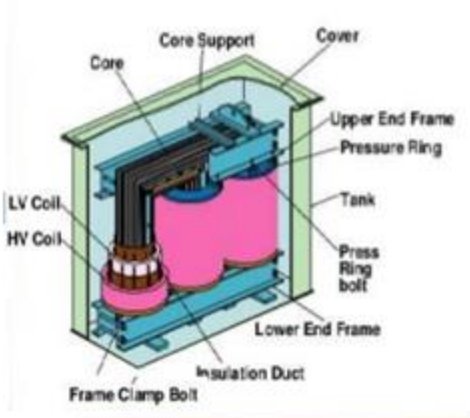
LABORATORY MANUAL
ELECTRICAL MACHINES LAB-II
II B.TECH -II Semester (EEE)



AY-2018-2019

Prepared by

Lab In-charge: Mr.M.Abdul Nabi, Associate Professor

MARRI LAXMAN REDDY
INSTITUTE OF TECHNOLOGY & MANAGEMENT
(Approved by AICTE-New Delhi, Accredited by NAAC with 'A' & Affliated to JNTU, Hyderabad)
Recognised Under Section 2(f) & 12(B) of The UGC act, 1956

Electrical Machines-II Lab Manual

Subject Code:**EE108ES/EE208ES**
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Class: II.B.Tech (EEE)–II Semister

Prepared by
Mr.M.Abdul Nabi
Associate professor

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

CERTIFICATE

This is to certify that this manual is a bonafide record of practical work in the **Electrical Machines lab-II** in **Second Semester of II year B.Tech (EEE,CSE& IT) programme** during the academic year **2018-19**.Thismanual is prepared by **Mr.M.Abdul Nabi (Assc.Professor)** Department of Electrical and Electronics Engineering.

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PREFACE

This book “transformers and their performance characteristics of different AC machines. The manual contains the exercise Electrical Machines-II” lab manual is intended to teach the AC machines and the performance characteristics of Transformers. Readers of this book need only be familiar with the basics of programs and viva questions for easy & quick understanding of the students. We hope that this practicalmanual will be helpful for students of electrical branche of engineering EEE students for understanding the subject from the point of view of applied aspects. There is always scope for improvement in the manual. We would appreciate to receive valuable suggestions from readers and users for future use.

By

Mr.M.Abdul Nabi,
Assc.professor

ACKNOWLEDGEMENT

It was really a good experience, working with ***Electrical Machines-II*** lab. First we would like to thank Dr.Isaac,Professor & HOD of Department of Electrical and Electronics Engineering, Marri Laxman Reddy Institute of Technology & Management for his concern and giving the technical support in preparing the document.

We are deeply indebted and gratefully acknowledge the constant support and valuable patronage of Dr.R.Kotaiah, Director, Marri Laxman Reddy Institute of technology & Management for giving us this wonderful opportunity for preparing the ***Electrical Machines-II*** laboratory manual.

We express our hearty thanks to Dr.K.Venkateswara Reddy, Principal, Marri Laxman Reddy Institute of technology & Management, for timely corrections and scholarly guidance.

At last, but not the least I would like to thanks the entire EEE Department faculties those who had inspired and helped us to achieve our goal.

By

Mr.M.Abdul Nabi,
Assc.professor

GENERAL INSTRUCTIONS

1. Students are instructed to come to Basic Electrical Engineering laboratory on time. Late comers are not entertained in the lab.

2. Students should be punctual to the lab. If not, the conducted experiments will not be repeated.

3. Students are expected to come prepared at home with the experiments which are going to be performed.

4. Students are instructed to display their identity cards before entering into the lab.

5. Students are instructed not to bring mobile phones to the lab.

6. Any damage/loss of system parts like Meters, Components during the lab session, it is student's responsibility and penalty or fine will be collected from the student.

7. Students should update the records and lab observation books session wise. Before leaving the lab the student should get his lab observation book signed by the faculty.

8. Students should submit the lab records by the next lab to the concerned faculty members in the staffroom for their correction and return.

9. Students should not move around the lab during the lab session.

10. If any emergency arises, the student should take the permission from faculty member concerned in written format.

11. The faculty members may suspend any student from the lab session on disciplinary grounds.

12. Never copy the output from other students. Write down your own outputs.

Instructions to the students to conduct an experiment:

1. Students are supposed to come to the lab with preparation, proper dress code and the set of tools required (1. Cutter, 2. Tester (small size), 3. Plier (6-Inches)).
2. Dress code:

   Boys: Shoe & Tuck.

   Girls: Apron & Cut shoe.
3. Don't switch on the power supply without getting your circuit connections verified.
4. Disciplinary action can be taken in the event of mishandling the equipment or switching on the power supply without faculty presence.
5. All the apparatus taken should be returned to the Lab Assistant concerned, before leaving the lab.
6. You have to get both your Observation book and your Record for a particular experiment corrected well before coming to the next experiment.

Guidelines to write your Observation book:

1. Experiment title, Aim, Apparatus, Procedure should be right side.
2. Circuit diagrams, Model graphs, Observations table, Calculations table should be left side.
3. Theoretical and model calculations can be any side as per convenience.
4. Result should always be at the end (i.e. there should be nothing written related to an experiment after its result).
5. You have to write the information for all the experiments in your observation book.
6. You are advised to leave sufficient no of pages between successive experiments in your observation book for the purpose of theoretical and model calculations.

INSTITUTION VISION AND MISSION

VISION

To be as an ideal academic institution by graduating talented engineers to be ethically strong, competent with qualityresearch and technologies

MISSION

To fulfill the promised vision through the following strategic characteristics and aspirations:

- Utilize rigorous educational experiences to produce talented engineers
- Create an atmosphere that facilitates the success of students
- Programs that integrate global awareness, communication skills and Leadership qualities
- Education and Research partnership with institutions and industries to prepare the students for interdisciplinary research

DEPARTMENT VISION, MISSION , PROGRAMME EDUCATIONAL OBJECTIVES AND SPECIFIC OUTCOMES

VISION

To impart high qulality technical knowledge in Electrical and Electronics Engineerimg and to transform them imto globally competent engineers,researchers and entrepreneurs and to make them ethically,emotionally strong enough to meet the technological challenges, to excel globally and thus excel to greater hights in their career.

MISSION

1. To provide the state of the art resources to achieve excellence in all apheres of Electrical Engineering related domains.
2. To bridge the gap between academics and industries through proper teaching and learning processes .
3. To inculcate moral and ethical values & environment among the students through knowledge centric education & research.

PROGRAMME EDUCATIONAL OBJECTIVES

The Programme Educational Objectives (PEOs) that are formulated for the Electrical engineering programme are listed below;

PEO1: To provide the sstudents with a sound foundation in the mathematics,science and engineering fundamentals necessarynto become employable.

PEO2: Graduates are able to apply their technical knowledge to take up higher responsibilities in industry,academics and create innovative ideas in the field of Electrical and Electronics Engineering.

PEO3: Equip graduates with the communication skills, leadership qualities and team wirk with multi disciplinary approach and zeal to provide solutions for engineering problems.

PEO4: to inculcate ethical values and aptitude for lifelong learning needed for a successful professional career of the graduates.

PROGRAM SPECIFIC OUTCOMES

PSO 1: The ability to analyze, design, implement and maintenance of the electrical & power systems for various industrial application.

PSO 2: The ability to apply analytical & experimental techniques for optimization of electrical and Power systems.

PSO 3: The ability to analyze electrical/electronic(s) systems with the help of analogous & discreet mathematical tools.

PROGRAMME OUT COMES

The Program Outcomes (POs) of the department are defined in a way that the Graduate Attributes are included, which can be seen in the Program Outcomes (POs) defined. The Program Outcomes (POs) of the department are as stated below:

PO1. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. 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 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. 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. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. 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. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. 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. 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. 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.

COURSE OBJECTIVES & OUTCOMES

COURSE OBJECTIVES:

The objective of the Electical Machines-II Laboratory is to expose students to the concepts of single phase and three phase transformers, synchronous and asynchronous machines and analyze their performance. It aims to impart knowledge on construction, performance and principle of operation of transformers, salient, non – salient type synchronous generator and induction machines. The starting and speed control of three-phase induction motors and single phase induction motors is also studied.

COURSE OUTCOMES:

Upon the completion of AC Machines practical course, the student will be able to attain the following:

1. Familiarity with the types of synchronous, asynchronous, transformers and their basic characteristics.
2. Ability to make a right decision related to a choice of the motor for a particular system in the industrial environment.
3. Understanding of the concepts of power and efficiency.
4. Understand the concept of efficiency and the short circuit impedance of a single-phase transformer from no - load test, winding resistance, short circuit test, and load test.
5. Understand the starting and connecting procedures of synchronous generators, and to obtain the „V‟ and inverted „V‟ curves of synchronous motors.
6. Experimentally obtain the load characteristics, starting current and starting torque of a three phase and single phase induction motor and to derive circuit parameters from no - load and blocked-rotor tests.

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Department of Electrical & Electronics Engineering

EE407ES: ELECTRICAL MACHINES LAB - II

LIST OF EXPERIMENTS/DEMONSTRATIONS:

1. O.C. & S.C. Tests on Single phase Transformer
2. Sumpner's test on a pair of single phase transformers
3. No-load & Blocked rotor tests on three phase Induction motor
4. Regulation of a three –phase alternator by synchronous impedance &m.m.f. methods
5. V and Inverted V curves of a three—phase synchronous motor.
6. Equivalent Circuit of a single phase induction motor
7. Determination of Xd and Xq of a salient pole synchronous machine
8. Load test on three phase Induction Motor
9. Separation of core losses of a single phase transformer.
10. Parallel operation of Single phase Transformers.
11. Scott Connection of transformer
12. Regulation of three-phase alternator by Z.P.F. and A.S.A methods

Ex No:
Date :

1. OPEN CIRCUIT AND SHORT CIRCUIT TESTS ON 1-ϕ TRANSFORMER

AIM: To conduct the open and short circuit tests on a single phase transformer to determine core losses, copper losses, and hence determine regulation and the parameters of the equivalent circuit.

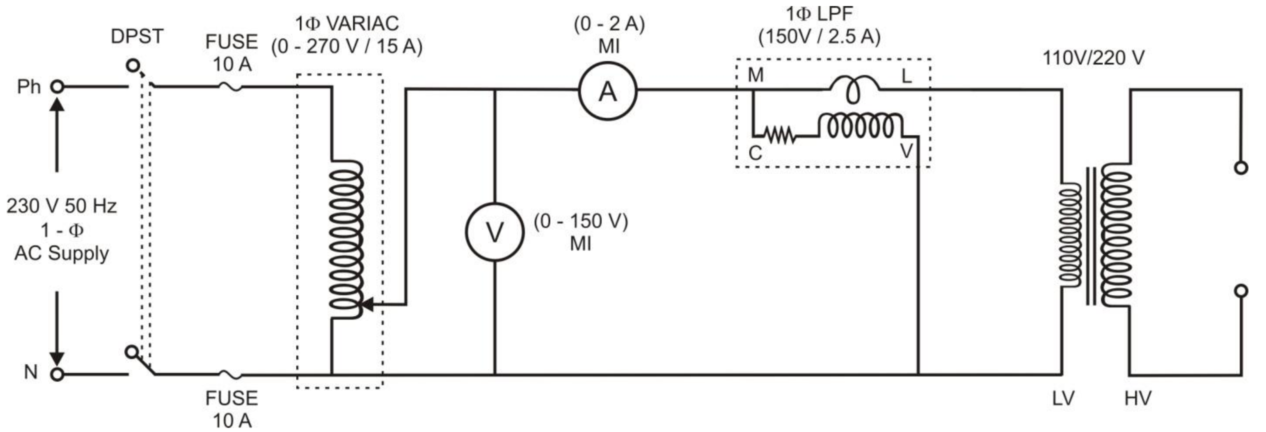
NAME PLATE DETAILS:

Volts primary	
Volts secondary	
Output	
Frequency	

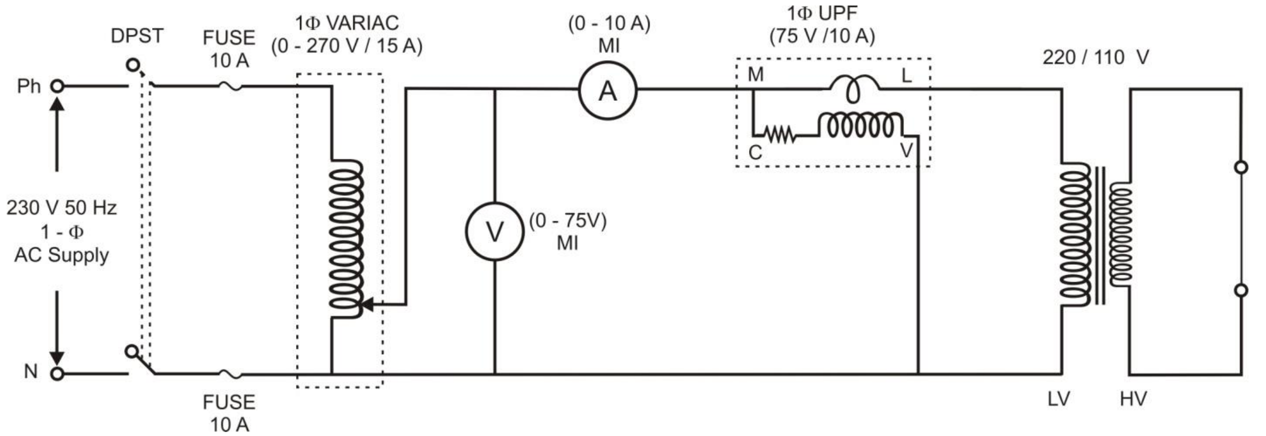
APPARATUS:

S. No.	Item	Type	Range	Quantity
1	Ammeter	(M.I)	0 – 15 A	1 No
2	Ammeter	(M.I)	0 – 1 A	1 No
3	Voltmeter	(M.I)	0 – 300 Volts	1 No
4	Voltmeter	(M.I)	0 – 50 Volts	1 No
5	Wattmeter	U.P.F	300 V / 10 A	1 No
6	Wattmeter	L.P.F	150 V / 5 A	1 No

CIRCUIT DIAGRAM:



OC TEST ON SINGLE PHASE TRANSFORMER



SC TEST ON SINGLE PHASE TRANSFORMER

PROCEDURE:

O. C TEST:

1. Do the connections as per the circuit diagram.
2. Apply rated voltage with the help of autotransformer across LV winding, with the HV winding as open circuited.
3. Note down the voltmeter (V), Ammeter (Io) and wattmeter (P_o) readings.

CALCULATIONS:

Iron losses, $P_I = P_o$ watts.

No load P.f., $\cos \phi_o = \frac{P_o}{VI_o}$

Magnetizing current, $I_m = I_0 \sin\phi_o$

Loss component of no load current, $I_w = I_0 \cos\phi_o$

Magnetizing reactance, $X_0 = \frac{V}{I_m}$

Equivalent resistance of iron losses, $R_0 = \frac{V}{I_m}$

PROCEDURE:

S. C TEST:

1. Make the connections as per the circuit diagram.
2. Adjust supply voltage by 1-ϕ booster Transformer or 1-ϕ variac such that the current through the transformer is the rated value and note down all meter readings.

Calculations:

Full load copper losses $P_{Cu} = P_{SC}$ Watts.

Power factor on short circuit, $\cos \phi_{oSC} = \frac{P_{sc}}{V_{sc} I_{sc}}$

Short circuit impedance $Z_{01} = \frac{V_{sc}}{I_{sc}}$ Ω.

Referred to primary.

HT equivalent resistance, $R_{01} = \frac{Psc}{I_{sc}^2}$.

HT equivalent reactance, $X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$

a) EFFICIENCY: At x times full load and power factor cosϕ, output, P_0= x S cos ϕ kW where S is the KVA rating of the transformer.

INPUT = OUTPUT +IRON LOSS+ X^2 P_{Cu}

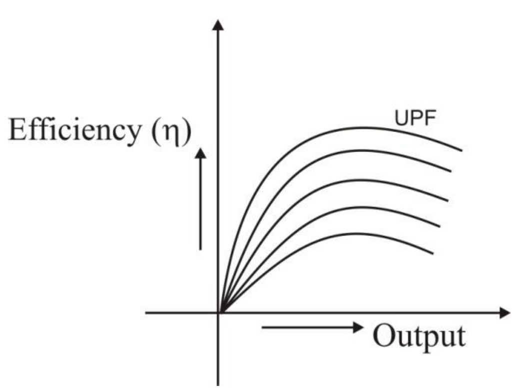
Percent efficiency, η = OUTPUT /INPUT x 100

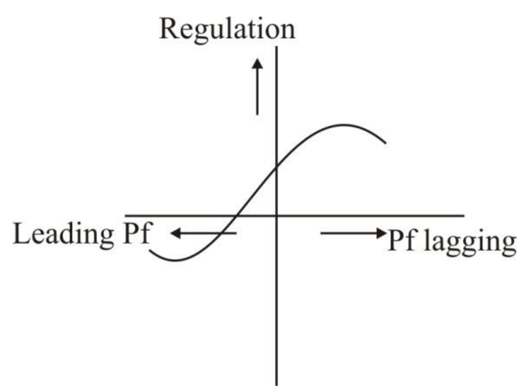
1. Calculate the efficiency of the transformer at U. P. F. and 0.8 pf and 0.6 pf for ¼, ½, ¾, 1 and 1 ¼ full load and draw the characteristics.
2. Calculate the maximum efficiency and the load corresponding to maximum efficiency and compare the result obtained from graph.

b) REGULATION: Regulation is percent drop in voltage from no load to full load at any power factor due to voltage drops in resistance and leakage reactance of the transformer.

1. Calculate the percent resistance $V_R = I_1 R_1/V_1 \times 100$ and percent reactance, $V_x = I_1 X_1/V_1 \times 100$.
2. Calculate the percent regulation, = V_r Cos ϕ + V_x Sinϕ at different power factors viz: UPF, 0.8 pf lagg & lead 0.6 pf lagg & lead and draw the regulation curve.

EXPECTED CURVES:





TABULAR COLUMN:

PART-I: EFFICIENCY CURVE

S.No.	x	Po	Pi	η
1.				

PART-II: REGULATION CURVE AT FULL LOAD

S.No.	Power Factor	Regulation
1.		

RESULT:

VIVA QUESTIONS:

1. Which losses are called magnetic losses?
2. Write equations for hysteresis and eddy-current losses.
3. Why O.C test will conduct on LV side?
4. Why S.C test will conduct on HV side?
5. Why transformer fails to operate on D.C supply?
6. Explain why low power factor meter is used in O.C test.
7. Why the iron losses are neglected when S.C test on a Transformer.

8. Draw the phasor diagram for a S.C. test on a transformer.
9. How do you reduce the hysteresis and eddy-current losses?
10. Under what condition the regulation of a transformer becomes zero.
11. Define voltage regulation with equation for lagging and leading loads?
12. Generally what is the efficiency percentage of a transformer?
13. What is the condition for maximum efficiency?

Ex No:
Date :

2. SUMPNER'S TEST ON A PAIR OF 1-Φ TRANSFORMERS

AIM: To conduct Sumpner's test on a pair of identical transformer and hence determine the equivalent circuit parameters.

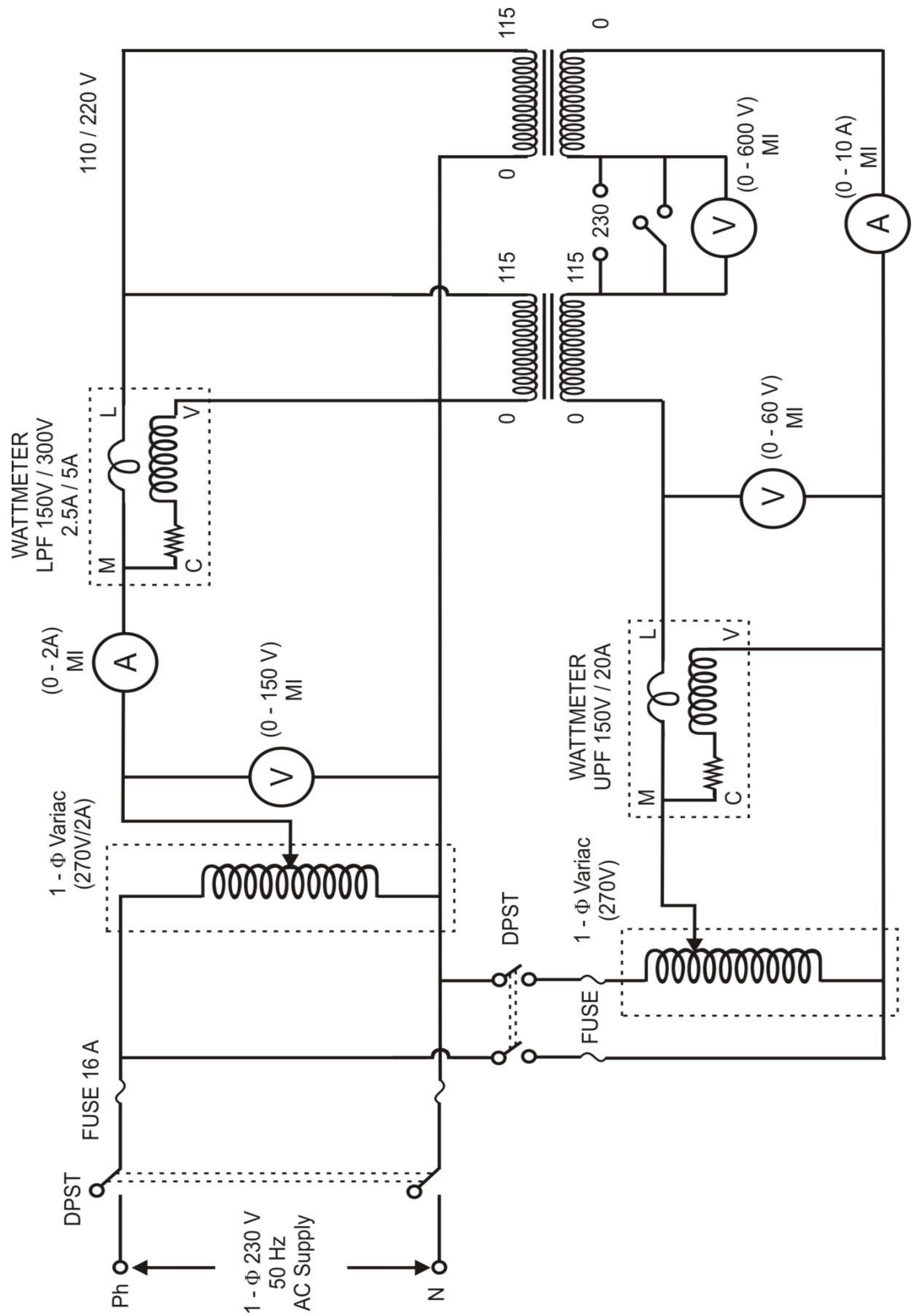
NAME PLATE DETAILS:

Primary Volts :	
Secondary volts :	
Primary Current :	
Secondary Current :	
kVA rating :	

APPARATUS:

Name	Range	Type	Quantity
Variac	20Amps	1-ϕ	2
Voltmeter	(0-300V)	MI	2
Voltmeter	(0-150V)	MI	1
Ammeter	(0-2A)	MI	1
Ammeter	(0-20A)	MI	1
Wattmeter	300V/10A	LPF	1
Wattmeter	75V/20A	UPF	1

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect the circuit diagram, with meters of appropriate ranges as shown in the circuit diagram.
2 Voltmeter (V3) used to check correctness of the polarity.
3. The primaries are connected in parallel to the 115V supply Keeping switch open (S1).
4. If the polarities are appropriate, V3 should read Zero (other wise it will read two times the rated secondary voltage; then one of the Secondaries has to be reverse connected).
5. When V3 reads zero, switch (S1) is closed and a low voltage is injected into the secondary winding, such that rated current is circulated.
6. This is only a circulation current in the secondary and does not cause any equivalent current to be drawn by the primaries from the supply.
7. The reflected current in the primaries flows as the circulating current in the closed loop formed by two primaries. This reflected current does not flow from the supply. It is to be noted that the net power drawn from the supply is only power corresponding to no load losses.
8. The two sets of meters are read and the parameters are calculated from the readings.
9. This test is OC test when you look from primary side and an SC test when look from the secondary side.

CALCULATIONS:

Predetermination of Efficiency:

No load losses = $\frac{Wo}{2}$ for each Transformer

Copper losses = $\frac{Wsc}{2}$ for each Transformer

$$\eta_{at\ FL} = \frac{FL\ \ power}{(FL\ \ power\ +\ No\,load\ lossess\ +\ FL\ Copper\ \ lossess)}$$

$$\eta_{at\ ½\ FL} = \frac{\frac{1}{2}FL\ \ power}{\frac{1}{2}FL\ \ power\ +\ No\ load\ \ lossess\ +\left(\frac{1}{2}\right)^2\ FL\ copper\ \ lossess}$$

No load current = $\frac{Io}{2}$ per transformer

Voltage applied = V_o

Using these values the Values of R_o & X_o are calculated as in the

OC test

$W_o=V_oI_o\ Cos\theta_o$

i.e $Cos\theta_o = (W_o/2)/(v*[I_o/2])$ (for each transformer)

$I_w =[I_o/2]Cos\theta_o$

$I_m = [I_o/2]Sin\theta_o$

$R_o = V_o/I_w$

$X_o = V_o/I_m$

SC current = $I_2 = I_{sc}$

SC voltage = $V_2/2 = V_{sc}$

SC power = $W_2/2 = W_{sc}$

Using these values, the series parameters R_{o2} and X_{o2} (referred to secondary) are calculated as in the sc test.

$$W_{sc} = I_{sc}^2 R_{o1}$$

$$R_{o1} = W_{sc} / I_{sc}^2$$

$$Z_{o1} = V_{sc} / I_{sc}$$

$$X_{o1} = \sqrt{(Z_{o1}^2 - R_{o1}^2)}$$

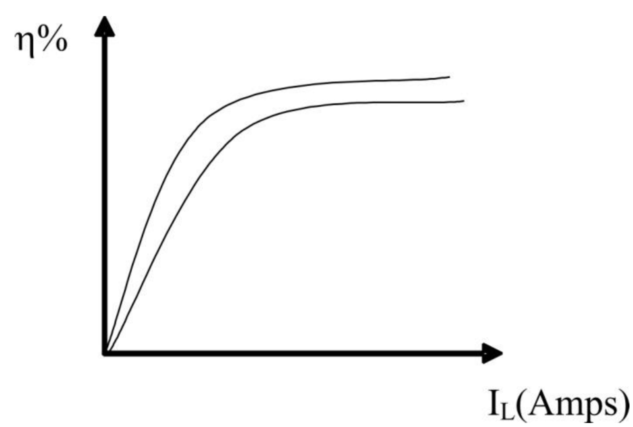
$$R_{o2} = R_{o1} K^2$$

$$X_{o2} = X_{o1} K^2$$

PRECAUTIONS:

The polarities of both secondary are checked, by noting the readings of Voltmeter (V2). Zero reading of Voltmeter (V2) ensures correct polarity.

EXPECTED GRAPH:



TABULAR COLUMN:

Si.No.	V_0(V)	I_0(A)	W_0(W)	V_2(V)	I_2(A)	W_2(W)
1.						

RESULT:

VIVA QUESTIONS:

1. Why two identical transformers are required for back to back test?
2. What is the material kept inside a breather?
3. Write the relations between line-currents, phase-currents and line voltage, phase voltages in a star and delta connections.
4. Draw star/star, star/delta, delta/delta delta/star winding connections when three single phase transformers are used.
5. What is the use of tertiary winding in a transformer?
6. How can you use a 3-phase auto-transformer as a step-up auto-transformer?
7. Explain the working principle of back to back transformer test?
8. Why the core is made of silicon steel laminations?
9. What is the role of Buchholz relay?
10. At which load transformer can give maximum efficiency?
11. Differentiate Sumpner's test and O.C and S.C tests on transformer?

Ex No:

Date :

3. NO-LOAD & BLOCKED ROTOR TESTS ON THREE PHASE INDUCTION MOTOR

AIM : To perform No-load test on 3- phase Induction motor and to find the magnetizing resistance and Reactance.

EQUIPMENT REQUIRED:

COMPONENTS REQUIRED:

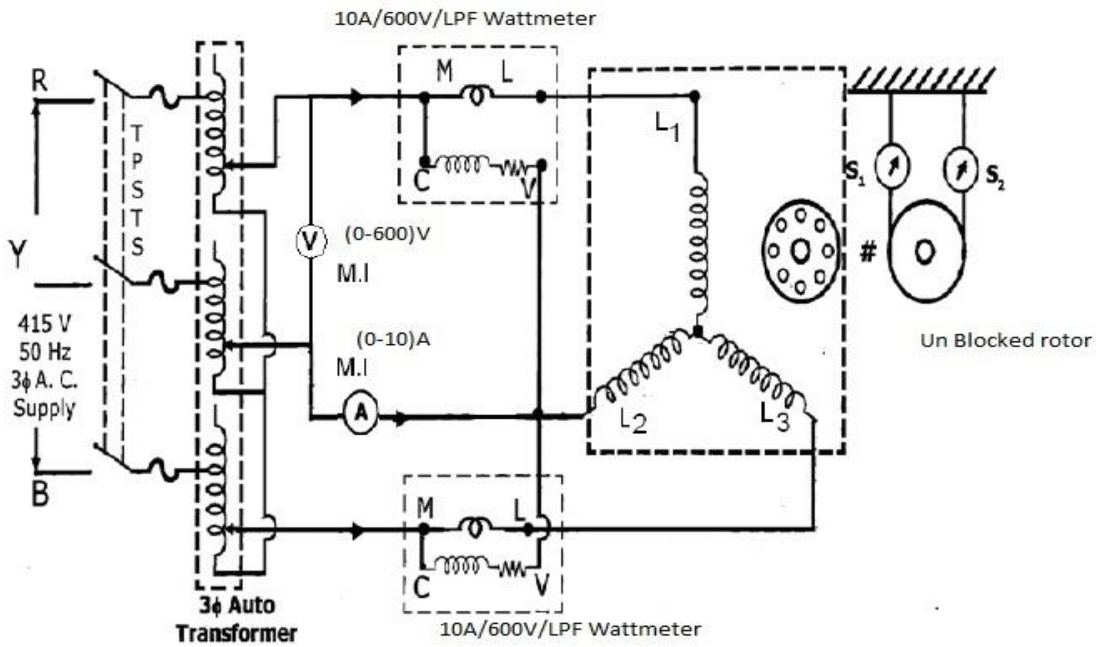
S.NO	COMPONENTS	TYPE	RANGE	Quantity
1	3 pole MCB	--	25A	1
2	Ammeter	MI	(0-20)A	1
3	Wattmeter	Dynamometer type	10A, 600V, UPF	2
4	Voltmeter	MI	(0-600)V	1
5	Mechanical Load	Brake drum with spring balances	--	1

CIRCUIT DIAGRAM:

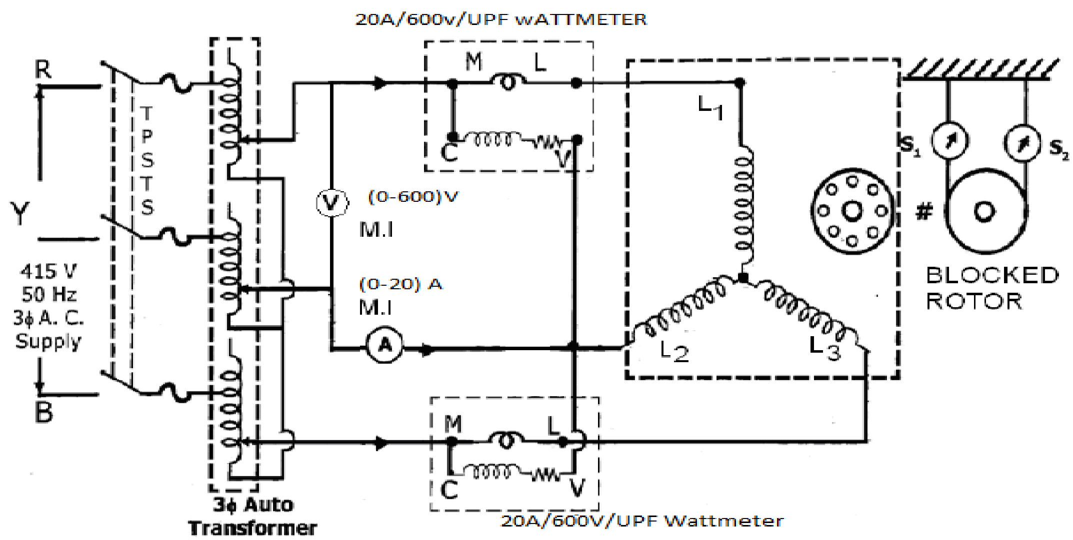
A)NO LOAD TEST

B) BLOCKED ROTOR TEST

NO LOAD TEST



BLOCKED ROTOR TEST



PROCEDURE:

1. Make the circuit as per the given circuit diagram.
2. Close the main switch and gradually increase the voltage applied to the stator through the auto transformer.
3. At each value of applied voltage, take the values of the two watt meters, stator current I_0, Stator voltage V, rotor current I_r and speed.
4. Tabulate the observations and calculate the power input and power factor for each reading.
5. Measure the stator resistance and make the necessary temperature correction.

CALCULATIONS:

The input Power = $W_1 + W_2 = P_0$

Stator copper loss = $3I_0^2 R_1$

We have $P_0 = \sqrt{3} VI_0 \cos\Phi_0$

$\cos\Phi_0 = P_0 / (\sqrt{3} VI_0)$

In phase component of load current= $I_0 \cos\Phi_0$

Magnetizing component of load current = $I_0 \sin\Phi_0$

Resistance in Magnetising circuit = voltage per phase/ $I_0 \cos\Phi_0$

Magnetising reactance = voltage per phase/ $I_0 \sin\Phi_0$

OBSERVATIONS :

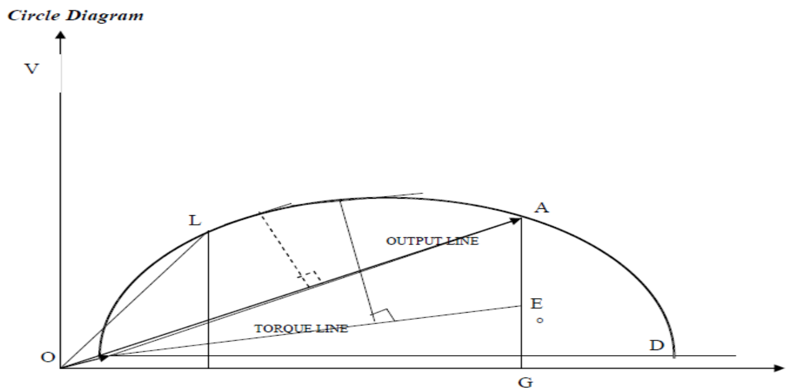
No-Load test:

V (Vats)	I (ANPS)	W_1 (Watts)	W_2 (Watts)

Blocked rotor test:

V (Vats)	I (AMPS)	W_1 (Watts)	W_2 (Watts)

GRAPHS:



RESULT:

Applications: This experiment is used to find the Rotor copper losses, stator copper losses, torque and efficiency of three phase induction motor.

Sample questions:

1. Find no load losses of 3 phase induction motor using suitable test.
2. Draw the circle diagram of 3 phase induction motor to find efficiency of 3 ph induction motor.
3. Draw the circle diagram of 3 phase induction motor to find max.torque of 3 ph induction motor.
4. Draw the circle diagram of 3 phase induction motor to find rotor and stator copper losses of 3 ph induction motor.
5. Draw the circle diagram of 3 phase induction motor to find max. output of 3 ph induction motor.

VIVA VOCE QUESTIONS :

1. Explain what is meant by a 3-phase induction motor?

2. Write the classification of 3-phase induction motor?

3. State the steps to draw the equivalent circuit of 3-phase induction motor?

4. State the condition for maximum torque of 3-phase induction motor?

5. Give the different methods of speed control of I.M.

6. How do you calculate slip speed?

7. State the condition when induction motor acts as induction generator?

8. Give the other name for induction generator?

Ex No:

Date :

4. REGULATION OF 3-ϕ ALTERNATOR BY SYNCHRONOUS IMPEDANCE AND MMF METHODS

AIM: To predetermine the regulation of an alternator by

a) Synchronous impedance method and

b) MMF method.

NAME PLATE DETAILS:

Motor

Voltage	
Current	
Output	
Speed	

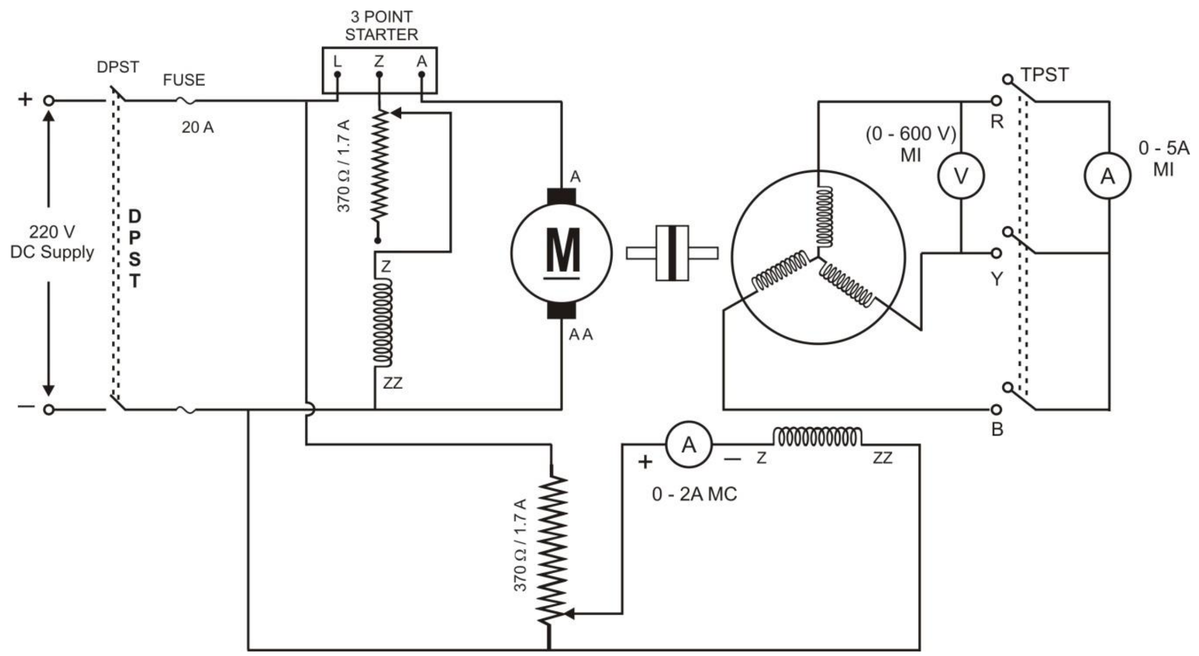
Generator

Voltage	
Current	
Output	
Speed	
Frequency	
phase	

APPARATUS:

Si.No.	Item	Type	Range	Quantity
1	Ammeter	(M.I)	0 – 5 A	1 No
2	Ammeter	(M.C)	0 – 2 A	1 No
3	Voltmeter	(M.I)	0 – 600 Volts	1 No
4	Rheostats		0 – 360 ohms / 1.7A	1 No
5	Rheostats		0 – 1000 ohms / 1.2A	1 No

CIRCUIT DIAGRAM:



PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Start the alternator with the help of prime mover (DC Shunt motor) and adjust speed to the synchronous speed. The speed of the alternator is to be kept constant throughout the experiment.
3. Excite the field winding alternator keeping armature open.
4. Note down the terminal voltage at different values of field currents.
5. Draw the graph of armature voltage versus field current to get the open circuit characteristic (O.C.C) of the Alternator.
6. Close the TPST switch.
7. Excite the field winding of the alternator till the rated current flows through the armature.
8. Note down all meter readings.
9. Draw the graph of the short circuit current versus field current to get the short circuit characteristic (SCC).
10. Obtain the synchronous impedance corresponding to the rated voltage.

    $Z_s = \frac{V_{oc}}{I_{sc}}$, I_f const

11. Measure the armature resistance per phase by drop method. The a.c. resistance will be 20% more than the D.C. Resistance: $R_a = 1.2\ R_{dc}$
12. Calculate the synchronous reactance, $X_s = \sqrt{Z^2_s - R^2_{ac}}$
13. Calculate the generated e.m.f. With full load at a power factor

    Cos¢ $E = [(V \cos¢ + I R_a)^2 \ (V \sin ¢ + I X_s)^2]^{1/2}$

    (+) sign for lagging p.f. and (-) sign for leading power factors.

14. Calculate full load regulation at different power factors.

15. Draw the graph of regulation versus p.f.

TABULAR COLUMN:

S.NO.	I_f	E_g	I_f	I_{SC}
1.				

RESULT:

VIVA QUESTIONS:

1. What is regulation of alternator?
2. Under what condition, Regulation is positive or negative?
3. What is regulation at UPF
4. Why Regulation is so important in alternator?
5. How the regulation is effected by armature reaction?

Ex No:

Date :

5. V AND INVERTED V- CURVES OF 3 - Φ SYNCHRONOUS MOTOR

AIM: To draw the V and inverted V- curves of Synchronous motor.

NAME PLATE DETAILS:

Motor

Voltage	
Current	
Output	
Speed	

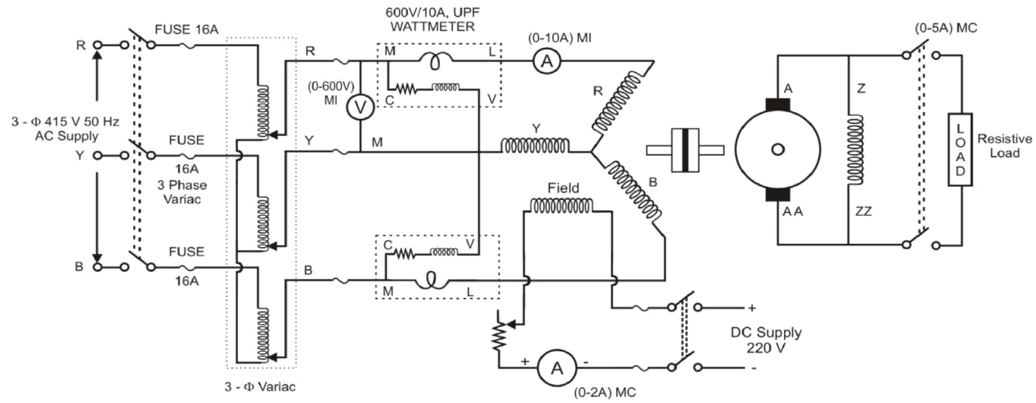
Generator

Voltage	
Current	
Output	
Speed	
Frequency	
phase	

APPARATUS:

Si.No.	Item	Type	Range	Quantity
1	Ammeter	(M.I)	0 – 5 A	1 No
2	Ammeter	(M.C)	0 – 2 A	1 No
3	Voltmeter	(M.I)	0 – 600 Volts	1 No
4	Rheostats		0 – 360 ohms / 1.7A	1 No
5	Rheostats		0 – 1000 ohms / 1.2A	1 No

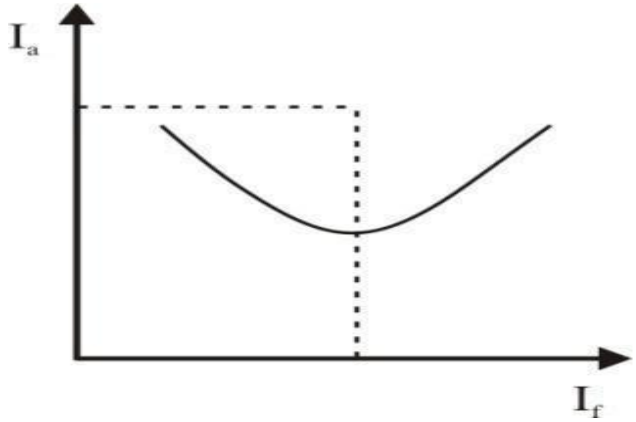
CIRCUIT DIAGRAM



PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Switch on the AC supply feeding to 3-phase synchronous motor and start the motor using 3- phase variac.
3. Ensure that the motor is running at no-load and synchronous Speed.
4. Now the field winding of the synchronous motor is exited with excitation unit.
5. Set the Rheostat of the field winding of the motor to the position of the normal excitation. (Here the armature current will draw the minimum current from the mains.)
6. Note down all meter readings at this position.
7. Decrease the excitation current in steps an note down ammeter and wattmeter readings. (Excitation current may be reduced till the rated armature current flows in the armature circuit of the synchronous motor) (I_f as I_a).
8. Again set back rheostat position to normal excitation position, now increase the excitation in steps and note down all meter readings.
9. Repeat the step - 5, 6, 7, and 8 for half load and full load.
10. Decrease the load on the motor and switch of the supply.

MODEL GRAPHS:



TABULAR COLUMN:

At Full load

S.No	I_f (A)	I_a (A)	W (Watts)	Cos Φ
1				
2				

Half full load

S.No	I_f (A)	I_a (A)	W (Watts)	Cos Φ
1				
2				

At No Load

S.No	I_f (A)	I_a (A)	W (Watts)	Cos Φ
1				
2				

PRECAUTIONS:

1. Loose connections are avoided.

2. Note down all meter readings without any parallax error.

3.If the watt meter reading shows negative reading (Kick backs), then interchange the connection of **M** and **L** of the wattmeter

RESULT:

VIVA QUESTIONS:

1. At what condition the power output of a synchronous generator connected to an infinite bus is maximum.
2. How can we run a synchronous motor as synchronous condenser?
3. Why Synchronous motor is not self-starting motor.
4. What happens if excitation is changed?
5. When load is increased on a synchronous motor, does the speed fall like an induction motor? If not, explain how the load torque is produced.

Ex No:

Date :

6. EQUIVALENT CIRCUIT OF A 1-ϕ INDUCTION MOTOR

AIM:

To determine the parameters of equivalent circuit of a 1-ϕ induction motor by conducting no load test and blocked rotor test.

APPARATUS:

NAME	***RANGE***	***TYPE***	***QUANTITY***
Ammeter	(0-10A)	MI	1
Ammeter	(0-20A)	MI	1
Voltmeter	(0-300V)	MI	1
Voltmeter	(0-75V)	MI	1

NAME PLATE DETAILS

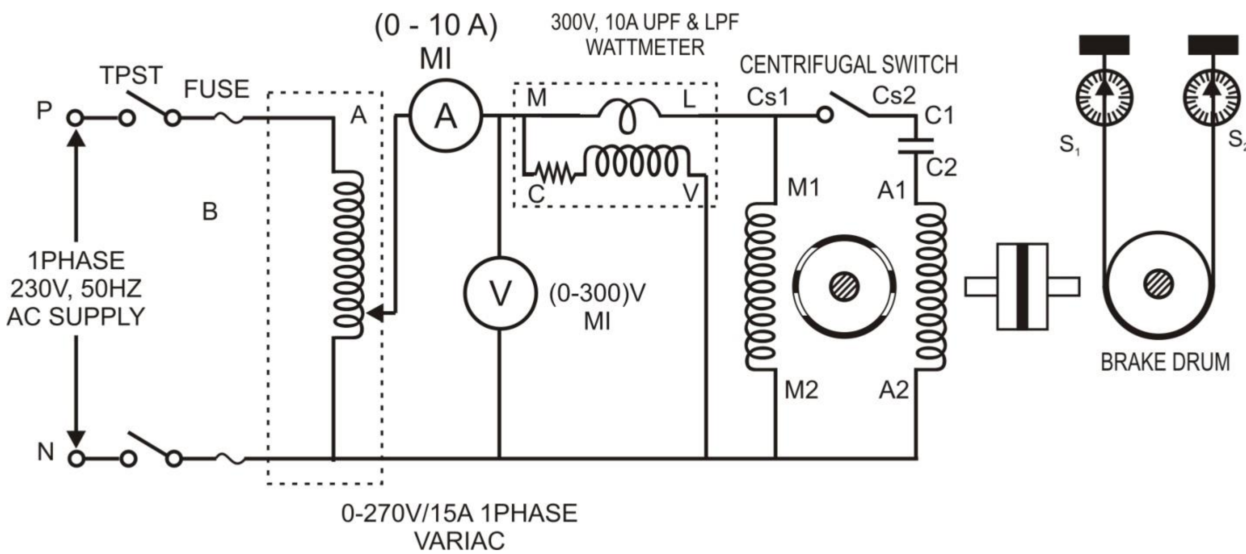
HP =

Volts =

RPM =

AMPS =

CIRCUIT DIAGRAM:



NO-LOAD TEST

1. Connections are made as per the circuit diagram.
2. Apply the rated voltage to the induction motor by varying auto transformer, so that the machine runs at rated speed.
3. Note down the corresponding Ammeter, Voltmeter and Wattmeter readings.
4. Restore the autotransformer to its initial position, and switch off the supply.

BLOCKED ROTOR TEST:

1. Connections are made as per the circuit diagram
2. Block the rotor with the help of brake drum arrangement.
3. Vary the supply voltage with the help of autotransformer so that the ammeter reads rated current and note down the corresponding Ammeter, Voltmeter and Wattmeter readings.
4. Reduce voltage to zero with auto transformer and switch off the supply.

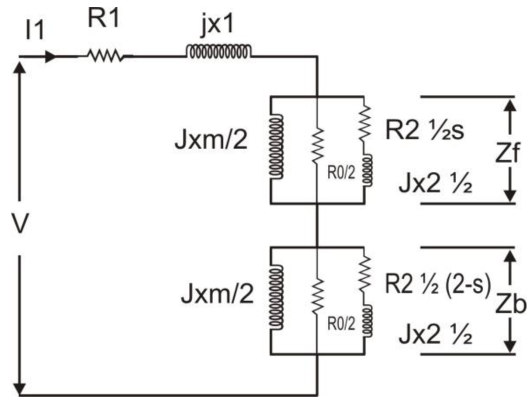


Fig. a: EQUIVALENT CIRCUIT OF 1-ϕ INDUTION MOTOR

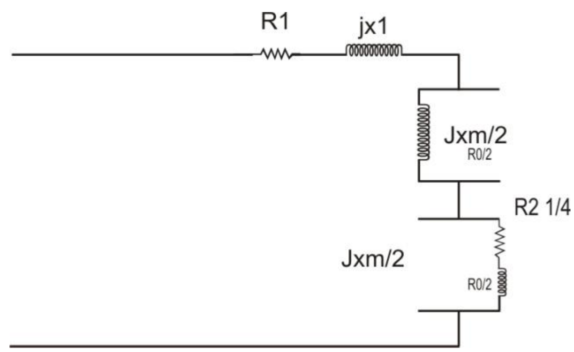


Fig b: EQUIVALENT CIRCUIT AT NO-LOAD CONDITIOIN

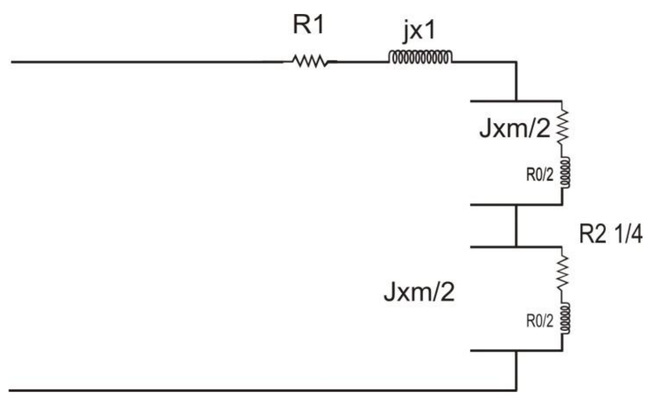


Fig c: EQUIVALENT CIRCUIT UNDER BLOCKED ROTOR CONDITION

PRECAUTIONS:

1. While conducting the Block rotor test, never apply the full voltage. Gradually increase the voltage from zero till full load current Flows in the circuit.
2. While conducting the no load test, make sure that brake drum is Released fully.
3. Under blocked rotor test, auxiliary winding should be opened before the start of the blocked rotor test.

TABULAR COLUMN:

BLOCKED ROTOR TEST

S.NO	***V_{sc} (Volts)***	***I_{sc} (amps)***	***W_{sc} (W)***

NO LOAD TEST

S.NO	***V_o(Volts)***	***I_o(Amps)***	***W_o (W)***

RESULT:

VIVA QUESTIONS:

1. How do you change the direction of rotation?
2. Why star point of the motor is not connected to neutral point of the supply?
3. Does the motor start when supply lines are connected?
4. Draw a two-phase supply waveform & leading current, lagging current with respect to the voltage.
5. Draw the 3-phase supply waveform & leading current, lagging current, with respect to the voltage.
6. What is the advantage of star-delta starter when compared to D.O.L Starter?

7. For a 6-pole machine what is the value of synchronous speed?
8. Why slip cannot be zero in induction motor.
9. What are the two different types of rotors?

Ex No:

Date :

7. DETERMINATION OF X_d AND X_q OF A SALIENT POLE SYNCHRONOUS MACHINE

AIM: To conduct slip test and determine X_d and X_q of a salient-pole synchronous machine

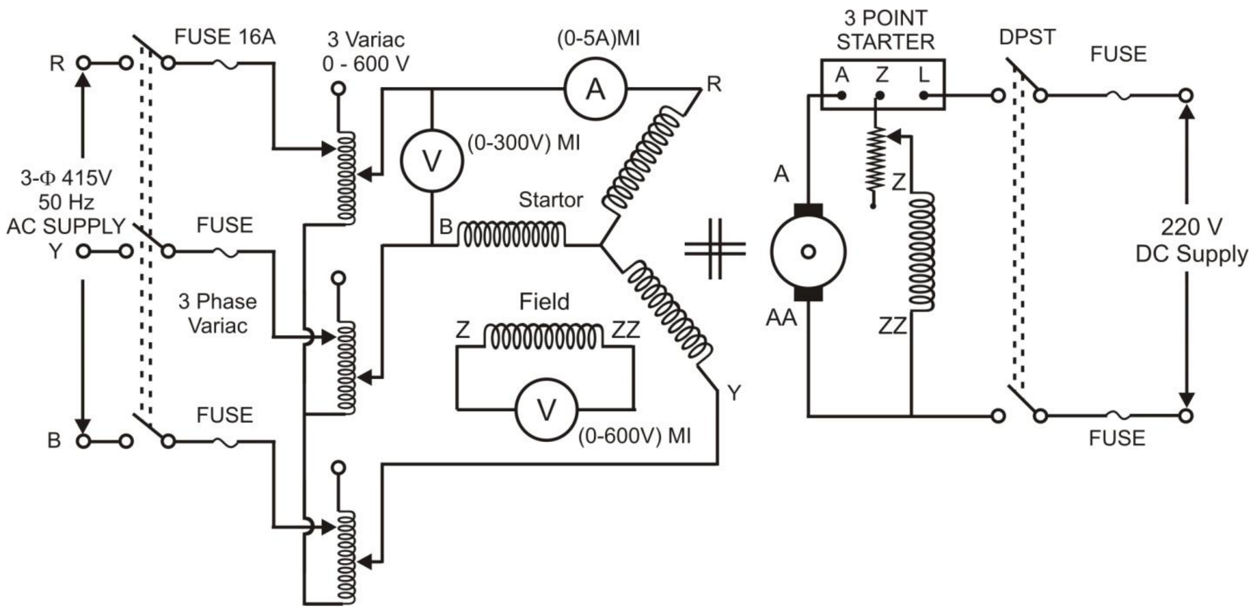
NAME PLATE DETAILS OF:

DC MOTOR		***ALTERNATOR***	
Kw	:	kVA	:
RPM	:	RPM	:
AMPS	:	AMPS	:
VOITS	:	VOLTS	:
EXCITATION VOLTS	:	EXCITATION VOLT	:
EXCITATION AMPS	:	EXCITATION AMPS	:

APPARATUS:

NAME	*RANGE*	*TYPE*	*QUANTITY*
Ammeter	(0-2A)	MC	1
Ammeter	(0-2A)	MI	1
Voltmeter	(0-600V)	MI	1
Rheostat	300Ω/1A		1
Tachometer			1
3-ϕ VARIAC	10A/415V		1

CIRCUIT DIAGRAM:



PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Run the alternator through the DC Motor at near synchronous speed, keeping the AC supply off.
3. Keeping the variac output voltage at minimum, connect the AC supply to the variac.
4. Note that the field winding is to be kept open through out.
5. Increase the variac output voltage so that a reasonable current passes through the armature.
6. If the directions of rotation of the rotor and stator field are the same, then a slight adjustment of speed causes significant oscillation of the armature current. Else reverse the direction of rotation of motor.
7. When the ammeter shows slow but wide oscillations note I_{max} and I_{min} and the corresponding voltages V_{min} and V_{max} and calculate X_d and X_q.
8. Using X_d and X_q, the regulation of the salient pole alternator at specified load condition can be determined using the appropriate phasor diagram.

CALULATIONS:

$$X_d = \frac{Maximum\ Volts\ per\ phase}{Maximum\ Current\ per\ phase}$$

$$X_q = \frac{Minimum\ Voltage\ per\ phase}{Minimum\ Current\ per\ phase}$$

$$Tan\delta = \frac{I_a X_q\ Cos\phi - I_a R_a\ Sin\phi}{V + I_a R_a\ Cos\phi}$$

$$I_q = I_a\ Cos\psi$$

$$Id = Ia\ Sin\psi$$

$$\psi = \phi + \delta$$

$$Eo = V\ Cos\delta + I_q R_a + I_d X_d$$

% Regulation = $\frac{E_0 - V}{V} X\,100$

PRECAUTIONS:

DC motor field rheostat should be kept at minimum resistance position before starting.

TABULAR COLUMN:

$V(ph)_{min}$ (Volts)	$V(ph)_{max}$ (Volts)	I_{min} (Amps)	I_{max} (Amps)	Xd (ohms)	X_q (ohms)

RESULT:

VIVA QUESTIONS:

1. Why ASA method is superior to ZPF method.
2. Why do you conduct Slip-test?
3. Describe voltage regulation of an alternator.
4. What is another name of Potier Triangle method?
5. What are the different methods used to find out the regulation. Compare them.
6. What is the reaction theory and what is its significance.
7. How do you calculate Synchronous impedance using OCC and SC tests on a synchronous machine?
8. What is the use of Damper Windings?
9. What are the different methods of starting a synchronous motor?
10. The armature winding of an alternator is in star or delta or both.

Ex No:

Date :

8. LOAD TEST ON 3-ϕ INDUCTION MOTOR

AIM: To obtain the performance characteristics of a 3-Phase squirrel cage induction motor by conducting brake test.

APPARATUS:

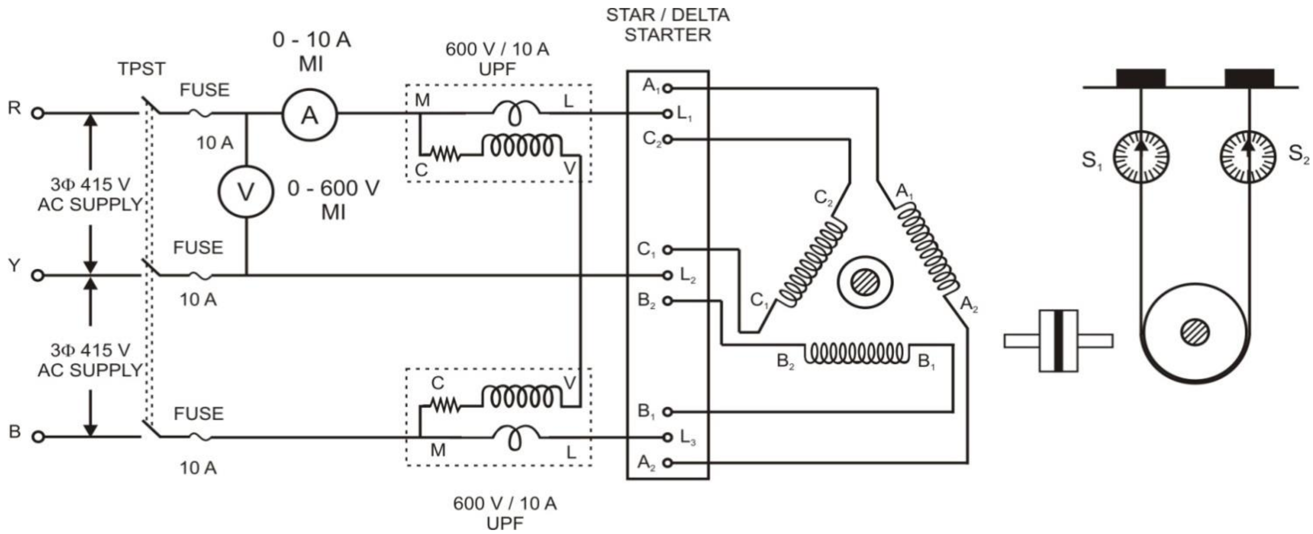
Sl.No.	Item	Type	Range	Quantity
1	Ammeter	(M.I)	0 – 5 A	1 No
2	Voltmeter	(M.I)	0 – 600 Volts	1 No
3	Wattmeter	U.P.F	(0 – 600) V, 15 A	1 No
4	3-ϕ Variac		0 –600 Volts	1 No

NAME PLATE DETAILS:

<u>Motor</u>

Voltage	
Current	
Output	
Speed	
Phases	
Frequency	

CIRCUIT DIAGRAM:



PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Start the 3-Φ IM on No Load by means of the star delta starter.
3. Note down all meters reading and the speed at no load.
4. Apply mechanical load by tightening the belt on the brake drum and note down the readings of the meters, spring balances, and the speed.
5. Repeat the above step-4 until the motor draws full load current.
6. Calculate the torque, slip, output, efficiency and power factor for each set of readings as per the model calculations.
7. Draw the performance curves of o/p Vs η, T, N, I_a, and P.f on one graph sheet.

CALCULATION:

Power input (P_I) = Wattmeter reading x multiplying factor.

Torque, T= W x g x r N-m

Where 'r' is the radius of the break drum.

Where output, P_o= 2Π NT/60.Watts.

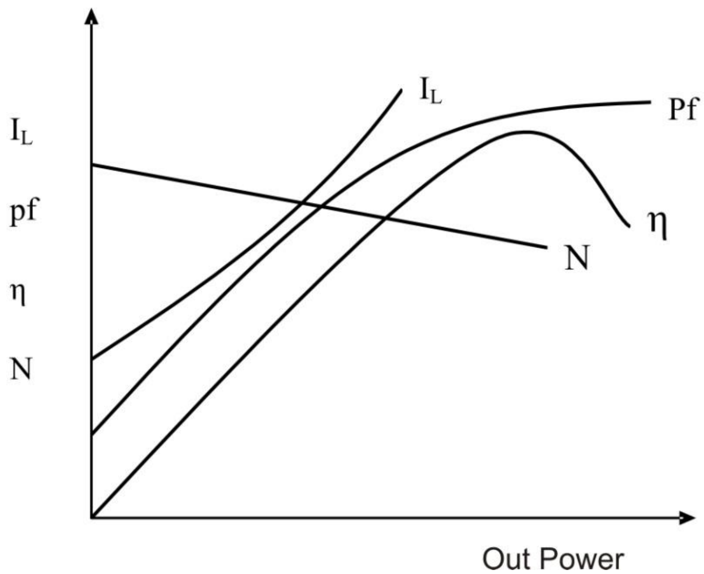
%Slip, s = [N_s – N] / N_S X 100.

Power Factor (cos.ϕ) = ($P_I \div \sqrt{3}$ X V_L X I_L)

TABULAR COLUMN:

SI. No	V_L Volts	I_L Amps	W_1 watts	W_2 watts	N rpm

EXPECTED CURVES:



RESULT:

VIVA QUESTIONS:

1. How do you connect the six terminals of the motor as delta or Star?
2. What are the different starting methods used to start induction motors?
3. What is the role of a rotating flux?
4. What is the difference between squirrel cage induction motor and slip ring induction motor?
5. Why the rotor winding of a slip–ring induction motor should be connected in star?
6. Explain the advantages and disadvantages of slip-ring induction motor?
7. What is the use of slip-rings in a slip-ring induction motor?
8. Is a slip-ring induction motor is a self start motor or not?
9. Draw the performance characteristics of a slip-ring induction motor?
10. What is the electrical equivalent of mechanical load in an induction motor?
11. What is the speed of an Induction motor for a) 4% slip b) 100% slip?

Ex No:

Date :

9. SEPARATION OF CORE LOSSES OF A 1-Φ TRANSFORMER

AIM: To separate Hysteresis and eddy current losses of a given single phase transformer at no load condition.

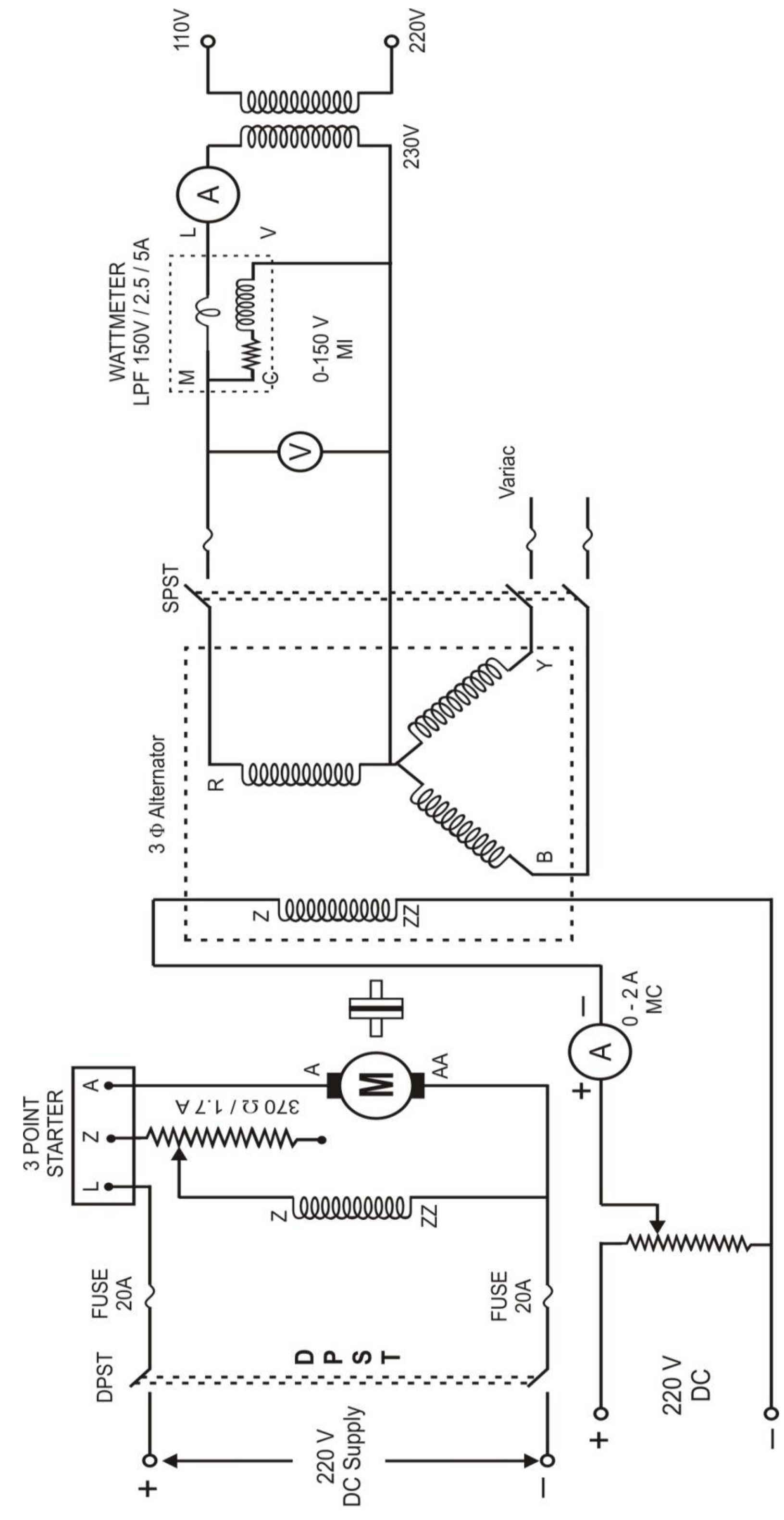
NAME PLATE DETAILS:

1-Φ Transformer	Alternator	DC Shunt Motor
Voltage: **Current:** **Frequency:** **Capacity:**	**Voltage:** **Current:** **Frequency:** **Capacity:**	**Voltage:** **Current:** **Capacity:** **Speed :**

APPARATUS:

Sl.No.	Equipment	Range	Type	Quantity
1	Ammeter	0-1 A	MI	1
2	Voltmeter	0-300 V	MI	2
3	Wattmeter	1/2 A, 150 V	LPF	1

CIRCUIT DIAGRAM:



PROCEDURE:

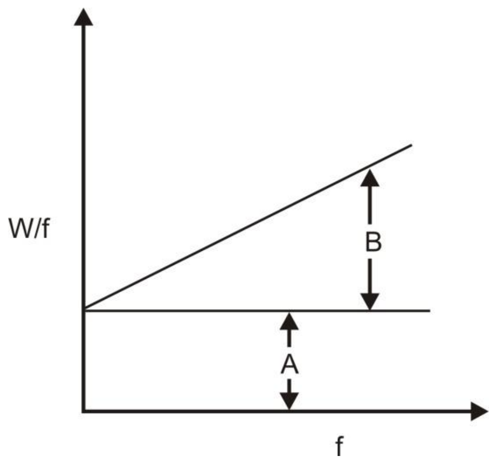
1. Make the connection as per the circuit diagram
2. Start the alternator with the help of prime mover (DC Motor).
3. Adjust the speed of the prime mover so that the alternator voltage frequency should be 50 Hz.
4. Vary the excitation of the alternator so that the required voltage builds across the armature (Say 230 V between line and neutral).
5. Note down all meter readings.
6. Repeat the above steps for different frequencies by changing the speed of the prime mover (With Speed control of DC Shunt motor by Armature control or Field Control).
7. Repeat step 6 for different frequencies of the alternator say 46 Hz, 48 Hz, 50 Hz, and 54 Hz keeping V/f ratio constant.
8. Plot the graph between V/f and core losses of the transformer.

NOTE: For each set of reading the ratio of V/f is to be maintained constant.

TABULAR COLUMN:

Sl. No.	Speed (N) rpm	Frequency Hz	Voltage volts	V/f	Current amps	W_1 watts	W_2 watts	$W=(W_1-W_2)$ watts

MODEL GRAPH:



RESULT:

Frequency Hz	W_h watt	W_e watt	W_T watt

GRAPH: Graph plotted between W/f and core losses (W_T)

RESULT:

VIVA QUESTIONS:

1. What factors does the core losses depends?
2. How the core losses of a transformer can reduce.
3. What is the relation between flux density and (V/f) ratio?
4. Why is V/f ratio maintained constant.
5. How V/f ratio maintained constant.

Ex No:

Date :

10. PARALLEL OPERATION OF 1-Φ TRANSFORMERS

AIM: To operate two single phase transformers in parallel and verify the load sharing.

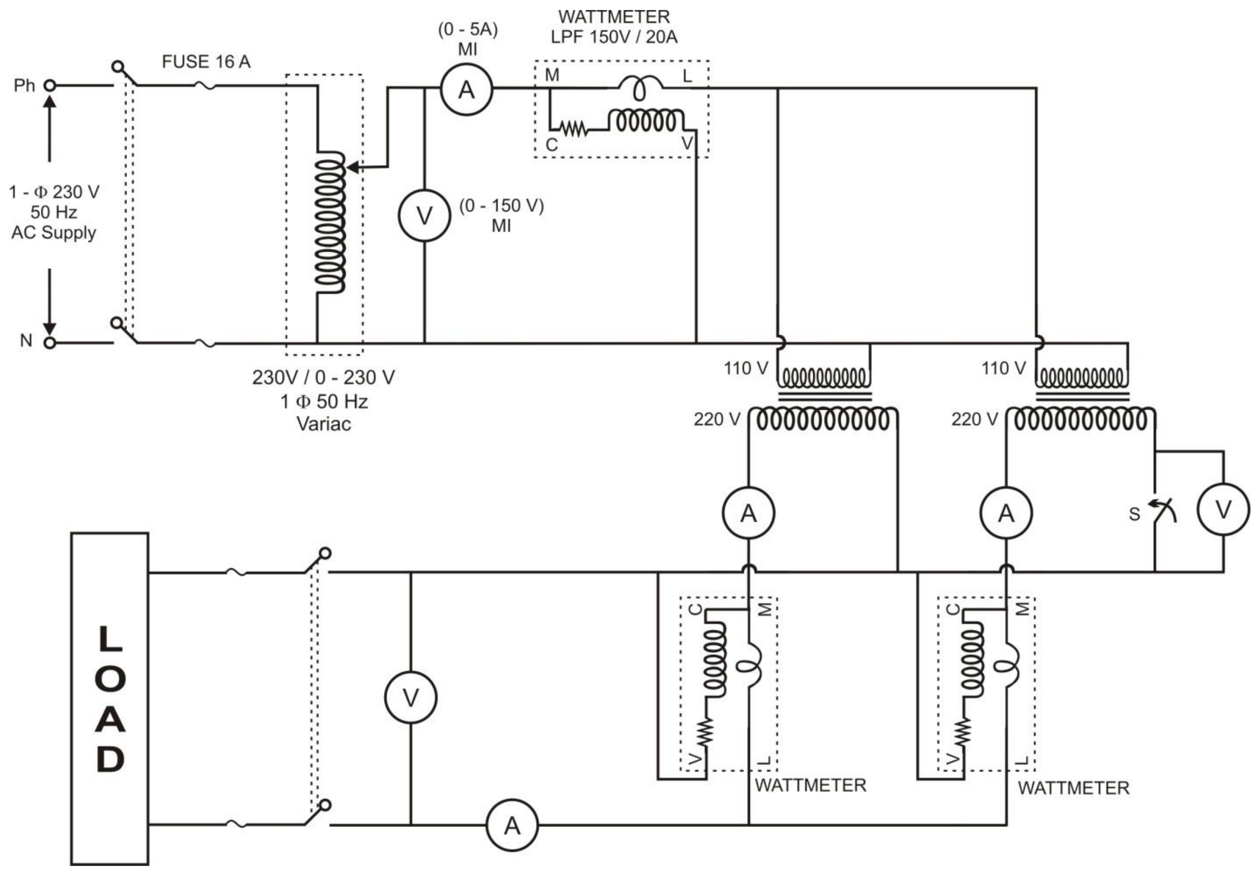
NAME PLATE DETAILS:

1-Φ TRANSFORMER- one	1-Φ TRANSFORMER - two
Voltage:	**Voltage:**
Current:	**Current:**
Frequency:	**Frequency:**
Capacity:	**Capacity:**

APPARATUS:

SI.No.	Equipment	Range	Type	Quantity
1	Ammeter	0-30 A	MI	1
2	Ammeter	0-15 A	MI	2
3	Voltmeter	0-300 V	MI	3
4	Wattmeter	15 A, 300 V	UPF	3

CIRCUIT DIAGRAM:



PROCEDURE:

1. Make the connection as per the circuit diagram.
2. Set the auto transformer at the zero position and switch on the supply.
3. Apply the rated voltage across the primary winding of the transformer gradually with the help of auto transformer.
4. If V3 is showing zero reading then close the SPST switch ‘S’, other wise reverse the transformer connection and close the switch ‘S’.
5. Apply load in steps till the rated current and note down all meter readings.
6. Conduct the SC test on two 1- Φ transformers and find the effective resistance and leakage reactance of each transformer.
7. Verify the practical values with theoretical values.

8. Draw the graphs of I_L versus I_1 and I_2.

TABULAR COLUMN:

SI. No.	Load Current (I_L Amps)	V_1 (Volts)	V_2 (Volts)	I_1 (Amps)	I_2 (Amps)	W_1 (Watts)	W_2 (Watts)

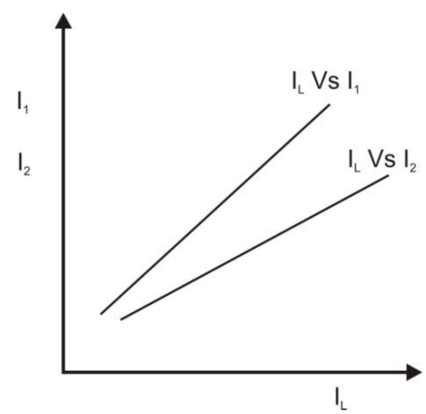
SC Test of I- st Transformer

Si No.	I_{sc} (Amps)	V (Volts)

SC Test of 2-nd Transformer

Si No.	I_{sc} (Amps)	V (Volts)

MODEL GRAPH:



Graph: Plot the graph between Total load current Vs current drawn by each transformer.

RESULTS:

VIVA QUESTIONS:

1. What are the conditions to connect two transformers in parallel?
2. Write equations for emf of a transformer?
3. What is the magnitude of no-load current?
4. How do you mark dot on a transformer?
5. Does flux in a transformer changes with load?
6. Why transformer no-load current is a small value in spite of its primary impedance is very small?
7. A transformer is designed for 50Hz. If the supply frequency is 60Hz. What is the change in its performance?
8. A transformer has primary more than secondary turns. Is it step-down or step-up transformer?
9. Compare the difference between P.T and C.T.
10. Is the transformer core laminations are insulated? Why?
11. Why the transformer rating is given in KVA?
12. What is the effect of PF on the efficiency of a transformer?

Ex No:

Date :

11. SCOTT CONNECTION OF TRANSFORMERS

AIM: Two transformers in Scott connection and verify that the relations between primary and secondary voltages and currents are as per the theoretical prediction.

NAME PLATE DETAILS:

Name	***Range***	***Type***	*Quantity*
Voltmeters	(0-300V)	MI	2
Voltmeters	(0-600V)	MI	2
Ammeter	(0-10A)	MI	3
Ammeter	(0-20A)	MI	2

APPARATUS:

Primary Volts :

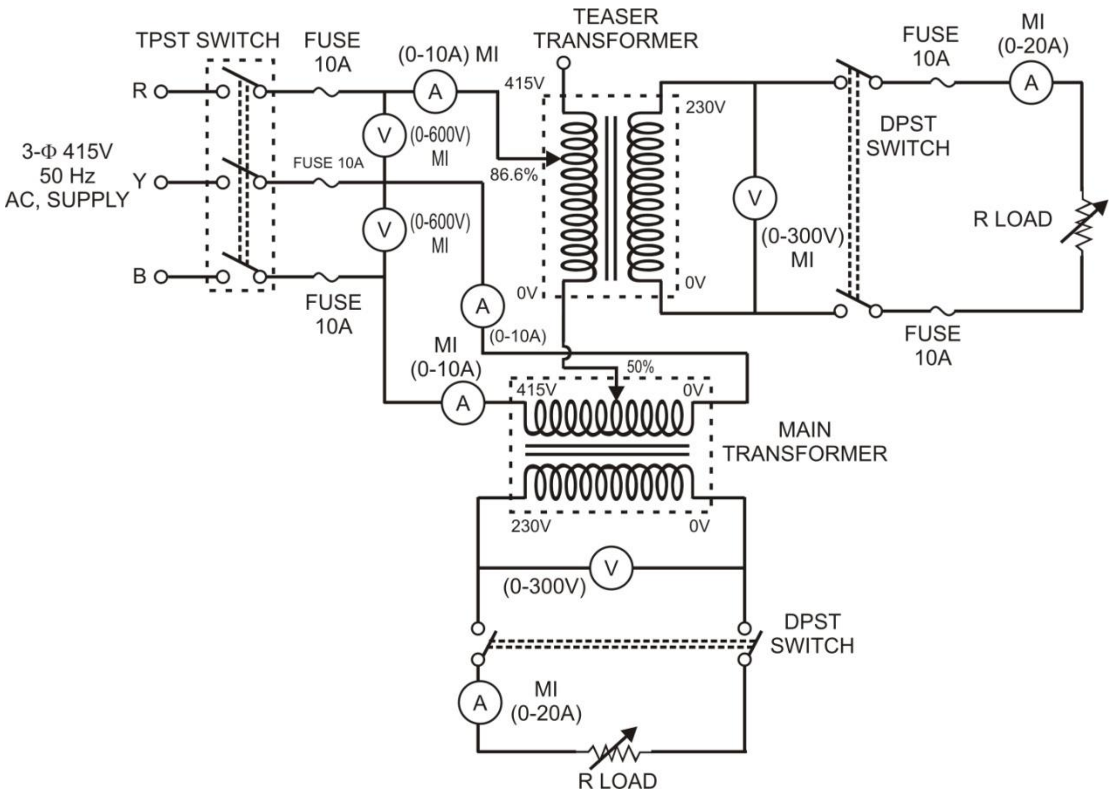
Secondary Volts :

Primary Current :

Secondary Current :

KVA Rating :

CIRCUIT DIAGRAM:



PROCEDURE:

1. **Make the connections as per the circuit diagram with meters of suitable ranges.**
2. Connect loads to the secondary side of the two transformers.
3. Gradually increase the load current on both transformers and note the readings of load currents and voltages.

PRECAUTIONS:

1. The main transformer tapping should be kept at 50%.
2. The teaser transformer tapping should be kept at 86.6%.

TABULAR COLUMN:

S.No	I_R (A)	I_Y (A)	I_B (A)	V_{RY} (V)	V_{YB} (V)	V_{TS} (V)	I_{TS} (A)	V_{MS} (V)	I_{MS} (A)
1.									

RESULT:

VIVA QUESTIONS:

1. What is the use of Scott connection?
2. Compare open delta, scoot connections?
3. How the Scott connection is formed?
4. One transformer has cruciform type and second transformer has square type of core which is the better one?
5. Draw the phasor diagram for Scott connection.
6. Draw the phasor diagrams for leading and lagging loads.
7. For a step-down transformer which winding has low resistance?
8. What is the full name of C.R.G.O.S core material?
9. How 6 phase supply is produced? Where it is used?
10. What happens in tap changing in a transformer?
11. For which winding the tap changing is provided?

Ex No:

Date :

12. REGULATION OF 3-PHASE ALTERNATOR BY ZPF AND ASA METHODS

AIM: To predetermine the regulation of three phase alternator by Potier and ASA methods and also to draw the vector diagrams.

EQUIPMENT REQUIRED:

S.No	Name of Equipment	Specifications
1	DC Motor	5 Hp, 220 V
2	Alternator	5 KVA, 440 V
3	Variable Inductive Load	20 A

APPARATURS REQUIRED:

S.No.	Name of the components	Type	Range	Quantity
1	Ammeter	MC	0 – 1/2 A	1
2	Ammeter	MI	0 – 5/10 A	1
3	Voltmeter	MC	0 – 10 V	1
4	Voltmeter	MI	0 – 600 V	1
5	Rheostat	Wire wound	250 Ω, 1.5 A	1
6	Rheostat	Wire wound	1200Ω, 0.8 A	1
7	Tachometer	Digital	---	1
8	TPST knife switch	--	--	1

REGULATION OF ALTERNATOR BY ZERO POWER FACTOR AND ASA METHODS

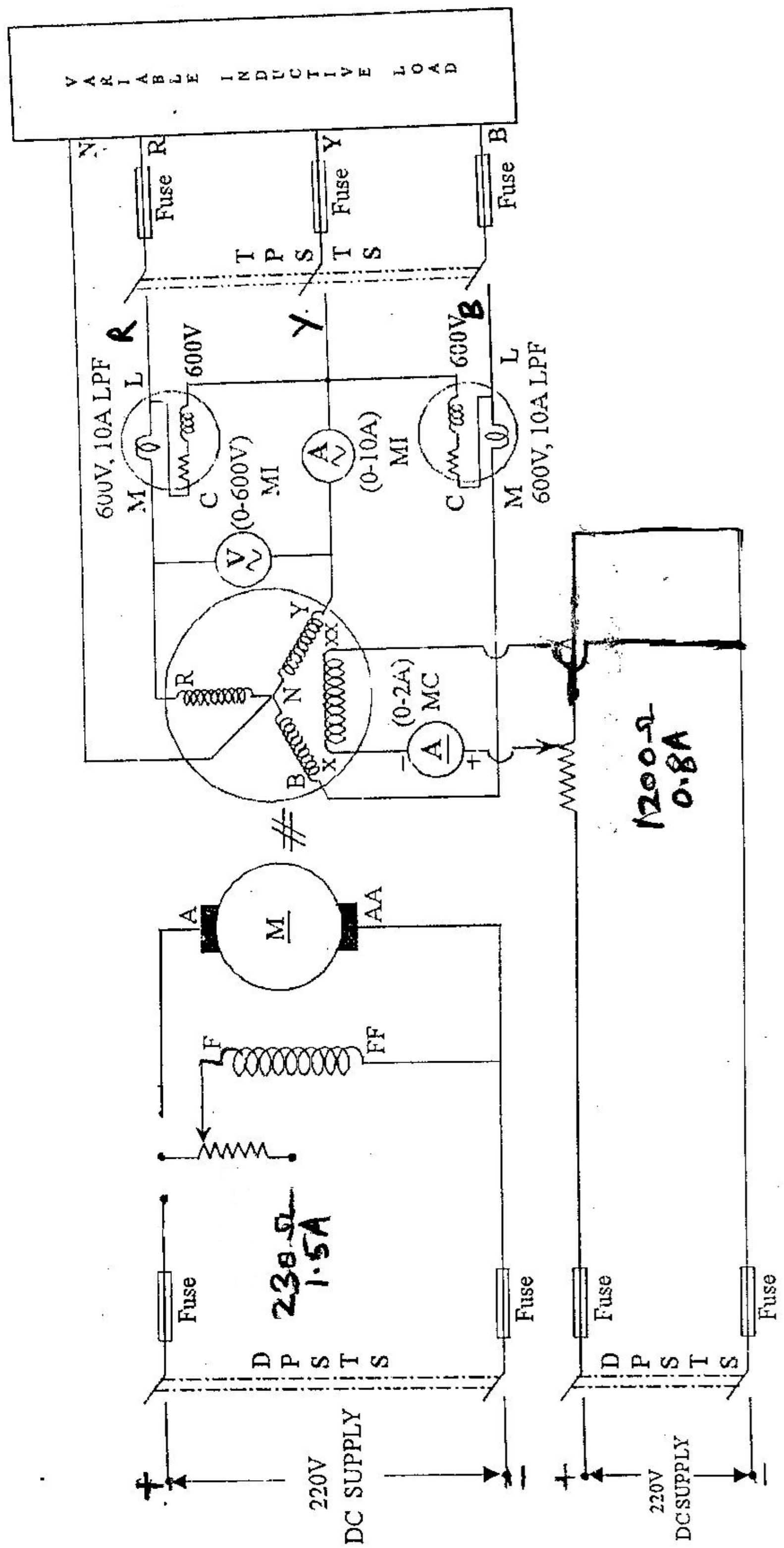


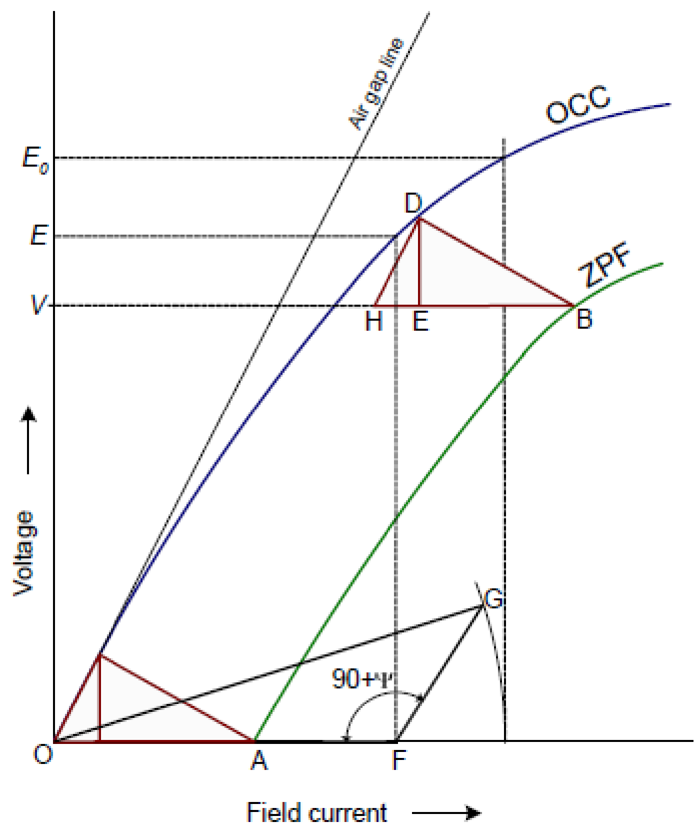
Fig : 11.1 circuit diagram of zpf method

THEORY:

ZPF method(Potier method)

Conduct tests to find OCC (upto 125% of rated voltage) SCC (for rated current)

ZPF (for rated current and rated voltage),Armature Resistance (if required)



Steps:

1. By suitable tests plot OCC and SCC
2. Draw tangent to OCC (air gap line)
3. Conduct ZPF test at full load for rated voltage and fix the point B.
4. Draw the line BH with length equal to field current required to produce full load current at short circuit.
5. Draw HD parallel to the air gap line so as to touch the OCC.
6. Draw DE parallel to voltage axis. Now,DE represents voltage drop IX_L and BE represents the field current required to overcome the effect of armature reaction.

Triangle BDE is called Potier triangle and X_L is the Potier reactance

7. Find E from V, IX_L and Φ. Consider R_a also if required. The expression to use is

$$E = \sqrt{(V\cos\Phi + IR_a)^2 + (V\sin\Phi + IX_L)^2}$$

8. Find field current corresponding to *E.*

9. Draw FG with magnitude equal to BE atangle (90+Ψ) from field current axis,where Ψ is the phase angle of current from voltage vector *E* (internal phase angle).

10. The resultant field current is given by OG. Mark this length on field current axis.

11. From OCC find the corresponding E_0.

ASA method

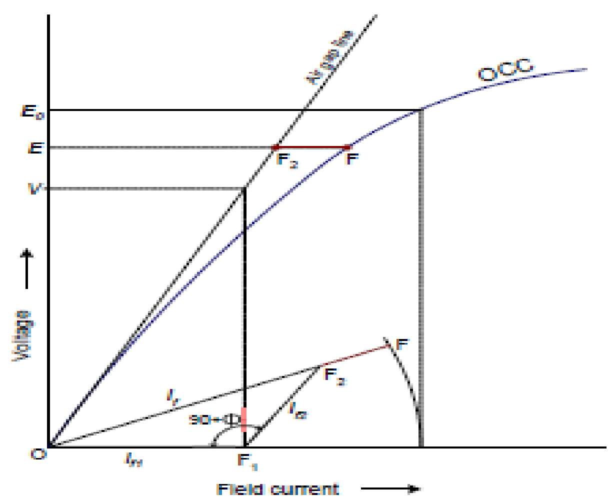
Tests:

Conduct tests to find OCC (upto 125% of rated voltage) SCC (for rated current)

ZPF (for rated current and rated voltage) Armature Resistance (if required)

Steps:

1. Follow steps 1 to 7 as in ZPF method.
2. Find *If1* corresponding to terminalvoltage *V* using air gap line (OF1 in figure).
3. xDraw *If2* with length equal to field current required to circulate rated current during short circuit condition at an angle (90+Φ) from *If1*. The resultant of *If1* and *If2* gives *If* (OF2 in figure).
4. Extend OF2 upto F so that F2F accounts for the additional field current accounting for the effect of saturation. F2F is found for voltage E as shown.
5. Project total field current OF to the field current axis and find corresponding voltage E0 using OCC.



FORMULAE USED:

Percentage regulation = $(E_o – V_{rated}) / V_{rated}$ x 100 (For both POTIER & ASA methods)

PRECAUTIONS:

(i) The motor field rheostat should be kept in the minimum resistance position.

(ii) The Alternator field potential divider should be in the position of minimum potential.

(iii) Initially all switches are in open position.

PROCEDURE FOR BOTH POTIER AND ASA METHODS:

1. Note down the complete nameplate details of motor and alternator.
2. Connections are made as per the circuit diagram.
3. Switch on the supply by closing the DPST main switch.
4. Using the Three point starter, start the motor to run at the synchronous speed by varying the motor field rheostat.
5. Conduct an Open Circuit Test by varying the Potential Divider for various values of Field current and tabulate the corresponding Open circuit voltage readings.
6. Conduct a Short Circuit Test by closing the TPST knife switch and adjust the potential divider the set the rated Armature current, tabulate the corresponding Field current.
7. Conduct a ZPF test by adjusting the potential divider for full load current passing through either an inductive or capacitive load with zero power and tabulate the readings.
8. Conduct a Stator Resistance Test by giving connection as per the circuit diagram and tabulate the voltage and Current readings for various resistive loads.

PROCEDURE TO DRAW THE POTIER TRIANGLE (ZPF METHOD):

(All the quantities are in per phase value)

1. Draw the Open Circuit Characteristics (Generated Voltage per phase VS Field Current)
2. Mark the point A at X-axis, which is obtained from short circuit test with full load armature current.
3. From the ZPF test, mark the point B for the field current to the corresponding rated armature current and the rated voltage.
4. Draw the ZPF curve which passing through the point A and B in such a way parallel to the open circuit characteristics curve.

5. Draw the tangent for the OCC curve from the origin (i.e.) air gap line.

6. Draw the line BC from B towards Y-axis, which is parallel and equal to OA.

7. Draw the parallel line for the tangent from C to the OCC curve.

8. 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).**

PROCEDURE TO DRAW THE VECTOR DIAGRAM (ZPF METHOD)

1. Select the suitable voltage and current scale.

2. For the corresponding power angle (Lag, Lead, Unity) draw the voltage vector and current vector OB.

3. Draw the vector AC with the magnitude of IRa drop, which should be parallel to the vector OB.

4. Draw the perpendicular CD to AC from the point C with the magnitude of IXL drop.

5. Join the points O and D, which will be equal to the air gap voltage (Eair).

6. Find out the field current (Ifc) for the corresponding air gap voltage (Eair) from the OCC curve.

7. Draw the vector OF with the magnitude of Ifc which should be perpendicular to the vector OD.

8. Draw the vector FG from F with the magnitude Ifa in such a way it is parallel to the current vector OB.

9. Join the points O and G, which will be equal to the field excitation current (If).

10. Draw the perpendicular line to the vector OG from the point O and extend CD in such a manner to intersect the perpendicular line at the point H.

11. Find out the open circuit voltage (Eo) for the corresponding field excitation current (If)

12. Find out the regulation from the suitable formula.

PROCEDURE TO DRAW THE POTIER TRIANGLE (ASA 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.

8. 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).**

9. Extend the line BC towards the Y-axis up to the point O'. The same line intersects the air gap line at point G.

10. Mark the point I in Y-axis with the magnitude of Eair and draw the line from I towards OCC curve which should be parallel to X-axis. Let this line cut the air gap line at point H and the OCC curve at point F.

11. Mention the length O'G, HF and OA.

PROCEDURE TO DRAW THE VECTOR DIAGRAM (ASA METHOD)

(To find the field Excitation current If)

1. Draw the vector with the magnitude O'G.

2. From G draw a vector with the magnitude of GH (OA) in such a way to make an angle of (90 ± Φ) from the line O'G [(90 + Φ) for lagging power factor and (90 – Φ) for leading power factor]

3. Join the points O' and, H also extend the vector O'F with the magnitude HF. Where O'F is the field excitation current (If).

4. Find out the open circuit voltage (Eo) for the corresponding field excitation current (If) from the OCC curve.

5. Find out the regulation from the suitable formula.

TABULATION FOR REGULATION OF THREE PHASE ALTERNATOR BY ZPF AND ASA METHODS

OPEN CIRCUIT TEST

S.No.	Field Current (I_f)	Open Circuit Line Voltage (V_{0L})	Open Circuit Phase Voltage ($V_{0(Ph)}$)
	Amps	Volts	Volts

SHORT CIRCUIT AND ZPF TEST

Multiflication Factor :

S.No.	Short circuit test		Zero Power Factor test							
	Field current (I_f)	Rated armature current (I_a)	Field current (I_f)	Rated armature current (I_a)	Rated armature voltage (V_a)	W1		W2		Total power (W1+W2)
						Obs.	Act.	Obs.	Act.	
	Amps	Amps	Amps	Amps	Volts	Watts	Watts	Watts	Watts	Watts

RESULT:

APPLICATION: This experiment is performed to find regulation of alternators by ZPF and EMF Methods.

SAMPLE QUESTIONS:

1. Find out voltage regulation of alternator by potier triangle method.
2. Find out voltage regulation of alternator based on separation of reactance due to leakage flux.
3. Calculate the voltage regulation of alternator based onA.I.E.E method.
4. Calculate the voltage regulation of alternator by conducting the direct load test using 3- phase inductors as load.
5. Calculate the voltage regulation of alternator by running the alternator as an over excited syn. Motor on no load.

VIVA-VOCE QUESTIONS:

1. What is meant by ZPF Test?
2. What is Potier reactance? How is it determined by Potier triangle?
3. What is meant by armature reaction reactance?
4. What is the significance of the ASA modification of MMF method?
5. What is air gap line in Potier method?