ELECTRICAL MACHINES LAB -II
LABORATORY MANUAL

B.TECH

(II YEAR – II SEM)
(2023-24)

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MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous Institution – UGC, Govt. of India)
Recognized under 2(f) and 12 (B) of UGC ACT 1956
(Affiliated to JNTUH, Hyderabad, Approved by AICTE - Accredited by NBA & NAAC – 'A' Grade - ISO 9001:2015 Certified) Maisammaguda, Dhulapally (Post Via. Kompally), Secunderabad – 500100, Telangana State, India.

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LABORATORY MANUAL

Subject Code	**:**	**R22A0283**
Regulation	**:**	**R22**
Class	**:**	**II Year II Semester (EEE)**

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

LIVE TO LEARN & LEARN TO SHARE

NAME: ______________________________

H.NO:______________________________

YEAR__________**SEM**___________

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LIST OF EXPERIMENTS

S.NO	NAME OF THE EXPERIMENT	PAGE NO	MARKS/ GRADE	SIGNATURE
1	LOAD TEST ON THREE PHASE INDUCTION MOTOR			
2	EQUIVALENT CIURCUIT AND PRE-DETERMINATION OF PERFORMANCE CHARACTERISTICS OF SINGLE -PHASE INDUCTION MOTOR			
3	SCOTT CONNECTION OF SINGLE PHASE TRANSFORMER			
4	REGULATION OF AN ALTERNATOR BY SYNCHRONOUS IMPEDANCE METHOD			
5	REGULATION OF AN ALTERNATOR BY MMF METHOD			
6	V & INVERTED V CURVES OF SYNCHRONOUS MOTOR			
7	NO LOAD & BLOCKED ROTOR TEST ON 3-ϕ INDUTION MOTOR			
8	SUMPNER'S TEST ON TWO IDENTICAL SINGLE - PHASE TRANSFORMERS			
9	REGULATION OF THREE PHASE ALTERNATOR BY ZPF METHOD			
10	DETERMINATION OF X_d & X_q OF A SALIENT POLE SYNCHRONOUSMACHINE			
11	O.C & S.C TEST ON SINGLE PHASE TRANSFORMER			

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

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

2. 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.

3.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.

4. 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.

5. Modern tool usage: 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.

6. 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.

7. 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.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. 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.

11. 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 multi disciplinary environments.

12. Life- long learning: Recognize the need for, and have the preparation and abilityto engage in independent and life-long learning in the broadest context of technological change.

MALLA REDDY COLLEGE OF ENGINEERING AND TECHNOLOGY

II YEAR B. Tech EEE – II SEM **L/T/P/C**

-/-/3/1.5

(R22A0285) ELECTRICAL MACHINES LAB -II

COURSEOBJECTIVES:

To understand the operation of synchronous machines

1. To understand the analysis of power angle curve of a synchronous machine.
2. To understand the equivalent circuit of a single-phase transformer and single-phase induction motor.
3. To understand the circle diagram of an induction motor by conducting a blocked rotor test.

PART-A

The following experiments are required to be conducted as compulsory experiments

1. Sumpner's test on a pair of single-phase transformers
2. No-load & Blocked rotor tests on three phase Induction motor
3. Regulation of a three –phase alternator by synchronous impedance method
4. Regulation of a three –phase alternator by MMF method
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

PART-B

In addition to the above experiments, at least any two of the following experiments are required to be conducted from the following list

9. Regulation of three-phase alternator by Z.P.F.
10. Measurement of sequence impedance of a three-phase alternator.
11. Scott Connection of transformer
12. Efficiency of 3 phase alternator.

COURSE OUTCOMES:

After the completion of this laboratory course,

1. The student will be able to understand the performance of different machines using different testing methods to convert from three phase to two phase and vice versa.

2. Compensate the changes interminal voltages of synchronous generator after estimating the change by different methods.

3. Control the active and reactive power flows in synchronous machines Start different machines and control the speed and power factor.

INSTRUCTIONS TO STUDENTS

1. Before entering the lab the student should carry the following things.
   - Identity card issued by the college.
   - Lab observation book
   - Lab Manual
   - Lab Record
2. Student must sign in and sign out in the register provided when attending the lab session without fail.
3. Come to the laboratory in time. Students, who are late more than 15 min., will not be allowed to attend the lab.
4. Students need to maintain 100% attendance in lab if not a strict action will be taken.
5. All students must follow a Dress Code while in the laboratory
6. Foods, drinks are NOT allowed.
7. All bags must be left at the indicated place.
8. The objective of the laboratory is learning.
9. The experiments are designed to illustrate phenomena in different areas of Physics and to expose you to measuring instruments, conduct the experiments with interest and an attitude of learning
11. You need to come well prepared for the experiment.
12. Work quietly and carefully
13. be honest in recording and representing your data.
14. If a particular reading appears wrong repeat the measurement carefully, to get a better for a graph
15. All presentations of data, tables and graphs calculations should be neatly and
16. Carefully done Graphs should be neatly drawn with pencil. Always label graphs andthe axes and display units.
17. If you finish early, spend the remaining time to complete the calculations and drawing graphs.
18. Return all the equipment you have signed out for the purpose of your experiment.

SPECIFIC SAFETY RULES FOR CONTROL SYSTEMS AND SIMULATIONLABORATORY

1. You must not damage or tamper with the equipment or leads
2. You should inspect laboratory equipment for visible damage before using it. If there is a problem with a piece of equipment, report it to the technician or lecturer. DONOT return equipment to a storage area
3. You should not work on circuits where the supply voltage exceeds 40 volts without very specific approval from your lab supervisor. If you need to work on such circuits, you should contact your supervisor for approval and instruction on how to do this safely before commencing the work.
4. Always use an appropriate stand for holding your soldering iron.
5. Turn off your soldering iron if it is unlikely to be used for more than 10 minutes. Never leave a hot soldering iron unattended.
6. Never touch a soldering iron element or bit unless the iron has been disconnected from the mains and has had adequate time to cool down. Never strip insulation from a wire with your teeth or a knife, always use an appropriate wire strippingtool.
7. Shield wire with your hands when cutting it with a pliers to prevent bits of wireflying about the bench.

INTRODUCTION TO TEST PROCEDURE WITH COMPUTER SETUP:

- The machines laboratory is setup with the following new features.
  - The motors are controlled using a static electronic power drive unlike the conventional method of using 3-point starters and DC output power.
  - Further, the motors can be controlled either manually by directly using the electronic drive unit or through PLC/Micro controller unit(Data logger)
- Hence the general procedure for all experiments is given in both methods.
- First, the power is extended to the test bench by switching on the corresponding MCB in the mains panel. Then the test panel is energized by switching on the MCB on the panel (Before switching on the local MCB it is to be confirmed that the drive control pot meter is in minimum position).
- The computer is switched on and ***DIAVIEW*** software is executed from the desktop.
- The computer now displays either the SCADA display (in case of PLC controlled set ups) and Data logger display (in case of data logger/micro controller setup)

MANUAL MODE:

1. **METHOD OF STARTING THE MOTOR:**

- The field rheostat is kept in minimum resistance position.
- Then the pot meter is rotated in clock wise gradually thus increasing the speed.
- In maximum position of the pot meter, motor is expected to reach slightly lesser than its rated speed.
- Now the field is weakened by increasing the field rheostat and the speed is brought to the rated speed as required for the respective test setup.

2. **DATA READ OUT/RECORDING PROCEDURES:**

- Depending upon the test setup all the relevant data like voltages, currents, speed and force are read out from the respective panel meters and noted down.
- Even in the manual mode of control the same data whatever is available on the panel meters can also be seen on the computer mimic diagram if the computer and PLC/Micro controller are kept in ON condition.
- This data at the end of the experiment can also be exported to the system memory with the required student information for further analysis and records.

PLC/MICRO CONTROLLER MODE:

1. **METHOD OF STARTING THE MOTOR:**

- The field rheostat is kept in minimum resistance position.
- Then using the mouse and the curser,
  - PLC/CONTROLLER mode is selected from mimic diagram.
  - Then motor start button is pressed
  - Speed is increased gradually by increasing the drive output voltage till the rated armature voltage is reached as read by the respected panel meter and the computer display.
- Now the field is weakened by increasing the field rheostat and the speed is brought to the rated speed as required for the respective test setup.

2. **DATA READ OUT/RECORDIND PROCEDURES:**

- Depending upon the test setup all the relevant data like voltages, currents, speed and force are read out are available on the mimic display

- The data at required instant of the experiment is logged by going to the data log in page and clicking on the data logger icon
- After collecting relevant experimental data in the ***DIAVIEW*** screen, the file is exported to system memory with the required student information for further analysis and records.

EXP.NO: 01

DATE :

LOAD TEST ON 3-PHASE INDUCTION MOTOR

AIM: To perform Load test on given 3-phase Induction Motor and obtain the characteristics of the motor from the test observations.

NAME PLATE DETAILS:

S.NO	Specifications	Ratings
1	Voltage	415V
2	Current	7.39Amps
3	Output	5H.P
4	R.P.M	1430
5	Cycle	50Hz
6	Connection	Δ

APPARATUS REQUIRED:

S.NO	Name of The Apparatus	Type	Range	Quantity
1.	Ammeter	Digital	(0-10) A	1
2.	Voltmeter	Digital	(0-600)V	1
3.	Wattmeter	Digital	600V,10A,UPF	2
4.	Tachometer	Digital	(0-3000)RPM	1
5.	Connecting wires	Copper	1.5Sqmm	required

THEORY:

A 3-phase induction motor consists of stator, rotor & other associated parts. In the stator, a 3- phase winding (provided) are displaced in spaceby120. A 3- phase current is fed to the winding so that a resultant rotating magnetic flux is generated. The rotor starts rotating dueto the induction effect produced due the relative velocity between the rotor Winding &the rotating flux.

As a general rule, conversion of electrical energy to mechanical energy takes place in to the rotating part on electrical motor. In DC motors, electrical power is conduct directly to the armature, i.e, rotating part through brushes and commutator. Hence, in this sense, a DC motor can be called as 'conduction motor'.

However, in AC motors, rotor does not receive power by conduction but by induction in exactly the same way as secondary of a two winding T/F receives its power from the primary. So, these motors are known as Induction motors. In fact an induction motor can be taken as rotating T/F, i.e, one in which primary winding is stationary and but the secondary isfree.

The starting torque of the Induction motor can be increase by improving its p.f by adding external resistance in the rotor circuit from the stator connected rheostat, the rheostat resistance being progressively cut out as the motor gathers speed. Addition of external resistance increases the rotor impedance and so reduces the rotor current. At first, the effect of improved pre dominates the current decreasing effect of impedance. So, starting torque is increased. At time of starting, external resistance is kept at maximum resistance position and after a certain time, the effect of increased impedance predominates the effect of improved p.f and so the torque starts decreasing. By this during running period the rotor resistance being progressively cut-out as the motor attains its speed. In this way, it is possible to get good starting torque as well as good running torque.

THEORITICAL CALCULATIONS:

Torque on the pulley(T)=9.81*S*r N-m

Where $S=S_1-S_2$

S1, S2 are load cell Readings in Kg

Where ‘r’ is the radius of the pulley in meters

Power Output=2πNT/60 Watts

Power Input=(W_1+W_2) Watts

Where W_1 &W2 are the wattmeter readings.

%Efficiency(%η)=(Output/Input)*100

Synchronous speed(N_s)=120*f/p.

Where f is frequency of supply in Hz‘p’ is no. of poles.

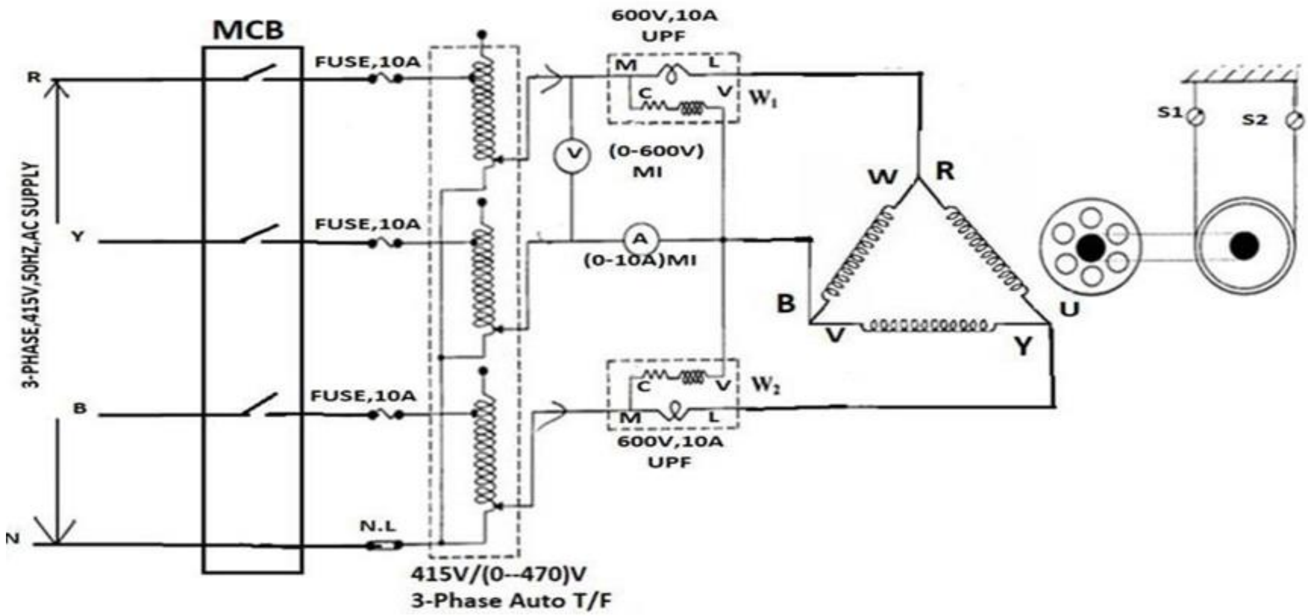
% Slip= (N_s-N)/N_s *100.

