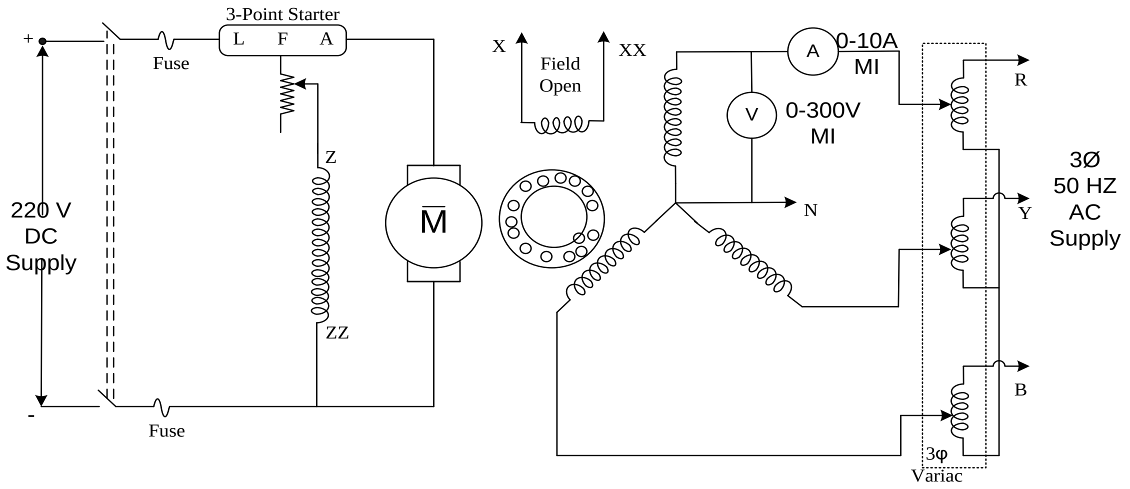
Sl.No	Meter	Range	Type	Quantity
1.	Voltmeter	0-600V	MI	1
2.	Ammeter	0-5A	MI	1
3.	Tachometer	0-10000 RPM	Analog	1
4.	Variac	3- Φ, 415 V /15 A		1

Theory:

The values of X_d and X_q are determined by applying areduced balanced external voltage (say, V volts) to an unexcited machine at 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 oscillograph. 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 Form:

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 $\Psi = \delta + \phi$

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

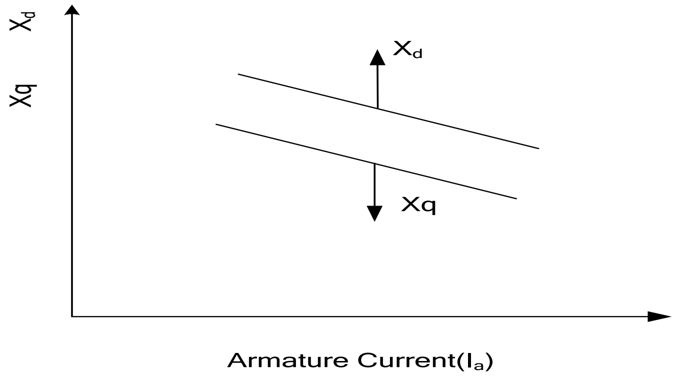
%Regulation $\%R = \frac{(E_o - V)}{V} X100$

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

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

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

Expected graph:



Result:

Expt. No.8.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:

