LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY
An Autonomous Institution
(Approved by A.I.C.T.E & Affiliated to JNTU, Kakinada)
Accredited by NBA & NAAC with "A" Grade
Jonnada (Village), Denkada (Mandal), Vizianagaram Dist – 535 005
Phone No. 08922-241111, 241112
E-Mail: lendi_2008@yahoo.com Website: www.lendi.org

Department of Electrical and Electronics Engineering

LAB MANUAL

Name of the Faculty : Mr. K.Praveen kumar yadav

Name of the laboratory : Electrical Machines-II

Regulation : R20

Subject Code : C218

Branch : Electrical and Electronics Engineering

Year & Semester : III B.Tech- I Semester

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INSTITUTE

VISION

Produce globally competent and quality technocrats with human values for the holistic needs of industry and society.

MISSION

- Creating an outstanding infrastructure and platform for enhancement of skills, knowledge and behaviour of students towards employment and higher studies.
- Providing a healthy environment for research, development and entrepreneurship, to meet the expectations of industry and society.
- Transforming the graduates to contribute to the socio-economic development and welfare of the society through value-based education.

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Department of Electrical and Electronics Engineering

VISION

To be a hub for imparting knowledge, skills, and behaviour for exemplary contributions in the field of Electrical and Electronics Engineering.

MISSION

- To impart Technical Education through the state-of-the-art infrastructure facilities, laboratories and instruction.
- To inculcate industry-oriented learning through industrial visits, internships, projects at Industries, MOUs, to make students' technically skills oriented.
- Creating conducive environment for higher education, employment and entrepreneurship through quality education, professional skills and research.
- To promote societal commitment among students by inculcating moral and ethical values.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates shall have strong foundation in core and allied Electrical and Electronics Engineering, in sciences and mathematics, to become globally competent in designing, modelling and critical problem solving.

PEO2: Graduates shall involve in research activities in the field of electrical and electronics engineering through lifelong learning and provide solutions to engineering problems for sustainable development of society.

PEO3: Graduates shall have good communication skills and socio-ethical values for getting employment or higher studies by excelling in competitive examinations and be able to work in supportive and leadership roles.

PROGRAM OUTCOMES (POs)

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of Solutions**: Design solutions for complex 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 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 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.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the 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 (PSOs)

PSO1: Capable of design, develop, test, verify and implement electrical and electronics engineering systems and products.

PSO2: Succeed in national and international competitive examinations for successful higher studies and employment.

COURSE OUTCOMES

S. No.	DESCRIPTION
C218.1	Analyze the performance characteristics of AC machines by Effective Collaboration in teams
C218.2	Apply speed control techniques on various AC machines that are required for project designs
C218.3	Estimate how much reactive power is reduced by capacitor banks in order to abide by environmental requirements
C218.4	Determine the voltage regulation using specific methods are applied in industrial alternators
C218.5	Estimate the reliable data by Conducting tests accurately for AC motor performance evaluation by Prioritizing safety protocols

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COURSE INFORMATION SHEET

(Academic Year: 2021-22)

PROGRAM: **ELECTRICAL AND ELECTRONICS ENGINEERING**	DEGREE: **B. TECH**
COURSE: **Electrical Machines-II Lab**	SEMESTER: **II-II** CREDITS: **1.5**
COURSE CODE: **C218** REGULATION: **R20**	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: **Electrical Machines**	CONTACT HOURS**: 3 hours/Week**.
CORRESPONDING LAB COURSE CODE (IF ANY):	LAB COURSE NAME (IF ANY):

SYLLABUS:

UNIT	DETAILS	HOURS
I	Demonstration of lab Experiments	**3**
II	Designing of Circuits by the students in lab observations	**3**
III	Brake test on Three Phase Induction Motor	**3**
IV	No–load & Blocked Rotor Tests on Three Phase Induction Motor	**3**
V	Speed Control of Induction Motor by V/f method	**3**
VI	Regulation of a Three –Phase Alternator by Synchronous Impedance method and MMF method	**3**
VII	Regulation of Three–Phase Alternator by Potier Triangle Method	**3**
VIII	Determination of Xd,Xq and Regulation of a Salient Pole Synchronous Machine	**3**
IX	Synchronization of alternator by Dark Lamp method	**3**
X	V and Inverted V Curves of a Three Phase Synchronous Motor	**3**
XI	Equivalent circuit parameters of Single-Phase Induction Motor	**3**
XII	Power factor improvement of Single-Phase Induction motor by using Capacitor bank	**3**
	Additional Experiments	
XIII	Determination of efficiency of three phase alternator by loading with three phase induction motor.	**3**
XIV	Load test on Single Phase Induction Motor.	**3**
XV	Practice of Experiments	**3**
XVI	Internal Examination	**3**
	TOTAL HOURS	**48**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
R	B. L. Theraja, “Fundamentals of Electrical Engineering”, Volume-II, S.Chand Publications
R	P.S.Bimbhra, “Electrical Machinery”, Khanna Publishers,2011.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
C213	**Electrical Machines-II**	Theoretical Knowledge on different types of starters and speed control methods.	**II-II**

COURSE OBJECTIVES:

1	To plot the magnetizing characteristics of Synchronous Machine
2	To control the speed of the Induction Motors.
3	TO Improve the power factor of an Induction motor
3	To determine and pre-determine the Regulation of Three –Phase Alternator.
4	To determine the Efficiency of three phase Induction Motors

COURSE OUTCOMES:

S. No.	DESCRIPTION	PO(1..12) MAPPING	PSO(1,2) MAPPING
C218.1	Analyze the performance characteristics of AC machines by Effective Collaboration in teams	PO1,PO2,PO3,PO4,PO6,PO7, PO8,PO9,PO10,PO11,PO12	PSO1,PSO2
C218.2	Apply speed control techniques on various AC machines that are required for project designs	PO1,PO2,PO3,PO4,PO6,PO7, PO8,PO9,PO10,PO11,PO12	PSO1,PSO2
C218.3	Estimate how much reactive power is reduced by capacitor banks in order to abide by environmental requirements	PO1,PO2,PO3,PO4,PO6,PO7, PO8,PO9,PO10,PO11,PO12	PSO1,PSO2
C218.4	Determine the voltage regulation using specific methods are applied in industrial alternators	PO1,PO2,PO3,PO4,PO6,PO7, PO8,PO9,PO10,PO11,PO12	PSO1,PSO2
C218.5	Estimate the reliable data by Conducting tests accurately for AC motor performance evaluation by Prioritizing safety protocols	PO1,PO2,PO3,PO4,PO6,PO7, PO8,PO9,PO10,PO11,PO12	PSO1,PSO2
COURSE OVERALL PO/PSO MAPPING: PO1,PO2,PO3,PO4,PO6,PO7,PO8,PO9,PO10,PO11,PO12/ PSO1,PSO2			

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1**):**

SNO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
C218.1	3	3	1	2	-	2	2	2	3	2	1	2	3	2
C218.2	3	3	2	2	-	2	2	2	3	2	1	2	3	2
C218.3	3	3	2	2	-	3	2	2	3	2	1	2	3	2
C218.4	3	3	2	2	-	2	2	2	3	2	1	2	3	2
C218.5	3	3	1	2	-	2	2	2	3	2	1	2	3	2
C218*	3	3	2	2	-	2	2	2	3	2	1	2	3	2

** For Entire Course, PO & PSO Mapping*

POs & PSO REFERENCE:

PO1	Engineering Knowledge	PO7	Environment & Sustainability	PSO1	Capable of design, develop, test, verify and implement Electrical and Electronics Engineering systems and products.
PO2	Problem Analysis	PO8	Ethics	PSO2	Succeed in national and international competitive examinations for successful higher studies and employment.
PO3	Design & Development	PO9	Individual & Team Work		
PO4	Investigations	PO10	Communication Skills		
PO5	Modern Tools	PO11	Project Mgt. & Finance		
PO6	Engineer & Society	PO12	Life Long Learning		

COs VS POs MAPPING JUSTIFICATION:

SNO	PO/PSO MAPPED	LEVEL OF MAPPING	JUSTIFICATION
C218.1	PO1	3	The magnetization characteristics of Synchronous Machine are substantially required in an engineering specialization to the solution of complex engineering problems.
	PO2	3	The operating principles of AC machines are substantially required for complex engineering problems.
	PO3	1	The characteristics the Synchronous Machine are slightly required to develop the solution in electrical field.

	PO4	2	The analyzing of AC machine performance is moderately required for some of the research methods.
	PO6	2	The performance of the AC machines is moderately required for Professional Engineering Practice.
	PO7	2	The performance of the AC Machine moderately need for sustainable development in electrical engineering field.
	PO8	2	AC motor technology is moderately required for Professional ethics.
	PO9	3	The characteristics of AC Machines are substantially required for individual and team work in electric field.
	PO10	2	Testing and AC Machine characteristics are moderately required for effective communicate on electrical engineering activities.
	PO11	1	AC motor applications are slightly required to manage electrical works in the respective projects.
	PO 12	2	AC motor applications are moderately required for Lifelong learning.
	PSO 1	3	Open & short circuit parameters of Synchronous Machine are substantially required for the design and development of electrical systems.
	PSO 2	2	The knowledge of AC Machine are moderately required for higher studies.
C218.2	PO 1	3	The methods of speed control for Induction Motor are substantially required in an engineering specialization to the solution of complex engineering problems.
	PO 2	3	Speed Control of Induction Motors are substantially required for complex engineering problems.
	PO 3	2	Designing of the speed of Induction Motors are moderately required to develop the solution in electrical field.
	PO 4	2	Power factor analyze of an Induction Motors are moderately required for some of the research methods.
	PO6	2	The adjustment of the speed of an Induction Motors is moderately required for Professional Engineering Practice.

	PO7	2	Poly-phase machine design and speed control are moderately need for sustainable development in electrical engineering field.
	PO8	2	AC motor technology developments are moderately required for Professional ethics.
	PO 9	3	The speed control methods and reactive power analysis of Induction Motors are substantially required for individual and team work in electric field.
	PO10	2	Conduction of different tests to control the speed of AC Machines is moderately required for effective communicate on electrical engineering activities.
	PO11	1	Connection diagrams for speed control methods of AC motor are slightly required to manage electrical works in the respective projects.
	PO 12	2	The technological changes for speed control of ac machines are moderately required for Lifelong learning.
	PSO 1	3	Design and develop circuit to control the speed by V/F control method are substantially required for the design and development of electrical systems.
	PSO 2	2	The knowledge of variable voltage and frequency are moderately required for higher studies and various competitive exams.
C218.3	PO1	3	Reactive power analysis is substantially required for complex Engineering problems.
	PO2	3	The analysis of reactive power is substantially required for engineering problem analysis.
	PO3	2	The analysis of capacitor banks is moderately required for design and development of engineering solutions.
	PO4	2	The analysis of reactive power for capacitive banks is moderately required for research methods of electrical engineering.
	PO6	3	Capacitor banks to reduce reactive power are not only substantially required to improve energy efficiency and reduce operational costs but also actively contribute to environmental preservation.
	PO7	2	Reactive power analysis is moderately required for professional engineering solutions.

	PO8	2	Reactive power analysis is moderately required for some of the ethical principles of electrical field.
	PO 9	3	Capacitor banks & Reactive power analysis is substantially required for individual team work.
	PO10	2	Reactive power analysis is moderately required for effective communicate on electrical engineering activities.
	PO11	1	Capacitor banks & Reactive power analysis are slightly required to manage electrical works in the respective projects.
	PO 12	2	Capacitor banks & Reactive power analysis are moderately required for Lifelong learning.
	PSO 1	3	Reactive power analysis are substantially required for the design and development of electrical systems
	PSO 2	2	Capacitor banks & Reactive power are moderately required for higher studies and various competitive exams.
C218.4	PO1	3	Regulation of Three –Phase Alternator is substantially required for complex Engineering problems.
	PO2	3	Analyze the characteristics of Three –Phase Alternator substantially required for engineering problem analysis
	PO3	2	The performance of Three –Phase Alternator is moderately required for design and development of engineering solutions.
	PO4	2	The behaviours of Three –Phase Alternator is moderately required for research-based knowledge and research methods to analyze.
	PO6	2	Three –Phase Alternator are moderately required for Professional Engineering Practice.
	PO7	2	Analyze the characteristics and find the Regulation of Three –Phase Alternators are moderately used for the society.
	PO8	2	AC motor technology moderately required to lead better societal outcomes.
	PO 9	3	The Regulation of Three –Phase Alternator is substantially required for individual team work
	PO10	2	Different tests on AC Machines for performance analysis are moderately required for effective communicate on electrical engineering activities.

	PO11	1	Understand the connection diagrams for voltage regulation methods applied to one's own work are slightly required to manage electrical works in the respective projects.
	PO 12	2	The technological changes to find voltage regulation are moderately required for Lifelong learning.
	PSO 1	3	Design and Regulation of Three –Phase Alternators are substantially required for the design and development of electrical systems.
	PSO 2	2	The knowledge of testing of Machines and its applications are moderately required for higher studies and various competitive exams.
C218.5	PO1	3	Testing of AC Motors are substantially required for complex Engineering problems.
	PO2	3	Performance of AC Motors is substantially required for engineering problem analysis.
	PO3	1	Various testing methods of AC machines are moderately required for design and development of engineering solutions.
	PO4	2	Analyze the characteristics of AC motors are moderately required for research-based knowledge and research methods to analyze.
	PO6	2	Three phase Induction Motors are moderately required for Professional Engineering Practice.
	PO7	2	Analyze the characteristics and find the Regulation of Three –Phase Alternator moderately used for the society.
	PO8	2	AC motor technologies are moderately required to lead better societal outcomes.
	PO9	3	Design of AC circuits is substantially required for individual team work.
	PO10	2	AC Machine performance analysis by are moderately required for effective communicate on electrical engineering activities.
	PO11	1	The connection diagrams for starting methods of AC motor are slightly required to manage electrical works in the respective projects.
	PO12	2	AC Circuits analysis is moderately required for Lifelong learning.
	PSO 1	3	The Efficiency of three phase Induction Motors are substantially required for the design and development of electrical systems.

	PSO 2	2	The knowledge of three phase Induction Motors speed control, starting methods are moderately required for higher studies and various competitive exams.

WEB SOURCE REFERENCES:

1	www.electrical4u.com
2	www.electricaleasy.com
3	www.learnengineering.org
4	www.studyelectrical.com

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☐ STUD. ASSIGNMENT	☐ WEB RESOURCES	☐ NPTEL/OTHERS
☐ LCD/SMART BOARDS	☐ STUD. SEMINARS	☐ ADD-ON COURSES	☑COLLABORATIVE LEARNING

ASSESSMENT METHODOLOGIES-DIRECT

☐ ASSIGNMENTS	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☑STUD. LAB PRACTICES	☑ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☐STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

Prepared by **Approved by**

PAC Member

Signature of HOD, EEE

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

ELECTRICAL MACHINES-II LABARATORY

Exp. No.	Experiment Name	CO's	PO's/PSO's
1.	Brake test on Three Phase Induction Motor	CO1, CO5	PO1, PO2, PO3, PO4, PO6 PO7, PO8, PO9, PO10 PO11,PO12, PSO1, PSO2
2.	No–load & Blocked Rotor Tests on Three Phase Induction Motor	CO1, CO5	PO1, PO2, PO3, PO4, PO6 PO7, PO8, PO9, PO10 PO11,PO12, PSO1, PSO2
3.	Speed Control of Induction Motor by V/f method	CO2	PO1, PO2, PO3, PO4, PO6 PO7, PO8, PO9, PO10 PO11,PO12, PSO1, PSO2
4.	Regulation of a Three –Phase Alternator by Synchronous Impedance method and MMF method	CO4	PO1, PO2, PO3, PO4, PO6 PO7, PO8, PO9, PO10 PO11,PO12, PSO1, PSO2
5.	Regulation of Three–Phase Alternator by Potier Triangle Method	CO4	PO1, PO2, PO3, PO6 PO7, PO8, PO9, PO10 PO11,PO12, PSO1, PSO2
6.	Determination of X_d , X_q and Regulation of a Salient Pole Synchronous Machine	CO4	PO1, PO2, PO3, PO4, PO6 PO7, PO8, PO9, PO10 PO11,PO12, PSO1, PSO2
7.	Synchronization of alternator by Dark Lamp method	CO1	PO1, PO2, PO3, PO4, PO6 PO7, PO8, PO9, PO10 PO11,PO12, PSO1, PSO2
8.	V and Inverted V Curves of a Three Phase Synchronous Motor	CO1, CO5	PO1, PO2, PO3, PO4, PO6 PO7, PO8, PO9, PO10 PO11,PO12, PSO1, PSO2
9.	Equivalent circuit parameters of Single-Phase Induction Motor	CO1, CO5	PO1, PO2, PO3, PO4, PO6 PO7, PO8, PO9, PO10 PO11,PO12, PSO1, PSO2
10.	Power factor improvement of Single-Phase Induction motor by using Capacitor bank	CO3	PO1, PO2, PO3, PO4, PO6 PO7, PO8, PO9, PO10 PO11,PO12, PSO1, PSO2
Experiments Beyond the curriculum			
11.	Determination of efficiency of three phase-alternator by loading with three phase Induction motor.	CO1	PO1, PO2, PO3, PO4, PO6 PO7, PO8, PO9, PO10 PO11,PO12, PSO1, PSO2
12.	Load test on Single phase induction motor.	CO1	PO1, PO2, PO3, PO4, PO6 PO7, PO8, PO9, PO10 PO11,PO12, PSO1, PSO2

1. BRAKE TEST ON 3- ϕ SQUIRREL CAGE INDUCTION MOTOR

AIM:

To determine the efficiency of 3- ϕ induction motor by performing load test. To Obtain the performance curves for the same.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-600) V	1 no
2	Ammeter	MI	(0-10) A	1 no
3	Wattmeter	Electro dynamo meter type	10A/600V UPF 10A/600V LPF	1 no 1 no
4	Tachometer	Digital	0-9999 RPM	1 no
5	Connecting Wires	*****	*****	Required

NAME PLATE DETAILS:

S.No	Specifications	Rating
1	Power	3 HP
2	Voltage	415V
3	Current	6A
4	Speed	1440rpm
5	Frequency	50Hz
6	PF	0.8

3- ϕ Auto transformer Details:

Input Voltage: 415V/ (0-470V)
Output Voltage: 415(Volt)

Current: 15(Amp.)

Freq.:50(Hz)

THRORY:
The **brake test** is a direct method of determining the performance of an **induction motor** by applying a mechanical load and measuring its input power, torque, speed, and output power. It helps in evaluating the **efficiency**, **torque-speed characteristics**, and **power losses** of the motor.