Where ‘N’ is the rotor speed in rpm.

Power factor (cosΦ) = (W_1+W_2)/√3 VI

Where V is the Voltage across the motor & ‘I’ is the current drawn from the motor

CIRCUIT DIAGRAM:



PROCEDURE:

1) Connect the circuit as per circuit diagram.
2) Check the belt on the pulley is free so that there is no load on pulley.
3) Close MCB& start the motor slowly using the auto transformer starter and run the motor atrated speed by giving the rated voltage.
4) Note down the readings of ammeter, voltmeter & wattmeter and speed at no-load.
5) Apply load on the pulley gradually in steps tightening belt around it.

6) Take the readings of ammeter, voltmeter & wattmeter connected to the motor and two loadcells readings and speed at every step.
7) Continue the experiment till full load of the motor is reached
8) Remove the load and switch off the supply
9) Tabulate the observations

PRECAUTIONS:

1) At the time of starting the motor should be in no-load condition.
2) Cool the pulley by using water while the experiment is performed.

OBSERVATIONS:

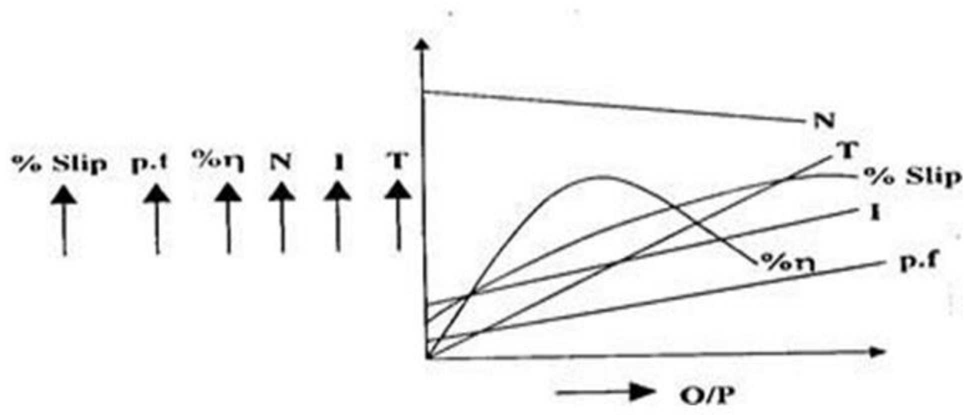
Table 1:

S.NO	Voltage (V)	Current (I)	Speed (N)	WattmeterReading			Load Cells Reading	Torque (T) 9.81*(S_1-S_2) r N-m	Output (watts) 2πNT/ 60	%η
				W_1	W_2	W1+W2 (I/P)	S			

Table 2:

S.NO	Voltage(V)	Current(I)	Speed(N)	% Slip	I/P Power ($W_{1+}W_2$)	P.F(Cos Φ)

EXPECTED GRAPHS:



DRAW THE CIRCUIT DIAGRAM:

RESULT:

VIVA – VOCE QUESTIONS:

1. Explain why the locus of the induction motor current is a circle.
2. What is the difference between the transformer equivalent circuit and induction motorequivalent circuit?
3. What are the reasons in conducting no-load test with rated voltage and blocked- rotor test withrated current?
4. Why do you choose LPF wattmeter in load test and hpf wattmeter in blocked rotor test?
5. How do you reverse the direction of rotation of induction motor?
6. What are the various applications of this motor?

EXP.NO: 02

DATE :

EQUIVALENT CIURCUIT AND PRE-DETERMINATION OF PERFORMANCE CHARACTERISTICS OF 1-Φ INDUCTION MOTOR

AIM: To conduct no load and blocked rotor tests and to find equivalent circuit parameters and performance characteristics

NAME PLATE DETAILS:

Parameter	1Φ-InductionMotor
Rated Power	1HP
Rated Voltage	230V
Rated Current	6A
Rated Speed	1430

APPARATUS REQUIRED:

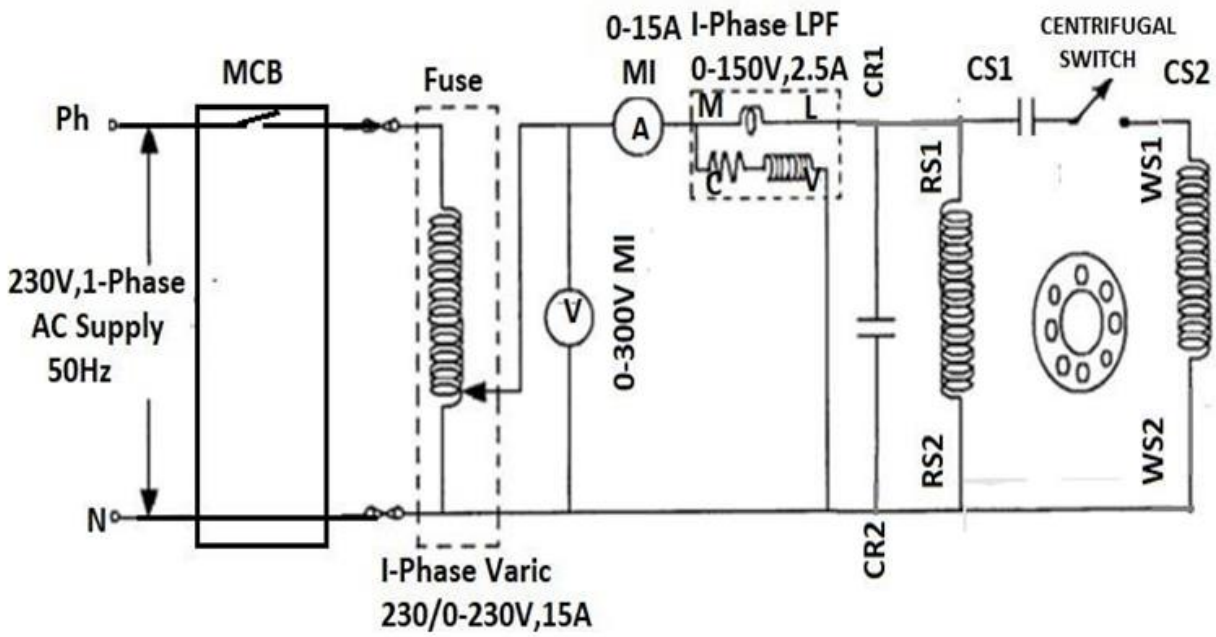
S. No	Name of Apparatus	Range	Type	Qty.
1	Voltmeter	0-300	Digital	
2	Ammeter	5A	Digital	
3	Wattmeter	300V,2A,LPF	Digital	
4	Wattmeter	75V,5A,UPF	Digital	
5	Connecting wires			

THEORY:

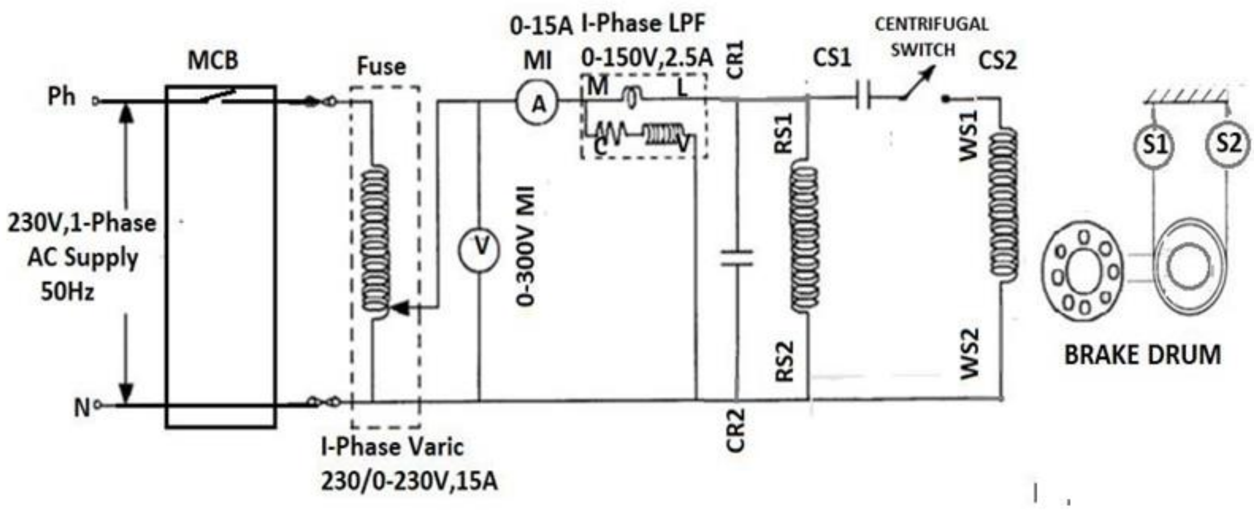
A 1-Φ induction motor consists of stator, rotor and other associated parts. In the rotor of a single phase winding is provided. The windings ofa1 -Φ winding (provided)are displaced in space by120º.A single phase current is fed to the windings so that a resultant rotating magnetic flux is generated. The rotor starts rotating due to the induction effect produced due to the relative velocity between the rotor winding and the rotating flux.

CIRCUIT DIAGRAM:

NOLOAD TEST ON SNGLE PHASE INDUCTION MOTOR:



BLOCKED ROTOR TEST ON SNGLE PHASE INDUCTION MOTOR:



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 theexperiment.
3. Now switch ON the supply and close MCB.
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.

BLOCKED ROTOR TEST:

1. To conduct blocked rotor test, necessary meters are connected to suit the full load conditionsof 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 theinduction 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 switchOFF the supply.
8. Loosen the rope after the experiment is done.

PRECAUTIONS:

NO LOAD TEST:

1 Initially MCB is kept open.
2 Autotransformer is kept at minimum potential position.
3 The machines must be started on no load.

BLOCKEDROTOR TEST:

1 Initially the MCB is kept open.
2 Autotransformer is kept at minimum position.

3 The machine must be started at full load (blocked rotor). Reff=1.5*Rdc

DRAW CIRCUIT DIAGRAM:

FORMULAE:

NO LOAD TEST:

$$V_o I_o \cos\phi_o = W_o$$

$$\cos\phi_o = \frac{W_o}{V_o I_o}$$

$$Z_o = \frac{V_o}{I_o}$$

$$X_o = Z_o \sin\phi_o$$

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

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

BLOCKEDROTOR TEST:

$$Z_{sc} = \frac{V_{sc}}{I_{sc}}$$

$$R_{sc} = \frac{W_{sc}}{I_{sc}^2}$$

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 $x_1 = x_2$

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

TABULAR COLUMNS

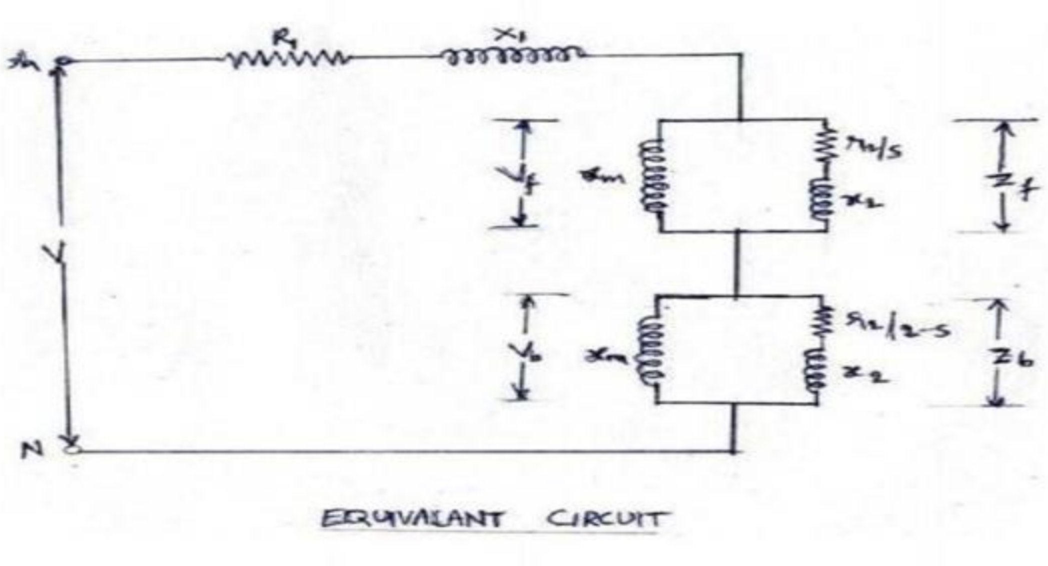
NO LOAD TEST:

S.No.	Vo(volts)	Io(amps)	Wo (watts)