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

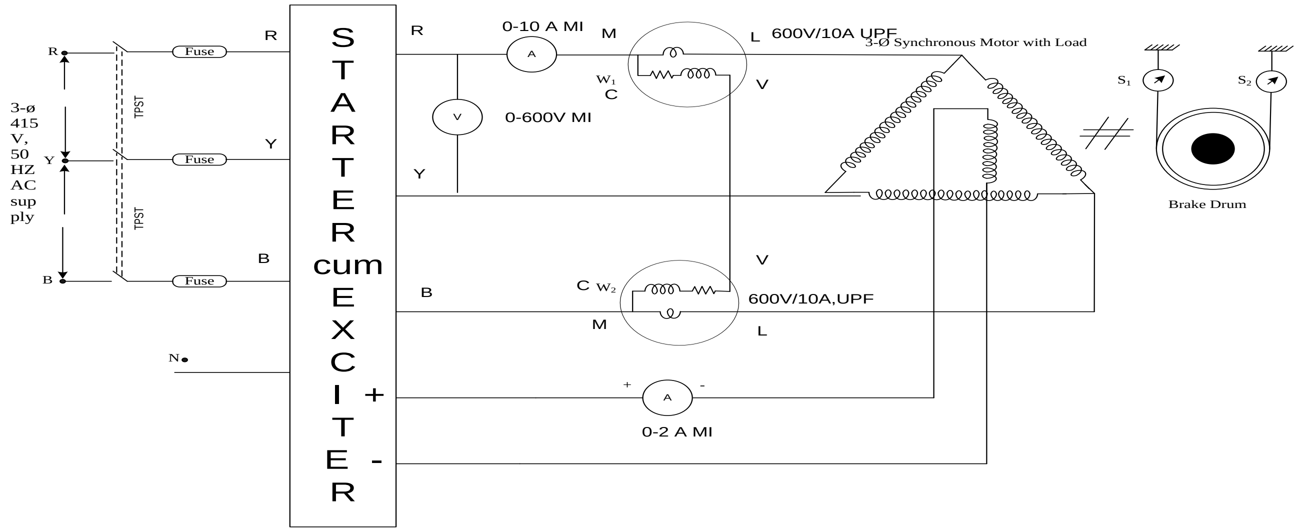
Theory:

If excitation is varied from very low (under excitation) to very high (over excitation) value, then current I_a 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 (I_a) against field current (I_f) 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(I_f), then the shape of the graph looks like an inverted V. such curves obtained by plotted p.f against I_f, at various load condition are called inverted V curves of synchronous motor

Circuit Diagram:



Procedure:

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

(2) Connections are made as per 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.

Tabular Form:

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.						

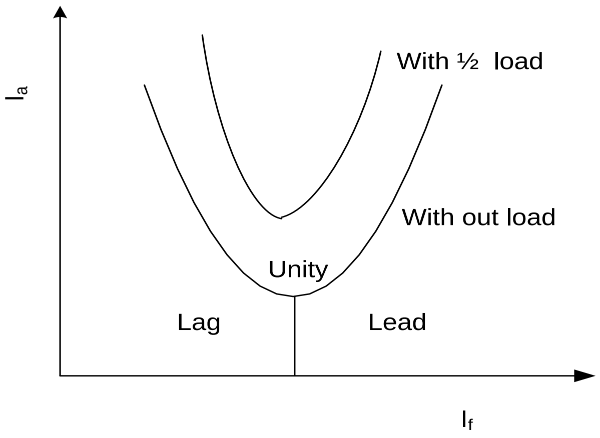
Load **V_L = ……..**						
Sl.No	Field Current I_f(A)	Armature Current I_a(A)	W1	W2	Power (P) = W1+W2	Power Factor = (P /√3 V_L I_a)
1.						
2.						
3.						
4.						
5.						
6.						

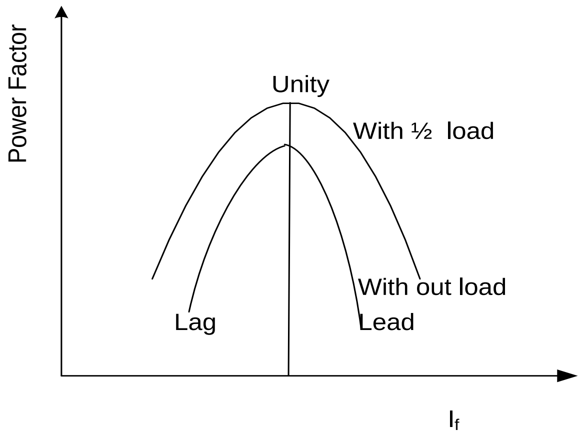
Expected graph:

The graph is drawn for-

(1) Armature current Vs Excitation current.

(2) Power factor Vs Excitation current.