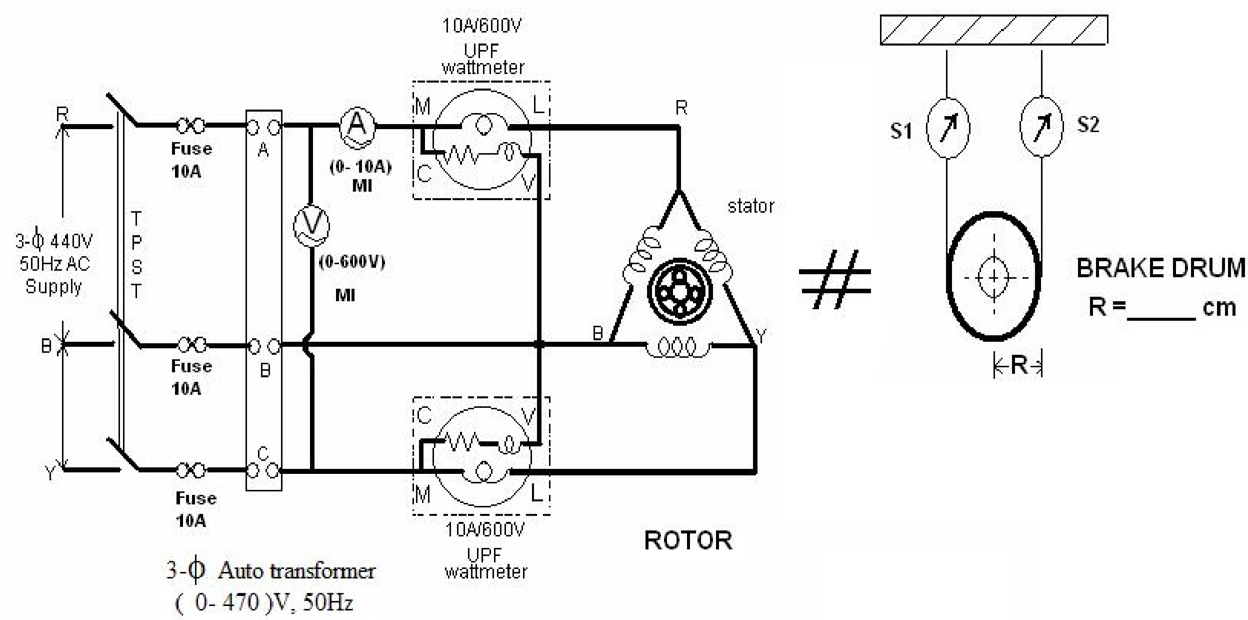
A three-phase slip ring induction motor consists of a stator (which receives three-phase AC supply) and a wound rotor (connected to external resistances via slip rings). The torque is produced due to electromagnetic induction between the stator and rotor windings.

In a brake test, the motor is loaded mechanically using either:

1. A Prony brake (friction-based braking system) or
2. A DC generator coupled to the motor shaft (electrical load).

The torque exerted by the braking system is used to calculate the mechanical power output, while the electrical input power is measured to determine the efficiency.

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Ensure that the 3- ϕ variac is kept at minimum output voltage position and belt is freely suspended.
3. Switch ON the supply. Increase the variac output voltage gradually until rated voltage is observed in voltmeter. Note that the induction motor takes large current initially, so, keep an eye on the ammeter such that the starting current should not exceed 7 Amp.
4. By the time speed gains rated value, note down the readings of voltmeter, ammeter, and wattmeter at no-load.
5. Now the increase the mechanical load by tightening the belt around the

brake drum gradually in steps.

6. Note down the various meter's readings at different values of load till the ammeter shows the rated current.
7. Reduce the load on the motor finally, and switch OFF the supply.

MODEL GRAPHS:

1. Speed or slip Vs output power
2. Torque Vs output power
3. % Efficiency Vs output power

TABULER FORM: -

S.No	Input Voltage (V)	Input Current (A)	Speed, N (rpm)	W_1 (watts)	W_2 (watts)	Spring Balance kg		Torque N-m	P_{in}= W1+W2 (Watts)	P_{out}, (Watts)	$\eta = P_{out}/P_{in}$ X 100 (%)
						S1	S2				
1	380	2.6	1488	0	560	0	0	0	560	0	0
2	380	2.75	1480	0	640	2	1	1.499	640	232.32	36.3
3	380	4.1	1452	400	1200	6	1	7.499	1600	1140.246	71.27
4	380	4.26	1440	480	1320	7	1	8.99	1800	1355.66	75.3
5	380	4.6	1438	560	1520	9	2	10.49	2080	1579.65	75.9
6	380	4.85	1430	720	1720	10	2	11.99	2440	1795.49	73.5
7	380	5.6	1408	840	2080	12	2	14.99	2920	2210.20	75.6
8	380	6.0	1400	960	2160	13	2	16.49	3120	2417.56	77.4

CALCULATIONS:

Torque = 9.81(S1-S2) R N-m

= (9.81) (12-2) (0.15)

= 14.99 N-m

Output Power = 2πNT/60

= (2π X 1408 X 14.99)/60

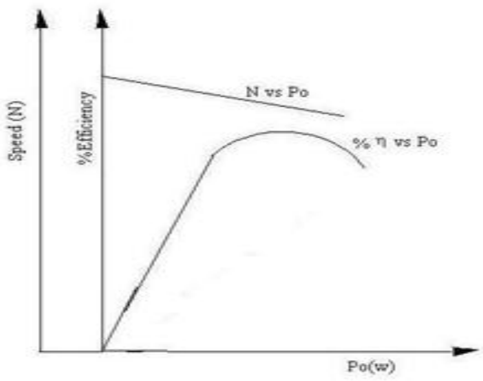
= 2210.20W

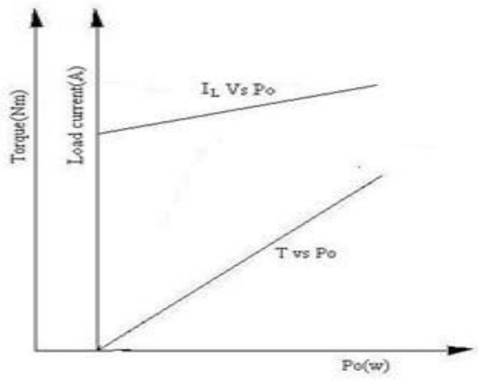
Input Power = W1+W2

= 2920W

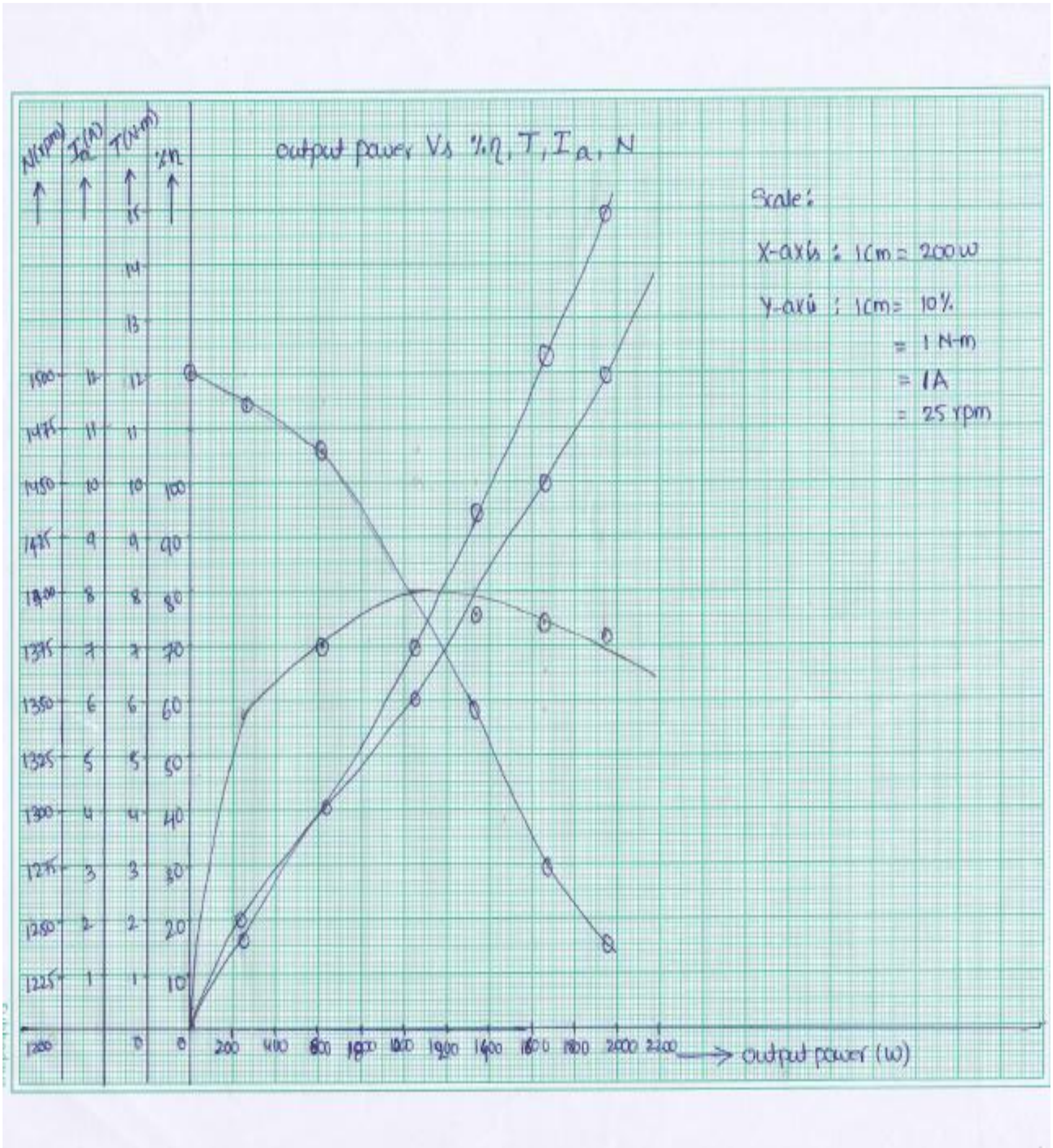
% Efficiency = (Output/ Input) x100

= (2210.20/2920) X 100 = 75.6


Speed (N)
%Efficiency
N vs Po
% η vs Po
Po(w)


Torque(Nm)
Load current(A)
IL Vs Po
T vs Po
Po(w)

GRAPH:


output power Vs %η, T, Ia, N
Scale:
X-axis : 1cm = 200W
Y-axis : 1cm = 10%
= 1 N-m
= 1A
= 25 rpm
output power (W)

PRECAUTIONS:

1. Avoid loose connections.
2. Switch OFF the Supply before making connections.
3. Do not touch the bare conductors.
4. Avoid parallax error while making observations.

RESULT: Brake test on three phase slip ring induction motor was conducted and Performance curves are plotted.

OUTCOME: By doing this experiment CO1, CO5, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1& PSO2 are attained

2. NO LOAD AND BLOCKED ROTOR TEST ON A 3- ϕ INDUCTION MOTOR

AIM:

To determine the equivalent circuit of a 3- ϕ induction motor and calculate Various parameters of induction motor with the help of circle diagram.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-600) V (0-150) V	1 no 1 no
2	Ammeter	MI	(0-10) A (0-5) A	1 no 1 no
3	Wattmeter	Electro dynamo meter type	5A/600V LPF 10A/150V UPF	2 no 2 no
4	Tachometer	Digital	*****	1 no
5	Connecting Wires	*****	*****	Required

NAME PLATE DETAILS:

S.No	Specifications	Rating
1	power	3HP
2	voltage	415V
3	current	4.7A
4	speed	1400
5	frequency	50 HZ
6	Power factor	lag

3- ϕ Auto transformer Details:

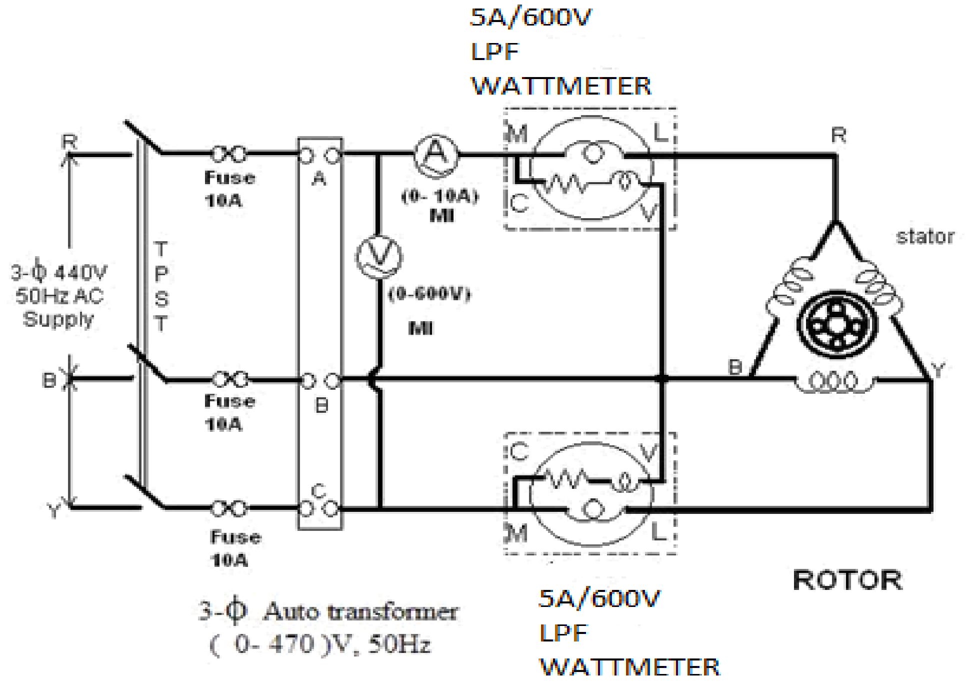
Input Voltage: 415V/ (0-470) (Volt)

Output Voltage: 415 (Volt)

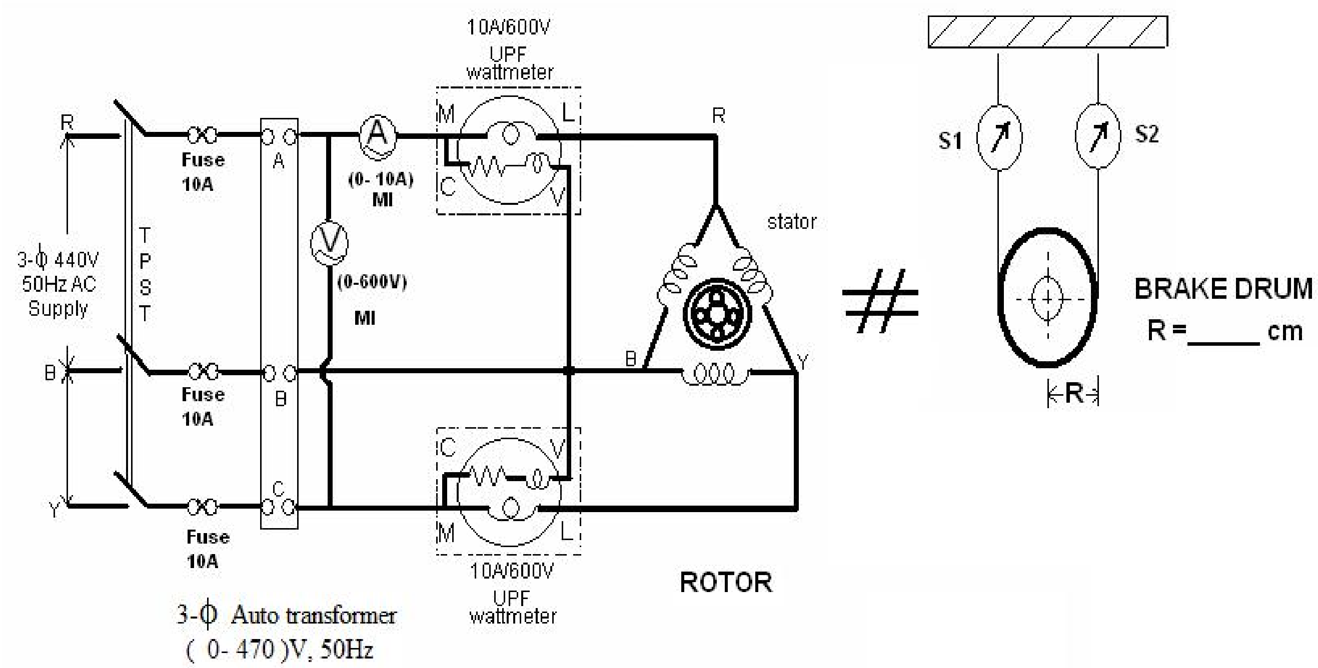
Current: 15 (Amp)

CIRCUIT DIAGRAM:

For no-load test: -



For blocked-rotor test: -



THEORY:

The no-load test and blocked rotor test are indirect methods used to determine the equivalent circuit parameters and performance characteristics of a three-phase squirrel cage induction motor. These tests help in calculating the motor's efficiency, power losses, and performance without requiring actual load conditions. When a three-phase squirrel cage induction motor runs without load, the stator draws a small current, mainly to:

1. Magnetize the core (leading to iron/core losses).
2. Overcome friction and wind age losses.

At no load, the slip is very small, meaning rotor copper losses are negligible, and most of the power supplied is used to excite the magnetic field and overcome mechanical losses.

PROCEDURE:

NO LOAD TEST:

1. Connections are made as per the circuit diagram.
2. Ensure that the 3- ϕ variac is kept at minimum output voltage position and belt is freely suspended.
3. Switch ON the supply. Increase the variac output voltage gradually until rated voltage is observed in voltmeter. Note that the induction motor takes large current initially, so, keep an eye on the ammeter such that the starting current should not exceed 7 Amp.
4. By the time speed gains rated value, note down the readings of voltmeter, ammeter, and wattmeter.
5. Bring back the variac to zero output voltage position and switch OFF the supply.

BLOCKED ROTOR TEST:

1. Connections are as per the circuit diagram.
2. The rotor is blocked by tightening the belt.
3. A small voltage is applied using 3- ϕ variac to the stator so that a rated current flow in the induction motor.
4. Note down the readings of Voltmeter, Ammeter and Wattmeter in a tabular column.
5. Bring back the Variac to zero output voltage position and switch OFF the supply.