BLOCKEDROTOR TEST:

S.No.	Vsc (volts)	Isc (amps)	Wsc(watts)
1			

EQIVALENT CIRCUIT:



RESULT:

VIVA – VOCE QUESTIONS:

1. What are the difficulties in starting single phase induction motor?
2. What are the commonly employed methods of starting a starting single phaseinduction motor?
3. What are the applications of starting single phase induction motor?
4. A capacitor start single phase induction motor will usually have a power factor of
5. A capacitor start, capacitor run single phase induction motor is basically a
6. The torque developed by a split phase motor is proportional to
7. A capacitor start single phase induction motor is switched on the supply with its capacitor replaced by an inductor of equivalent reactance value. It will

EXP.NO: 03

DATE :

SCOTT CONNECTION OF SINGLE-PHASE TRANSFORMER

AIM: To perform the scott connection of 1-phase transformer and converting 3-phase supply into 2-phase supply voltage

NAME PLATE DETAILS:

S.No	Specification	Range
1	Voltage	230/115V
2	Current	13A
3	Cycles	50Hz.
4	Output	3KVA
5	Phase	1-phase

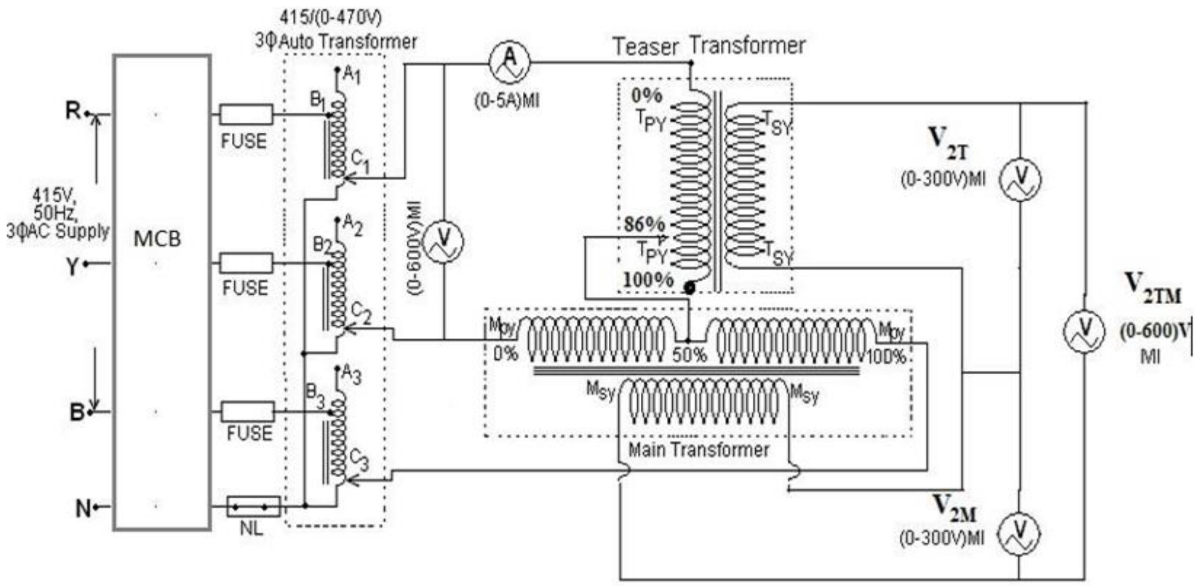
APPARATUS REQUIRED:

S.No.	Name of the apparatus	Range	Type	Quantity
1.	Transformer	2KVA		2
2.	Teaser transformer	2KVA	100%,86.6%,50% 0% Tappings	1
3.	Voltmeter	(0-600)V	Digital	2
4.	Voltmeter	(0-300)V	Digital	2
5.	Ammeter	(0-10)A	Digital	2
6.	Ammeter	(0-5)A	Digital	3
7.	Connecting wires	-	-	required

THEORY:

Conversion from three phase supply to two phase supply is achieved through Scott (or) tree connections of two phase transformers. This 3Φ phase to two phase conversion is commonly used in electric furnace installations where it intended to run two single phase furnaces together and draw a balanced load from a three phase supply system. Two specially tapped transformers are required for this purpose. One is called the main transformer which has a centre-tapped primary. The other is called the teaser transformer and has a primary voltage rating of the main transformer primary. The secondary of both transformers have equal voltage ratings.

CIRCUIT DIAGRAM:



DRAW CIRCUIT DIAGRAM:

PROCEDURE:

1. Connections are made as per the circuit diagram
2. Ensure that output voltage of the variac is set in zero position before starting the experiment.
3. Switch ON the supply.
4. The output voltage of the variac is gradually increased in steps upto rated voltage of single phase MAIN transformer and readings are correspondingly taken in steps.
5. Enter the readings in tabular column.
6. After observations, the variac is brought to zero position and switch OFF the supply

CALCULATIONS:

Prove

$$V_{2TM} = \sqrt{V_{2T}^2 + V_{2M}^2}$$

TABULAR COLUMN:

Sl no.	Voltmeter reading V_1	Ammeter reading I_1	Voltmeter reading V_{2T}	Voltmeter reading V_{2M}	Voltmeter reading V_{2TM}	Theoretical calculation $V_{2TM} = \sqrt{(V^2_{2T} + V^2_{2M})}$

RESULT:

VIVA-VOCE QUESTIONS:

1 What is Scott connection of transformer?

2 What is the application of Scott connection?

3 How do you parallel two single phase transformers?

4 What will happen if two transformers are connected in parallel with unequal impedances?

5 How do you parallel a transformer?

6 Why potential transformers are connected in parallel?

EXP.NO: 04

DATE :

REGULATION OF AN ALTERNATOR BY SYNCHRONOUS IMPEDANCEMETHOD

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

NAME PLATE DETAILS:

Specifications	Motor	Alternator
Rated voltage	220V	415V
Rated Current	19A	4.2A
Rated Power	5H.P.	3KVA
Rated Speed	1500rpm	1500rpm
Type of connection	Shunt	Star

APPARATUS REQUIRED:

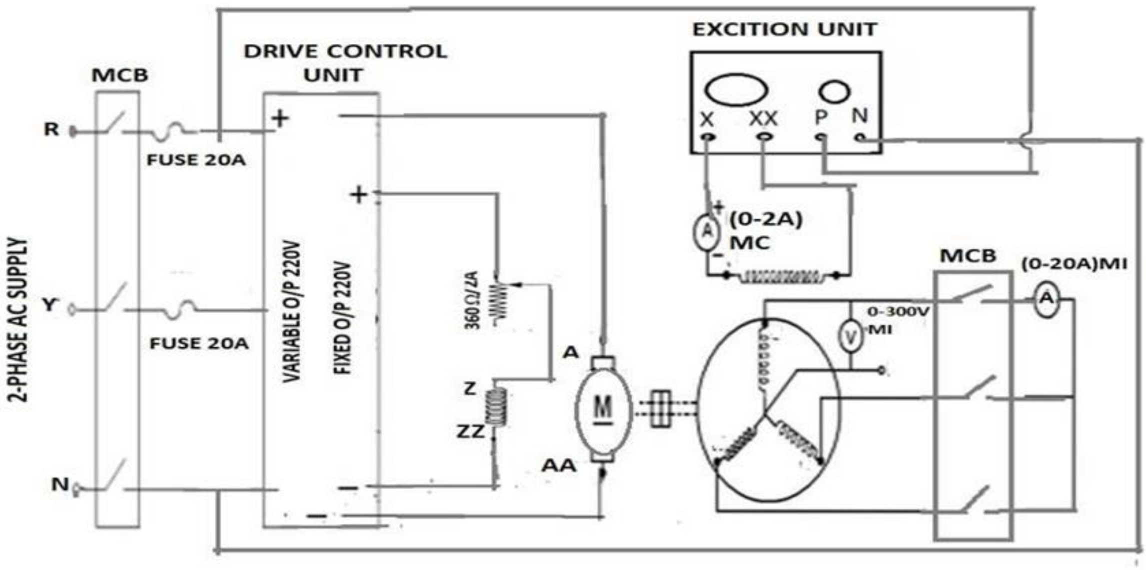
S.No.	Name of the apparatus	Range	Type	Quantity
1	Voltmeter	(0-300)V	Digital	1
2	Ammeter	(0-5)A	Digital	1
3	Ammeter	(0-2)A	Digital	1
4	Rheostat	300 Ω/2A	Digital	1
5	Tachometer	(0-3000)rpm	Digital	1
6	Connecting wires	--	--	Required

THEORY:

The regulation of a 3-phase alternator may be predetermined by conducting the Open Circuit (OC) and the Short Circuit (SC) tests. The methods employed for determination of regulation are EMF or synchronous impedance method, MMF or Ampere Turns method and the ZPF or Potier triangle method. In this experiment, the EMF and MMF methods are used.

The OC and SC graphs are plotted from the two tests. The synchronous impedance is found from the OC test. The regulation is then determined at different power factors by calculations using vector diagrams. The EMF method is also called pessimistic method as the value of regulation obtained N is N much more than the actual value. The MMF method is also called optimistic method as the value of regulation obtained is much less than the actual value. In the MMF method the armature leakage reactance is treated as an additional armature reaction. In both methods the OC and SC test data are utilized.

CIRCUIT DIAGRAM:



DRAW CIRCUIT DIAGRAMS:

PROCEDURE (EMF):

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 circuitand field regulator rheostat of motor circuit is set minimum resistance position.
3. Switch ON the supply, and start the DC motor using drive control unit.
4. Adjust the field rheostat of DC motor to attain rated speed (equal to synchronous speed ofalternator)
5. By decreasing the field resistance of Alternator, the excitation current of alternator isincreased gradually in steps.
6. Note the readings of field current, and its corresponding armature voltage in a tabularcolumn.
7. The voltage readings are taken upto 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 zerooutput position, i.e., resistance should be zero in value.
2. Now close the MCB.
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:

O.C. Test

S.NO	Field Current(If) (Amps)	No-Load Voltage (Vo) (Volts)

S.C.Test

S.NO	Field Current(If)(Amps)	Short Circuit current(Isc) (amps)

MODEL CALCULATIONS:

EMF METHOD:

$Z_S = \frac{V_{OC}}{I_{SC}}$ for the same I_f and speed: $X_S = \sqrt{Z_S^2 - R_a^2}$ [R_{ac}=1.6R_{dc}]

Generated emf of alternator on no load is

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

+ for lagging p.f.
- for leading p.f.

The percentage regulation of alternator for a given p.f. is

$$\% \operatorname{Re} g = \frac{E_0 - V}{V} \times 100$$

Where

E_0 – generated emf of alternator (or excitation voltage per phase)

V – full load, rated terminal voltage per phase.

PRECAUTIONS:

1. At the time of starting the field rheostat of motor should be in minimum position and field rheostat of an alternator should be in maximum position

RESULT:

VIVA – VOCE QUESTIONS:

1) Define Voltage Regulation of an Alternator?
2) Define Synchronous Impedance?
3) On which factors Voltage regulation depends on?
4) Why synchronous impedance method is called pessimistic method?
5) Mention the advantages and disadvantages of finding regulation of an alternator by synchronous impedance method(indirect method)and by direct loading method.
6) Explain about the salient pole and non salient pole rotors of an alternator?
7) What is the another name of Synchronous Impedance method?
8) Explain the different methods used for finding the regulation of an alternator?
9) Why regulation up is considered for Alternator?
10) Why the Alternator is called Synchronous Generator

EXP.NO: 05

DATE :

REGULATION OF AN ALTERNATOR BY MMF METHOD

AIM: To determine the regulation of a 3-phase alternator by using MMF method.

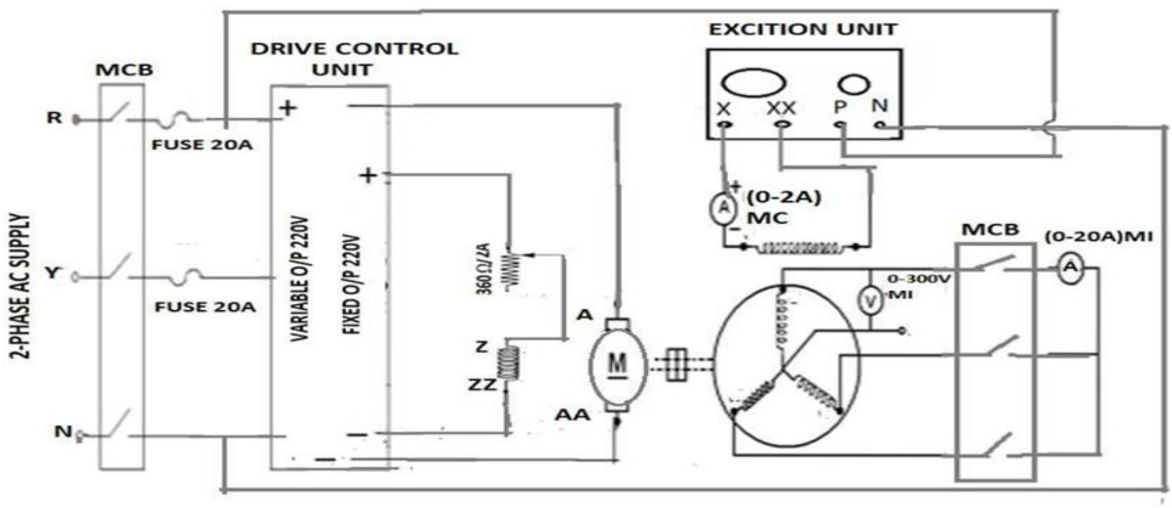
NAME PLATE DETAILS:

Specifications	Motor	Alternator
Rated voltage	220V	415V
Rated Current	19A	4.2A
Rated Power	5H.P.	3KVA
Rated Speed	1500rpm	1500rpm
Type of connection	Shunt	Star

APPARATUS REQUIRED:

S.No.	Name of the apparatus	Range	Type	Quantity
1	Voltmeter	(0-300)V	Digital	1
2	Ammeter	(0-5)A	Digital	1
3	Ammeter	(0-2)A	Digital	1
4	Rheostat	300 Ω/2A	Digital	1
5	Tachometer	(0-3000)rpm	Digital	1
6	Connecting wires	--	--	Required

CIRCUIT DIAGRAM:



PROCEDURE (MMF):

1) Make the connections as per the circuit diagram.
2) Give the supply to the dc-motor by closing the MCB.
3) Start the dc-motor with the help of Drive control unit.
4) By adjusting the field rheostat, bring the motor at rated speed of alternator.

O.C.Test

1) by opening the o/p of the alternator and adjusting the excitation gradually note downvoltmeter & ammeter readings.
2) Repeat the above procedure till the 125% of the rated voltage.

S.C.Test:

1) Short ckt the open terminals of the alternator by thick wire.
2) Gradually increase the excitation current and take both ammeter's readings.
3) Repeat the above procedure till the 125% of the rated current.

DRAW CIRCUIT DIAGRAMS:

OBSERVATIONS:

O.C. Test

S.NO	Field Current(If)(Amps)	No-Load Voltage (Vo)(Volts)

S.C.Test

S.NO	Field Current(If)(Amps)	Short Circuit current(Isc) (amps)

MMF METHOD:

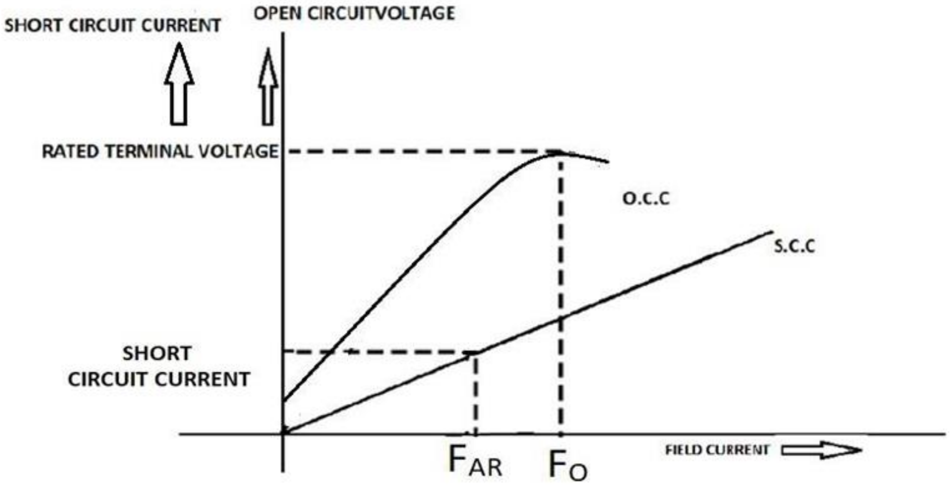
$If1$ Corresponds to drop of $(Vph + IaphRa \cos \emptyset)$

$If2$ *corresponds to full load short circuit current*

$I_f = \sqrt{I_{f1}{}^2 + I_{f2}{}^2 + 2I_{f1}I_{f2} \cos[180° - (90 \pm \emptyset)]}$

Regulation= $\frac{Eph-Vph}{V_{ph}} \times 100$

EXPECTED GRAPH:



PRECAUTIONS:

1. At the time of starting the field rheostat of motor should be in minimum position and field rheostat of an alternator should be in maximum position

RESULT:

EXP.NO: 06

DATE :

V & INVERTED V CURVES OF SYNCHRONOUS MOTOR

AIM: To obtain V and inverted V curves of a synchronous motor.

NAME PLATE DETAILS:

S.NO	Specifications	Ratings
1	Voltage	415V
2	Power	3kVA
3	current	4.2A
4	Speed	1500RPM

APPARATUS REQUIRED:

S.No.	Name of the apparatus	Range	Type	Quatity
1.	Ammeter	(0-2)A	Digital	1
2.	Ammeter	(0-10)A	Digital	1
3.	Voltmeter	(0-600)V	Digital	1
4.	Wattmeter	600V,10A	Digital	1
5.	Tachometer	(0-3000)rpm	Digital	1
6.	Rheostat	220Ω/2A	Wire wound	2
7.	Connecting wires		-	required

THEORY:

The variation of field current effects the power factor at which the synchronous motor operates. For a synchronous motor, the armature current phasor is given by Ia=V-E where V is the applied voltage .From the above equation it is clear that the magnitude and phase angle of phasor Ia depends upon the value of DC excitation. When the syn. Motor is operated at constantload with variable field excitation, it is observed that:

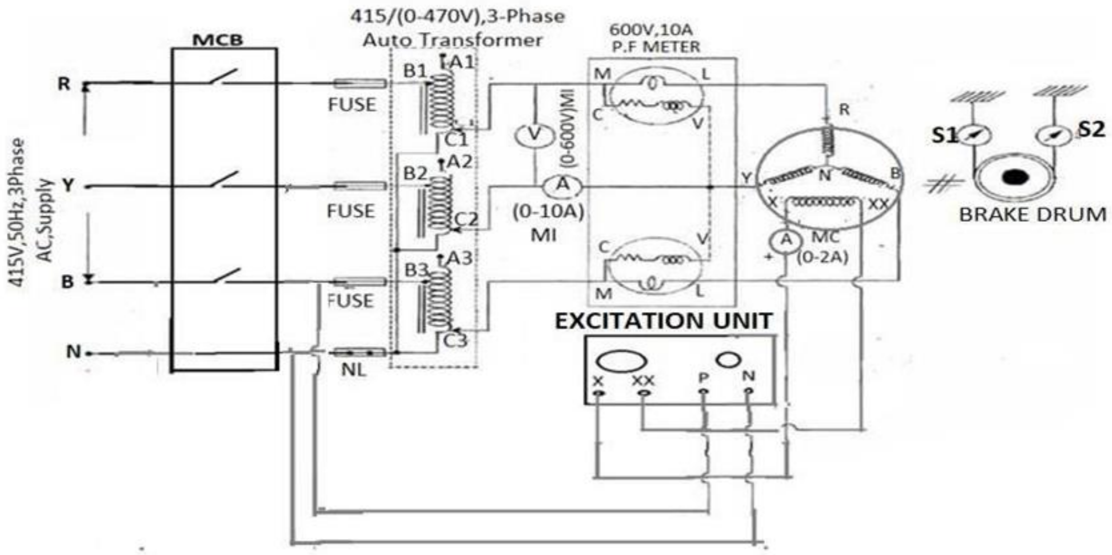
1. When the excitation is low, the armature current is lag in nature & the magnitude iscomparatively high.
2. If the excitation is gradually increased, the magnitude of Ia is gradually decreasing

andthe angle of lag is gradually reduced.

3. At one particular excitation, the magnitude of Ia corresponding to that load in minimumand vector will be in phase with V vector.

5. If the excitation is further increased, the magnitude of Ia again gradually increased and Ia,vector goes to leading state and the angle of load is also gradually increased.

CIRCUIT DIAGRAM:



DRAW CIRCUIT DIAGRAM:

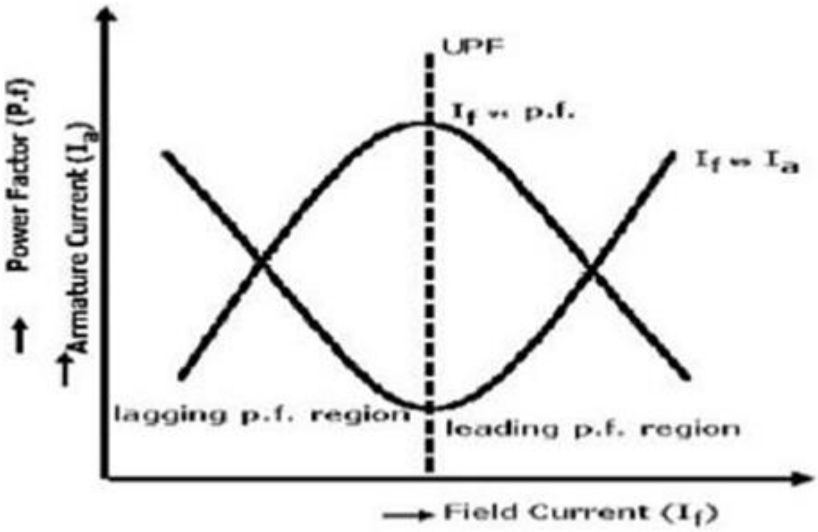
PROCEDURE:

1) Connect the circuit as per the diagram.
2) Before starting the synchronous motor, field terminals are left open.
3) Start synchronous motor by using 3-phase variac.
4) Adjust 3phase variac until it reaches rated voltage.
5) Field Terminals are connected to X, XX of Excitation unit.
6) Close MCB of excitation circuit by gradually increasing the excitation, note down the values ofammeter and wattmeter readings.
7) Repeat experiment until armature current reaches 125% of rated current.
8) Gradually decrease excitation and switch off supply
9) Tabulate the readings.

OBSERVATIONS:

S.No.	Field Current(If) (Amps)	Armature current(Ia) (Amps)	Wattmeter (P)(Watts)	CosΦ= P/(√3*V*I)

EXPECTED GRAPHS:



RESULT:

VIVA-VOCE QUESTIONS:

1 What is V curve and inverted V curve?

2 What happens when the field current of a synchronous motor is increased beyond the normal value atConstant input?

3 Inverted V-curves for a synchronous motor show---------

4 In synchronous generator if excitations is increase leading P.F then armature current will be------

5 In synchronous if excitations is increase lag P.F then armature current will be-------

6 The induced emf in a synchronous motor working on leading pf will be ------

7In a synchronous motor, the armature current has the highest value when excitation is ---

EXP.NO: 07

DATE :

NO LOAD & BLOCKED ROTOR TEST ON 3- ϕ INDUTION MOTOR

AIM: To conduct no load and blocked rotor test on given 3-phase induction motor, to predetermine theefficiency and to draw the equivalent circuit diagram.

NAME PLATE DETAILS:

S.NO	Specifications	Ratings
1	Voltage	415V
2	current	7.5Amps
3	output	5H.P
4	R.P.M	1430
5	cycle	50Hz
6	connection	Δ(Delta)

APPARATUS REQUIRED:

S.No.	Name of the apparatus	Type	Range	Quantity
1	Ammeter	Digital	(0-10)A	1
2	Ammeter	Digital	(0-2)A	1
3	Voltmeter	Digital	(0-600)V	1
4	Voltmeter	Digital	(0-30)V	1
5	Wattmeter	Digital	600V,5A,LPF	2
6	Wattmeter	Digital	150V,10A,UPF	2
7	Tachometer	Digital	(0-300)rpm	1
8	Connecting wires	-		required

THEORY:

A 3-phase induction motor consists of stator, rotor & other associated parts. In the stator, a 3- phase winding (provided) are displaced in spaceby120. A 3- phase current is fed to the winding so that a resultant rotating magnetic flux is generated. The rotor starts rotating dueto the induction effect produced due the relative velocity between the rotor Winding &the rotating flux

As a general rule, conversion of electrical energy to mechanical energy takes place in to the rotating part on electrical motor. In DC motors, electrical power is conduct directly to the armature, i.e, rotating part through brushes and commutator. Hence, in this sense, a DC motor can be called as 'conduction motor'.

However, in AC motors, rotor does not receive power by conduction but by induction in exactly the same way as secondary of a two winding T/F receives its power from the primary. So, these motors are known as Induction motors. In fact an induction motor can be taken as rotating T/F, i.e, one in which primary winding is stationary and but the secondary is free.

The starting torque of the Induction motor can be increase by improving its p.f by adding external resistance in the rotor circuit from the stator connected rheostat, the rheostat resistance being progressively cut out as the motor gathers speed. Addition of external resistance increases the rotor impedance and so reduces the rotor current. At first, the effect of improved pre dominates the current decreasing effect of impedance. So, starting torque is increased. At time of starting, external resistance is kept at maximum resistance position and after a certain time, the effect of increased impedance predominates the effect of improved p.f and so the torque starts decreasing. By this during running period the rotor resistance being progressively cut-out as the motor attains its speed. In this way, it is possible to get good starting torque as well as good running torque.

THEORITICAL CALCULATIONS:

NO LOAD TEST:

No load power factor $Cos\Phi_o = W_o/(V_o*I_o)$

Where W_o = Power input per phase on no load in Watts.

V_o = Rated applied voltage per phase on no load in Volts.

I_o = No load current per phase in Amps.