Result:

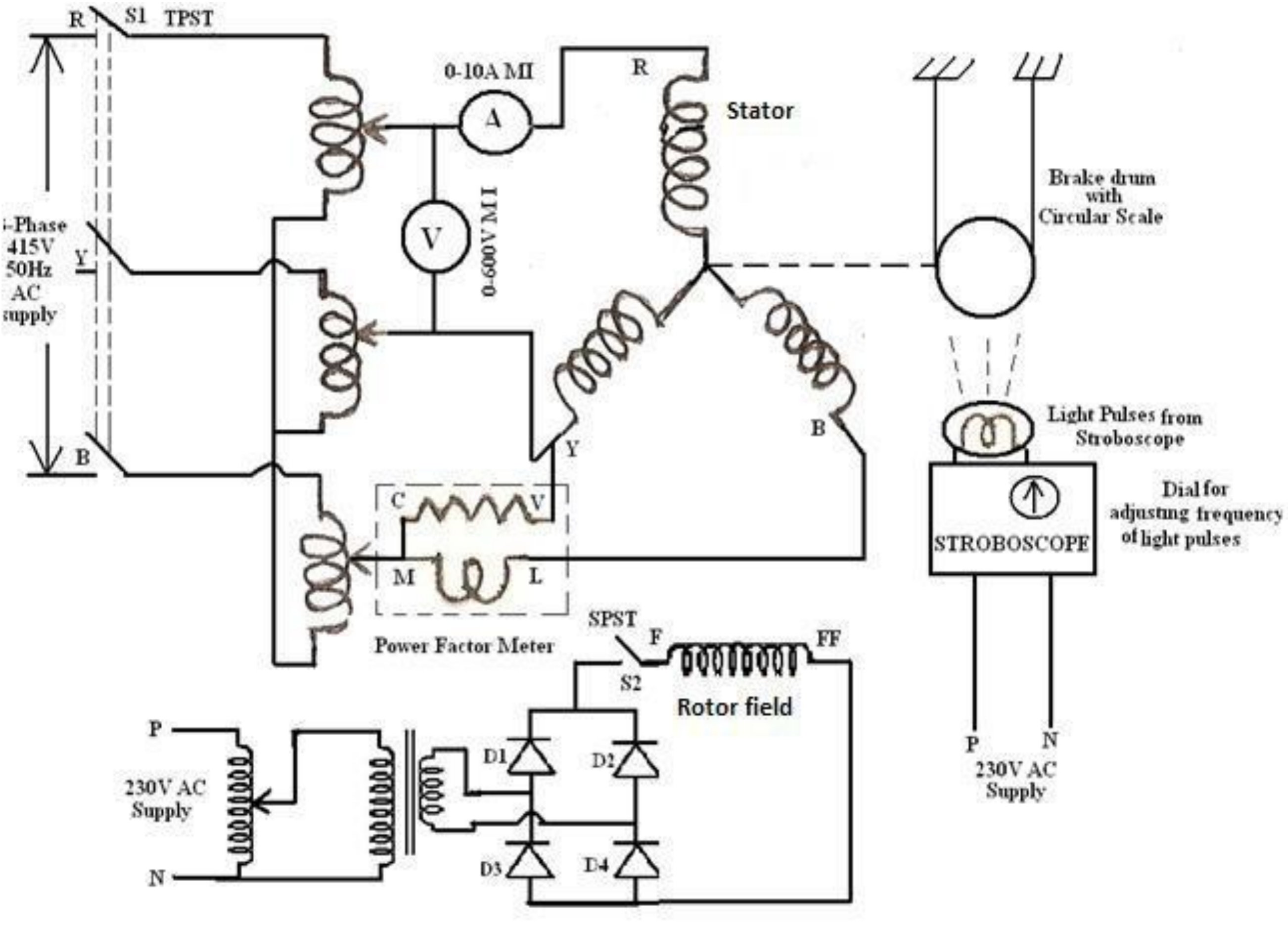
Expt. No.9.POWER ANGLE CHARACTERISTICS OF SYNCHRONOUS MOTOR

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

Apparatus:

Sl.No	Equipment	Range and Type	Quantity
1.	Voltmeter	(0-600V, MI)	1 No
2.	Ammeter	(0-10A, MI)	1 No
3.	Power factor meter	(0-10A, 600V, 0.5lag,1,0.5lead)	1 No
4.	Stroboscope	--	1 No
5.	Tachometer	(0-9999rpm)	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.
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 ofthe synchronous motor. Switch on the supply to the field. Adjust the excitation till the pf meterreads unity. Keep the pf at unity throughout the experiment.

3. Switch on the power supply tothe stroboscope and let thelight fall on the circular scale attached to the brake drum.Adjust the number of light pulses falling on the circular scale till the index mark appears steady. 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.