OBSERVATIONS:

No Load Test:

S No.	Voltmeter Reading V_o (V)	Ammeter reading I_o (A)	Wattmeter reading		W_{nl} (P_{nl}) W_1+W_2 (watts)
			W_1 (Watts)	W_2 (watts)	
1	410	2.1	382	508	176

Blocked Rotor Test

S No.	Voltmeter Reading V(volts)	Ammeter reading I (A)	Wattmeter reading		W_{br} (P_{br}) W_1+W_2 (Watts)
			W_1 (Watts)	W_2 (Watts)	
1	100	4.5	0	384	384

MODEL CALCULATIONS:

Power factor of the motor $\cos \phi_o = \frac{W}{\sqrt{3}VI}$

V= V_O, no load voltage

I =I_O, no load current

W= W_O, no load power

Power factor of the motor $\cos \phi_{sc} = \frac{Wsc}{\sqrt{3}\,VscIsc}$

V= V_{sc}, short circuit voltage

I =I_{sc}, short circuit current

W= W_{sc}, short circuit power

Short circuit current at normal voltage $I_{SN} = I_{SC}\frac{V_O}{V_{SC}}$

Short circuit power at normal voltage$W_{SN} = W_{SC}[\frac{V_O}{V_{SC}}]^2$

Rotor copper losses = $\frac{full\ load\ output}{power\ scale}$

Full load slip = rotor copper losses/ rotor input

Percentage efficiency = $\frac{OUTPUT\ POWER}{INPUT\ POWER} * 100$

Model graph:

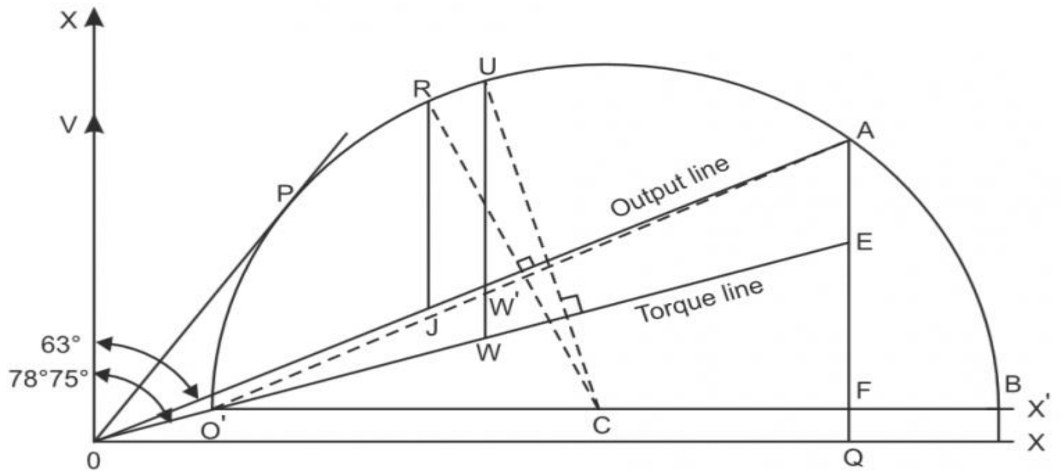
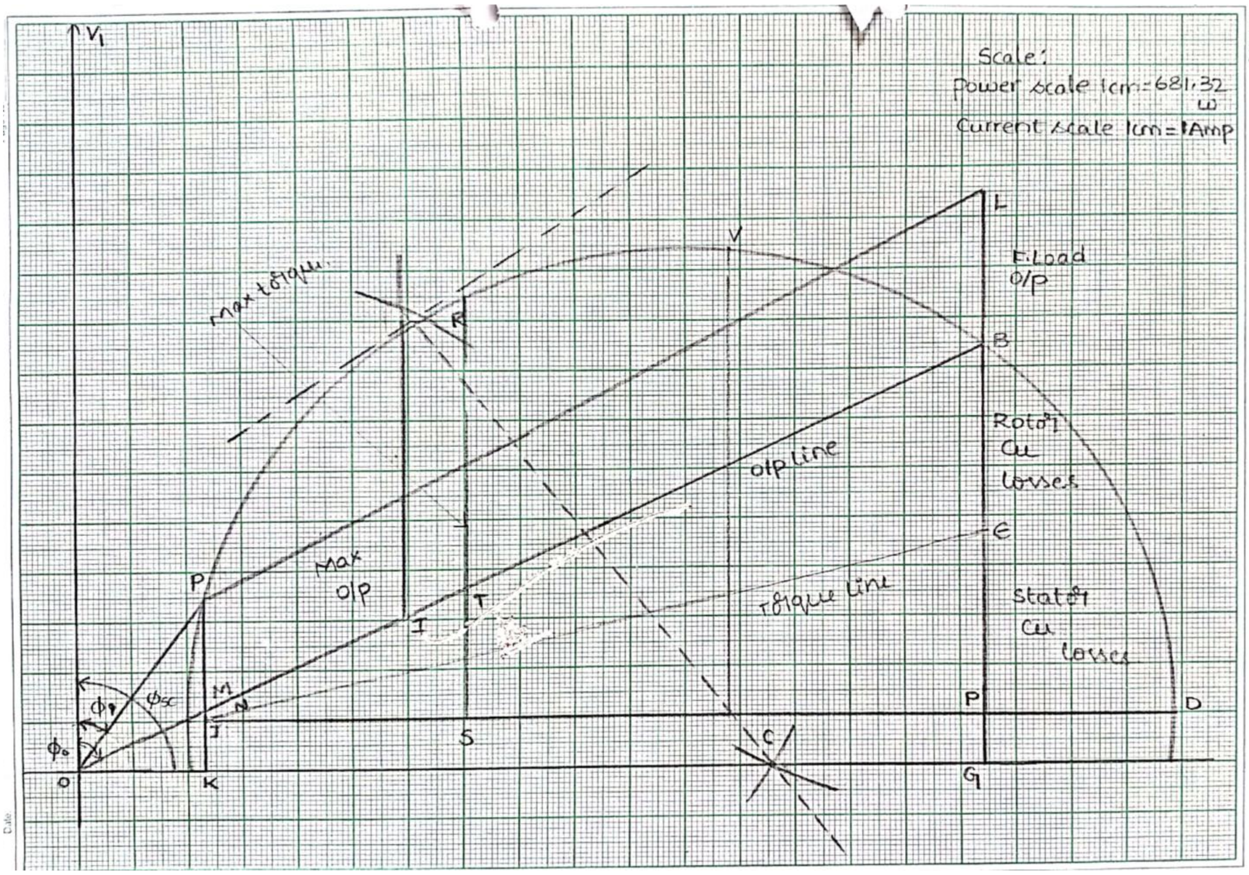


Fig. 9.47 Circle diagram



PRECAUTIONS:

1. Avoid loose connections.
2. Switch OFF the Supply before making connections.
3. Do not touch the bare conductors.
4. Avoid parallax error while making observations.

RESULT: The no load and blocked rotor test on a three-phase induction motor was conducted and circle diagram was plotted

Outcome: By doing this experiment CO1, CO5, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1& PSO2 are attained

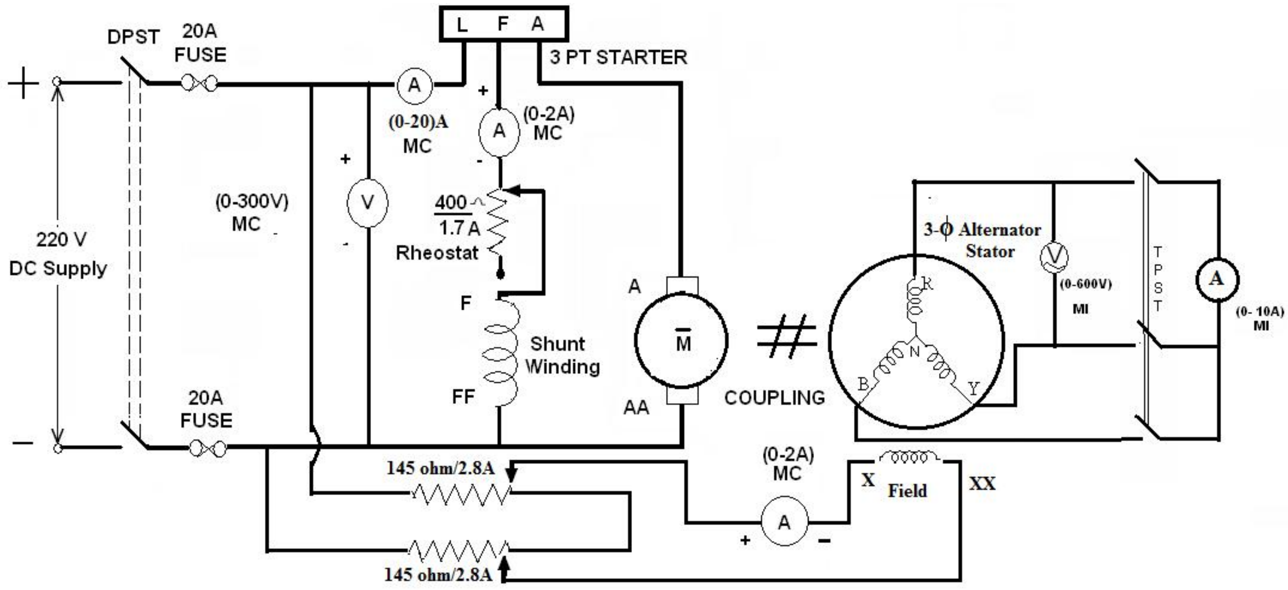
3. REGULATION OF ALTERNATOR USING SYNCHRONOUS IMPEDANCE & MMF METHODS

AIM: To find the regulation of a 3 - ϕ alternator by using synchronous impedance method.

APPARATUS REQUIRED:

S.No.	Equipment	Type	Range	Quantity
1	Voltmeter Voltmeter	MI MC	(0-600)V (0-300)V	1No 1No
2	Ammeter Ammeter	MI MC	(0-600)V (0-300)V	1No 1No
3	Rheostat	Wire wound	400 Ω /1.7A 145Ω /2A	1No 1No
4	Tachometer	Digital		1No
5	Connecting wires			Required

CIRCUIT DIAGRAM:



THEORY:

The synchronous impedance method (also called the EMF method) is an analytical approach used to determine the voltage regulation of an alternator. It is based on equivalent circuit parameters obtained from open-circuit and short-circuit tests.

The major Advantages Simple and easy to perform, Requires only no-load and short-circuit tests. And Disadvantages Assumes constant synchronous reactance, which is not valid due to magnetic saturation, Tends to overestimate voltage regulation.

This method provides a conservative (higher) estimate of voltage regulation and is useful for theoretical analysis and preliminary design evaluations.

PROCEDURE:

Open Circuit Test:

1. Make the connections as per the circuit diagram.
2. Before starting the experiment, the potential divider network in the alternator field circuit and field regulator rheostat of motor circuit is set minimum resistance position.
3. Switch ON the supply and close the DPST switch. The DC motor is started by moving starter handle.
4. Adjust the field rheostat of DC motor to attain rated speed (equal to synchronous speed of alternator)
5. By decreasing the field resistance of Alternator, the excitation current of alternator is increased gradually in steps.
6. Note the readings of field current, and its corresponding armature voltage in a tabular column.
7. The voltage readings are taken up to and 10% beyond the rated voltage of the machine.

Short Circuit Test:

1. For Short circuit test, before starting the experiment the potential divider is brought back to zero output position, i.e., resistance should be zero in value.
2. Now close the TPST switch.
3. The excitation of alternator is gradually increased in steps until rated current flows in the machine and note down the readings of excitation current and load current (short circuit current)
4. Switch OFF the supply.

OBSERVATIONS:

OC TEST:

S.NO	I_f (amps)	V_{oc} (volts)
1	80	0.12
2	120	0.20
3	160	0.28
4	200	0.41
5	240	0.64
6	280	1.20

SC TEST:

S.NO	I_f (amps)	I_{sc} (amps)
1	0.39	4.2

VOLTAGE REGULATION:

S.No	Cos Φ	Sin Φ	Lagging P.F full load Eo	Leading P.F full load Eo
1	0.2	0.97	436.4	72.03
2	0.4	0.91	430.08	113.57
3	0.6	0.8	420.36	189.98
4	0.8	0.6	401.07	215.09
5	1	0	324.18	324.18

MODEL CALUCALATIONS:

$V_{Ph} = \frac{V_L}{\sqrt{3}}$ = 440/1.732 = 254 V

Z $= \frac{Voc}{I_{SC}}$ = 198/4.2 = 47.14Ω

$R_{AC} = 1.5 \times R_{DC}$ = 1.5 X 4.2 = 6.3Ω

$X_S = \sqrt{Z^2 - R_{AC}^2}$ = 46.71Ω

For lagging P.F:

Let: 0.8 PF, sinφ = 0.6.

By substituting all the values in $E_{o,}$ we will get

$$E_0 = \sqrt{((V_{Ph}Cos\,\emptyset + I_{Sc}R_a)^2) + ((V_{Ph}Sin\,\emptyset + I_{Sc}x)^2)}$$

= 401.07 V

For leading P.F:

Let: 0.8 PF, sinφ = 0.6.

By substituting all the values in $E_{o,}$ we will get

$$E_0 = \sqrt{((V_{Ph}Cos\,\emptyset + I_{Sc}R_a)^2) + ((V_{Ph}Sin\,\emptyset - I_{Sc}x)^2)}$$

= 215.09V

Percentage Regulation: At 08 PF lag

$$\textbf{\% R} = \frac{E_0 - V_{Ph}}{V_{Ph}} \times 100$$

= ((401.07 – 254)/254) x 100

= 57.9

Procedure to find synchronous impedance from OC and SC tests:

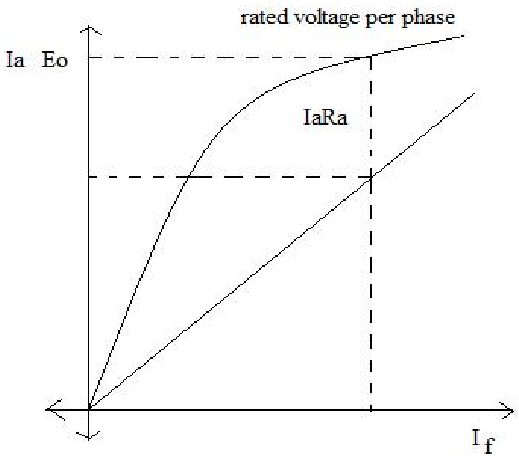
1. Plot open circuit voltage, short circuit current verses field current on a graph sheet.

2. From the graph, the synchronous impedance for the rated value of excitation is calculated.

3. The excitation emf is calculated at full load current which is equal to the terminal voltage at No load.
4. The voltage regulation is calculated at rated terminal voltage.

MODEL GRAPHS:

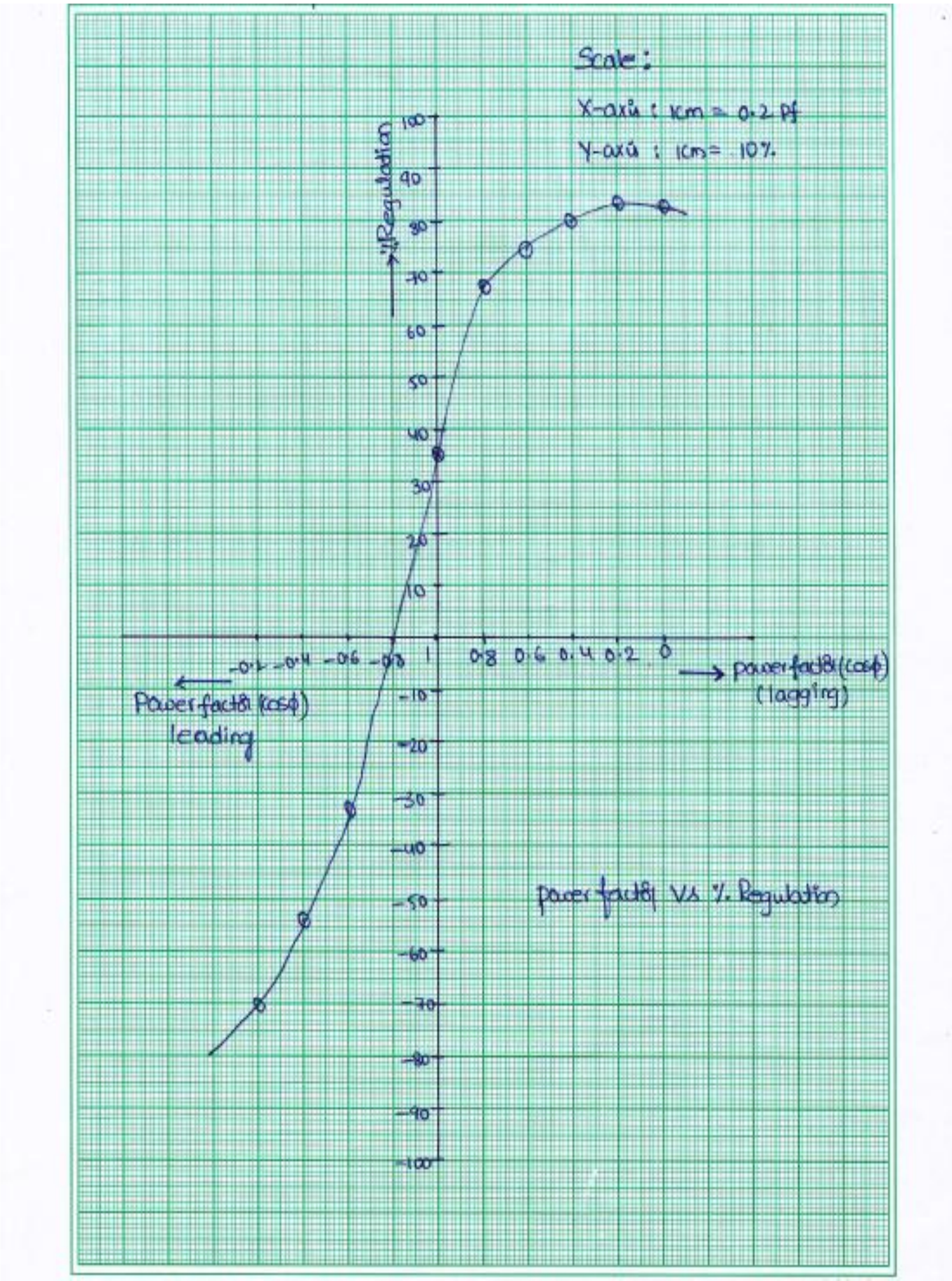
Draw the graph between I_f V_S E_0 per phase
And I_f V_S I_{SC}



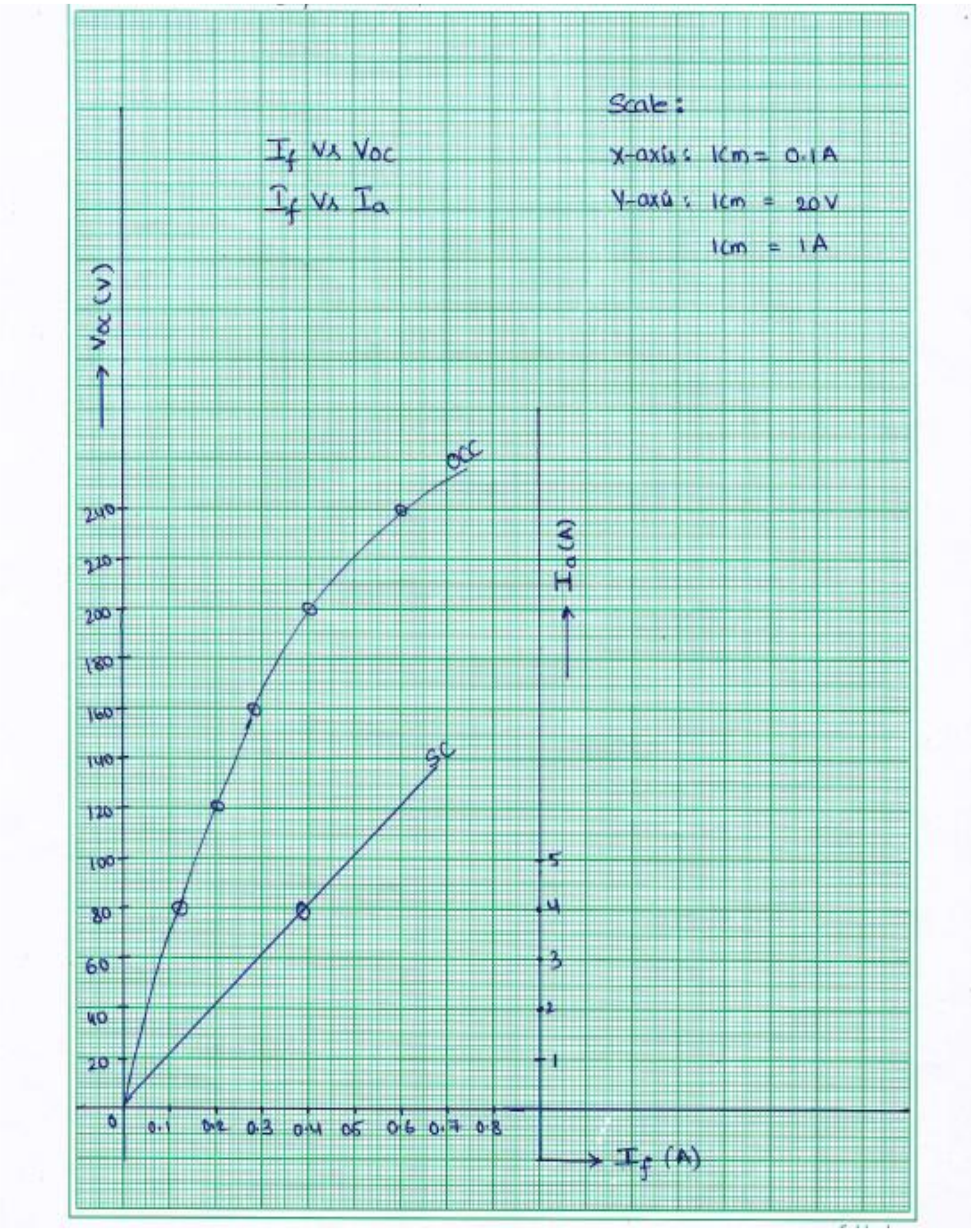
PRECAUTIONS:

1. Avoid loose connections.
2. Switch OFF the Supply before making connections.
3. Do not touch the bare conductors.
4. Avoid parallax error while making observations.

GRAPH:



Scale:
X-axis : 1cm = 0.2 Pf
Y-axis : 1cm = 10%
% Regulation
100
90
80
70
60
50
40
30
20
10
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-0.2 -0.4 -0.6 -0.8 1 0.8 0.6 0.4 0.2 0
power factor (cosφ) (lagging)
Power factor (cosφ) leading
power factor vs % Regulation



RESULT: The regulation of a three-phase alternator using synchronous impedance method is obtained.

OUTCOME: By doing this experiment CO4, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1& PSO2 are attained

4. REGULATION OF THREE-PHASE ALTERNATOR BY USING POTIER TRIANGLE METHOD

AIM:

To find the regulation of a 3 - ϕ alternator by using potier triangle method.

APPARATUS REQUIRED:

S.No.	Equipment	Type	Range	Quantity
1	Voltmeter Voltmeter	MI MC	(0-600)V (0-300)V	1No 1No
2	Ammeter Ammeter	MI MC	(0-600)V (0-300)V	1No 1No
3	Rheostat	Wire wound	400 Ω /1.7A 145Ω /2A	1No 1No
4	Tachometer	Digital		1No
5	Connecting wires			Required

THEORY:

The Potier Triangle Method is an improved graphical method used to determine the voltage regulation of an alternator. Unlike the Synchronous Impedance Method, this method accounts for the effect of armature reaction, leading to more accurate results.

It uses two tests:

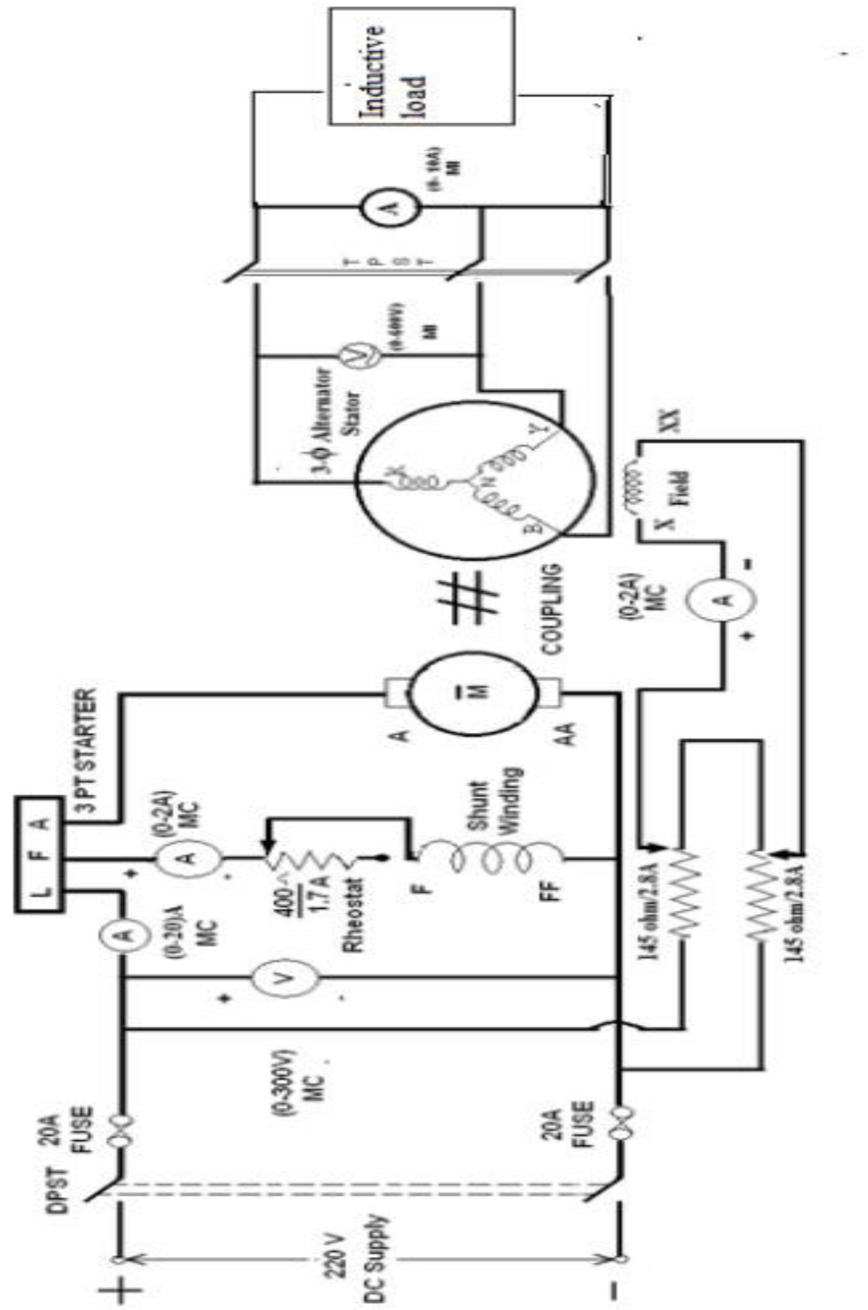
- Open-Circuit Test (OCT) – Determines the open-circuit characteristic (OCC).
- Zero Power Factor Test (ZPFT) – Obtains the ZPF characteristic curve, which accounts for leakage reactance.

Using these curves, a Potier Triangle is drawn to determine the synchronous reactance and armature reaction voltage. The Potier Triangle Method is a reliable way to determine alternator voltage regulation, offering better accuracy than the Synchronous Impedance Method by separately accounting for armature reaction and leakage reactance effects. This method is an analytical approach used to determine the voltage regulation of an alternator. It is based on equivalent circuit parameters obtained from open-circuit and short-circuit tests.

The major Advantages Simple and easy to perform, Requires only no-load and short-circuit tests. And Disadvantages Assumes constant synchronous reactance, which is not valid due to magnetic saturation, Tends to overestimate voltage regulation.

This method provides a conservative (higher) estimate of voltage regulation and is useful for theoretical analysis and preliminary design evaluations.

CIRCUIT DIAGRAM:



PROCEDURE:

Open Circuit Test:

1. Make the connections as per the circuit diagram.
2. Before starting the experiment, the potential divider in the alternator field circuit should be in maximum and field regulator rheostat of motor circuit is set minimum resistance position.
3. Switch ON the supply and close the DPST switch. The DC motor is started by moving starter handle.
4. Adjust the field rheostat of DC motor to attain rated speed (equal to

synchronous speed of alternator)

5. By decreasing the field resistance of Alternator, the excitation current of alternator is increased gradually in steps.
6. Note the readings of field current, and its corresponding armature voltage in a tabular column.
7. The voltage readings are taken up to and 10% beyond the rated voltage of the machine.

Short Circuit Test:

1. For Short circuit test, before starting the experiment the potential divider is brought back to zero output position, i.e., resistance should be maximum value.
2. Now close the TPST switch.
3. The excitation of alternator is gradually increased in steps until rated current flows in the machine and note down the readings of excitation current and load current (short circuit current)
4. Switch OFF the supply.

Load test (or) ZPF test

1. With machine running at rated speed bring the alternator field resistance to maximum position.
2. Gradually reduce alternator field resistance in steps and simultaneously increase the load in steps such that rated current flows in the alternator
3. Note down the corresponding voltmeter and ammeter readings
4. Obtain a number of readings keeping alternator load current at rated value
5. Tabulate under ZPF test
6. Switch off the DC supply by open the DPST switch

OBSERVATIONS:

OPEN CIRCUIT TEST:

S.NO	V_{oc} (volts)	I_f (amps)
1	80	0.12
2	120	0.20
3	160	0.28
4	200	0.41
5	240	0.64
6	280	1.20

SHORT CIRCUIT TEST:

S.NO	I_f (amps)	I_{sc} (amps)
1	0.1	1
2	0.2	2.2
3	0.3	3.1
4	0.4	4.2

Load test:

S.NO	Voltage(V)	I_f (amps)	I_{sc} (amps)
1	60	0.41	4.2
2	140	0.5	4.2
3	250	0.6	4.2
4	350	0.82	4.2
5	415	1.1	4.2

VOLTAGE REGULATION:

S.No	Cos Φ	Sin Φ	Lagging P.F full load Eo	Leading P.F full load Eo
1	0.2	0.97	436.4	72.03
2	0.4	0.91	430.08	113.57
3	0.6	0.8	420.36	189.98
4	0.8	0.6	401.07	215.09
5	1	0	324.18	324.18

MODEL CALUCALATIONS:

$$E_0 = \sqrt{((V_{Ph}Cos\,\emptyset + I_{Sc}R_a)^2) + ((V_{Ph}Sin\,\emptyset + I_{Sc}x)^2)}$$

Lagging power factor:

1. **Cos ø =0.8, sin ø = 0.6**

I_a= 4.2A, Ra = 6 ohms, X_L= 3.8 ohms, I_{f2}= 0.32ohms, Vph = 239.6V

$$E_g = \sqrt{((239.6 * 0.8 + 4.2 * 0.6)^2) + ((239.6 * 0.6 + 4.2 * 3.8)^2)}$$

Eg = 269.34V corresponding I_f = 0.9A,

$$I_f = \sqrt{((0.9^2) + (0.3)^2 + 2(0.9)(0.32)COS(90 + 36.86)\ \ )}$$

I_f = 0.753A corresponding EMF from the graph E_O= 258V

$$\% \mathbf{R} = \frac{E_0 - V_{Ph}}{V_{Ph}} \times 100$$

$$\% \mathbf{R} = \frac{258-239.6}{239.6} \times 100$$

= 7.67%

<u>For leading P.F:</u>

1. **Cos ø =0.8, sin ø = 0.6**

I_a= 4.2A, Ra = 6 ohms, X_L= 3.8 ohms, I_{f2}= 0.32ohms, Vph = 239.6V

$$E_g = \sqrt{((239.6 * 0.8 + 4.2 * 0.6)^2) + ((239.6 * 0.6 - 4.2 * 3.8)^2)}$$

Eg = 251.73V corresponding I_f = 0.68A, from graph

$$I_f = \sqrt{((0.68^2) + (0.32)^2 + 2(0.68)(0.32)COS(90 + 36.86)\ \ )}$$

$I_{f\,=}$ 0.551A corresponding EMF from the graph E_O= 226V

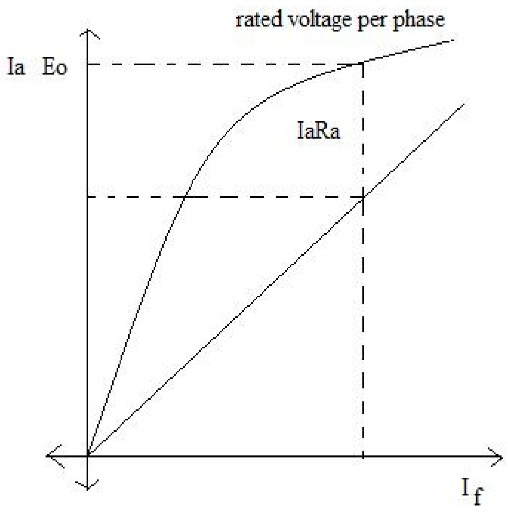
$$\% \mathbf{R} = \frac{E_0 - V_{Ph}}{V_{Ph}} \times 100$$

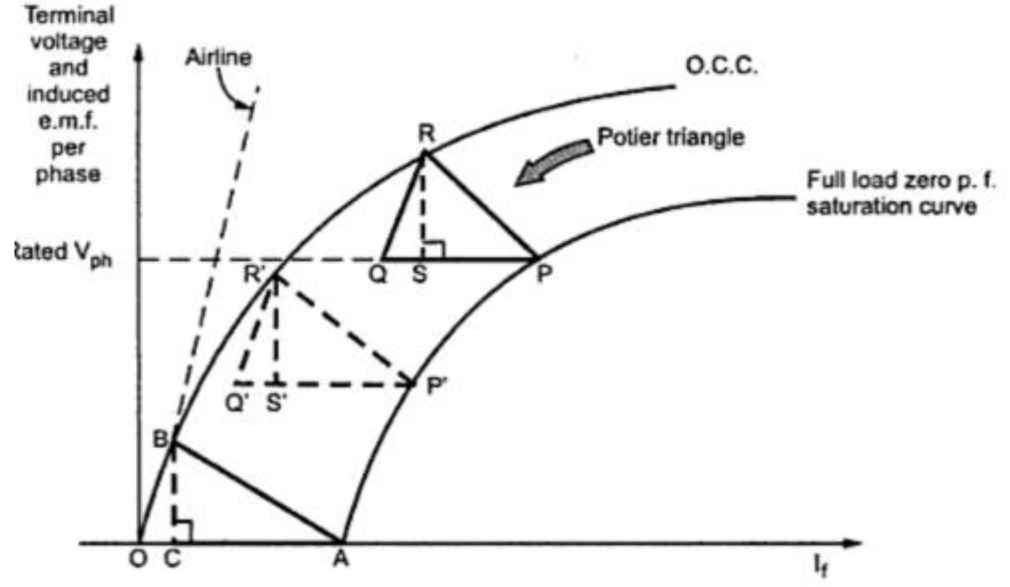
$$\% \mathbf{R} = \frac{226-239.6}{239.6} \times 100$$

= -5.67%

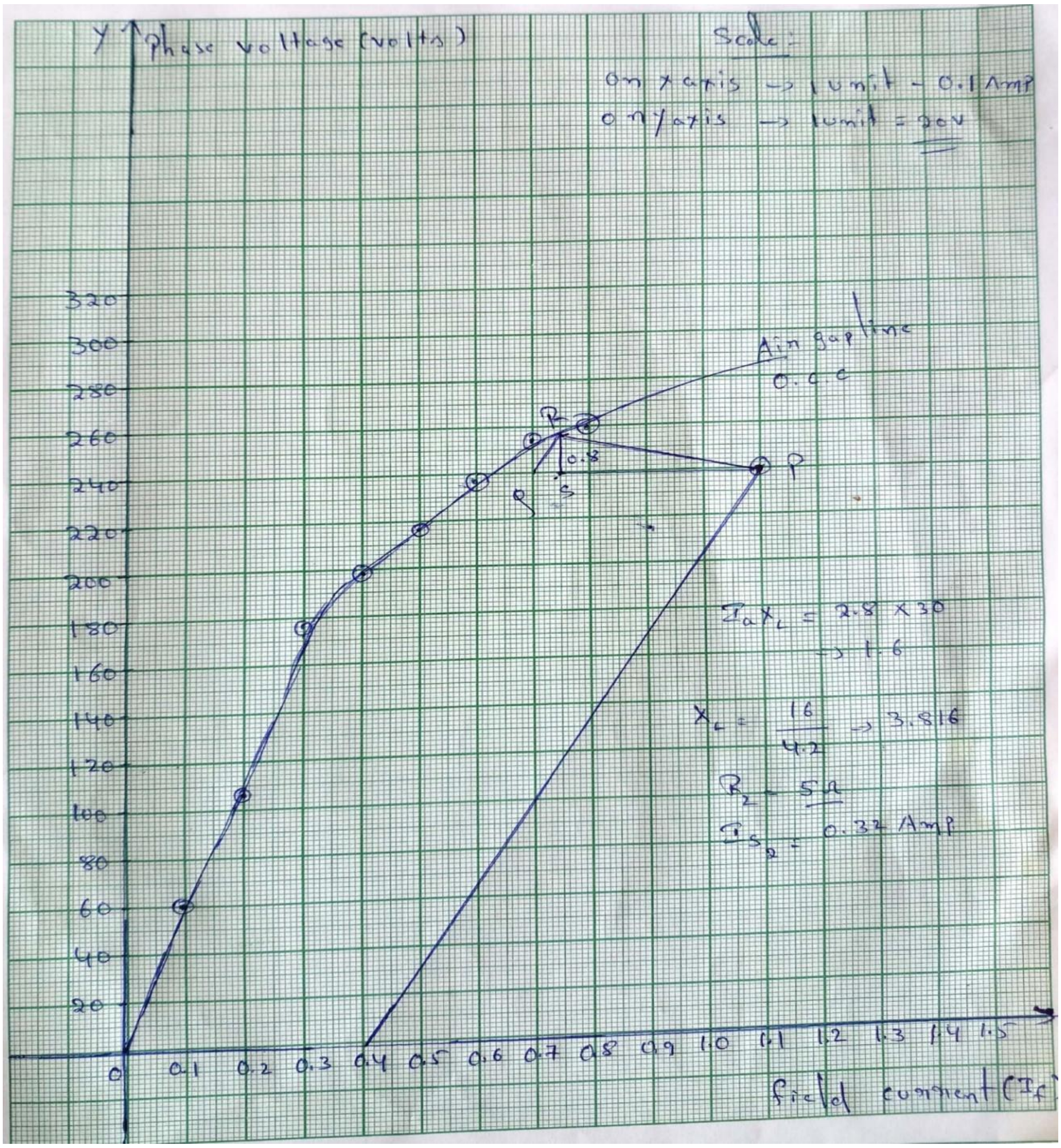
MODEL GRAPHS:

Draw the graph between I_f V_S E_0 per phase
And I_f V_S I_{SC}

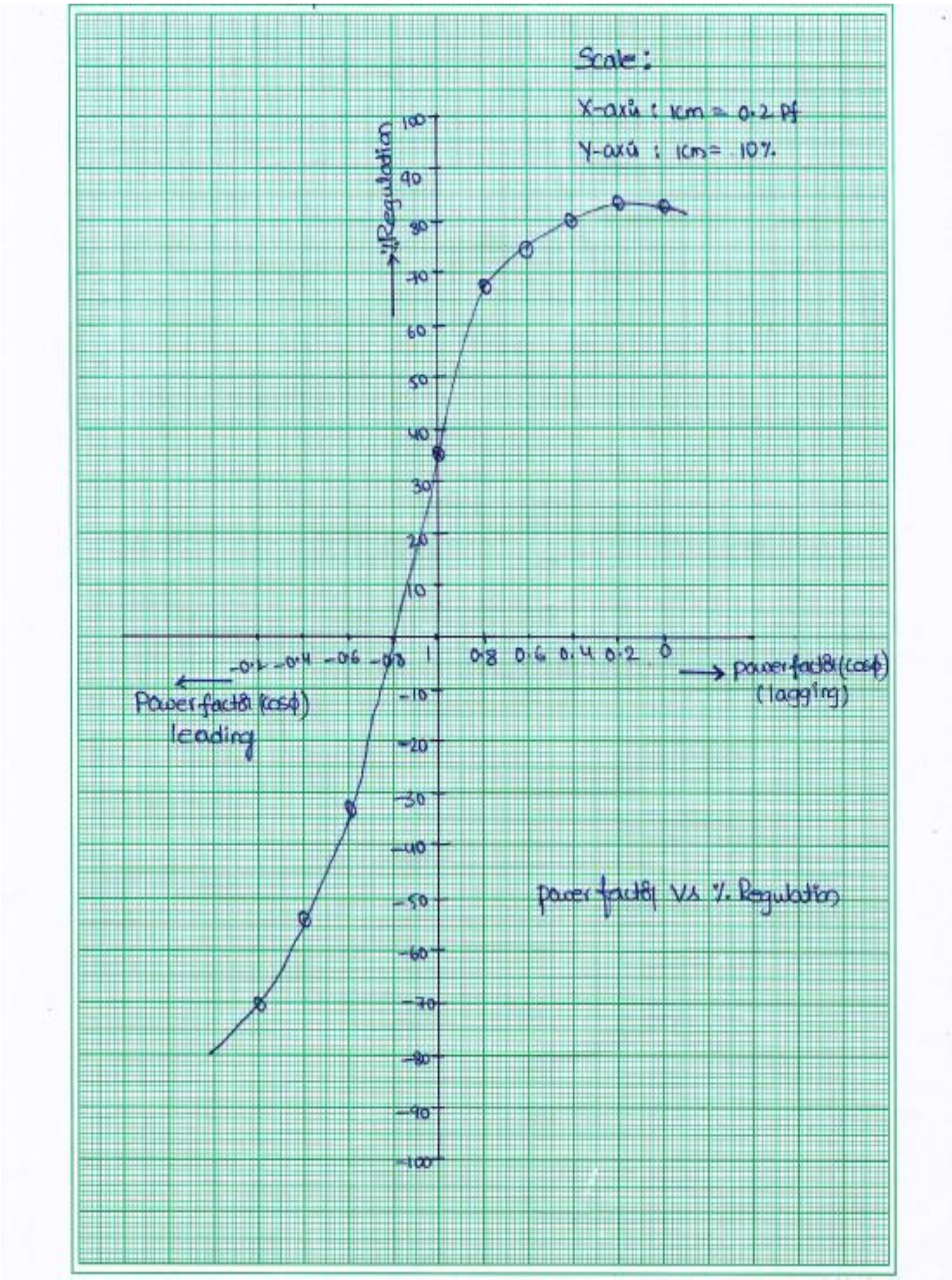




Terminal voltage and induced e.m.f. per phase
Airline
O.C.C.
Potier triangle
Full load zero p. f. saturation curve
Rated V_{ph}
R
R'
Q
S
P
Q'
S'
P'
B
O
C
A
I_f



Y phase voltage (volts)
Scale:
On x axis → 1 unit = 0.1 Amp
On Y axis → 1 unit = 20 V
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
Air gap line
O.C.C
R
P
Q
S
0.8
$I_a X_L$ = 2.8 × 30
→ 1.6
X_L = 16 / 4.2 → 3.816
R_2 = 5 Ω
I_{sc} = 0.32 Amp
field current (I_f)



Scale:
X-axis : 1cm = 0.2 pf
Y-axis : 1cm = 10%
%Regulation
powerfactor (cosϕ) (lagging)
Powerfactor (cosϕ) leading
power factor Vs % Regulation

PRECAUTIONS:

1. Avoid loose connections.
2. Switch OFF the Supply before making connections.
3. Do not touch the bare conductors.
4. Avoid parallax error while making observations.

RESULT: The regulation of a three-phase alternator using potier triangle method is obtained.

OUTCOME: By doing this experiment CO4, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1& PSO2 are attained

5. ‘V’ AND ‘INVERTED V’ CURVES OF SYNCHRONOUS MOTOR

AIM:

To plot the ‘v’ and ‘inverted v’ curves of Synchronous motor.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-600) V	1 no
2	Ammeter	MC MI	(0-2.5) A (0-10) A	1 no 1 no
3	Rheostat	Wire-wound	400 Ω /1.7A	1 no
4	Tachometer	Digital	*****	1 no
5	Wattmeter	Electrodynamometer	10A, 600V UPF	2 no
6	Connecting Wires	*****	*****	Required

NAME PLATE DETAILS

3- ϕ Synchronous motor	
Power Rating:	3HP
PF	LAG
Line voltage:	415V
Speed	1500RPM
Frequency.	50HZ
Rated Current:	3.5A
Field current (I_f)	1.4A
Field Voltage (V_f)	220v DC

3- ϕ Auto transformer details

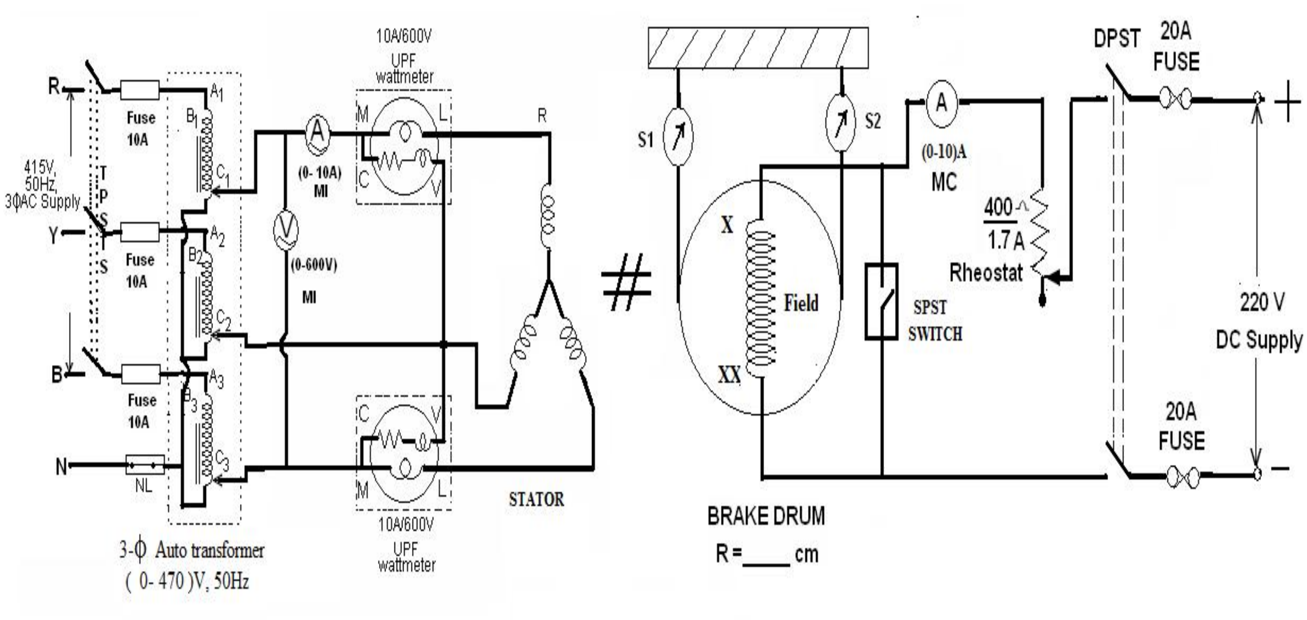
Input voltage: 415V/ (0-470) (Volt)

Output Voltage: 415 (Volt)

Frequency: 50(Hz)

Current: 15(Amp)

CIRCUIT DIAGRAM:



THEORY:

The **V-curves** and **inverted V-curves** of a **synchronous motor** represent the variation of **armature current** and **power factor** with respect to field excitation. These curves are essential for understanding the operational characteristics of synchronous motors, especially in power system applications. The V-curve is a plot of armature current against field excitation current at a constant load. The name "V-curve" comes from the characteristic V-shape of the graph.

The inverted V-curve is a plot of power factor against field current. It appears as an inverted V-shape.

The **V and Inverted V-curves** are crucial for understanding and optimizing synchronous motor operation. They help in setting the **field excitation** for **power factor correction** and **efficient motor performance**.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Opening the SPST switch connected across the field DC supply is given to the field and field current is adjusted to 0.3A (20% of rated field current)
3. The DC supply to the field is removed and SPST switch is connected across the field by closing the switch
4. As 3- ϕ, 440V, 50Hz AC supply is applied to 3- ϕ dimmer stator keeping it in minimum output position, keeping it prior to that motor is kept in no load state.
5. Gradually supply voltage to synchronous motor is increased and then motor starts running as squirrel cage induction motor. The direction of rotation is observed. if it is not proper then supply phase sequence is altered.
6. Observing I_a, the voltage is gradually increased. It will reach a high value and suddenly falls to a low value.
7. At that instant, open SPST switch connected across the field. The DC supply is then given to the field. Then the motor is pulled into synchronism and motor now works as a synchronous motor.

8. Gradually the supply voltage to stator is increased by observing the armature current. If I_a, increases above the rated value then increase If such that I_a will be within limits and thus full rated supply voltage is gradually given to the motor. Now motor will work as synchronous motor with full rated voltage.
9. By varying If in steps, armature currents are recorded at no-load.
10. By applying half of full load on motor, If and I_a are recorded again. The same experiment is repeated at 3/4th load, full load and corresponding readings are recorded.
11. Completely removing the load on motor, the 3- ϕ supply to stator and then the DC supply to the field are switched OFF

OBSERVATION TABLE:

S.No	Supply Voltage (volts)	Wattmeter W1 (watts)	Wattmeter W2 (watts)	Field current I_f (Amp)	Armature current I_a (Amp)	Cos ϕ
1	415	250	-160	0	4.5	0.11
2	415	√ 180	-120	0.1	3.3	0.10
3	415	-20	75	0.6	1.4	0.21

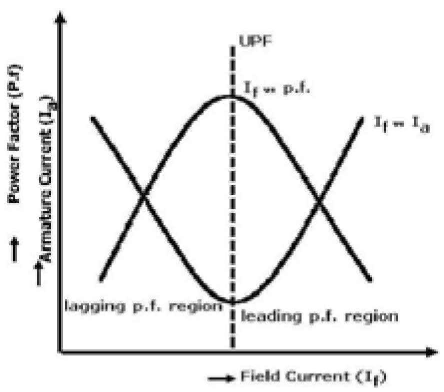
CALCULATIONS: -

$$COS\phi = \left\{ tan^{-1} \frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2} \right\}$$

$$\phi = COS \left\{ tan^{-1} \frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2} \right\}$$

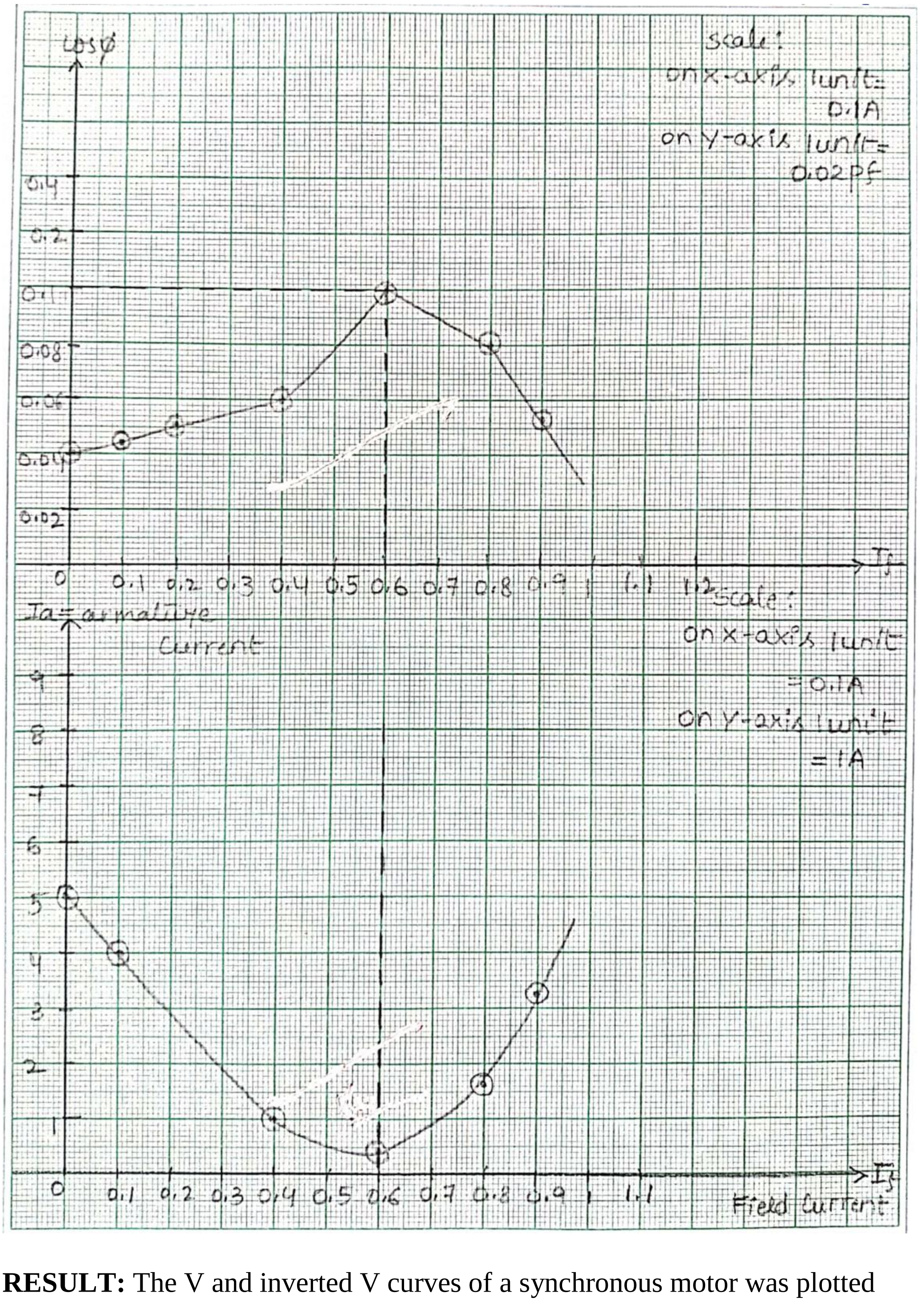
$$\mathbf{COS\phi} = \frac{(250-160)4}{415*4.5*\sqrt{3}} = \mathbf{0.11}$$

MODEL GRAPHS:



PRECAUTIONS:

1. Avoid loose connections.
2. Switch OFF the Supply before making connections.
3. Do not touch the bare conductors.
4. Avoid parallax error while making observations.



RESULT: The V and inverted V curves of a synchronous motor was plotted

Outcomes: By doing this experiment CO1, CO5, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1& PSO2 are attained

6. DETERMINATION OF X_d AND X_q OF SALIENT POLE SYNCHRONOUS MOTOR

AIM:

To determine the direct axis reactance X_d and quadrature axis reactance X_q by conducting a slip test on a salient pole synchronous machine.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter Voltmeter	MI MC	(0-300) V (0-300) V	1 no 1 no
2	Ammeter	MI MC	(0-5) A (0-2) A	1 no 1 no
3	Rheostat	Wire-wound	400 Ω /1.7A	1 no
4	Tachometer	Digital	*****	1 no
5	Connecting Wires	*****	*****	Required

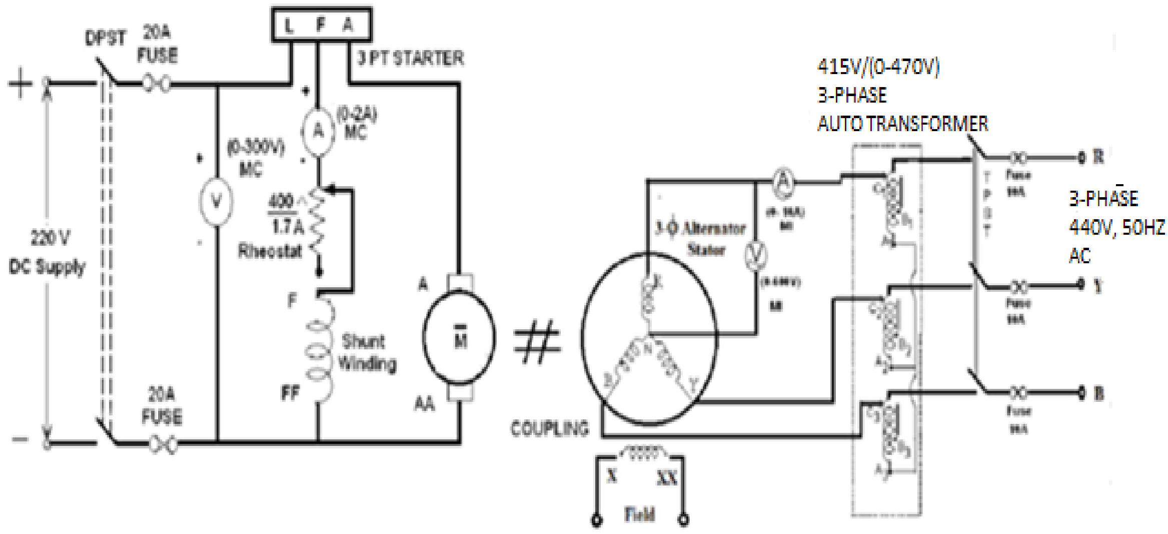
NAME PLATE DETAILS:

DC Motor (prime mover)	**3- ϕ Alternator**
KW :	Power Rating:
Voltage :	PF :
Current :	Line voltage:
Speed :	Speed
Exctn : Shunt	Exctn Voltage:
Voltage :	Rated Current:
Field current:	

3- ϕ Auto transformer Details:

Input Voltage: 415V/ (0-470) Volt
Output Voltage: 110 Volt
Current: 15 Amp
Frequency: 50 Hz

CIRCUIT DIAGRAM



THEORY:

In a synchronous machine, the performance and behaviour under different operating conditions depend on the magnetic axis alignment of the rotor and stator fields. These alignments are categorized into:

1. Direct Axis (d-axis)
2. Quadrature Axis (q-axis)

These axes influence the machine's reactances and voltage regulation, especially in salient pole synchronous machines. The direct and quadrature axis characteristics are determined through tests that measure reactances and their effects on machine operation. It Used for designing power system stability studies. Helps in calculating power factor correction for synchronous machines. Determines machine efficiency and voltage regulation.

The Direct Axis (d-axis) and Quadrature Axis (q-axis) characteristics provide insights into the magnetic properties and operational performance of synchronous machines, particularly salient pole alternators. The determination of Xd and Xq is crucial for power system stability, voltage regulation, and machine control.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Initially set field regulator, 3-ϕ variac at minimum position and TPST switch open.
3. The DC motor is started slowly by sliding starter handle and it is run at a speed slightly less than the synchronous speed of the alternator.
4. Close the TPST switch.
5. With field winding left open, a positive sequence balanced voltage of reduced Magnitude (around 25% of rated Value) and of rated frequency are

Impressed across the armature terminals.

6. The prime mover (DC motor) speed is adjusted till ammeter and voltmeters pointers swing slowly between maximum and minimum positions.
7. Under this condition, readings of maximum and minimum values of both ammeter and voltmeter are recorded

TABULAR COLUMN:

S No.	**Speed** (RPM)	**Vmax** **(V_L)** (volts)	**Vmin** **(V_L)** (volts)	**Imax** **(I_L)** (Amps)	**Imin** **(I_L)** (Amps)	**X_d** (ohms)	**X_q** (ohms)
1	1460	59	57	4.5	4.4	13.409	12.667

CALCULATIONS:

MINIMUM CURRENT = 4.4A

MAXIMUM CURRENT = 4.5A

MINIMUM VOLTAGE =57V

MAXIMUM VOLTAGE = 59V

$$Xd = \frac{V\max}{\mathrm{Im}in} = \frac{59}{4.4} = 13.409\ \Omega$$

$$Xq = \frac{V\min}{\mathrm{Im}ax} = 57/4.5 = 12.667\ \Omega$$

PRECAUTIONS:

1. Avoid loose connections.
2. Switch OFF the Supply before making connections.
3. Do not touch the bare conductors.
4. Avoid parallax error while making observations.

RESULT: The determination of the direct axis reactance X_d and quadrature axis reactance X_q by conducting a slip test on a salient pole synchronous machine was performed.

Outcomes: By doing this experiment CO1, CO4, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1& PSO2 are attained

7. EQUIVALENT CIRCUIT OF A SIGLE PHASE INDUCTION MOTOR

AIM:

To determine the equivalent circuit parameters of a single-phase induction motor by performing the no- load and blocked rotor tests.

APPARATUS REQUIRED:

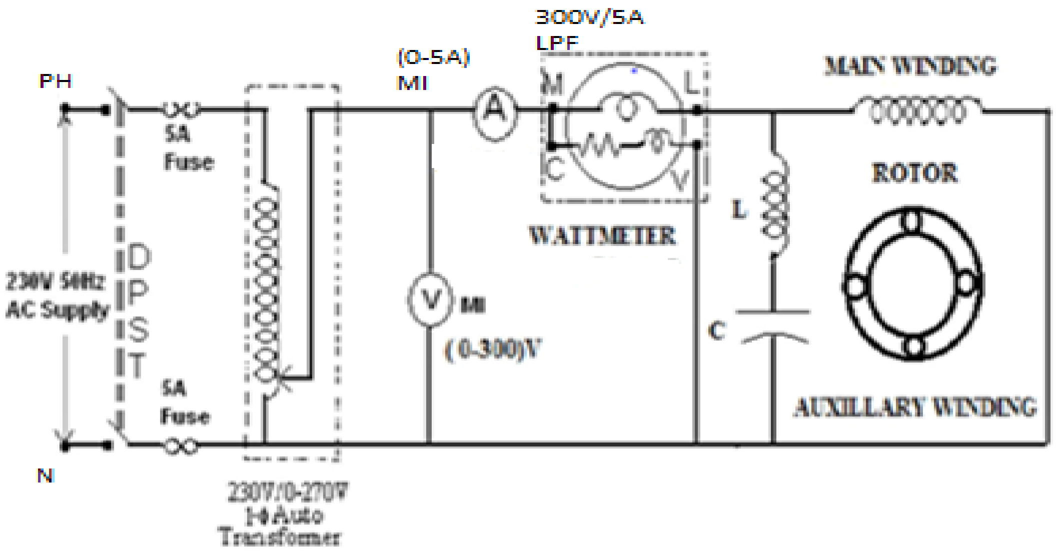
S.No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300) V	1 no
2	Ammeter	MI	(0-10) A	1 no
3	Wattmeter	Dynamo-type	5A/300V LPF	1 no
4	Wattmeter	Dynamo-type	10A/150V UPF	1 no
5	Connecting Wires	*****	*****	Required

1 - ϕ Induction motor specifications:

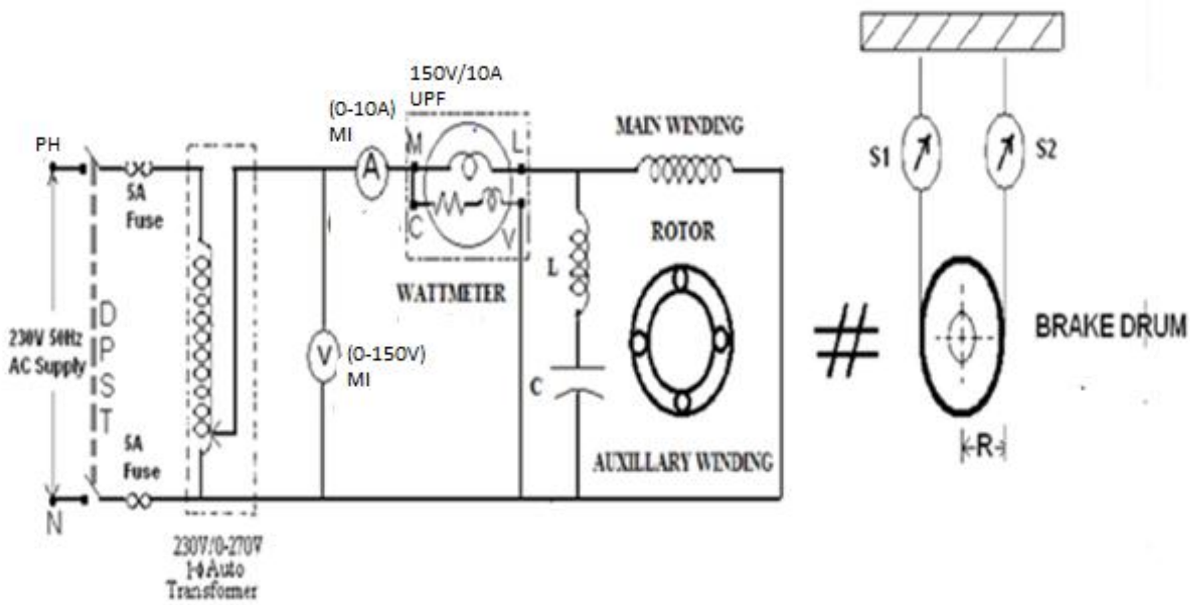
Sl.no	Quantity	Rating
1	Rated power	1 HP
2	Rated voltage	230V
3	Current	5.8 amp
4	Speed RPM	1440 rpm
5	Power factor	Lag
6	Frequency	50 hz
7	Rotor	Squirrel cage

CIRCUIT DIAGRAM:

No load test:



Blocked rotor test:



THEORY:

A **single-phase induction motor** is similar in construction to a **three-phase induction motor** but operates on a **single-phase AC supply**. Unlike three-phase induction motors, a single-phase motor **does not have self-starting capability** due to the nature of the rotating magnetic field. To analyze its performance, an **equivalent circuit model** is used. A single-phase induction motor can be analyzed using the Double Revolving Field Theory, which assumes that the stator magnetic field can be divided into:

1. Forward rotating field (+direction)
2. Backward rotating field (− direction)

Each field induces rotor currents that interact with the stator field to produce torque. The equivalent circuit of a single-phase induction motor consists of two parts:

1. Main (Forward) Component – Represents the main working field.
2. Backward Component – Represents the opposing field.

Both components can be modelled using an equivalent circuit similar to a transformer with a short-circuited secondary.

PROCEDURE:

No load Test:

1. The circuit connections are made as per the circuit diagram.
2. Be sure that variac (auto transformer) is set to zero output voltage position before starting the experiment.
3. Now switch ON the supply and close the DPST switch.
4. The variac is varied slowly, until rated voltage is applied to motor and rated speed is obtained.
5. Take the readings of Ammeter, Voltmeter and wattmeter in a tabular column.
6. The variac is brought to zero output voltage position after the experiment is done, and switch OFF the supply.

Blocked Rotor Test:

1. To conduct blocked rotor test, necessary meters are connected to suit the full load conditions of the motor.
2. Connections are made as per the circuit diagram.
3. Before starting the experiment variac (auto transformer) is set to zero output voltage position.
4. The rotor (shaft) of the motor is held tight with the rope around the brake drum.
5. Switch ON the supply, and variac is gradually varied till the rated current flows in the induction motor.
6. Readings of Voltmeter, Ammeter, and wattmeter are noted in a tabular column.
7. The variac is brought to zero output voltage position after the experiment is done, and switch OFF the supply.
8. Loosen the rope after the experiment is done.

Calculation for No-Load Test:

$$V_0 I_0 \cos\phi_0 = W_0$$

$$\cos\phi_0 = \frac{W_0}{V_0 I_0}$$ =190/ (230*4.5) =0.18

$$Z_0 = \frac{V_0}{I_0}$$ =230/4.5 = 51.1Ω

$$X_0 = Z_0 \sin\phi_0$$ = 51.04Ω

$$X_0 = X_1 + \frac{1}{2}(X_2 + X_m)$$

$$X_m = 2(X_0 - X_1) - X_2$$

Calculation For Blocked Rotor Test:

$$Z_{sc} = \frac{V_{sc}}{I_{sc}}$$ =35/5.8 =6.03 Ω

$$R_{sc} = \frac{W_{sc}}{I_{sc}^2}$$ =200/ (5.8*5.8) = 5.95Ω

r_1 is the DC resistance of stator of motor

$$r_2 = R_{sc} - r_1$$

$$x_1 + x_2 = X_{sc}$$

since leakage reactance can't be seperated out , it is common practice to to assume $x_1 = x_2$ =0.98Ω

$$x_1 = x_2 = \frac{X_{sc}}{2} = X_{sc} = \frac{1}{2}\sqrt{Z_{sc}^2 - R_{sc}^2}$$

OBSERVATIONS:

For No-Load Test:

Sl no.	Voltmeter reading V_o	Ammeter reading I_o	Wattmeter reading W_o
1	230	4.5	190

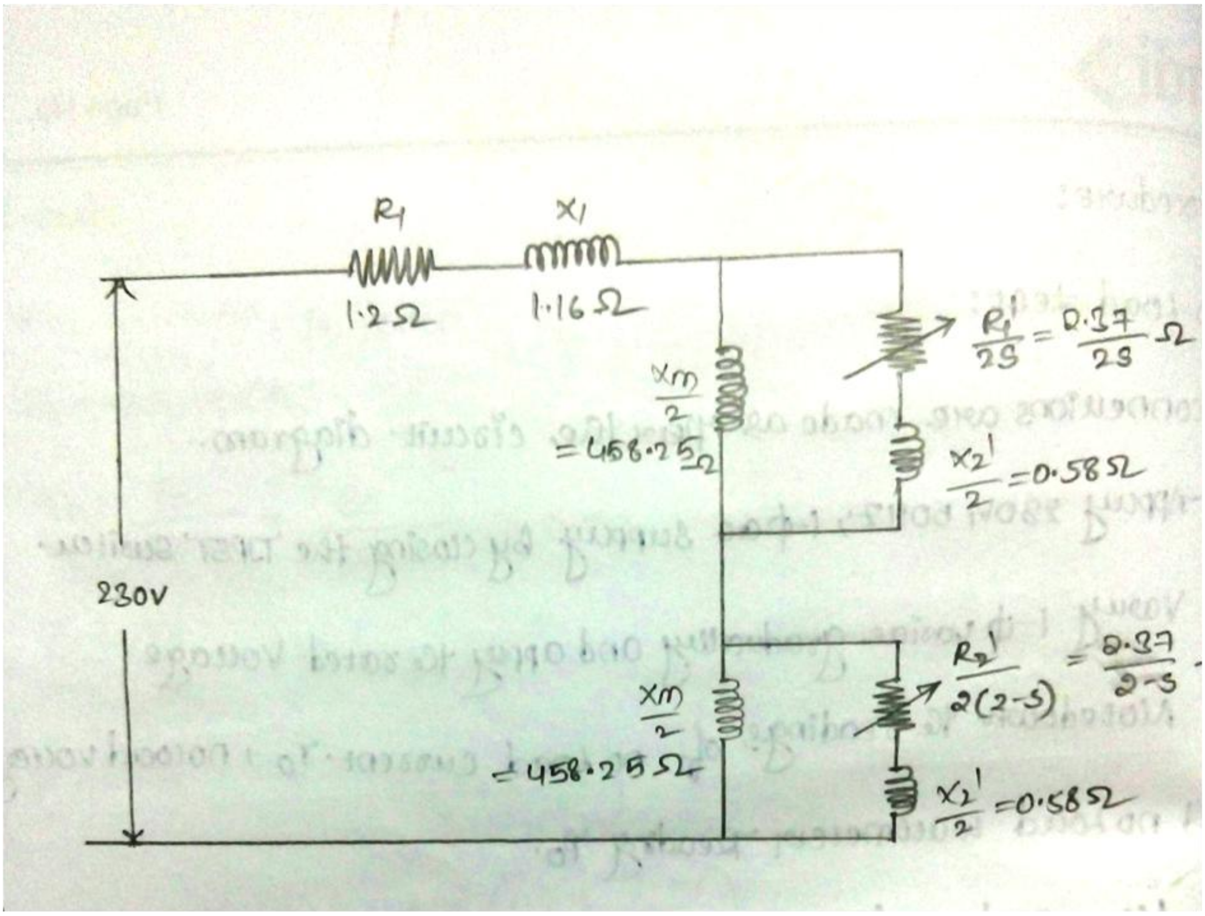
For Blocked Rotor Test:

Sl no.	Voltmeter reading V_{sc}	Ammeter reading I_{sc}	Wattmeter reading W_{sc}
1	35	5.8	200

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Initially rheostat is set at maximum resistance position.
3. Switch ON the supply, and vary the rheostat gradually and note down the readings of ammeter and voltmeter
4. For the corresponding values, average of r1 is taken

EQUIVALENT CIRCUIT



PRECAUTIONS:

1. Avoid loose connections.
2. Switch OFF the Supply before making connections.
3. Do not touch the bare conductors.
4. Avoid parallax error while making observations.

RESULT

By performing the no- load and blocked rotor tests, the equivalent circuit parameters of a single-phase induction motor were determined

Outcomes: By doing this experiment CO1, CO5, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1& PSO2 are attained

8. SPEED CONTROL OF 3-PHASE INDUCTION MOTOR

AIM:

To control the speed of 3 - ϕ induction motor at no-load by using variable frequency method by maintaining V/F constant.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-600) V	1 no
2	Ammeter	MI	(0-10) A	1 no
3	Wattmeter	Electro dynamo meter type	10A/600V UPF 10A/600V LPF	1 no 1 no
4	Tachometer	Digital	(0-9999) RPM	1 no
5	Connecting Wires	*****	*****	Required

NAME PLATE DETAILS:

S.No	Specifications	Rating
1	Power	3 HP
2	Voltage	415V
3	Current	6A
4	Speed	1440rpm
5	Frequency	50Hz
6	PF	0.8

THEORY:

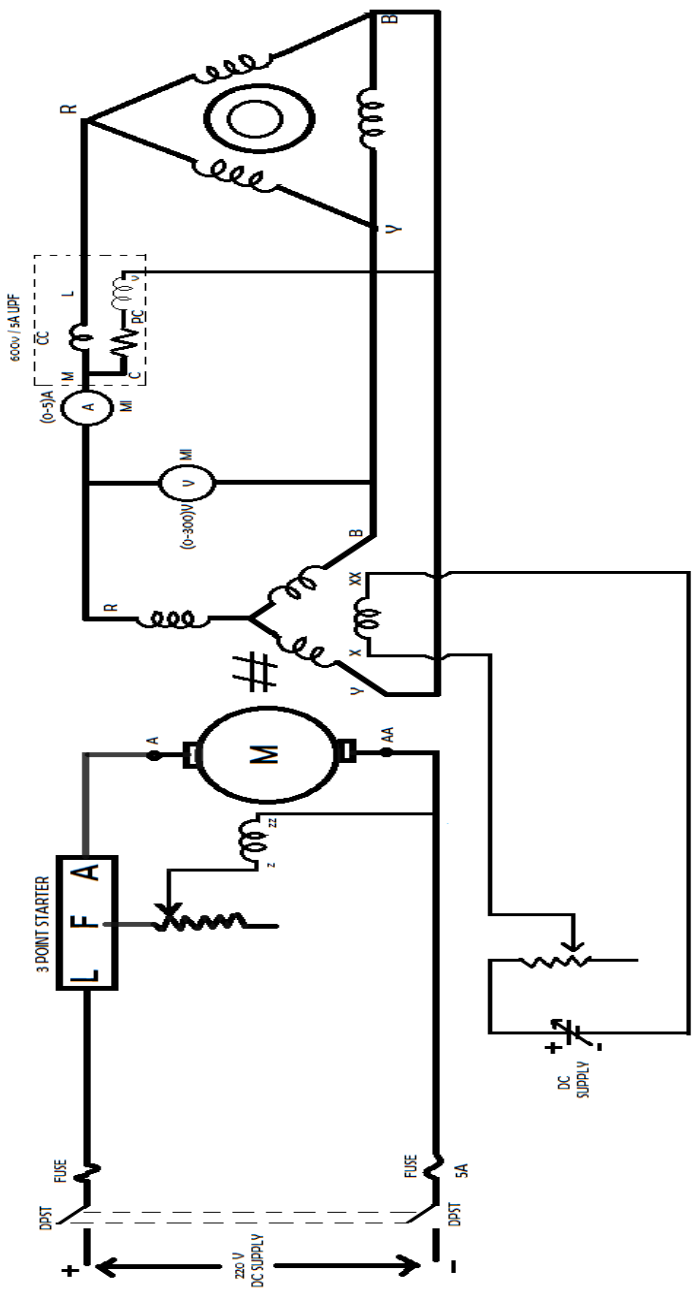
A. Stator Side Control Methods

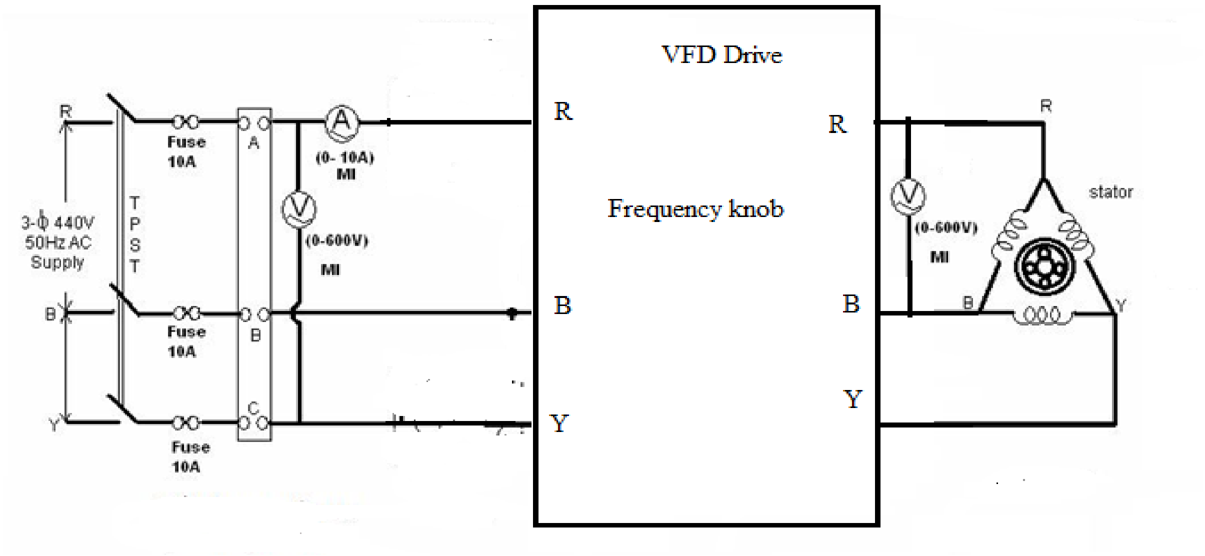
1. Frequency Control (V/f Control)
    - Varies the supply frequency while maintaining a constant Voltage/Frequency (V/f) ratio.
    - Used in variable frequency drives (VFDs).
    - Provides smooth control with high efficiency.
    - Common in industrial applications.
2. Pole Changing Method
    - Used in specially wound motors.
    - Changes the number of poles (PPP) to control speed.
    - Suitable for fan and pump applications.
3. Voltage Control Method
    - Controls motor speed by reducing stator voltage.
    - Used in fan and pump applications.
    - Not efficient for high-load applications due to increased losses.

B. Rotor Side Control Methods (For Wound Rotor Induction Motors)

4. Rotor Resistance Control
    - Inserts external resistances into the rotor circuit.
    - Effective for low-speed and high-torque applications like cranes and hoists.
    - Less efficient due to energy dissipation in resistors.
5. Slip Power Recovery Methods
    - Recovers slip energy and feeds it back to the supply.
    - Two types:
        - Scherbius Drive – Uses a rotary converter.
        - Kramer Drive – Uses a DC machine.
    - Used in high-power applications.

CIRCUIT DIAGRAM:





PROCEDURE:

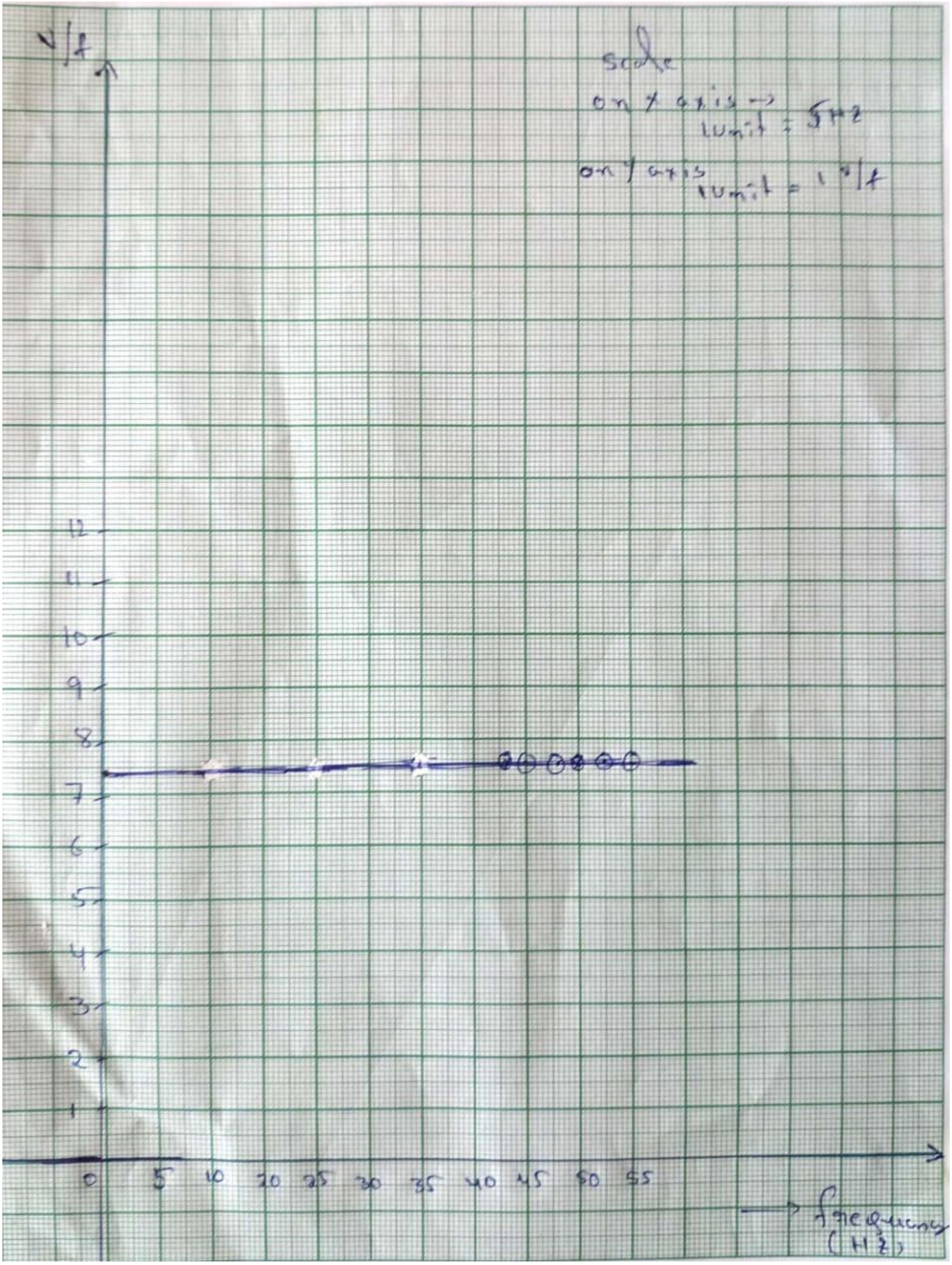
1. Connections are made as per the circuit diagram.
2. Switch ON the DC supply. Vary the 3-point starter up to its final position the motor will reaches its rated speed.
3. Note down the readings of voltmeter and ammeter values of alternator. Also measure the speed of induction motor.
4. Apply variable frequency values to the induction motor by changing the speed of dc shunt motor and note down the speed of induction motor.
5. Bring the rheostat positions to normal value and switch off the supply.

TABULAR FORM:

S.NO	VOLTAGE volts	SPEED IN RPM	FREQUENCY hz	V/F
1	368	1496	50	7.36
2	360	1464	49	7.34
3	352	1438	48	7.3
4	344	1408	47	7.3
5	336	1376	46	7.3
6	330	1348	45	7.3
7	328	1316	44	7.45

PRECAUTIONS:

- Do not touch the bare conductors
- Avoid parallax error while making observations.
- Connections must be made tight
- Before making or breaking the circuit, supply must be switched off



RESULT: The speed control of three phase slip ring induction motor was conducted and Curves are plotted.

OUTCOME: By doing this experiment CO2, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1& PSO2 are attained

9. POWER FACTOR IMPROVEMENT OF A SIGLE PHASE INDUCTION MOTOR

AIM: To improve the power factor of a single-phase induction motor by using capacitor bank

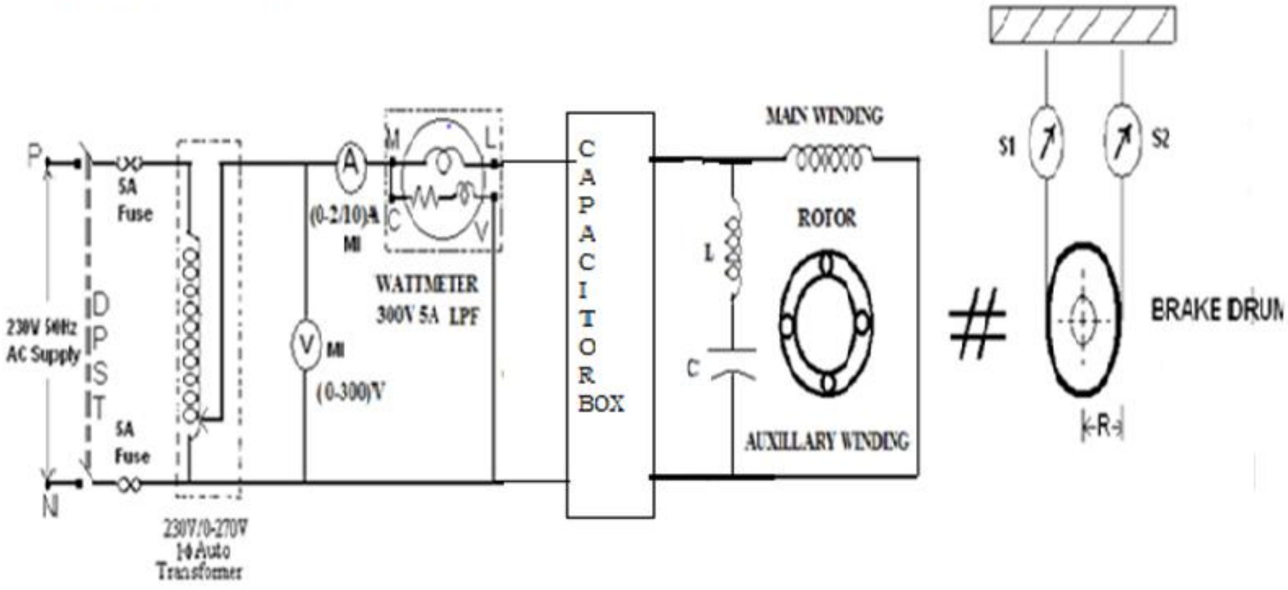
APPARATUS REQUIRED:

	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300) V	1 no
2	Ammeter	MI	(0-10) A	1 no
3	Capacitor box	-	------	1 no
4	Wattmeter	Dynamo-type	5A/300V UPF	1 no
5	Connecting Wires	*****	*****	Required

1 - ϕ Induction motor specifications:

Sl.no	Quantity	Rating
1	Rated power	1 HP
2	Rated voltage	230V
3	Current	5.8 amp
4	Speed RPM	1440 rpm
5	Power factor	Lag
6	Frequency	50 hz
7	Rotor	Squirrel cage

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect the circuit as per the circuit diagram
2. Switch on the supply by closing the DPST switch
3. Now by using the rheostat adjust the motor to its rated speed by varying rheostat
4. Under that condition note down the voltmeter and ammeter readings
5. Now by using the potential divider apply the rated voltage by varying the potential divider
6. Now the motor is running under no load condition after taking the values apply load on the motor
7. Apply capacitor bank for every load and observe the variation in power factor improvement

OBSERVATIONS:

Without capacitor:

S no.	Voltmeter reading V_o (volts)	Ammeter reading I_o (amps)	Wattmeter reading W_o(watts)	Speed (N) RPM	Spring balance	
					S_1 (kg)	S_2 (kg)
1	230	4.5	140	1480	0	0
2	230	4.8	300	1460	1	2
3	230	5.0	320	1440	1.5	3
4	230	5.2	400	1420	2	4
5	230	5.3	440	1390	3.5	6.5
6	230	5.4	460	1340	4	7.5

With capacitor:

S no.	Voltmeter reading Vo(volts)	Ammeter reading Io (amps)	Wattmeter reading W_{0} (watts)	Speed (N) RPM	Spring balance	
					S 1(kg)	S 2(kg)
1	230	3	140	1480	0	0
2	230	3.1	300	1460	1	2
3	230	3.7	320	1440	1.5	3
4	230	3.9	400	1420	2	4
5	230	4.3	440	1390	3.5	6.5
6	230	4.7	460	1340	4	7.5

MODEL CALCULATIONS:

Power factor without capacitor box **cos ø** = W/(V*I)

I= Current without capacitance

1. Cos ø = 140/ (230*4.5) = 0.135
2. Cos ø = 300/ (230*4.8) = 0.271
3. Cos ø = 320/ (230*5) = 0.278
4. Cos ø = 400/ (230*5.2) = 0.334
5. Cos ø = 440/ (230*5.3) = 0.360
6. Cos ø = 460/ (230*5.4) = 0.370

Power factor with capacitor box **cos ø** = W/(V*I_c)

I_c= Current without capacitance

1. Cos ø = 140/ (230*3) = 0.202
2. Cos ø = 300/ (230*3.1) = 0.420
3. Cos ø = 320/ (230*3.7) = 0.376
4. Cos ø = 400/ (230*3.9) = 0.445
5. Cos ø = 440/ (230*4.3) = 0.447
6. Cos ø = 460/ (230*4.7) = 0.425

PRECAUTIONS:

1. Avoid loose connections.
2. Switch OFF the Supply before making connections.
3. Do not touch the bare conductors.
4. Avoid parallax error while making observations.

RESULT: The improvement of the power-factor on single phase induction motor by using capacitor bank was achieved.

Outcomes: By doing this experiment CO3, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1& PSO2 are attained

10. SYNCHONIZATION OF ALTERNATOR BY DARK LAMP METHOD

Aim: To study the synchronization of alternator with infinite bus bar arrangement of dark lamp method.

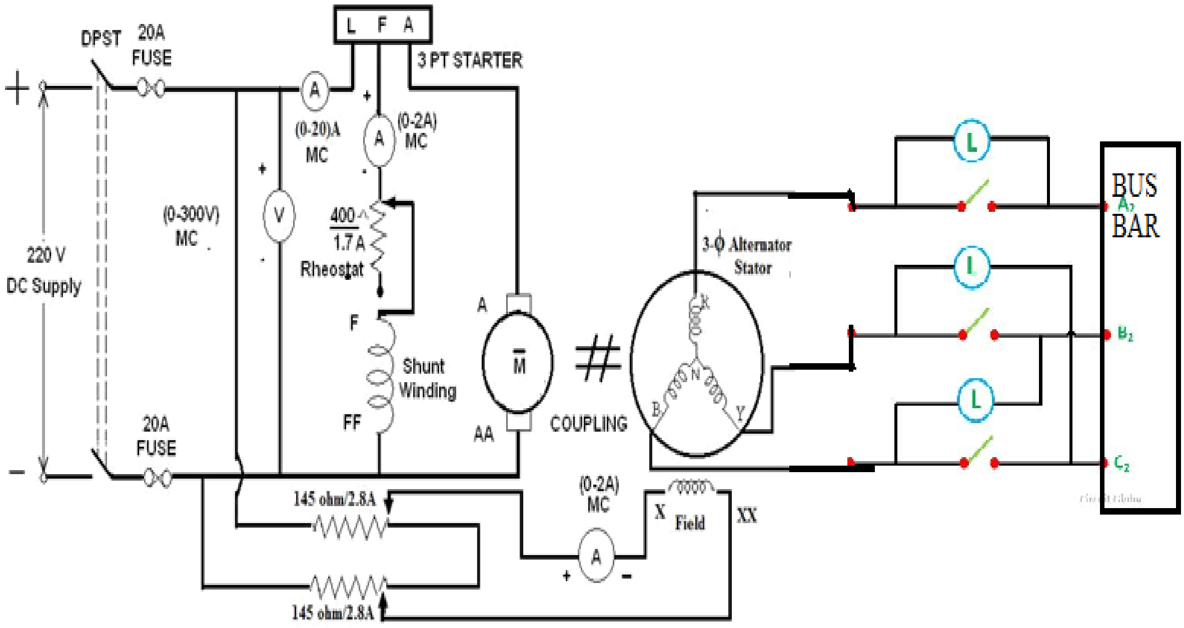
Name plate details:

S.NO	PARAMETER	DC MOTOR	ALTERNATOR
1	Power	5HP	3KVA
2	Armature voltage	220V	415V, 3 Phase
3	Armature current	19A	4.2A
4	Excitation voltage	220V	220V
5	Excitation current	1A	1.4A
6	Speed	1500 RPM	1500RPM

Apparatus required:

S.NO	APPARATUS	TYPE	RANGE	QUANTITY
1	Voltmeter	MI	(0-600) V	2NO
2	Tachometer	Digital	(0-10000) RPM	1NO
3	Dark lamp	--	--	3NO
4	Rheostat	WW	300Ω/2A	1NO
			200Ω/2A	1NO
5	Connecting wires	--	--	Required

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect the circuit as per the circuit diagram
2. Now we need to connect alternator with bus-bar frequency and we need to run power prime mover of alternator at nearly the synchronous speed.
3. To match terminal voltage of alternator with bus bar voltage we need to adjust the field current of alternator until it makes with bus-bar voltage.
4. To draw whether the phase sequence of the alternator matches with bus-bar phase sequence we have condition, if all the 3 bulbs on and off continuously then we can say phase sequence of alternator matches with bus-bar.
5. For each and every step note down corresponding voltmeter, ammeter and wattmeter.
6. After completion of experiment remove the load on brake drum.

PRECAUTIONS:

1. Avoid loose connections.
2. Switch OFF the Supply before making connections.
3. Do not touch the bare conductors.
4. Avoid parallax error while making observations.

RESULT: Hence synchronization of alternator with infinite bus-bar by dark lamp method is studied.

Outcomes: By doing this experiment CO1, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1& PSO2 are attained

11. LOAD TEST ON SIGLE PHASE INDUCTION MOTOR

AIM:

To conduct the direct load test on the given single phase induction motor and to determine and plot its performance characteristics.

APPARATUS REQUIRED:

S.No.	Name of Apparatus	Range	Type	Quantity
1.	Voltmeter	(0-300)V	MI	1
2.	Wattmeter	300V,10A	UPF	1
3.	Ammeter	(0-10)A	MI	1
4.	Tachometer	-	Digital	1
5.	TPST Switch	-	-	1
6.	Single phase Variac	-	-	1
7.	Connecting Wires	-	-	As Needed

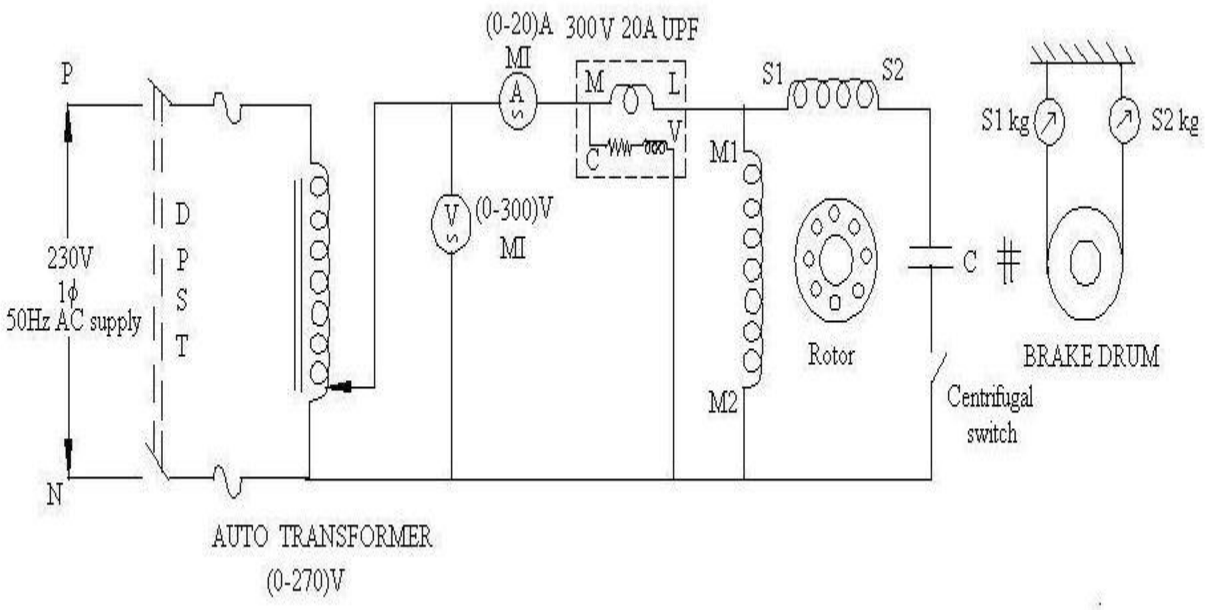
1 - ϕ Induction motor specifications:

Sl.no	Quantity	Rating
1	Rated power	1 HP
2	Rated voltage	230V
3	Current	5.8 amp
4	Speed RPM	1440 rpm
5	Power factor	Lag
6	Frequency	50 hz
7	Rotor	Squirrel cage

THEORY:

Single phase Induction motor is not self-starting IM. One method of making them of self- starting is by providing auxiliary winding on the stator. The rotor has a proper 3-phase winding with three leads brought out through slips rings and brushes. These leads are normally short circuited when the motor is running. Resistances are introduced in the rotor circuit via the slip rings at the time of starting to improve the starting torque. The rotating field created by the stator winding moves past the shorted rotor conductors inducing currents in the latter. These induced currents produce their own field which rotates at the same speed (synchronous) with respect to the stator as the stator – produced field. Torque is developed by the interaction of these two relatively stationary fields. The rotor runs at a speed close to synchronous but always slightly lower than it. At the synchronous speed no torque can be developed as zero relative speed between the stator field and the rotor implies no induced rotor currents and therefore no torque.

CIRCUIT DIAGRAM:



PROCEDURE:

Connections are given as per the circuit diagram.

1) Switch on the supply at no load condition.
2) Apply the rotor voltage to the motor using the variac and note down the readings at ammeter and wattmeter.
3) Vary the load in suitable steps and note down all the meter readings till fill load condition.

TABULER FORM: -

S.No	Input Voltage (V)	Input Current (A)	Speed, N (rpm)	W_1 (watts)	W_2 (watts)	Spring Balance kg		Torque N-m	$P_{in=}$ W1+W2 (Watts)	$P_{out,}$ (Watts)	$\eta=P_{out}/P_{in}$ X 100 (%)
						S1	S2				
1	230	2.6	1440	0	560	0	0	0	560	0	0
2	230	2.75	1420	0	640	2	1	1.499	640	232.32	36.3
3	230	4.1	1401	400	1200	6	1	7.499	1600	1140.246	71.27
4	230	4.26	1360	480	1320	7	1	8.99	1800	1355.66	75.3
5	230	4.6	1338	560	1520	9	2	10.49	2080	1579.65	75.9
6	230	4.85	1320	720	1720	10	2	11.99	2440	1795.49	73.5
7	230	5.6	1300	840	2080	12	2	14.99	2920	2210.20	75.6
8	230	6.0	1290	960	2160	13	2	16.49	3120	2417.56	77.4

CALCULATIONS:

Torque = 9.81(S1-S2) R N-m

= (9.81) (12-2) (0.15)

= 14.99 N-m

Output Power = 2πNT/60

= (2π X 1408 X 14.99)/60

= 2210.20W

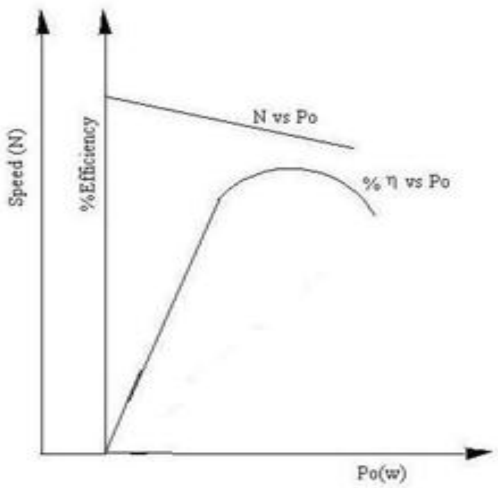
Input Power = W1+W2

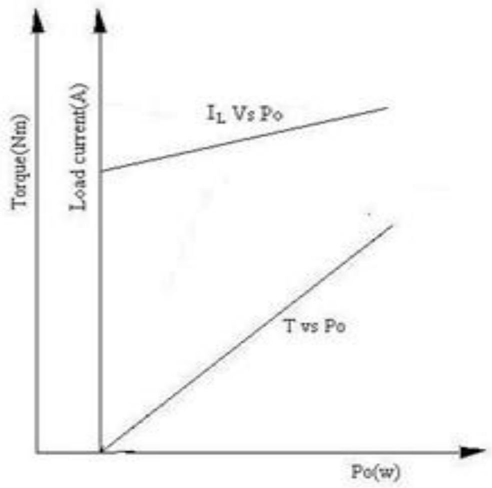
= 2920W

% Efficiency = (Output/ Input) x100

= (2210.20/2920) X 100 = 75.6

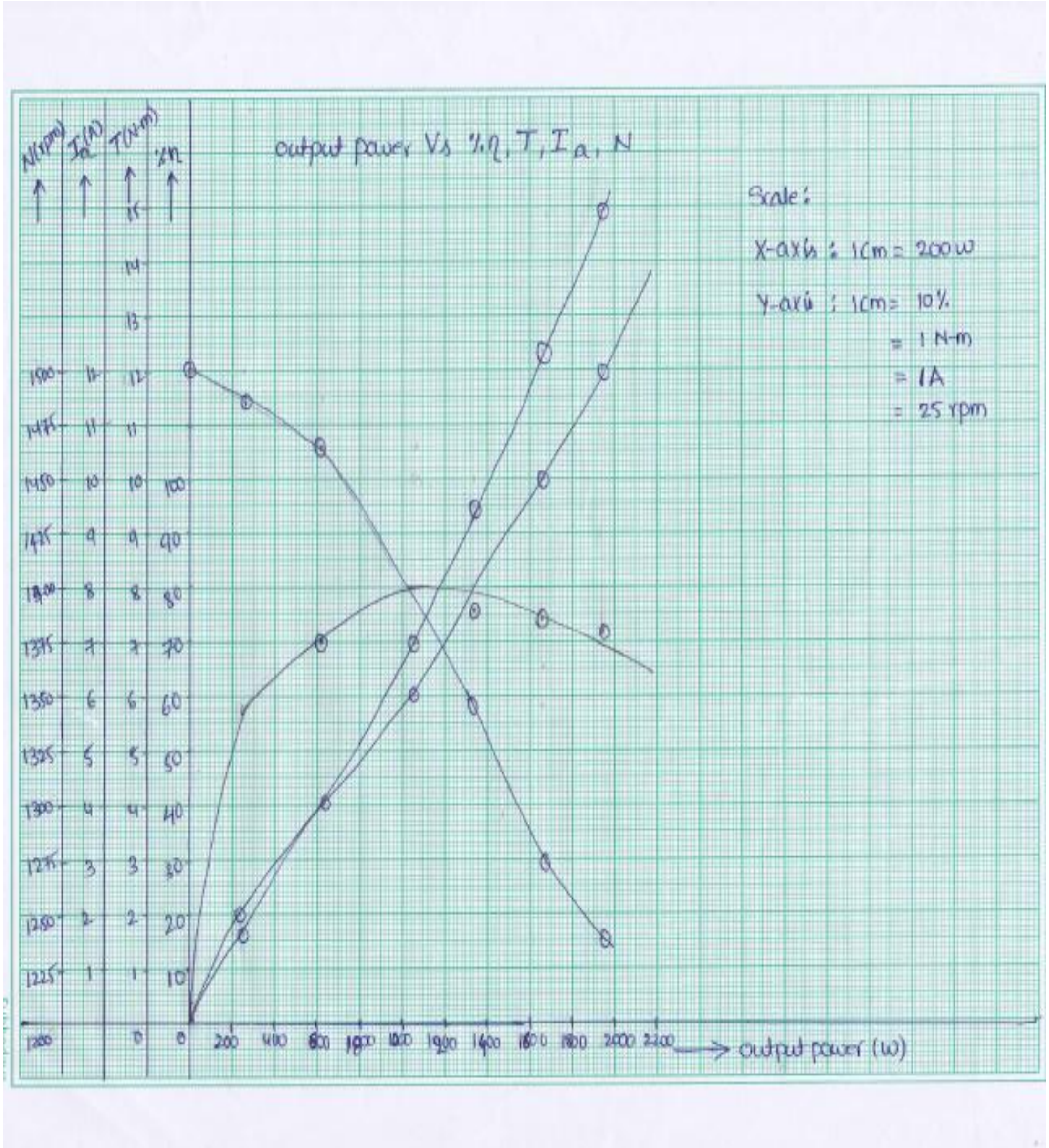
MODEL GRAPH:





PRECAUTIONS:

1. Avoid loose connections.
2. Switch OFF the Supply before making connections.
3. Do not touch the bare conductors.
4. Avoid parallax error while making observations.



RESULT

Thus load test on the single phase induction motor has been conducted and its performance characteristics determined.

Outcomes: By doing this experiment CO1, CO5, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1& PSO2 are attained

12. DETERMINATION OF EFFICIENCY OF THREE PHASE ALTERNATOR BY LOADING WITH THREE PHASE INDUCTION MOTOR

AIM:

To determination of efficiency of three phase alternator by loading with three phase induction motor.

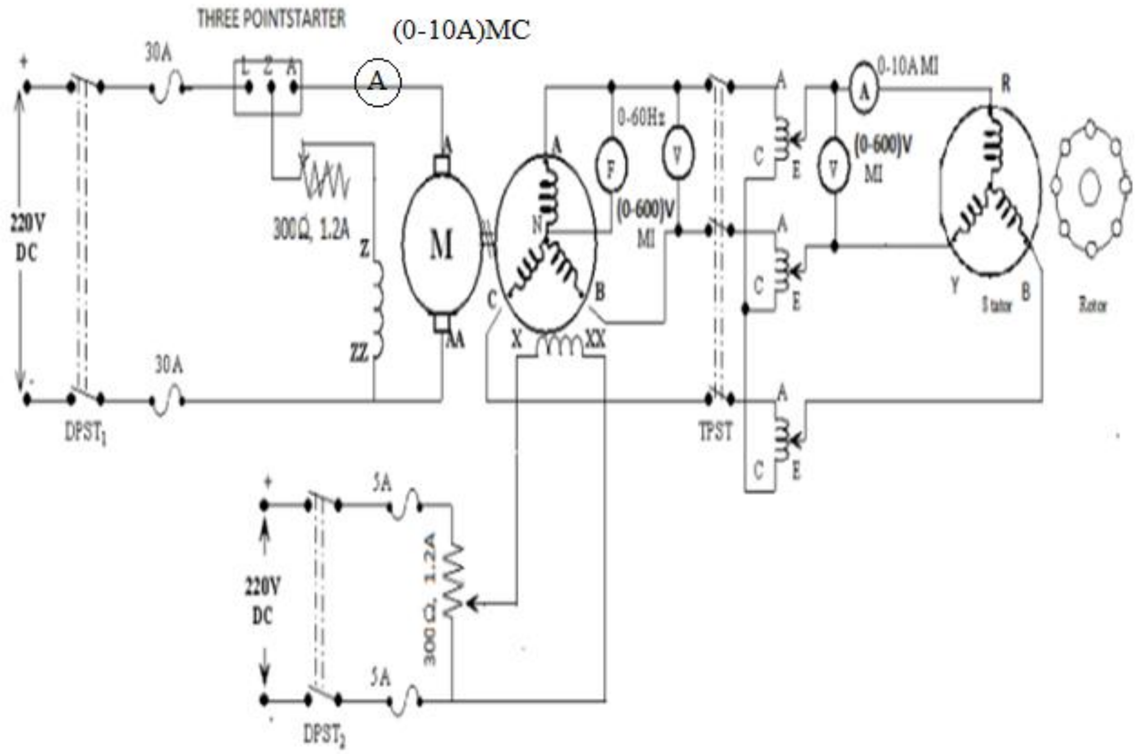
Name plate details:

S.NO	PARAMETER	DC MOTOR	ALTERNATOR
1	Power	5HP	3KVA
2	Armature voltage	220V	415V, 3 Phase
3	Armature current	19A	4.2A
4	Excitation voltage	220V	220V
5	Excitation current	1A	1.4A
6	Speed	1500 RPM	1500RPM

Apparatus required:

S.NO	APPARATUS	TYPE	RANGE	QUANTITY
1	Voltmeter	MI	(0-600) V	2NO
2	Tachometer	Digital	(0-10000) RPM	1NO
3	Ammeter	MI	(0-10) A	1NO
		MC	(0-10) A	1NO
4	Rheostat	WW	300Ω/1.2A	1NO
			300Ω/1.2A	1NO
5	Wattmeter	UPF	600V,10A	2NO
6	Connecting wires	--	--	Required

CIRCUIT DIAGRAM:



PROCEDURE:
PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Before starting the experiment, the potential divider network in the alternator field circuit and field regulator rheostat of motor circuit is set minimum resistance position.
3. Switch ON the supply and close the DPST switch. The DC motor is started by moving starter handle.
4. Adjust the field rheostat of DC motor to attain rated speed (equal to synchronous speed of alternator)
5. By decreasing the field resistance of Alternator, the excitation current of alternator is increased gradually in steps.
6. Close the TPST Switch and run the induction motor with rated speed by using three-phase variac.

TABULAR FORM:

S.NO	Alternator Voltage (V)	Load Current (I_L)	Power (W)	Efficiency
1	415	0	0	0
2	412	0.9	700	75
3	409	1.4	950	83
4	400	2.2	1300	93
5	395	3	1730	94
6	390	3.8	2300	86

PRECAUTIONS:

1. Avoid loose connections.
2. Switch OFF the Supply before making connections.
3. Do not touch the bare conductors.
4. Avoid parallax error while making observations.

RESULT

The determination of efficiency of three-phase Alternator by Induction motor loading has been conducted and its performance characteristics determined.

Outcomes: By doing this experiment CO1, CO5, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1& PSO2 are attained