No load working component of current(I_w) = $I_oCos\Phi_o$

No load magnetizing component of current (I_μ) = $I_oSin\Phi_o$

No load resistance = (R_o) = V_o/I_w No load reactance = $(X_o) = V_o/I_\mu$

BLOCKED ROTOR TEST:

Motor equivalent impedance per phase referred to stator (Z_{sc}) = V_{sc}/ I_{sc} in ohms.

Motor equivalent resistance per phase referred to stator (R_{sc}) = $W_{sc}/(I_{sc}^2)$. in ohms.

Motor equivalent reactance per phase referred to stator (X_{sc}) = $\sqrt{(Z_{sc}^2 - R_{sc}^2)}$ in ohms.

Where W_{sc} = short circuit power per phase in Watts.

I_{sc} = short circuit current per phase in Amps.

V_{sc} = short circuit voltage per phase in Volts.

Rotor resistance per phase referred to stator $R_2' = R_{sc} - R_1$ ohms

Rotor reactance per phase referred to stator

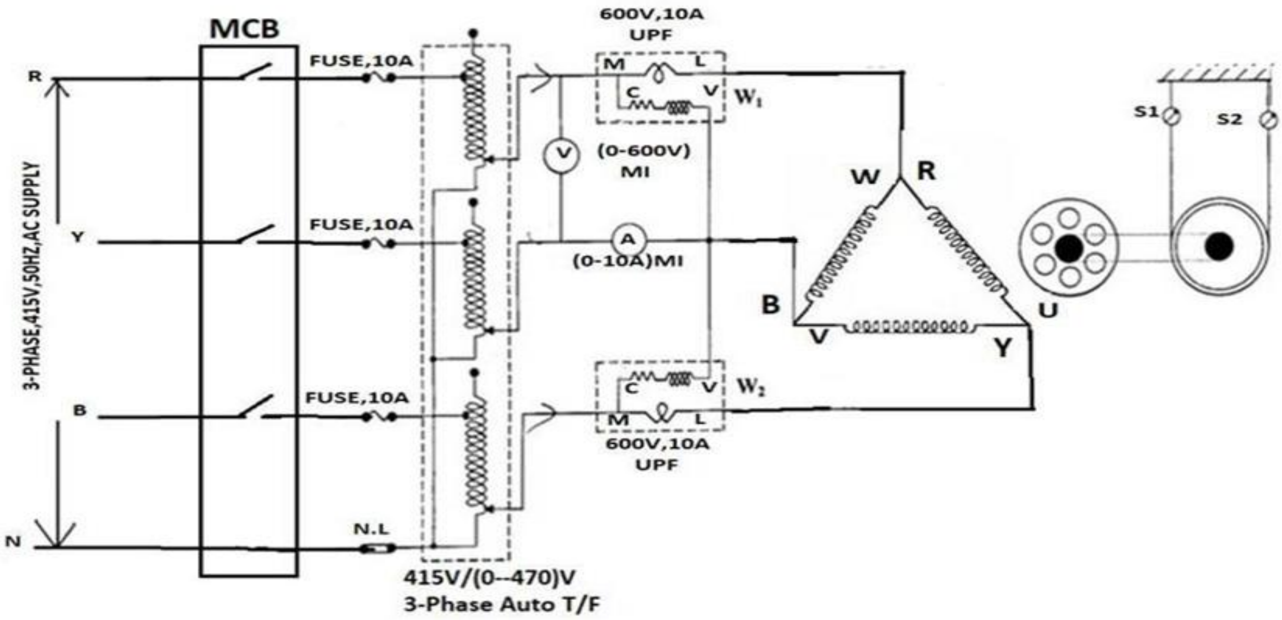
$X_2' = X_{sc}/2 = X_1$ ohms.

Where R_1 = stator resistance per phase in ohms.

X_1= stator reactance per phase in ohms.

Equivalent load resistance (R_L') = R_2' (1/s – 1) in ohms.

CIRCUIT DIAGRAM:



DRAW CIRCUIT DIAGRAM:

PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. For no-load test apply the rated voltage by adjusting the auto transformer and note down ammeter, voltmeter & wattmeter readings. In this test rotor is free to rotate.
3. For blocked rotor test apply the rated current by adjusting the auto transformer & note down ammeter, voltmeter & wattmeter readings. In this test rotor is blocked.
4. Find the stator resistance by using ammeter voltmeter method.
5. Switch OFF the supply.

PRECAUTIONS:

1. The auto transformer should be kept in minimum position.
2. At the time of starting stator winding should be in connected in delta.

OBSERVATIONS:

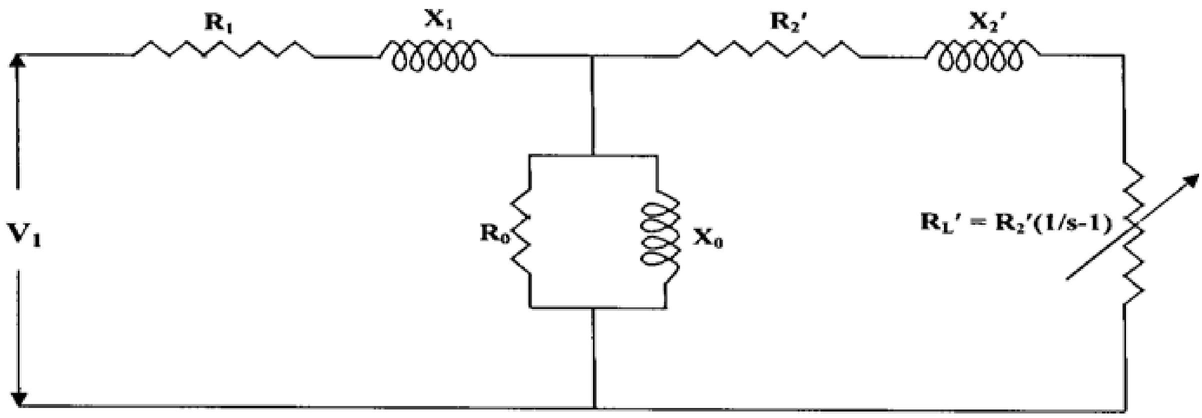
No-Load test:

S.No.	Open Ckt Voltage(Volt)	No load current (amp)	W1	W2	Open kt power W0=W1+W2 (Watt)	$\Phi 0=Cos^{-1}(W0/\sqrt{3}\ V0*I0)$

BLOCKED ROTOR TEST:

S.No.	Short Circuit Voltage (Volt)	Short Circuit current (amp)	W_1	W_2	Short circuit power Wsc= W_1+W_2 (Watt)	$\Phi sc=Cos^{-1}(Wsc/\sqrt{3}\ Vsc*Isc)$

MODEL EQUIVALENT CIRCUIT:



RESULT:

Viva-Voice Questions

1) The power factor of an induction motor decreases as the applied voltage is increased Explainthis with the help of a phasor diagram.
2) Express the no-load stator current corresponding to rated stator voltage as a %of rated full loadcurrent.
3) State the frequency of the rotor induced emf when the rotor is (a) rotating at a slip of (**S)** and

   (b) blocked, the stator supply frequency is 50HZ.
4) Show how you can calculate the efficiency of an induction motor from the results of copperlosses in the windings.
5) What is the difference between the LPF and UPF Watt meters?
6) Under blocked rotor condition, the frequency of rotor currents in a 50Hz,3-Φ induction motor?
7) What are the advantages of indirect testing over the direct testing of an induction motor?
8) Why the LPF watt meters are used in no-load test?
9) What is the reading of the wattmeter, when the p.f. is less than 0.5 lag.
10) What is the slip value at no-load?

EXP.NO: 08

DATE :

SUMPNER'S TEST ON TWO IDENTICAL 1-PHASE TRANSFORMERS

AIM: To conduct Sumpner's test on a given two identical 1-Phase transformers and predetermination of

1) Efficiency 2) Regulation 3) Equivalent circuit parameters.

NAME PLATE DETAILS:

S.No	Specification	Rating
1	Voltage	220/110 V
2	Current	8.7A
3	Cycles	50Hz
4	Output	2KVA
5	Phase	1-Phase

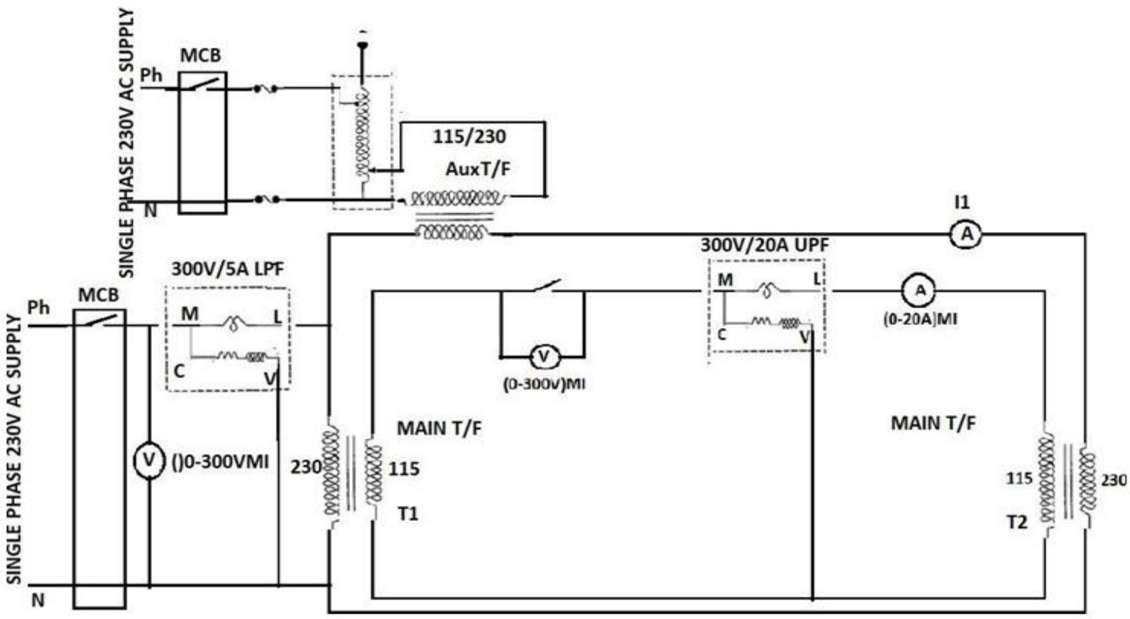
APPARATUS REQUIRED:

S.No	Name Of The Apparatus	Type	Range	Quantity
1)	Ammeter	MI	(0-20)A	1
2)	Ammeter	MI	(0-2.5)A	1
3)	Voltmeter	MI	(0-300)V	1
4)	Voltmeter	MI	(0-30)V	1
5)	Wattmeter	Dynamo	300V,5A,LPF	1
6)	Wattmeter	Dynamo	75V,10A,UPF	1
7)	Voltmeter	MI	(0-600)V	1
8)	1-Phase Auto Transformer	-	230V/(0-270)V	2
9)	Connecting Wires	-	(0-20)A	Required

THEORY:

This test is also called Heat Run Test. Two identical transformers are required to conduct this test. This is an indirect test similar to the OC & SC tests in transformers. Sumpner's test is a combination of both OC& SC tests from the result of this test parameters of equivalent circuit, the efficiency & Regulation of each transformer can be determined. In addition to the above parameters, temperature rise in the transformers can also be determined since the transformers are subjected to full load copper loss & core loss.

CIRCUIT DIAGRAM:



DRAW CIRCUIT DIAGRAM:

OC-TEST:

No-Load power factor ($\cos\Phi_0$) = ($W_0/2$) (V0/($I_0/2$))

Where W_0 = Open circuit power in Watts

V_0 = Open circuit Voltage in Volts

I_0 = Open circuit Current in Amps

No-Load working component of current (I_w) = $(I_0/2)*\cos\Phi_0$

No-Load magnetizing component of current (I_u) = $(I_0/2)*\sin\Phi_0$

SC-TEST:

Equivalent impedance referred to HV side $(Z_{02}) = ((V_{sc}/2)/I_{sc})$ ohm

Equivalent Resistance referred to HV side $(R_{02}) = (W_{sc}/2)/(I_{sc}^2)$ ohm

Equivalent Reactance referred to HV side $(X_{02}) = \sqrt{(Z_{02}^2 - R_{02}^2)}$ ohm

Where W_{sc} = Short Circuit Power in watts

V_{sc} = Short Circuit Voltage in volts

I_{sc} = Short Circuit Current in Amps.

Equivalent Circuit of 1-phase transformer referred to LV side:

$\cos\Phi_0 = (W_0/2)/(V_0 * I_0/2)$

$I_w = I_0/2 * \cos\Phi_0$

$I_\mu = I_0/2 * \sin\Phi_0$

$R_0 = V_0 / I_w$

$X_0 = V_0 / I_\mu$

$Z_{02} = (V_{sc}/2)/I_{sc}$

$R_{02} = (W_{sc}/2)/ I^2_{sc}$

$X_{02} = \sqrt{(Z_{02}^2 - R_{02}^2)}$

Transformer ratio (k) $= V_2/V_1$

Equivalent Resistance referred to LV side $(R_{01}) = R_{02} /k^2$

Equivalent Reactance referred to HV side $(X_{01}) = X_{02} / k^2$

Efficiency & Regulation Of 1-phase transformer.

Output power= $(X*KVA* \cos\Phi_0)$

Where X = Fraction of load

KVA = power rating of transformer

$\cos\Phi_0$ = power factor

Iron losses(W_i)= $W_0/2$

Copper losses of each transformer (W_{cu}) = $X^2 * W_{sc}/2$

Efficiency of each transformer= (Output power/ Output power+ losses) * 100

Regulation Of each transformer = $(X.I_{sc}[R_{02}\cos\Phi \pm X_{02}\sin\Phi]/V_2*)\ 100$

Where "+" for lagging.

"-" for leading.

PROCEDURE:

1) Make connections as per the circuit diagram.
2) Initially kept SPSTs switch to be open & give supply to primarily by closing MCB.
3) By adjusting auto transformer apply rated voltage across primaries.
4) If the voltmeter connected across SPST s voltage reads zero then close the switch. If not interchange the connections of any one of the transformer winding is ensure that voltmeter reading should be zero.
5) By adjusting Booster transformer pass rated current through high voltage side.
6) Note down the readings of voltmeter, Ammeter & wattmeter.
7) Slowly bring the auto transformer to the initial position and switch off the supply.

PRECAUTIONS:

1. MCB & SPST switch should be kept in open while making connections
2. Make connections tightly.
3. The SPSTs Should kept open till the voltage across the SPSTs is brought to zero.
4. High voltage & low voltage sides of the transformer should be properly used as primary or secondaryrespective to the experiments.

OBSERVATIONS:

OC Test			SC Test		
V0(Volts)	I0/2(amps)	W0/2(Watts)	Vsc/2(volts)	Isc(amps)	Wsc/2(watts)

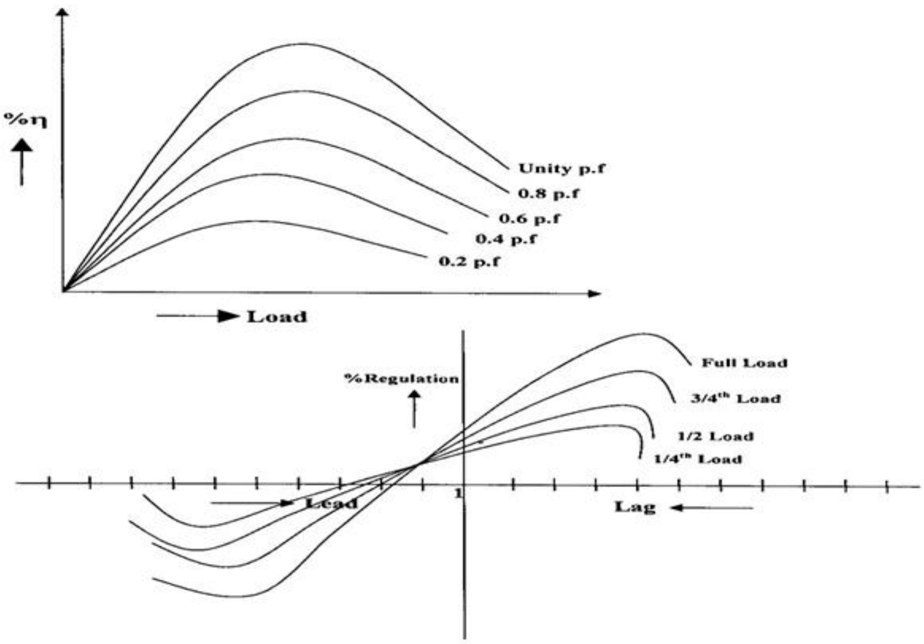
TABULATION TO FIND THE EFFICIENCY:

CosΦ	Fractional load (X)	O/P (watts)	Iron losses (Wi)	Cu losses (Wcu)	Total losses	%η
0.2						
0.4						
0.6						
0.8						
1						

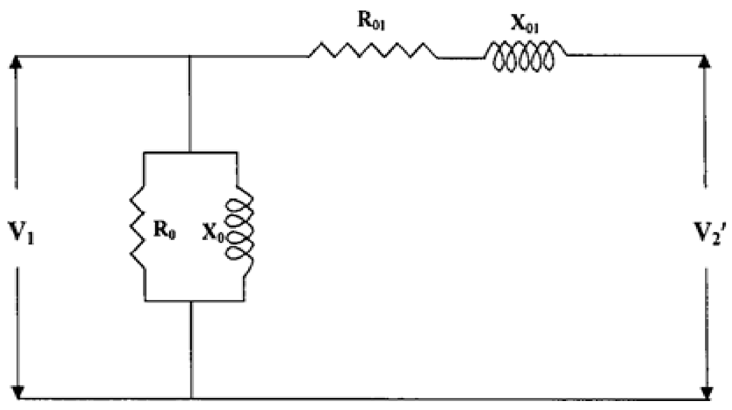
TABULATION TO FIND OUT THE REGULATION:

Fraction of load (X)	P.F(CosΦ)	%Reg(lag)	%Reg(lead)
¼			
½			
¾			
1			

EXPECTED GRAGHS.



EQUIVALENT CIRCUIT:



RESULT:

VIVA-VOCE QUESTIONS:

1. what is sumpner's test
2. When secondaries are connected in phase opposition, power drawn by the circuit is equal to----
3. Total power required for Sumpner's test is given by----
4. why sumpner's is called heat run test and back to back test-----
5. what are the advantages of Sumpner's test over conventional OC & SC test----
6. While conducting the sumpner's test, the primaries of the two identical transformers are connected in parallel across the supply. The secondary's are connected in-----
7. In sumpner's test, the net voltage in the local circuit of secondary's is------
8. While performing sumpner's test on transformer, if the secondary's are not in series opposition then themeter will read-----

EXP.NO: 09

DATE :

REGULATION OF THREE PHASE ALTERNATOR BY ZPF METHOD

AIM: To predetermine the percentage regulation of the given three phase alternator by ZPF (Potier's Triangle)Method, by conducting Open Circuit, Short circuit and ZPF test.

NAME PLATE DETAILS:

Specifications	**Alternator**	**Motor**
Voltage	415V	220V
Current	4.2A	19.5A
Power	3KVA	5H.P.
Speed	1500	1500
Connection	Star	DC

APPARATUS REQUIRED:

S. No	**Name of Apparatus**	**Range**	**Type**	**Qty.**
1	Voltmeter	(0—600v)	Digital	1
2	Voltmeter	(0—150v)	Digital	1
3	Ammeter	(0—10A)	Digital	1
4	Ammeter	(0—10A)		1
5	Ammeter	(0—2A)		1
6	Rheostat	Wire wound		1
7	Rheostat	Wire wound		1
8	Connecting wires	-		Required

THEORY:

Regulation is defined as the change in terminal voltage, expressed as a percentage of the rated voltage, when the load at a given power factor is removed, with speed and field current remaining unchanged. Therefore,

% voltage regulation = (E_f – V_t) X 100 / V_t

Here, E_f is the no load excitation voltage and V_t is the full load terminal voltage at the same speed and field excitation. For lagging power factor load, E_f always increases and for leading power factor load, E_f may decrease consequently the voltage regulation may be positive or negative. Though the use of automatic voltage regulators have curtailed the importance of computing the voltage regulation of synchronous machines, it is still worthwhile to know it s value because of the following reasons.

1. When the load is thrown off, the voltage rise must be known, since the winding insulation should be able to withstand this increased voltage.
2. Voltage regulation determines the type of automatic voltage control equipment to beused
3. Steady state short circuit condition and stability are affected by voltage regulation.
4. Parallel operation of one alternator with other alternators is affected considerably byoutput voltage regulation.

In case of small machines, the voltage regulation can be obtained by actually loading it.In large machines. It may nor be possible to obtain the voltage regulation by actual loading. It causes huge amount of wastage of power. Certain simple tests, involving only small amounts of power are conducted and from these the machine constants are determined to compute the voltage regulation. One of the method is described below:

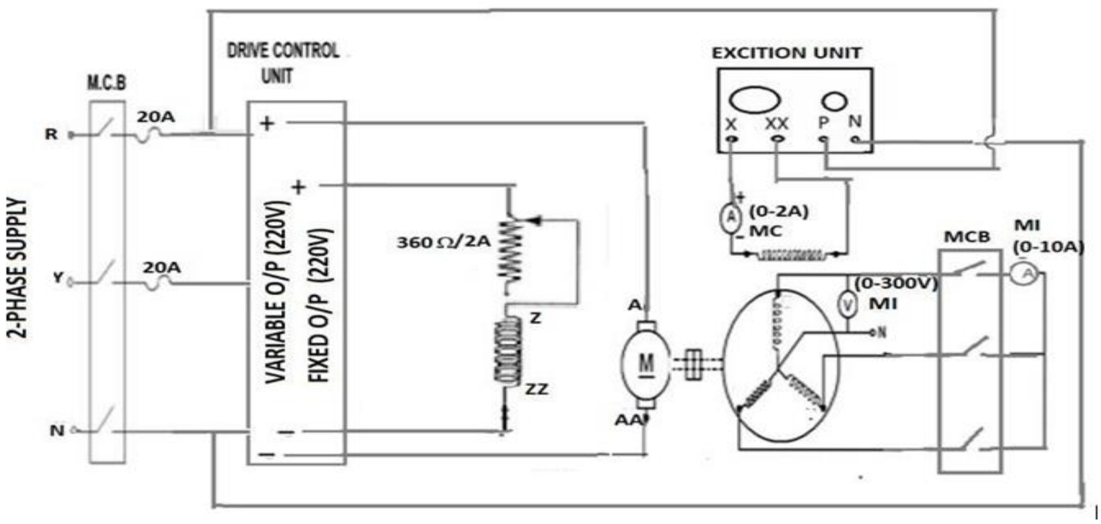
SYNCHRONOUS IMPEDANCE METHOD:

This method, though gives inconsistent results for voltage regulation, it is quite useful because it introduces the concept of synchronous reactance. This procedure can be applied to cylindrical rotor synchronous machines only, because the resultant air-gap flux is not affected by the angular position of the rotor. The iron part of the magnetic circuit is assumed to have constant permeability i.e., saturation is neglected. This permits the replacement of mmfs by their corresponding fluxes and therefore, the corresponding emfs. In short the mmfs can be replaced by their corresponding emfs and it is because of this reason that this procedure of determining voltage regulation is called the EMF method.

MAGNETO MOTIVE FORCE METHOD (MMF):

The MMF method is also called optimistic method as the value of regulation obtained is much less than the actual value. In the MMF method the armature leakage reactance is treated as an additional armature reaction. In both methods the OC and SC test data are utilized.

CIRCUIT DIAGRAM:



DRAW CIRCUIT DIAGRAMS:

FORMULAE USED:

1. From Poitier triangle BCD, the armature leakage reactance drop is l (DE) Iph * XL_{ph} = l (DE) x scale.
2. I_{ph} = KVA/(√3* V_L) Ampere.
3. $(E1_{ph})2 = (V_{ph} \cos \phi + I_{ph} Ra_{ph})2 + (V_{ph} \sin \phi \pm I_{ph} XL_{ph})2$

   + for lag; - for lead.
4. Field excitation If_1 required to induce $E1_{ph}$ is obtained from open circuit characteristics.
5. The field current If_2 required to balance armature reaction is obtained from Potier triangle. If_2 = l(BE) x scale
6. Resultant field current, $If_2 = I2f_1 + I2f_2 - 2\, If_1\, If_2 \cos(90 \pm \varphi)$

   + for lag; - for lead.
7. Obtain Eph corresponding to resultant field current, If from open circuit characteristics. 8. %regulation =( )x 100

TABULATION:

OPEN CIRCUIT TEST:

S.NO	Field Current (If) (Amp)	Open Circuit Line Voltage (Voc)L (Volts)	Open Circuit Phase Voltage (Voc) ph = (Voc)L / √3 (Volts)

SHORT CIRCUIT AND ZPF TEST:

	Short Circuit Test		Zero Power Factor Test		
S.NO	Field Current (If)(Amp)	Short Circuit Current (Isc)(Amp)	Field Current (If) (Amp)	Rated Armature current (Ia)(Amp)	Rated Armature Voltage (Volt)

PRECAUTION:

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

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Supply is given by closing MCB.
3. Observing all the precautions, the motor is started using Drive Control Unit and the speed is increased until the rated armature voltage (of motor) is reached. At this instant the speed would be slightly lesser than the rated speed.
4. Now by adjusting the field rheostat, the motor is brought to the rated speed.
5. Conduct an open circuit test by varying the potential divider for various of field current andtabulate the corresponding open circuit voltage readings.
6. Conduct a short circuit test by closing the MCB and adjust the potential divider to set the ratedarmature current and tabulate the corresponding field current.
7. Conduct a ZPF test by adjusting inductive load with zero power and tabulate the readings until full load current.

PROCEDURE TO DRAW THE POTIER TRIANGLE:

1.Draw the open circuit characteristics curve (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 armaturecurrent.

3.From the ZPF test, mark the point B for the field current to the corresponding rated armaturecurrent and the rated voltage.

4.Draw the ZPF curve which passing through the point A and B in such a way parallel to the opencircuit characteristics curve.

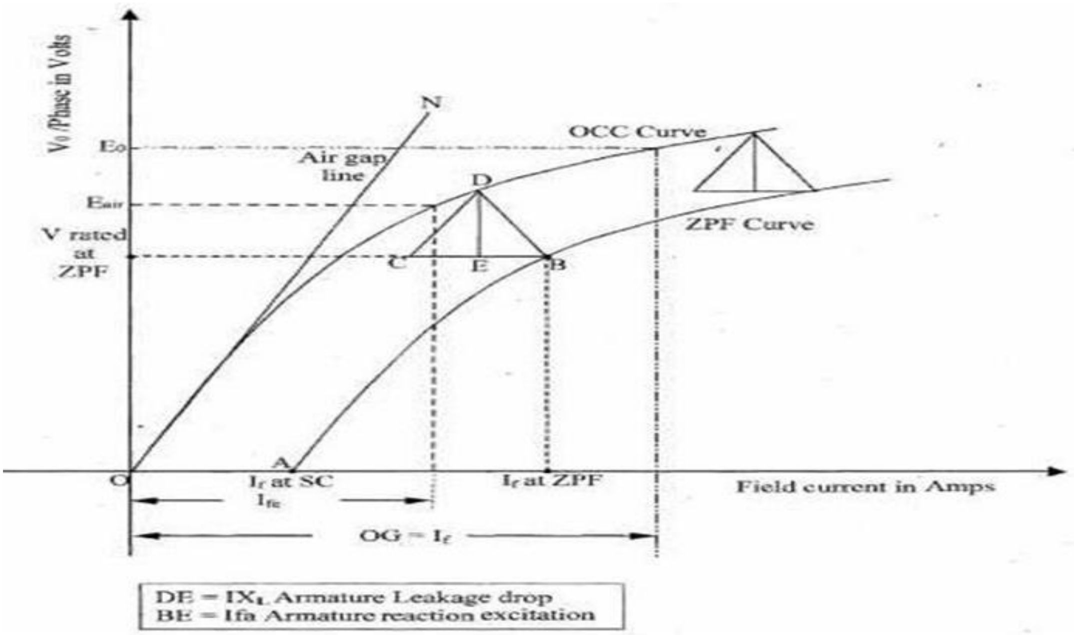
5.Draw the tangent for the OCC from the origin (i.e.,) air gap line.

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

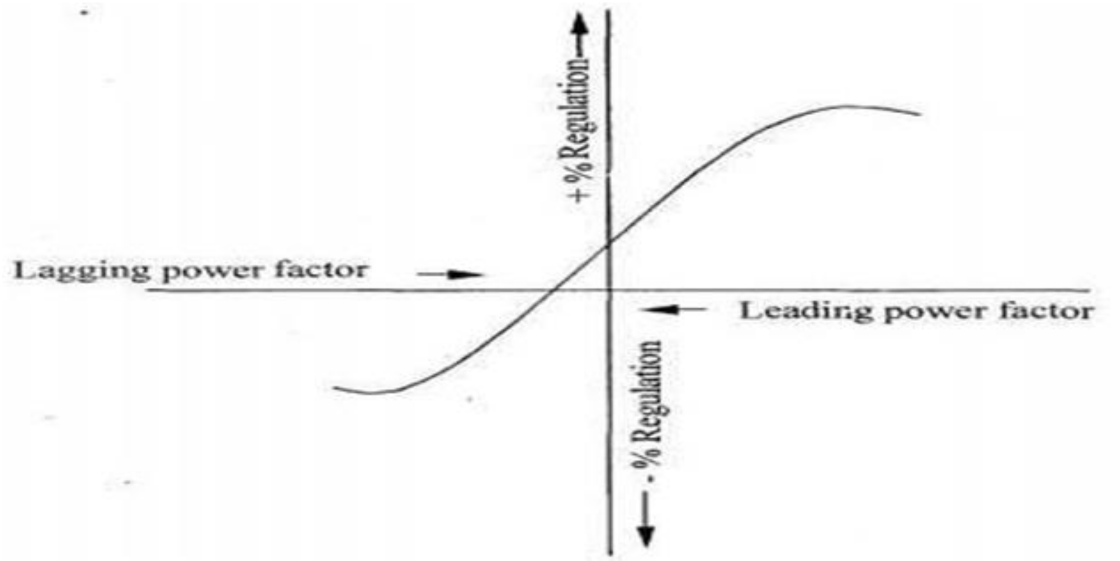
7.Draw the parallel line for the tangent from C to the OCC curve.

8.Join the point B and D. Also drop a perpendicular line DE to BC. Line DE represent armatureleakage reactance drop (IXL) and BE represent armature reaction excitation.

MODEL GRAPH:



MODEL GRAPH FOR % REGULATION:



TABULATION FOR % REGULATION:

S.NO	Power factor	E1 ph Volts		If 1 (A)		If 2 (A)	If (A)		Eph (V)		% Regulation	
		Lag	Lead	Lag	Lead		Lag	Lead	Lag	Lead	Lag	Lead
1	0.1											
2	0.2											
3	0.3											
4	0.4											
5	0.5											
6	0.6											
7	0.7											
8	0.8											
9	0.9											
10	1											

RESULT:

VIVA-VOCE QUESTIONS:

1. Which of the following voltage regulation method is accurate ?
2. In which of the following, voltage regulation may be zero or negative
3. Consider a purely inductive load connected to the alternator having zero lagging power factor. In thiscase the effect of armature reaction will be
4. In an alternator, the voltage regulation will be positive when the power factor of the load is
5. On unity power factor, the terminal voltage of an alternator is
6. Which method for finding percentage regulation in synchronous machines is called pessimistic method**?**
7. For high capacity alternators, which method is not suitable for finding percentage regulation?
8. For finding voltage regulation of an alternator, the method which gives most accurate result is

EXP.NO: 10

DATE :

DETERMINATION OF X_d & Xq OF A SALIENT POLESYNCHRONOUS MACHINE

AIM: To find Xd & Xq of given salient pole synchronous machine by conducting slip test.

NAME PLATE DETAILS:

Specifications	Alternator	DC Motor
Voltage	415V	220V
Current	4.2A	19.5A
Power	3KVA	5H.P.
Speed	1500 RPM	1500 RPM
Connection	Star	Shunt

APPARATUS REQUIRED:

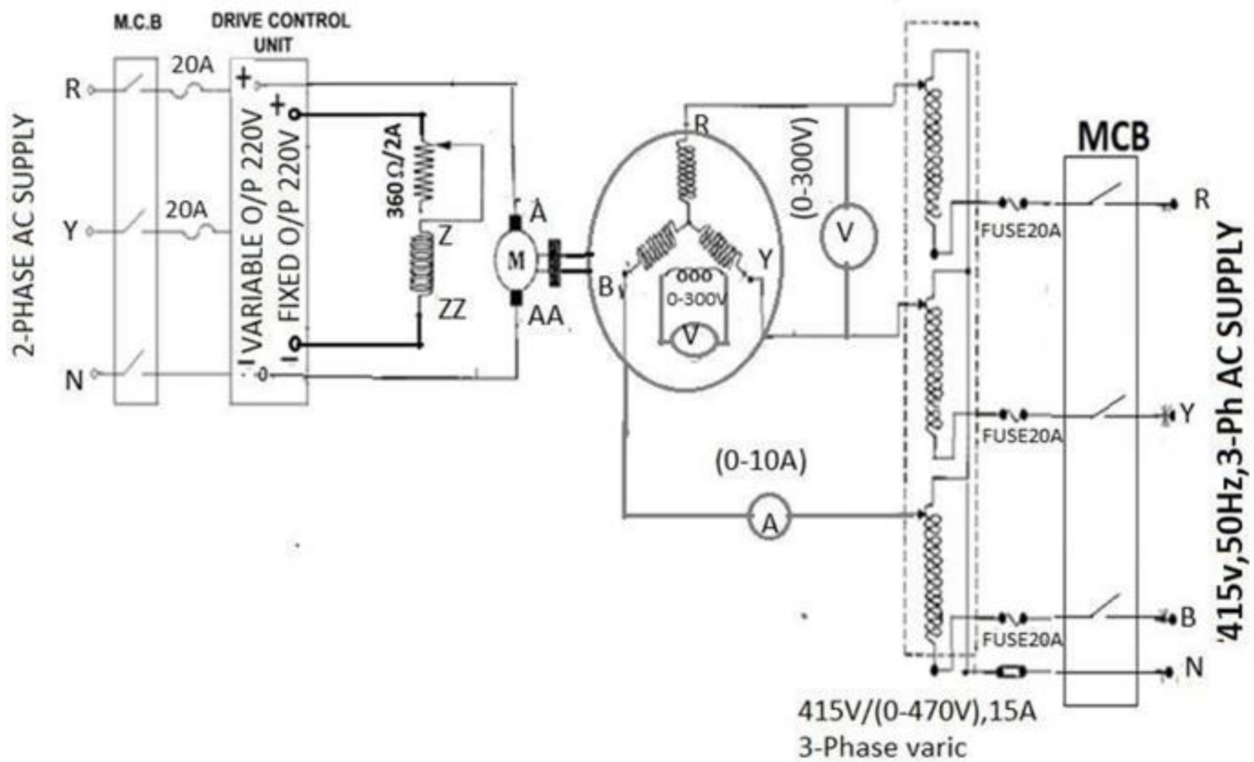
S.No.	Name of the apparatus	Range	Type	Quantity
1.	Ammeter	(0-10)A	Digital	1
2.	Voltmeter	(0-600)V	Digital	1
3.	3-Φ variac	415-470V,10A	-	1
4.	Tacho meter	(0-3000)rpm	Digital	1
5.	Voltmeter	(0-300)V	Digital	1
6.	Ammeter	(0-2)A	Digital	1
7.	Connecting wires	-	-	required

THEORY:

In a salient pole alternator, the reactance of magnetic circuit along is along its quad stator axis. The alternator is driven by auxiliary prime mover at a speed slightly less than the synchronous speed under these conditions. The armature current is when the armature currentmmf is in line with the field poles. The reactance by the magnetic field current is minimum. The ratio of maximum voltage to minimum current gives the direct axis impedance and the ratio of minimum voltage to maximum current gives the armature axis impedance.

The values of X_d & X_q are determined by conducting the slip-test. The syn. machine is driven by a separate prime mover at a speed slightly different from synchronous speed. The field winding is left open and positive sequence balanced voltages of reduced magnitude (around 25%of the rated value) and of rated frequency and impressed across the armature terminals. Here, the relative velocity b/w the field poles and the rotating armature mmf wave is equal to the difference b/w syn. speed and the rotor speed i.e, the slip speed. When the rotor is along the d-axis, then it has a position of min reluctance, min flux linkage and max flux produced links with the winding. Then Xd=(max. armature terminal voltage/ph) /(min. armature current/ph)As the current is small then Vt will be high as drop will be small. When the rotor is along q-axis, then it is max, then the flux linkage would be max. Then The min fluxproduced links with winding. So max emf. Xq=(min. armature terminal voltage/ph) /(max. armature current/ph)

CIRCUIT DIAGRAM:



DRAW CIRCUIT DIAGRAM:

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. By keeping 3-ϕ variac at minimum position and MCB in open position.
3. Observing all the precautions, the motor is started using Drive Control Unit and the speed is increased until the rated armature voltage (of motor) is reached. At this instant the speed would be slightly lesser than the rated speed.
4. Now by adjusting the field rheostat, the motor is brought to the rated speed.

5. With field winding left open, a positive sequence balanced voltages 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 slowlybetween maximum and minimum positions.
7. Under this condition , readings of maximum and minimum values of both ammeter andvoltmeter are recorded

PRECAUTIONS:

1) Motor field rheostat should kept in minimum position
2) Direction of rotation due to prime mover & due to alternator run as motor should be same.
3) Initially all switches are kept open.

OBSERVATIONS:

S.No.	Imin	Imax	Vmin	Vmax	Xd = Vmax/Imin	Xq =Vmin/Imax
1.						

RESULT:

VIVA-VOCE QUESTIONS:

1 The d- Axis Reactance is determined by?

2 Slip test is use to determine?

3 During slip test it will be observed that (Swing of ammeter or voltmeter)?

4 Slip test must be conducted at low armature terminal voltage. This is due to?

5 In which one of the following is reluctance power developed?

6 What is meant by two reaction theory?

7 Why we do take speed less than synchronous speed in slip test?

EXP.NO: 11

DATE :

O.C & S.C TEST ON SINGLE PHASE TRANSFORMER

AIM: To conduct O.C. & S.C. test on a given transformer and predeterminations of

1) Efficiency,
2) Regulation,
3) Equivalent circuit

NAME PLATE DETAILS:

S.NO	Specifications	Ratings
1	Voltage	220/110v
2	output	3kVA
3	cycle	50Hz
4	phase	1-ϕ

APPARATURS REQUIRED:

S.No.	Equipment	Type	Range	Quantity
1.	Ammeter	DIGITAL	(0-2)A	1
2.	Ammeter	DIGITAL	(0-20)A	1
3.	Voltmeter	DIGITAL	(0-300)V	1
4.	Voltmeter	DIGITAL	(0-150)V	1
5.	Wattmeter	DIGITAL	300V,2A,LPF	1
6.	Wattmeter	DIGITAL	75V,20A,UPF	1
7.	1- Φ auto transformer	-	230/(0-270)V,2KVA	1
8.	Connecting wires	Copper	1.5sqmm	Required

THEORY:

These two tests on a transformer helps to find determine

1. The parameters of equivalent circuit

2. The voltage regulation
3. Efficiency

Complete analysis of the transformer can be carried out once it's equivalent circuit parameters are known. The power required during these two tests is equal to the appropriate power loss occurring in the transformer

O.C.TEST:

This test is conducted by opening the HV side of a transformer. The core loss of the transformer can be determined from this test. It also gives the no-load current I0, which is used to calculate the parameters R0, Xm of the magnetizing circuit. The transformer is connect as indicated in the ckt diagram. One of the windings usually the low voltage winding is connected to the supply voltage source while the high voltage winding is kept open..This ensure magnification of the no-load current I0 , The rated voltage applied to the transformer using auto- transformer, the ammeter gives the total power loss and the ratio of voltmeter readings V1/V2 gives the ratio of the turns.

No load power factor (CosΦ0) = W0/(I0 * V1)

Where W0 = open ckt power in watts

I0 = Open ckt current in Amps

V1 =Open ckt voltage in Volts

No- load working component of current (Iw) = I0 Cos Φ0

No-load working magnetizing component of current (Iμ) = I0 Sin Φ0

R0 =V0/ Iw in ohms

X0 = V0/ Iμ in ohms

S.C. TEST:

This test gives the full load copper loss. In this test, secondary side low voltage winding is short circuited. A small voltage applied to the primary and increased carefully till the current (Isc) in the primary winding reaches the rated full-load value. Under these conditions, the copper loss inthe in the winding is same as that on full load.

Equivalent impedance referred to HV side Z02 = Vsc/Isc in ohms.

Equivalent resistance referred to HV side R02 = Wsc/I^2sc in ohms.

Equivalent reactance referred to HV side X02 = $\sqrt{(Z^2 02 - R^2 02)}$ in ohms

Equivalent circuit of 1-φ transformer referred to lv side:

$(\cos\Phi_0) = W_0/(I_0 *$
$V_1)(I_w) = I_0 \cos \Phi_0$
$(I_\mu) = I_0 \sin \Phi_0$

$Z_{02} = V_{sc}/I_{sc}$, $R_{02} = W_{sc}/I^2_{sc}$,

$X_{02} = \sqrt{(Z^2_{02} - R^2_{02})}$

Transformation ratio $(K) = V_2/V_1$

Equivalent resistance referred to LV side $(R_{01}) = R_{02} / K^2$

Equivalent reactance referred to LV side $(X_{01}) = X_{02}/K^2$

Efficiency & Regulation of 1- Φ transformer:

Output power = (X*KVA*Cos Φ)

Where X = fraction of load. (X=1/4,1/2,3/4,1)

KVA = power rating of transformer, Cos Φ = power factorIron losses (Wi) = W0

Copper losses (Wcu)= X^2*Wsc

Total losses = Cu losses + Iron losses.

$$\textbf{Efficiency} = \frac{\text{Output power}}{\text{(output power+ losses)}} * 100$$

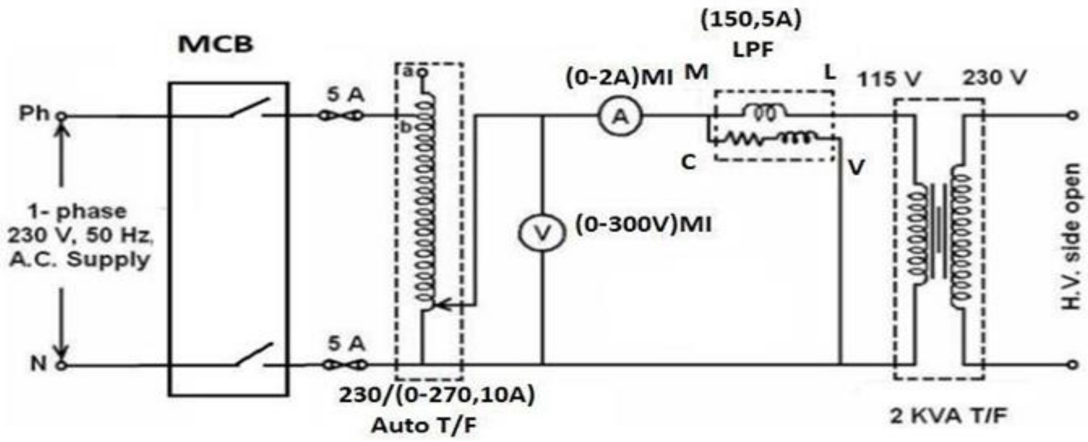
$$\textbf{Regulation} = \frac{X.I_{sc}\,[R_{02}\cos\Phi \pm X_{02}\sin\Phi]}{V2} * 100$$

Where " +" for lagging.

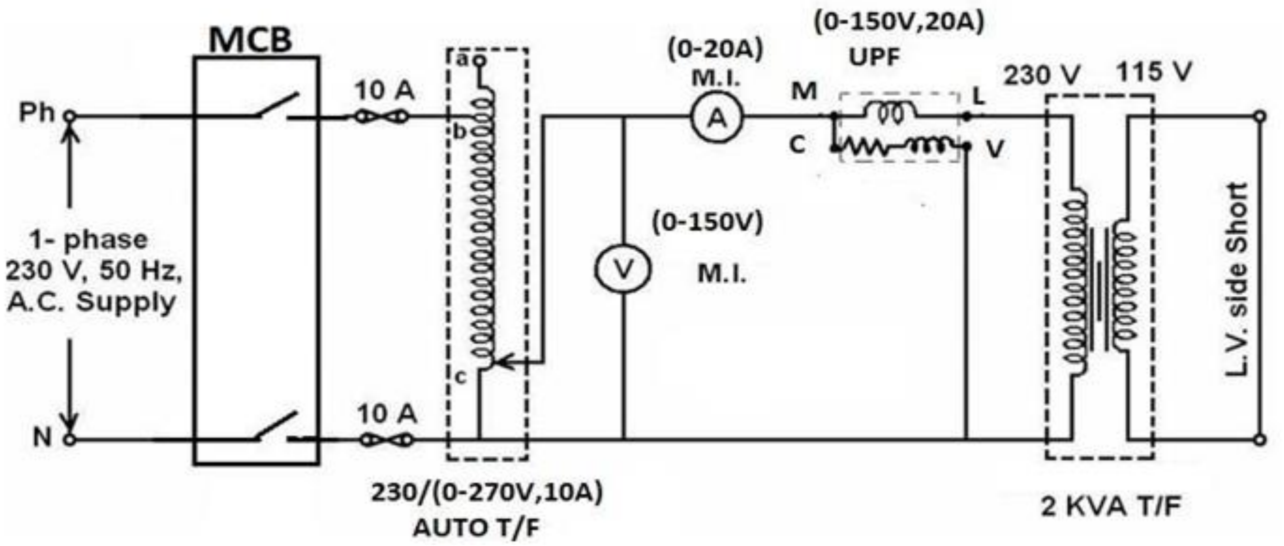
"-" for leading.

CIRCUIT DIAGRAM:

OPEN CIRCUIT:



SHORT CIRCUIT:



PROCEDURE:

Open circuit test:

1. Connections are made as per the circuit diagram.
2. Ensure that variac is set to zero output voltage position before starting the experiment.
3. Switch ON the supply. Now apply the rated voltage to the Primary winding by using variac.
4. The readings of the Voltmeter, ammeter and wattmeter are noted down in Tabular form.
5. Then variac is brought back to minimum position and switch OFF the supply.
6. Calculate $\mathbf{R_o}$ and $\mathbf{X_o}$ from the readings.

Short Circuit Test:

1. Connections are made as per the circuit diagram.
2. Ensure that variac is set to zero output voltage position before starting the experiment.
3. Switch ON the supply. Now apply the rated current to the Primary winding by using Variac.
4. The readings of the Voltmeter, ammeter and wattmeter are noted down in Tabular form.
5. Then variac is set to zero output position and switch OFF the supply.
6. Calculate $\mathbf{R_{01}}$ and $\mathbf{X_{01}}$ from the readings.

OBSERVATIONS:

O.C. Test

S.No.	V_1(Volts)	I_o(Amps)	W_o(Watts)

S.C.Test:

S.No.	V_{sc}(Volts)	I_{sc}(Amps)	W_{sc}(Watts)

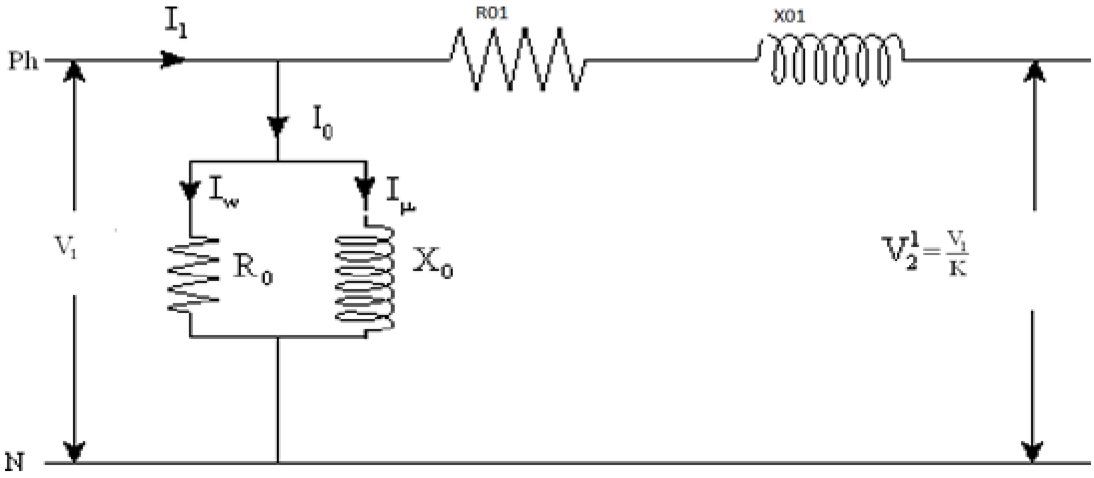
TABULATION TO FIND THE EFFICIENCY:

Fractinal load (X)	O/P (watts)	Iron losses (Wi)	Cu losses (Wcu)	Total losses	%η
¼					
½					
¾					
1					

TABULATION TO FIND OUT THE REGULATION:

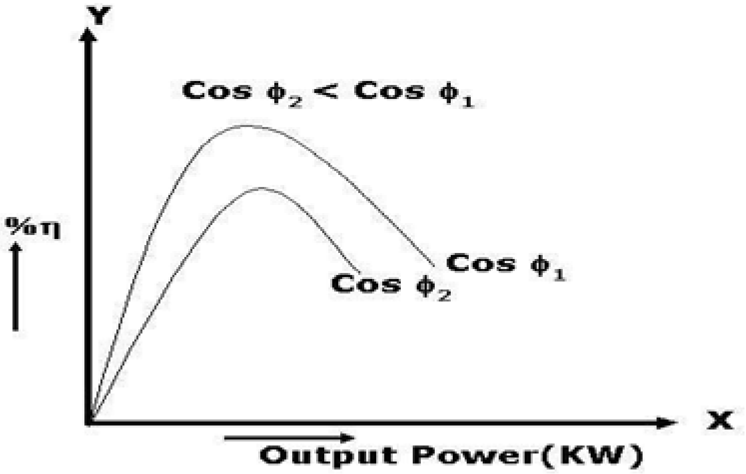
Fraction of load (X)	P.F(CosΦ)	%Reg(lag)	%Reg(lead)
¼			
½			
¾			
1			

EQUIVALENT CIRCUIT DIAGRAM:

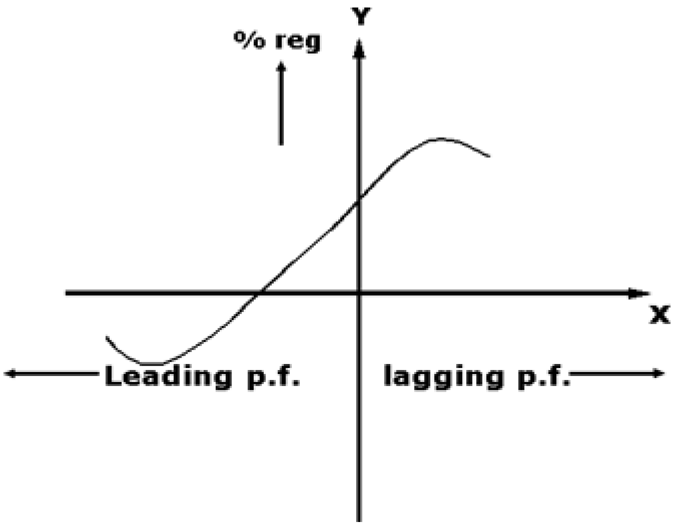


EXPECTED GRAPHS:

GRAPHS: Plots drawn between



(i) % efficiency Vs output



% Regulation Vs Power factor

RESULT:

VIVA – VOCE QUESTIONS:

1. How would you calculate the multiplying factor of a wattmeter?
2. Why should we select LPF & UPF wattmeter's while conducting OC & SC test?
3. Why Iron losses are considered as negligible while conducting SC test?
4. Why copper losses are considered as negligible while conducting OC test?
5. What are the Advantages and Disadvantages of OC & SC test?
6. What are the requirements to be fulfilled while conducting OC & SC tests?
7. Why the no-load power factor of a transformer is small?
8. Why the transformer rating is in KVA?
9. What is the effect of variation of voltage & frequency on Iron Losses?
10. How the Hysteresis & Eddy current losses are reduced?