Tabular Form:

Sl.No	**Reading on circular scale**	**Difference ΔQ (degrees)**	**Speed (N) rpm**	**W_1**	**W_2**	**Torque (T)= 9.81(W1-W2)r Nm**	**Power(P)= 2πNT/60 Watts**	**Input power= √3VIcosΦ Watts**

Sample calculations:

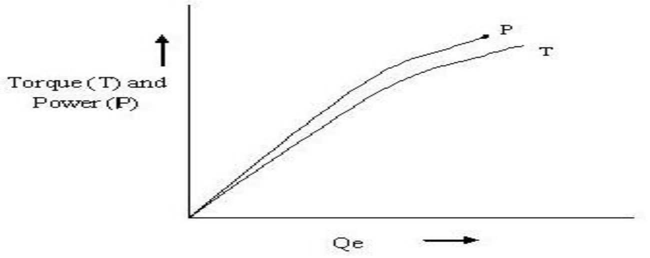
In space **$\theta e = (2/P)\ \theta m$**

Where

θe= torque angle in electrical degrees,

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

Expected graph:



Result:

Expt. No.10.BRAKE TEST ON A 3- PHASE INDUCTION MOTOR

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

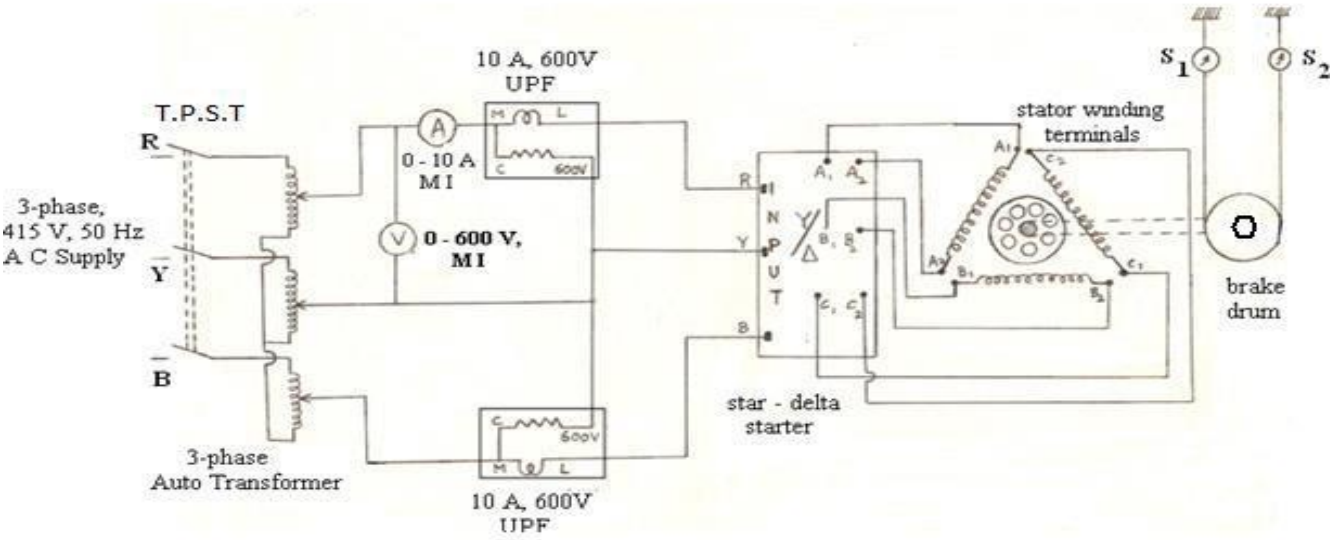
Apparatus:

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:

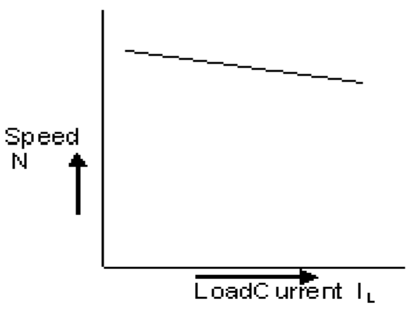
1. Give the connections as per the circuit diagram.

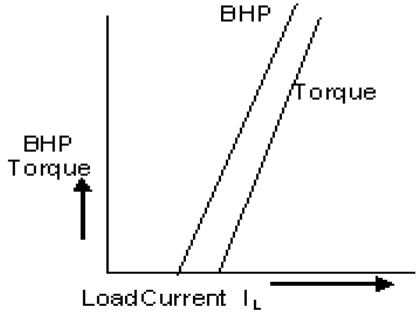
2. By using Variac, gradually apply the rated voltage i.e. 415 V to the motor.
3. Take no–load readings of current and power.
4. Now by increasing load on the motor, note the corresponding current and power readings.
5. Increase the load gradually until rated current flows.
6. Take at least six readings.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

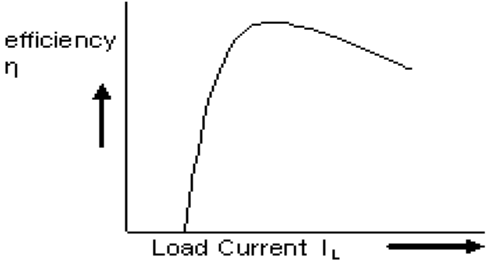
Tabular Form:

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 = $\frac{2\pi NT}{60}$ (watts)**	I/P = W1 + W2 (watts)	$\eta = \frac{O/P}{I/P} \times 10$
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									

Expected graphs:


1.Speed vs. Load current


2. BHP & Torque vs. Load Current


3. Efficiency vs. Load current.

Result:

Expt. No.11.MEASUREMENT OF NEGATIVE AND ZERO SEQUENCE IMPEDANCE OF ALTERNATOR

Aim:

To determine experimentally Positive, Negative and Zero Sequence Impedances of 3-Phase Alternator.

Apparatus:

S. No	Item	Type	Range	Quantity
1	Voltmeter	MI	(0-600)V	1
2	Ammeter	MI	(0-5)A	1
3	Ammeter	MC	(0-2)A	1
4	Rheostats	WW	300Ohms/1.5A	3
5	Variac	1-Phase	(0-270)V	1
6	Tachometer	Digital	(0-9999)RPM	1
7	Connecting Wires			As Needed

Theory:

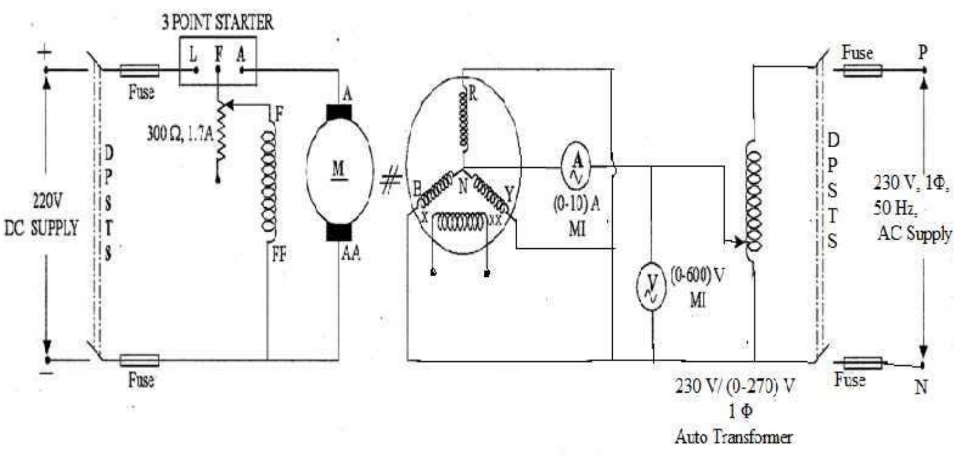
The sequence Impedances of an equipment or a component of power system are the positive, negative and zero sequence impedances. They are defined as the impedance offered by the equipment to the flow of corresponding sequence currents.

In asymmetrical rotating machines the impedances met by armature currents of a given sequence are equal in the three phases .Since by definition the inductance, which forms apart of impedances, is the flux linkages per ampere, It will depend upon the phase order of the sequence current relative to the direction of rotation of the rotor; positive, negative and zero sequence impedances are unequal in the general case.
In fact for rotating machine, the positive sequence impedance varies, having minimum value immediately following the fault and then increases with time until steady state conditions are reached when the positive sequence impedance corresponds to the synchronous impedance.
The positive sequence impedance depends upon the working of the machine, i.e. whether it is working under sub transient, transient or steady state condition .The impedance under steady state condition is known as the synchronous circuitand measured by the well- known open circuit and short circuit tests.

For the measurement of Negative sequence impedance, the machine is driven at rated speed and a reduced voltage is applied to circulate approximately the rated current .It is to be noted here that since negative sequence currents flow in this case, there is possibility of hunting which will results in oscillation of the pointer of the ammeter .The mean reading maybe taken.

Zero Sequence Impedance is quite variable and depends upon the distribution i.e. the pitch and breadth factors. If the windings were uniformly distributed so that each phase produces a sinusoidal distribution of the mmf, then the superposition of the three phases with equal instantaneous currents cancel each other and produce zero sequence reactance except for slot and end-connection fluxes .In general zero sequence impedance is much smaller than positive and negative sequence impedances. The machine must, of course, be star connected for otherwise the term zero sequence has no significance as no zero-sequence currents can flow. The machine is at standstill and a reduced voltage is applied.

Circuit Diagram:



Procedure:

(A)Measurement of Positive Sequence Impedance (Z_1): O.C (Open Circuit) Test:

1. ConnecttheAlternatorsetasshowninthecircuitdiagramandstartthemotorandadjustthe speed to the rated value
2. Switch ON the DC supply to the field of the Alternator
3. By increasing the excitation gradually note the field current If and generated voltage pf the Alternator.
4. Record the readings and plot the OC Characteristics as shown in the Model Graph.

(B) S.C (Short Circuit) Test:

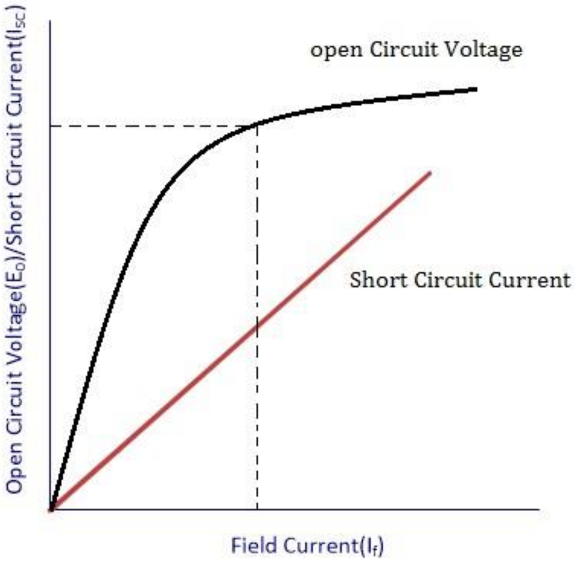
1. Keeping the previous connections unchanged replace voltmeter by ammeter and short the other two phase with neutral as shown in the circuit diagram.
2. RuntheAlternatorsetatratedspeedandnotedowntheexcitationcurrentwithrespectto short circuit current.
3. PlotthecurvefieldcurrentversusShortcircuitcurrentonthesamegraphdrawnforOpen circuit test.

Tabular Form:

O.C (Open Circuit)Test		
Sl.No	**Field Current (I_f)in**	**Open Circuit Voltage(E_0)**

SC(Short Circuit)Test		
Sl.No	**Field Current(I_f)**	**Short Circuit Current(I_{SC})**

Expected graphs:



Calculations:

Measurement of Positive Sequence Impedance (Z_1):

Positive sequence impedance

$$Z_1 = Z_S = \frac{E_0 \ (Per\ phase\ open\ circuit\ voltage0)}{I_{SC} \ (Per\ phase\ short\ circuit\ current)}$$

Measurement of Negative Sequence Impedance (Z_2):

1. Connect the machine as shown in figure.
2. Run the machine at rated speed.
3. Gradually increase the excitation such that the short circuit does not exceed full load value.
4. Note down the readings of Voltage, Current and Power.

Sl.No	Voltage (V)	Current(A)	Power(W)

Negative sequence impedance

$$Z_2 = \frac{V}{\sqrt{3} \times I}$$

Wattmeter reading W=VI Sin_θ

Therefore Negative Sequence Impedance $X_2 = Z_2 \times \sin\theta$

Measurement of Zero Sequence Impedance (Z_0):

1. Connect the armature windings in parallel as shown in the circuit diagram.
2. Short circuit the Alternator field winding.
3. In this case machine need not be in running condition.
4. Applyratedcurrenttoeachphasewindingwhichareconnectedinparallelthroughasingle phase Variac.
5. Take readings of voltage and current.

Sl.No	Voltage (V)	Current(A)

Zero Sequence Impedance $Z_0 = \frac{V}{3 \times I}$

Precautions:

1. Avoid loose and wrong connections.
2. Ensure that the auto transformer is at minimum position before powering the circuit.
3. Do not exceed the rated current of transformer while conduction experiment

Result:

Expt. No.12.LOAD TEST ON 3-PHASE INDUCTION MOTOR

Aim:

To conduct load test on 3-phase induction motor and draw the performance characteristics curves

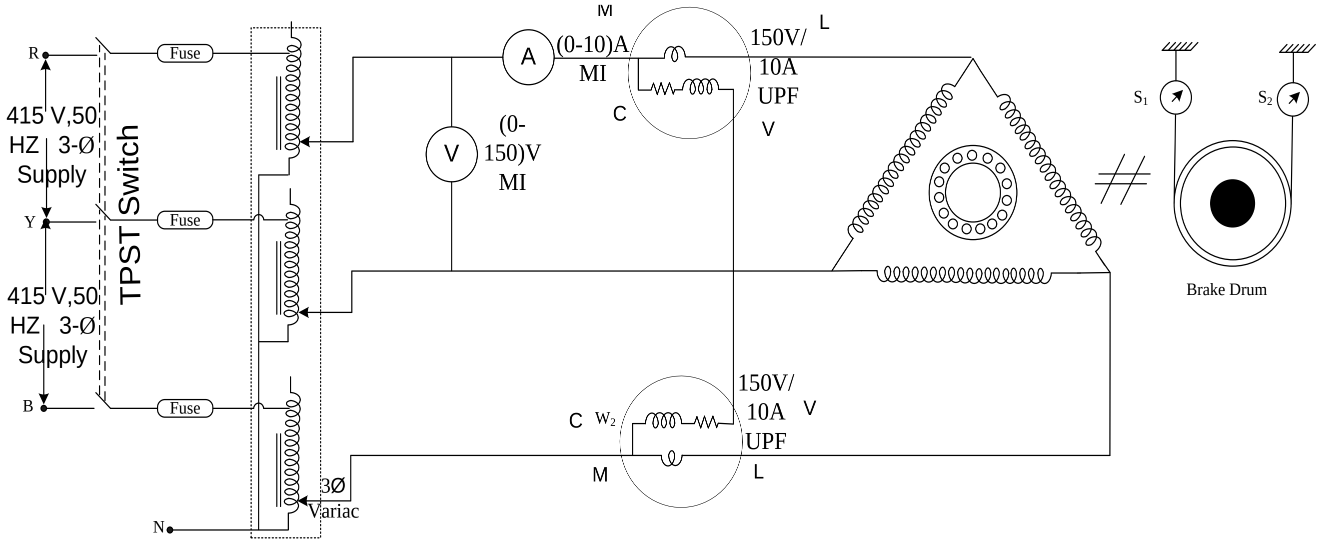
Apparatus:

S.NO	Equipment	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

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 wind age loss+ Iron loss) and then decreases with further increase in load.

Circuit Diagram:



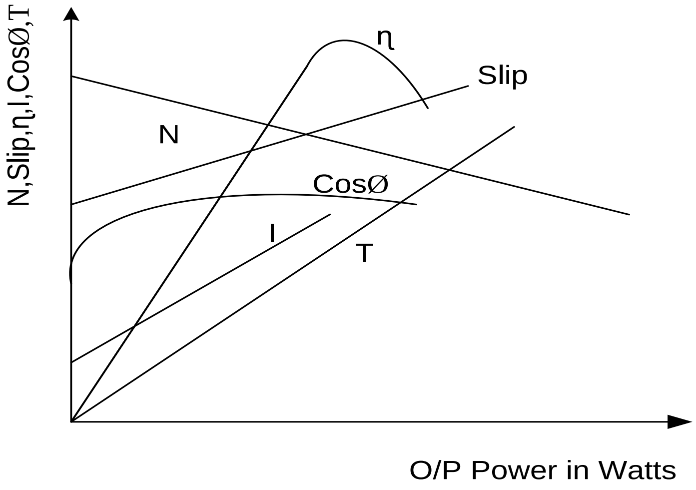
Procedure:

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.

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

Expected graphs:



Result: