AARUPADAI VEEDU
INSTITUTE OF TECHNOLOGY
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VINAYAKA MISSION'S
RESEARCH FOUNDATION
(Deemed to be University under section 3 of the UGC Act 1956)

DEPARTMENT OF
ELECTRICAL AND ELECTRONICS ENGINEERING

ELECTRICAL MACHINES – II LABORATORY LAB MANUAL

EEE – IV SEMESTER

REGULATION – 2017

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PREFACE

This Laboratory manual for Electrical Machines – II Lab has been revised and updated in order to meet the Curriculum changes, laboratory equipment upgrading and the latest circuit simulation.

Every effort has been made to correct all the known errors, but nobody is perfect, if you find any additional errors or anything else you think is an error, Please feel free to inform the HOD / EEE at eeedept@avit.ac.in.

The Authors thanked all the staff members from the department for their valuable Suggestions and contributions.

The Authors
Department of EEE

LIST OF EXPERIMENTS:

1. Regulation of 3 - phase alternator by EMF and MMF methods.
2. Regulation of 3 - phase alternator by ZPF and ASA methods.
3. Slip test on 3 - phase alternator.
4. Load characteristics of 3 - phase alternator by bus bar loading.
5. V and inverted V curve of synchronous motors.
6. Load test on 3 - phase induction motor
7. Load test on 1 - phase induction motor
8. No load and blocked rotor test on 3 - phase induction motor.
9. Equivalent circuit and pre – determination of performance characteristics of Single of Induction Motor
10. Separation of losses in three-phase induction motor.
11. Speed control of three phase induction motor
12. Study of Linear induction motor and Synchronous Induction motor.

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LABORATORY PRACTICE

SAFETY RULES

1. Safety is of paramount importance in the Electrical Engineering Laboratories.

2. Electricity NEVER EXECUSES careless persons. So, exercise enough care and attention in handling Electrical equipment and follow safety practices in the laboratory. (Electricity is a good servant but a bad master).

3. Avoid direct contact with any voltage source and power line voltages. (Otherwise, any such contact may subject you to electrical shock).

4. Wear rubber-soled shoes. (To insulate you from earth so that even if you accidentally contact a live point, current will not flow through your body to earth and hence you will be protected from electrical shock).

5. Wear laboratory-coat and avoid loose clothing. (Loose clothing may get caught on an equipment/instrument and this may lead to an accident particularly if the equipment happens to be a rotating machine).

6. Girl students should have their hair tucked under their coat or have it in a knot.

7. Do not wear any metallic rings, bangles, bracelets, wristwatches and neck chains. (When you move your hand/body, such conducting items may create a short circuit or may touch a live point and thereby subject you to electrical shock).

8. Be certain that your hands are dry and that you are not standing on wet floor. (Wet parts of the body reduce the contact resistance thereby increasing the severity of the shock)

9. Ensure that the power is OFF before you start connecting up the circuit (Otherwise you will be touching the live parts in the circuit).

10. Get your circuit diagram approved by the staff member and connect up the circuit strictly as per the approved circuit diagram.

11. Check power chords for any sign of damage and be certain that the chords use safety plugs and do not defeat the safety feature of these plugs by using ungrounded plugs.

12. When using connection leads, check for any insulation damage in the leads and avoid such defective leads.

13. Do not defeat any safety devices such as fuse or circuit breaker by shorting across it. Safety devices protect YOU and your equipment.

14. Switch on the power to your circuit and equipment only after getting them checked up and approved by the staff member.

15. Take the measurement with one hand in your pocket. (To avoid shock in case you accidentally touch two points at different potentials with your two hands).

16. Do not make any change in the connection without the approval of the staff member.

17. In case you notice any abnormal condition in your circuit (like insulation heating up, resistor heating up etc), switch off the power to your circuit immediately and inform the staff member.

18. Keep hot soldering iron in the holder when not in use.

19. After completing the experiment show your readings to the staff member and switch off the power to your circuit after getting approval from the staff member.

20. While performing load-tests in the Electrical Machines Laboratory using the brake-drums:

    i. Avoid the brake-drum from getting too hot by putting just enough water into the brake-drum at intervals; use the plastic bottle with a nozzle (available in the laboratory) to pour the water. (When the drum gets too hot, it will burn out the braking belts).

    ii. Do not stand in front of the brake-drum when the supply to the load-test circuit is switched off. (Otherwise, the hot water in the brake-drum will splash out on you).

    iii. After completing the load-test, suck out the water in the brake-drum using the plastic bottle with nozzle and then dry off the drum with a sponge which is available in the laboratory. (The water, if allowed to remain in the brake-drum, will corrode it).

21. Determine the correct rating of the fuse/s to be connected in the circuit after understanding correctly the type of the experiment to be performed: no-load test or full-load test, the maximum current expected in the circuit and accordingly use that fuse-rating. (While an over-rated fuse will damage the equipment and other instruments like ammeters and watt-meters in case of over load, an under-rated fuse may not allow one even to start the experiment).

22. At the time of starting a motor, the ammeter connected in the armature circuit overshoots, as the starting current is around 5 times the full load rating of the motor. Moving coil ammeters being very delicate may get damaged due to high starting current. A switch has been provided on such meters to disconnect the

moving coil of the meter during starting. This switch should be closed after the motor attains full speed. Moving iron ammeters and current coils of wattmeters are not so delicate and hence these can stand short time overload due to high starting current. No such switch is therefore provided on these meters. Moving iron meters are cheaper and more rugged compared to moving coil meters. Moving iron meters can be used for both AC and DC measurement. Moving coil instruments are however more sensitive and more accurate as compared to their moving iron counterparts and these can be used for DC measurements only. Good features of moving coil instruments are not of much consequence for you as other sources of errors in the experiments are many times more than those caused by these meters.

23. Some students have been found to damage meters by mishandling in the following ways:

    i. Keeping unnecessary material like books, lab records, unused meters etc. causing meters to fall down the table.

    ii. Putting pressure on the meter (specially glass) while making connections or while talking or listening somebody.

STUDENTS ARE STRICTLY WARNED THAT FULL COST OF THE METER WILL BE RECOVERED FROM THE INDIVIDUAL WHO HAS DAMAGED IT IN SUCH A MANNER.

I have read and understand these rules and procedures. I agree to abide by these rules and procedures at all times while using these facilities. I understand that failure to follow these rules and procedures will result in my immediate dismissal from the laboratory and additional disciplinary action may be taken.

GUIDELINES FOR LABORATORY NOTEBOOK

The laboratory notebook is a record of all work pertaining to the experiment. This record should be sufficiently complete so that you or anyone else of similar technical background can duplicate the experiment and data by simply following your laboratory notebook. Record everything directly into the notebook during the experiment. Do not use scratch paper for recording data. Do not trust your memory to fill in the details at a later time.

Organization in your notebook is important. Descriptive headings should be used to separate and identify the various parts of the experiment. Record data in chronological order. A neat, organized and complete record of an experiment is just as important as the experimental work.

1. HEADING

The experiment identification (number) should be at the top of each page. Your name and date should be at the top of the first page of each day's experimental work.

2. OBJECT

A brief but complete statement of what you intend to find out or verify in the experiment should be at the beginning of each experiment.

3. DIAGRAM

A circuit diagram should be drawn and labeled so that the actual experiment circuitry could be easily duplicated at any time in the future. Be especially careful to record all circuit changes made during the experiment.

4. EQUIPMENT LIST

List those items of equipment which have a direct effect on the accuracy of the data. It may be necessary later to locate specific items of equipment for rechecks if discrepancies develop in the results.

5. PROCEDURE

In general, lengthy explanations of procedures are unnecessary. Be brief. Short commentaries along side the corresponding data may be used. Keep in mind the fact that the experiment must be reproducible from the information given in your notebook.

6. DATA

Think carefully about what data is required and prepare suitable data tables. Record instrument readings directly. Do not use calculated results in place of direct data; however, calculated results may be recorded in the same table with the direct data. Data tables should be clearly identified and each data column labeled and headed by the proper units of measure.

7. CALCULATIONS

Not always necessary but equations and sample calculations are often given to illustrate the treatment of the experimental data in obtaining the results.

8. GRAPHS

Graphs are used to present large amounts of data in a concise visual form. Data to be presented in graphical form should be plotted in the laboratory so that any questionable data points can be checked while the experiment is still set up. The grid lines in the notebook can be used for most graphs. If special graph paper is required, affix the graph permanently into the notebook. Give all graphs a short descriptive title. Label and scale the axes. Use units of measure. Label each curve if more than one on a graph.

9. RESULTS

The results should be presented in a form which makes the interpretation easy. Large amounts of numerical results are generally presented in graphical form. Tables are generally used for small amounts of results. Theoretical and experimental results should be on the same graph or arrange in the same table in a way for easy correlation of these results.

10. CONCLUSION

This is your interpretation of the results of the experiment as an engineer. Be brief and specific. Give reasons for important discrepancies.

TROUBLE SHOOTING HINTS

1. Be Sure that the power is turned ON.

2. Be sure the ground connections are common.

3. Be sure the circuit you build is identical to your circuit diagram (Do a node by node check).

4. Be sure that the supply voltages are correct.

5. Be sure that the equipment is set up correctly and you are measuring the correct parameters.

6. If steps I through 5 are correct then you probably have used a component with the wrong value or one that doesn’t work. It is also possible that the equipment does not work (although this is not probable) or the protoboard you are using may have some unwanted paths between nodes. To find your problem you must trace through the voltages in your circuit node by node and compare the signal you expect to have. Then if they are different use your engineering judgment to decide what is causing the different or ask your lab assistant.

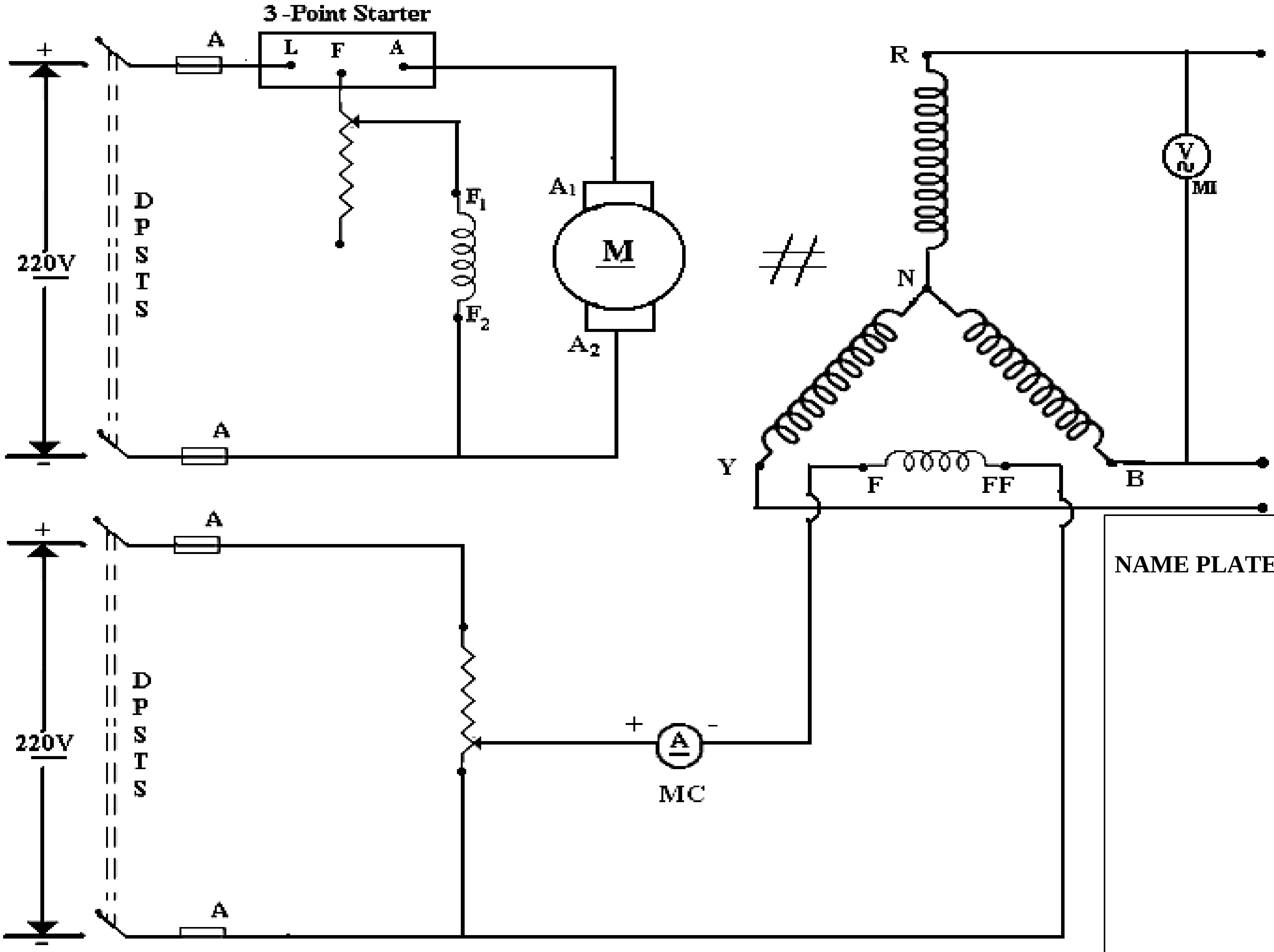
IMPORTANT INSTRUCTIONS TO THE CANDIDATE WHILE ENTERING THE LABORATORY DURING LAB HOURS

- ✓ Wear your lab coat and leather shoe while entering the laboratory
- ✓ Do not touch the apparatus or connection wires when the supply is switched ON.
- ✓ Do not wear long chain, hand rings, bracelets, wrist watches, bangles (gold or gold coated), at the time of lab hours.
- ✓ Girls should plait their hair and should be inserted inside your lab coat during lab hours.
- ✓ Use proper meters and proper fuse rating for that experiment
- ✓ Candidate should come with their own stationeries like pen, pencil, eraser, pro-circle, scale, calculator etc.
- ✓ Do not draw the circuit diagrams, model graphs etc in free hand.
- ✓ Roaming outside the lab during lab hours is totally prohibited. If found severe action will be taken by lab- in charge / HOD/Principal.
- ✓ The number of students per batch to do the experiment in maximum three.
- ✓ Boys students should not wear full sleeve shirts when the come to the lab during lab hours.
- ✓ For load test measure circumference of the brake drum and thickness of the belt before starting the machine.
- ✓ Before entering the laboratory, read the Viva- voce questions and answers given in this manual.

EXPERIMENT – 1

REGULATION OF
3 – PHASE
ALTERNATOR BY
EMF AND MMF METHODS

OPEN CIRCUIT TEST (EMF METHOD)



FUSE RATING

NAME PLATE DETAILS

EXP. NO.: 1 **DATE:**

REGULATION OF THREE PHASE ALTERNATOR BY EMF AND MMF METHODS

a) EMF METHOD:

AIM:

To predetermine the voltage regulation of the three phase alternator at full load at different power factors by EMF method and to draw the regulation curve.

APPARATUS REQUIRED:

SI. NO.	Apparatus	Range	Type	Qty

THEORY:

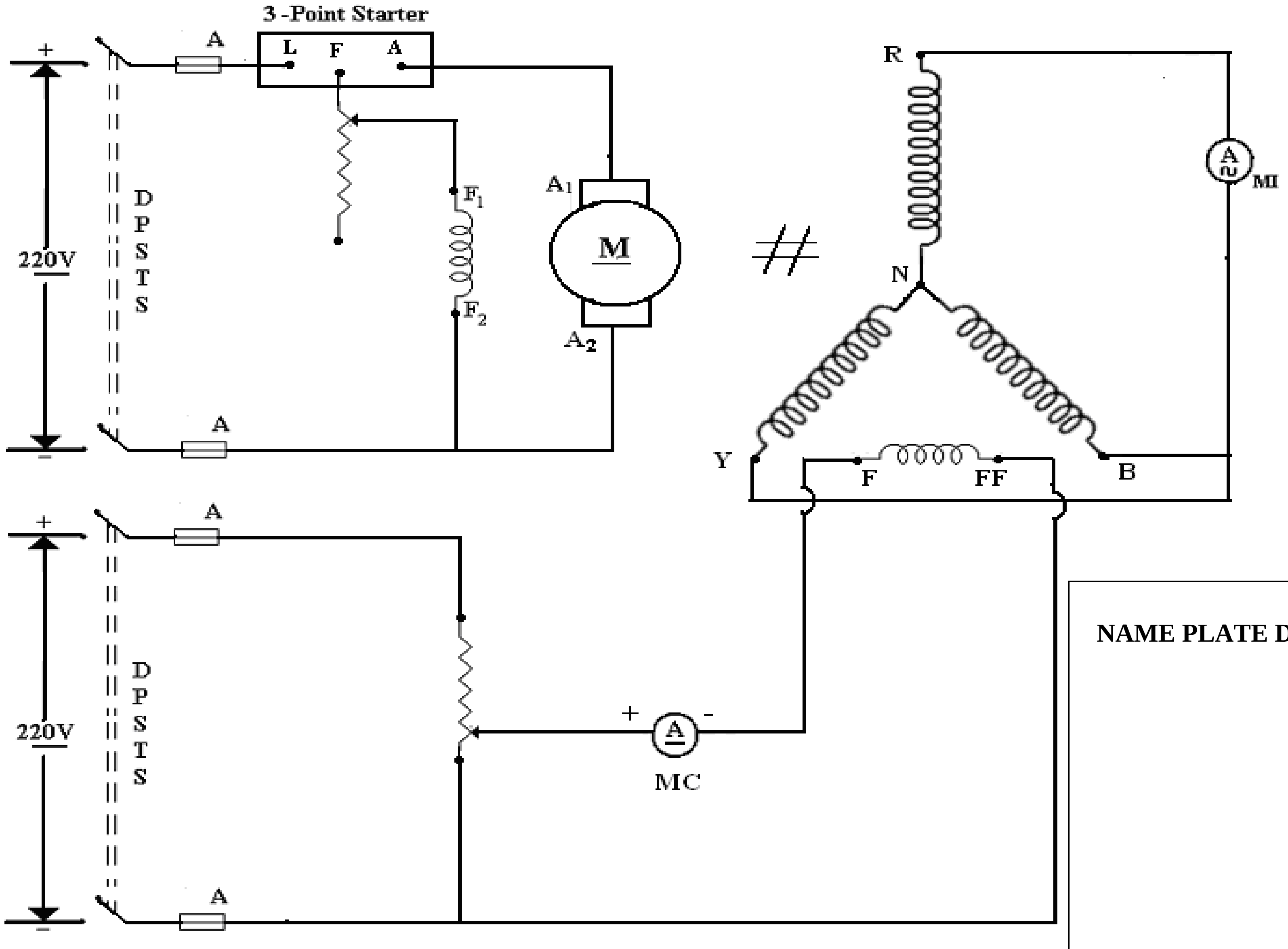
The method is also called Synchronous Impedance Method of determining the regulation. The method requires following data to calculate the regulation.

1. The armature resistance per phase (Ra)
2. Open circuit characteristic which is the graph of open circuit voltage against the field current. This is possible by conducting open circuit test on the alternator.
3. Short circuit characteristic which is the graph of short circuit current against field current. This is possible by conducting short circuit test on the alternator.

The circuit diagram to perform open circuit as well as short circuit test on the alternator. The alternator is coupled to a prime mover capable of driving the alternator at its synchronous speed. The armature is connected to the terminals of a switch. The other terminals of the switch are short circuited through an ammeter. The voltmeter is connected across the lines to measure the open circuit voltage of the alternator.

The field winding is connected to a suitable DC supply with rheostat connected in series. The filed excitation i.e. field current can be varied with the help of this rheostat.

SHORT CIRCUIT TEST (EMF METHOD)



NAME PLATE DETAILS

FUSE RATING

ADVANTAGES AND LIMITATIONS OF SYNCHRONOUS IMPEDANCE METHOD:

The main advantage of this method is the value of synchronous impedance for any load condition can be calculated. Hence regulation of the alternator at any load condition alternator and hence method can be used for very high capacity alternators.

The main limitation of this method is that the method gives large values of synchronous reactance. This leads to high values of percentage regulation than the actual results. Hence this method is called pessimistic method.

PRECAUTIONS:

- The prime mover (DC Motor) field rheostat should be kept at the minimum resistance position while starting.
- An Alternator filed potential divider (1200 Ω / 0.8 A) should be in the minimum voltage position
- Ensure that initially all the switches like DPSTS are in open condition.
- Ensure that there is no loose connections before starting the experiment.
- Check for proper fuse ratings, meter ratings.

TABULAR COLUMN

OPEN CIRCUIT TEST

S.No.	Field current (I_f)	Open Circuit Line Voltage (V_{OL})	Open circuit Phase Voltage (V_{0Ph})
	(A)	(V)	(V)

SHORT CIRCUIT TEST

S.No.	Field current (I_f)	Short Circuit current (I_{SC})
	(A)	(A)

REGULATION TABULATION

Load	I_L	% Regulation		
	(A)	0.8 pf (lag)	0.8 pf (lead)	UPF
1				
¾				
½				
¼				

PROCEDURE:

- Connections are given as per the circuit diagram
- The supply is given by closing the DPST switch.
- Initially the prime- mover (Motor) rheostat is kept in minimum resistance position.
- The prime- mover (Motor) is started to run at rated speed by varying the motor field rheostat.
- The open-circuit test is conducted by varying the potential divider for various values of field current and all the meter readings are noted down.
- By closing the TPST switch the short-circuit test is conducted with the rated armature current which has been set by adjusting the potential divider and corresponding field current is noted down.
- By giving connection as per the circuit diagram for stator resistance test , the stator winding is loaded gradually and all the meter readings are noted down for different values of load.

MODEL CALCULATION

FORMULAE USED:

1) Armature Resistance, $R_a = 1.6 (R_{dc})$

Where, R_{dc} = Resistance in D.C Supply.

2) Synchronous Impedance, Z_S = (Open – Circuit Voltage / Short – Circuit Current) Ω

= (AC / AB) Ω { From graph}.

3) Synchronous Reactance, $X_s = \sqrt{(Z_S^2 - R_a^2)}$

4) Open- Circuit Voltage per Phase,

a) $E_{o/ph} = \sqrt{\{ (V_{ph} * \cos\Phi + I_a R_a)^2 + (V_{ph} * \sin\Phi + I_a X_s)^2 \}}$ ---{ for pf lag}

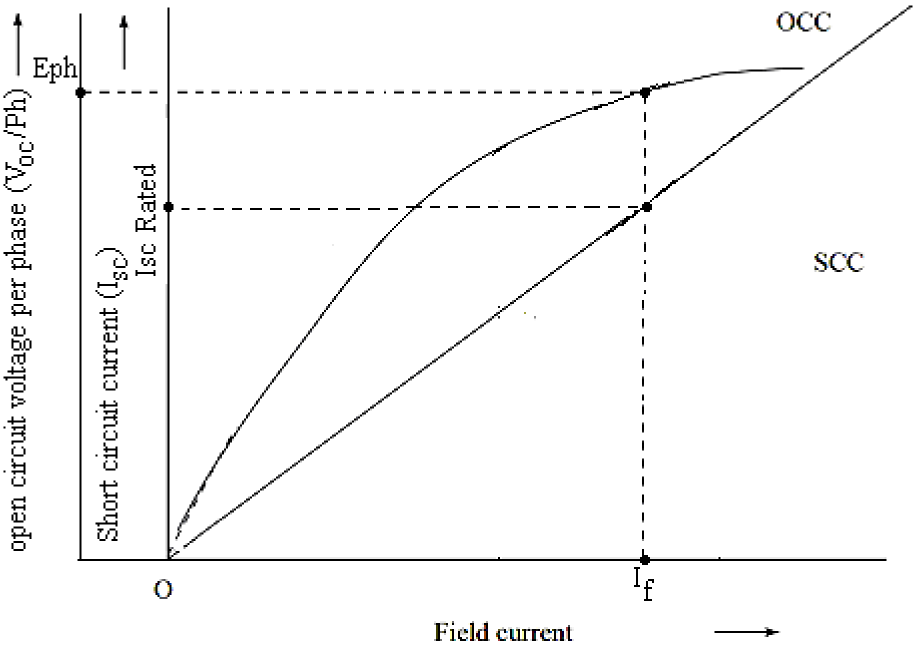
b) $E_{o/ph} = \sqrt{\{ (V_{ph} * \cos\Phi + I_a R_a)^2 + (V_{ph} * \sin\Phi - I_a X_s)^2 \}}$ --- { for pf lead}

c) $E_{o/ph} = \sqrt{\{ (V_{ph} + I_a R_a)^2 + (I_a X_s)^2 \}}$ --- {for upf }

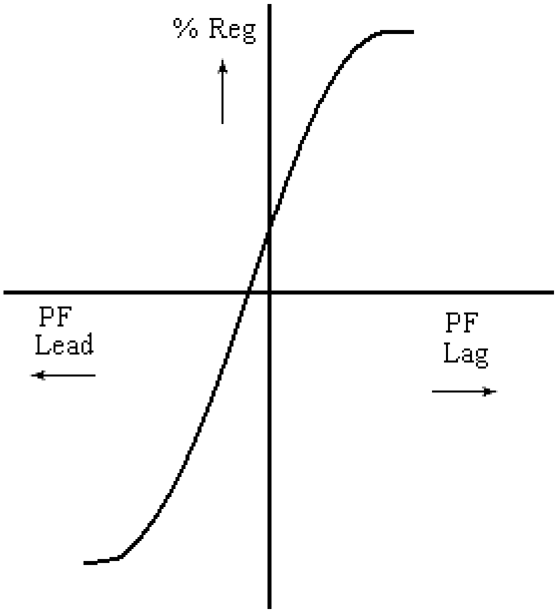
5) Percentage regulation = $\{ (E_{o/ph} - V_{ph}) / V_{ph}\} * 100$

MODEL GRAPH

OPEN CIRCUIT & SHORT CIRCUIT GRAPH



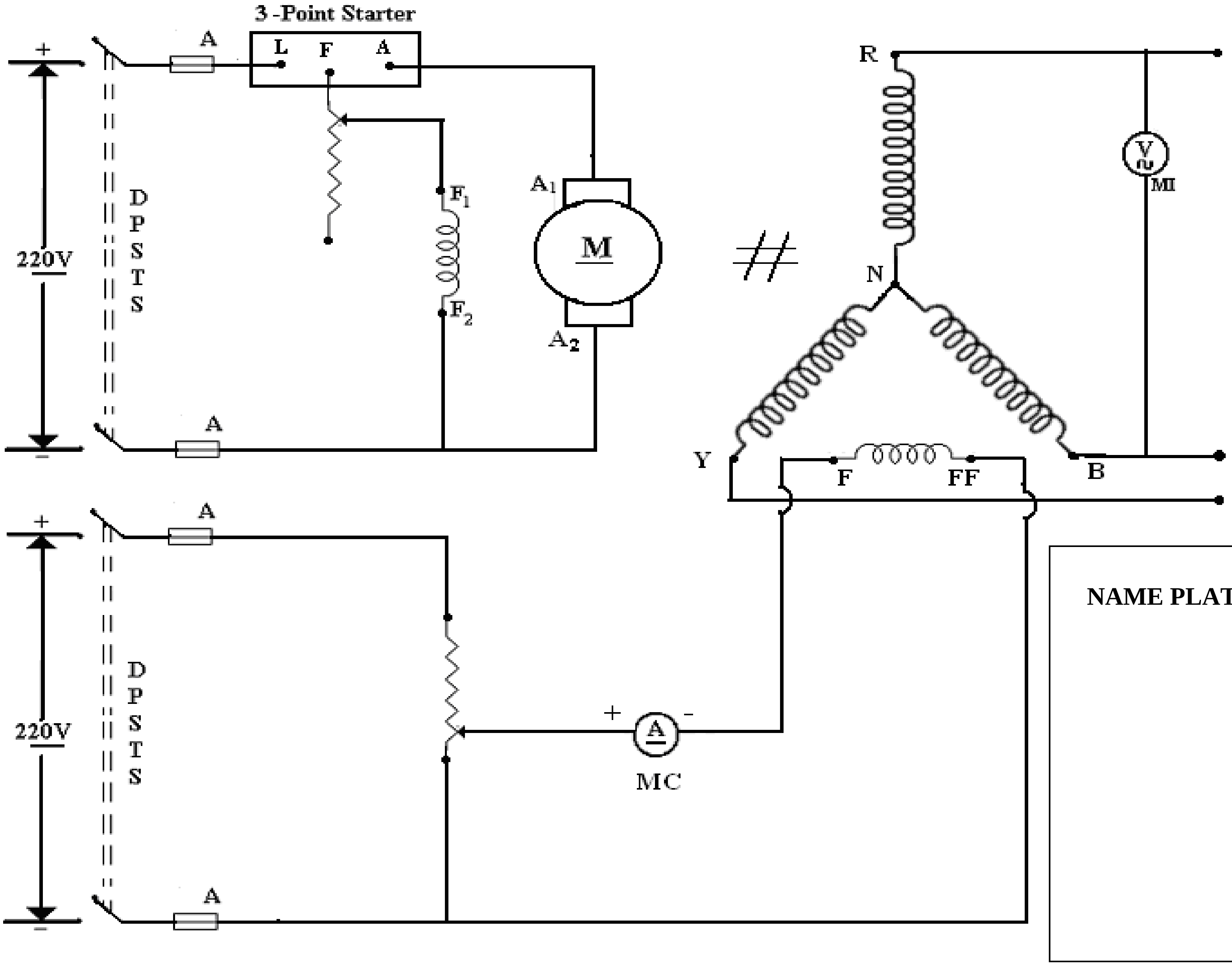
REGULATION GRAPH



RESULT:

Thus, the regulation of three-phase alternator has been predetermined by EMF method.

OPEN CIRCUIT TEST (MMF METHOD)



NAME PLATE DETAILS

FUSE RATING

b) MMF METHOD:

AIM:

To predetermine the voltage regulation of the three phase alternator at full load at different power factors by MMF method and to draw the regulation curve.

APPARATUS REQUIRED:

SI. NO.	Apparatus	Range	Type	Qty

THEORY:

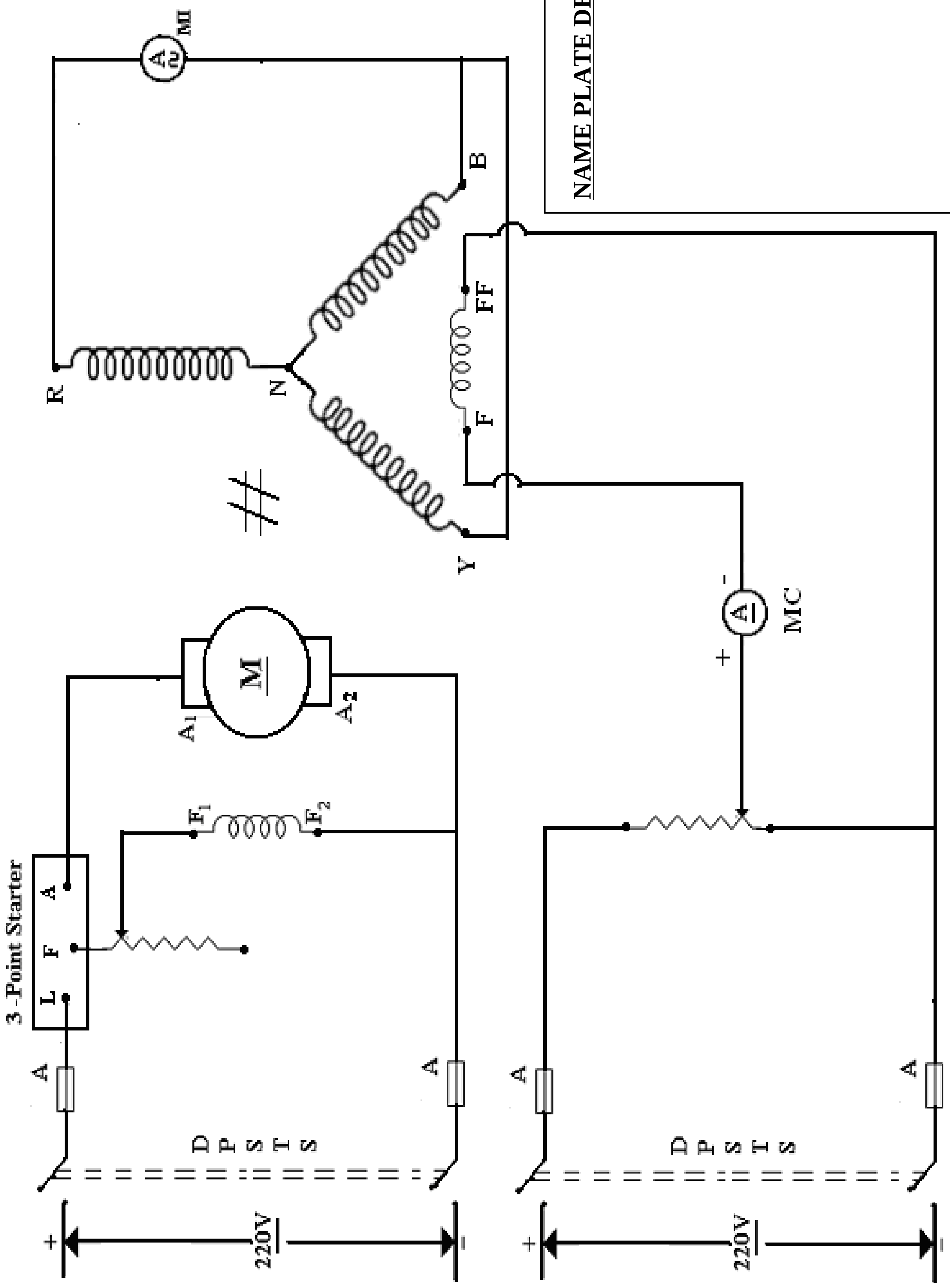
This method of determining the regulation of an alternator is also called Ampere turn method or Rothert's MMF method. The method is based on the results of open circuit test and short circuit test on an alternator.

For any synchronous generator i.e. alternator, it requires MMF which is product of field current and turns of field winding for two separate purposes.

1. It must have an MMF necessary to induce the rated terminal voltage on open circuit.
2. It must have an MMF equal and opposite to that of armature reaction MMF.

In most of the cases as number of turns on the field winding is not known, the MMF is calculated and expressed in term of the field current itself. The field MMF required to induce the rated terminal voltage on open circuit can be obtained from open circuit test results and open circuit characteristics. We known that the synchronous impedance has two components, armature resistance and synchronous reactance. Now synchronous reactance also has two components, armature leakage reactance and armature reaction reactance.

SHORT CIRCUIT TEST (MMF METHOD)



NAME PLATE DETAILS

FUSE RATING

In short circuit test, field MMF is necessary to overcome drop across armature resistance and leakage reactance and also to overcome effect of armature reaction. But drop across armature resistance and leakage reactance is very small and can be neglected. Thus in short circuit test, field MMF circulates the full load current balancing the armature reaction effect. The value of ampere turns required to circulate full load current can be obtained from short circuit characteristics. Under short circuit condition as resistance and leakage reactance of armature do not play any significant role, the armature reaction reactance is dominating and hence the power factor of such purely reactive circuit is zero lagging.

PRECAUTIONS:

- The prime mover (DC Motor) field rheostat should be kept at the minimum resistance position while starting.
- An Alternator filed potential divider (1200 Ω / 0.8 A) should be in the minimum voltage position
- Ensure that initially all the switches like DPSTS are in open condition.
- Ensure that there is no loose connections before starting the experiment.
- Check for proper fuse ratings, meter ratings.

TABULAR COLUMN

OPEN CIRCUIT TEST

S.No.	Field current (I_f)	Open Circuit Line Voltage (V_{OL})	Open circuit Phase Voltage (V_{0Ph})
	(A)	(V)	(V)

SHORT CIRCUIT TEST

S.No.	Field current (I_f)	Short Circuit current (I_{SC})
	(A)	(A)

REGULATION TABULATION

Power Factor	I_L	% Regulation	
	(A)	0.8 pf (lag)	0.8 pf (lead)
0.8			
0.6			
0.4			
0.2			

PROCEDURE:

- Connections are given as per the circuit diagram
- The supply is given by closing DPST switch.
- The prime-mover (Motor) is started to run at its rated speed by varying motor field rheostat.
- The open-circuit test is conducted by varying the potential divider for various values of field current and all meter readings are noted.
- By closing TPST switch the SC test is conducted with the rated armature current which has been set by adjusting potential divider and field current is noted.
- Open TPST switch, bring the prime-mover (Motor) rheostat to original position, open DPST switch and switch off the power supply.
- Tabulate the readings.
- Draw the graphs as shown in model graphs.

MODEL CALCULATION:

FORMULAE USED:

1) Armature Resistance $R_{ac} = 1.6\ R_{dc}$

2) $E_1 = V_{ph} + I_a R_a \cos \Phi$

3) $I_{fo} = \sqrt{} I_{f1}^2 + I_{f2}^2 + 2 I_{f1} I_{f2} \cos \{180 - (90 \pm \Phi)\}$

Where, $I_{f1} =$ field current corresponding to $E_{1.}$ (see from graph)

$I_{f2} =$ field current corresponding to $I_{sc.}$ (see from graph)

Note: (90+ Φ) represents for pf lag.

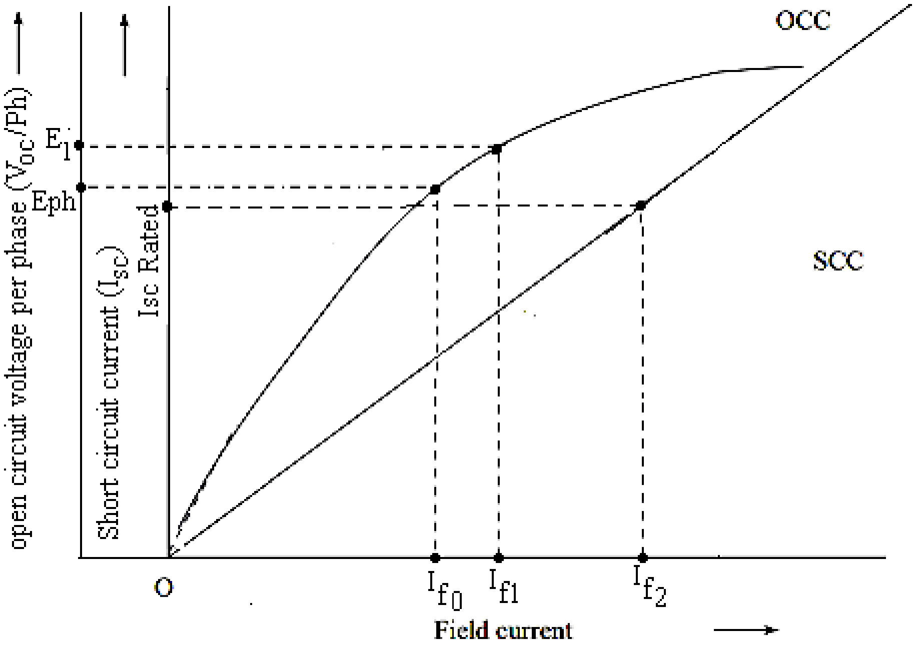
4) Percentage regulation $= \{(E_{o/ph} - V_{ph}) / V_{ph}\} * 100$

Where,

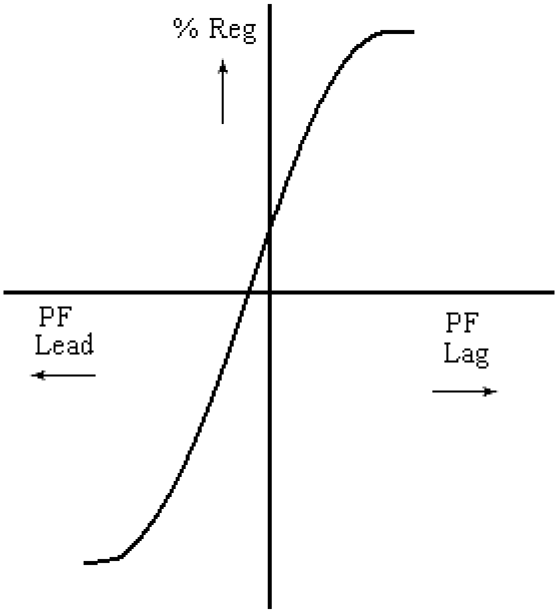
$E_{o/ph}$ is the value of $V_{oc/ph}$ from occ corresponding to field current I_{fo} .

MODEL GRAPH

OPEN CIRCUIT & SHORT CIRCUIT GRAPH



REGULATION GRAPH



RESULT:

Thus, the regulation of three-phase alternator has been predetermined by MMF method.

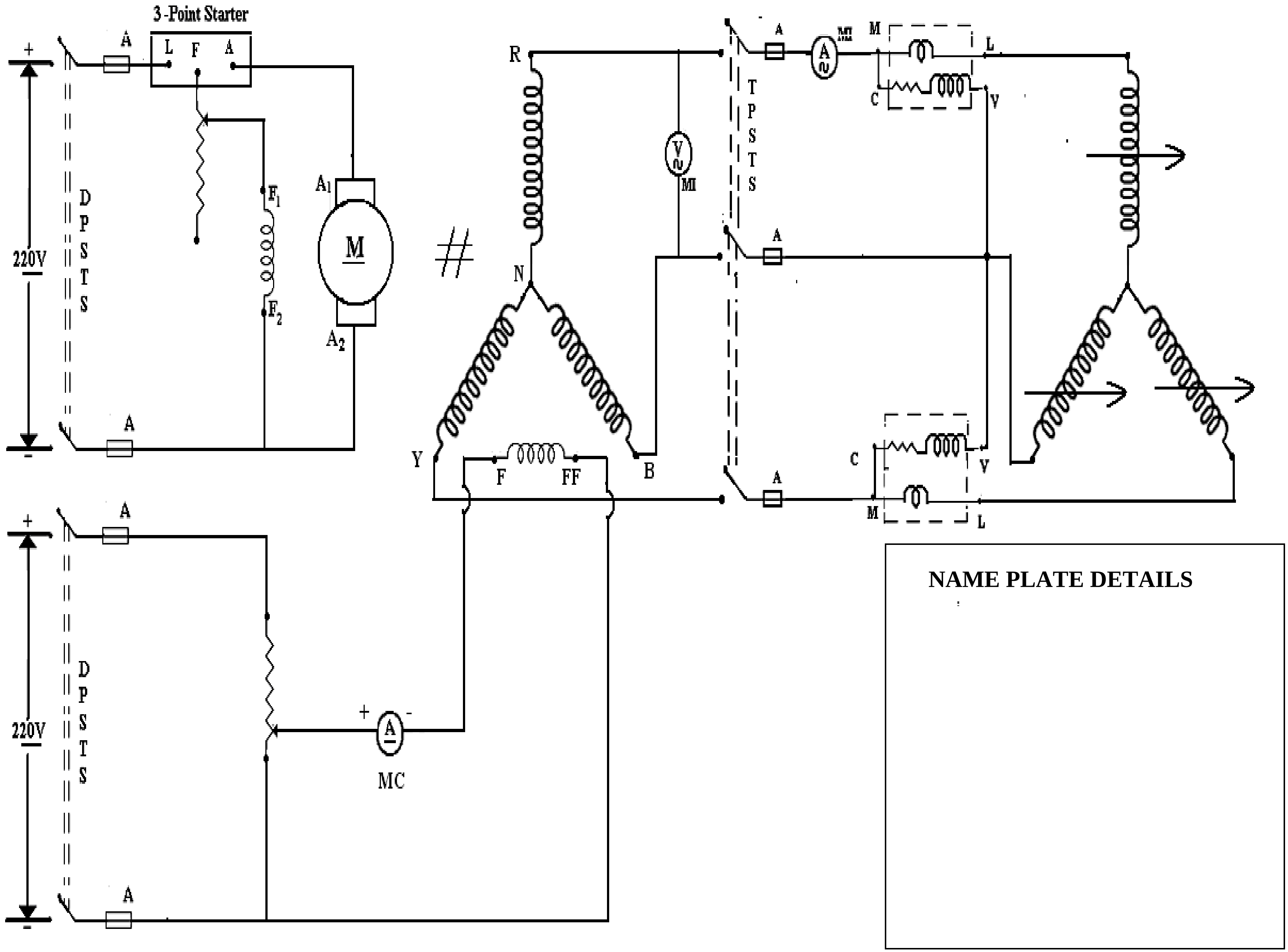
VIVA QUESTION:

1. What is meant by voltage regulation?
2. What is meant by Synchronous Impedance?
3. What is OC test ?
4. What is SC test?
5. What is meant by mmf or field ampere turns?
6. What do you mean by single layer and double layer winding?
7. What is meant by pitch factor of an armature winding?
8. What is meant by full pitched winding?
9. Define distribution factor.
10. Name the two types of alternators depending on the rotor construction.
11. Explain the meaning of synchronous reactance.
12. Explain why the value of regulation calculated by synchronous impedance method is more than the actual value.
13. State the type of synchronous generator used in a hydroelectric power station.

EXPERIMENT – 2

REGULATION OF
3 – PHASE
ALTERNATOR BY
ZPF AND ASA METHODS

OPEN CIRCUIT TEST (ZPF & ASA METHOD)



NAME PLATE DETAILS

FUSE RATING

EXP. NO.: 2 **DATE:**

REGULATION OF THREE PHASE ALTERNATOR BY ZPF AND ASA METHODS.

a) ZPF METHOD

AIM:

To predetermine the voltage regulation of three phase alternator at full load at different power factor by ZPF method and to draw the regulation curve.

APPARATUS REQUIRED:

SI. NO.	Apparatus	Range	Type	Qty

THEORY:

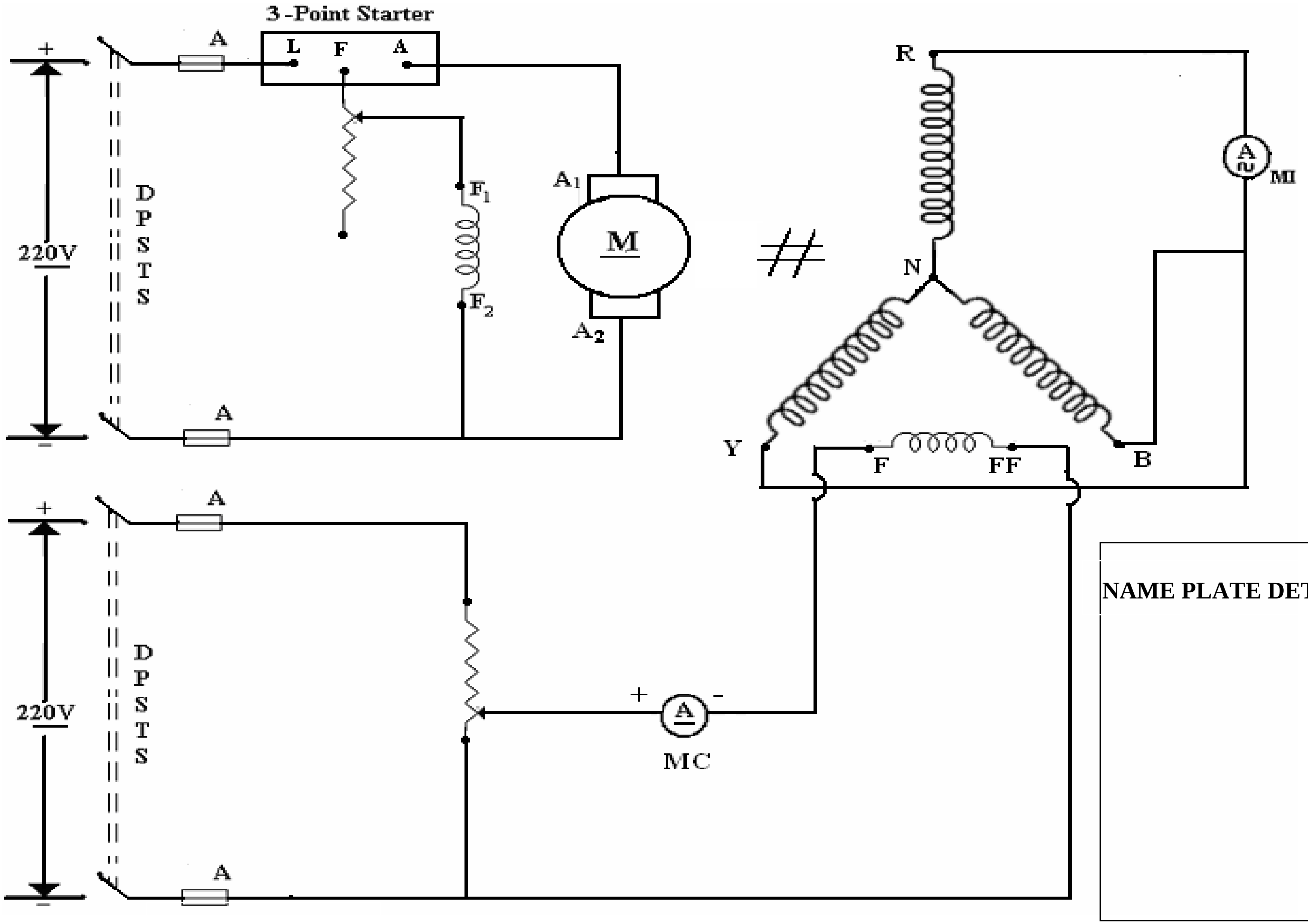
This method is also called Potier Method. In the operation of any alternator, the armature resistance drop Ira and armature leakage reactance drop IX_L are actually EMF quantities while the armature reaction is basically MMF quantity. In this synchronous impedance all the quantities are treated as EMF quantities as against this in MMF method all are treated as MMF quantities. Hence in both the methods, we are away from reality.

This method is based on the separation of armature leakage reactance and armature reaction effects. The armature leakage reactance X_L is called Potier reactance in this method; hence method is also called Potier reactance method.

To determine armature leakage reactance and armature reactance MMF separately, two tests are performed on the given alternator. The two tests are,

1. Open circuit test.
2. Zero power factor test.

SHORT CIRCUIT TEST (ZPF & ASA METHOD)



FUSE RATING

NAME PLATE DETAILS

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 (IX_L), 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 IX_L 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) from the OCC curve.
12. Find out the regulation from the suitable formula.

TABULAR COLUMN

OPEN CIRCUIT TEST

S.No.	Field current (I_f)	Open Circuit Line Voltage (V_{OL})	Open circuit Phase Voltage (V_{0Ph})
	(A)	(V)	(V)

SHORT CIRCUIT TEST

S.No.	Field current (I_f)	Short Circuit current (I_{SC})
	(A)	(A)

ZERO POWER FACTOR TEST

Rated Line Voltage (V_L)	Rated Line Current (I_L)	Wattmeter Readings		Field current (I_f)
(V)	(A)	W_1	W_2	(A)
		(W)	(W)	

REGULATION TABULATION

Power Factor	I_L	% Regulation	
	(A)	0.8 pf (lag)	0.8 pf (lead)
0.8			
0.6			
0.4			
0.2			

PRECAUTIONS:

- The prime mover (DC Motor) field rheostat should be kept at the minimum resistance position while starting.
- An Alternator filed potential divider (1200 Ω / 0.8 A) should be in the minimum voltage position
- Ensure that initially all the switches like DPSTS are in open condition.
- Ensure that there are no loose connections before starting the experiment.
- Check for proper fuse ratings, meter ratings.

PROCEDURE FOR BOTH POTIER AND ASA METHODS:

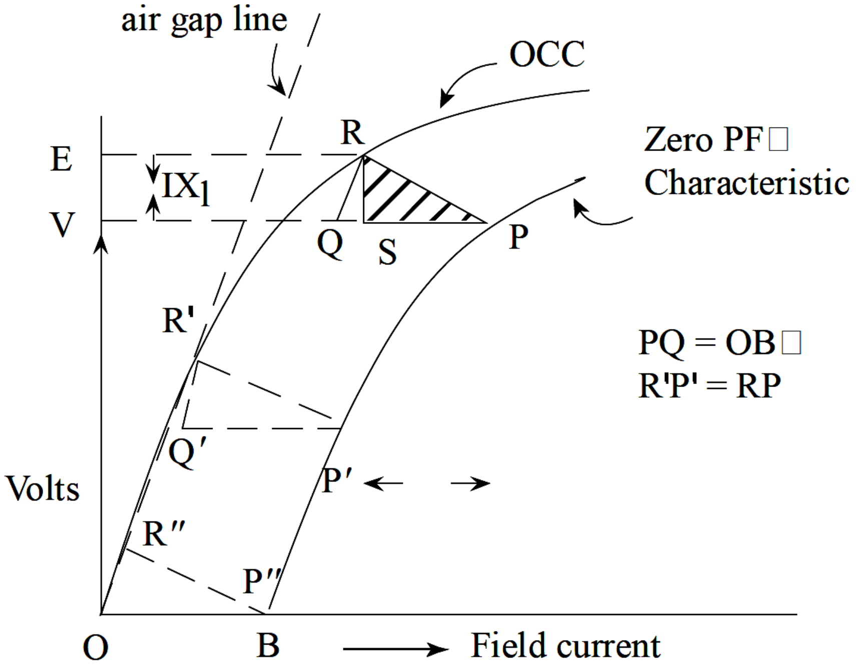
1. Note down the complete nameplate details of motor and alternator.
2. Connections are made as per the circuit diagram.
3. Switch on the supply by closing the DPST main switch.
4. Using the Three point starter, start the motor to run at the synchronous speed by varying the motor field rheostat.
5. Conduct 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.

MODEL CALCULATION

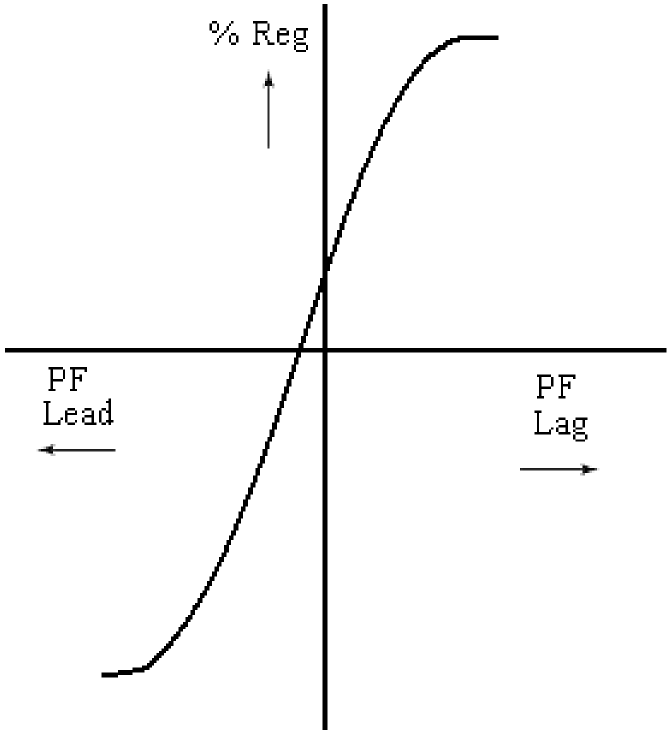
FORMULAE USED:

- Armature Resistance $R_{ac} = 1.6\ R_{dc}$
- From Potier Triangle $I_a X_l = I_a X_s = RS$
- From Potier Triangle field current $I_{f\,2} = SP$
- $E_{1/ph} = \sqrt{\{ (V_{ph} * \cos\Phi + I_a R_a)^2 + (V_{ph} * \sin\Phi + I_a X_l)^2 \}}$ ---{ for pf lag}
- $E_{1/ph} = \sqrt{\{ (V_{ph} * \cos\Phi + I_a R_a)^2 + (V_{ph} * \sin\Phi - I_a X_l)^2 \}}$ ---{ for pf lead}
- From graph find $I_{f\,1}$, $I_{f\,2}$, $I_{f\,o}$ and $E_{o/ph}$ for pf lag and pf lead.
- Percentage regulation $= \{ (E_{o/ph} - V_{ph}) / V_{ph}\} * 100$

MODEL GRAPH

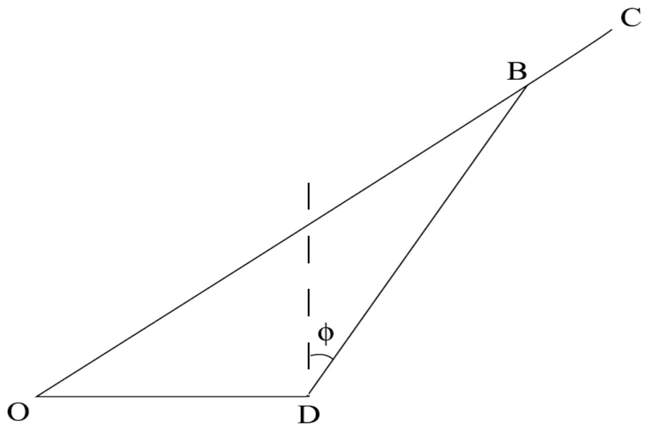


REGULATION GRAPH



RESULT:

Thus, the regulation of three – phase alternator has been predetermined by ZPF method.


C
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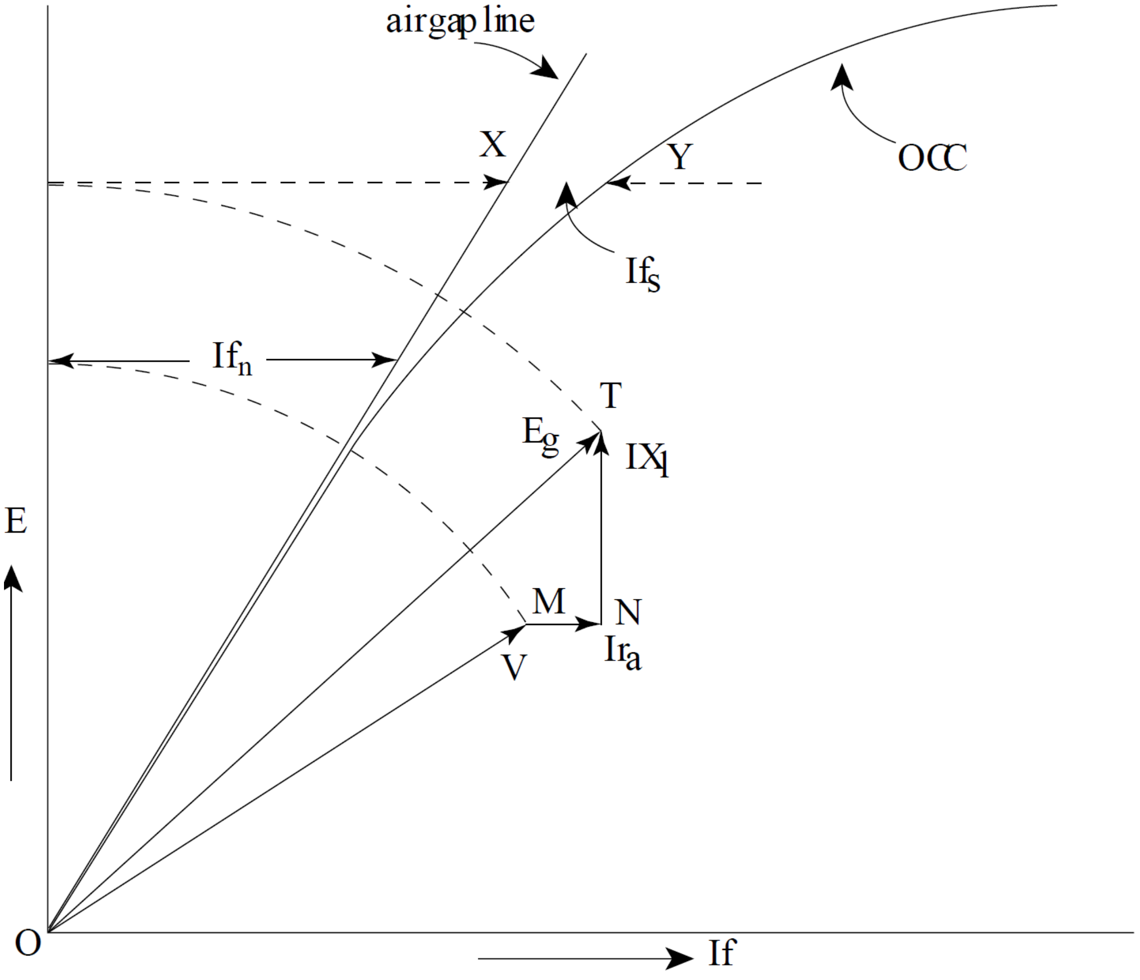

airgap line
X
Y
OCC
If_s
If_n
T
E_g
IX_l
E
M
N
Ir_a
V
O
If

b) ASA METHOD

AIM:

To predetermine the voltage regulation of three phase alternator at full load at different power factor by ASA method and to draw the regulation curve.

APPARATUS REQUIRED:

SI. NO.	Apparatus	Range	Type	Qty

THEORY:

We have seen that neither of the two methods, MMF and EMF method is capable of giving the reliable values of the voltage regulation. The error in the results of these methods is mainly due to the two reasons,

1. In these methods, the magnetic circuit is assumed to be unsaturated. This assumption is unrealistic as in practice. It is not possible to have completely unsaturated magnetic circuit.
2. In salient pole alternators, it is not correct to combine field ampere turns and armature ampere turns. This is because the field winding is always concentrated on a pole core while the armature winding is always distributed. Similarly the field and armature MMF act on magnetic circuits having different reluctances in case of salient pole machine hence phasor combination of field and armature MMF is not fully justified

In spite of these short comings, due to the simplicity of constructions the ASA modified form of MMF method is very commonly used for the calculation of voltage regulation.

ASA method is a modification of the MMF and Potier methods. The field current Ifn (= OD) corresponds to rated voltage V is found out by referring to the air gap line. To that DB (= field current required to circulate the load current under short circuit conditions obtained from the short circuit characteristic) is added at an angle of (90 + φ) to get the resultant field current OB. OB is now increased by a small amount BC which takes into account its saturation (BC is needed to force the flux through the iron of the circuit). BC is found as follows.

REGULATION TABULATION

Cos φ	Sin φ	% Regulation	
		Lag	Lead
0.8			
0.6			
0.4			
0.2			

MODEL CALCULATION

The rated voltage vector V is drawn at an angle φ with the horizontal axis. To this armature resistance drop Ira and Potier reactance drop IX_l are added vectorially as shown to get the voltage Eg. Project OM and OT by arcs to the vertical axis. Then project these intercepts horizontally to the open circuit characteristic (OCC) as shown. By referring to OCC and air gap line the difference in field currents XY is found out corresponding to the voltage Eg. BC = XY (= Ifs) OC is the total field current and no load voltage (E0) corresponding to OC is found out.

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 (IX_L)
   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.

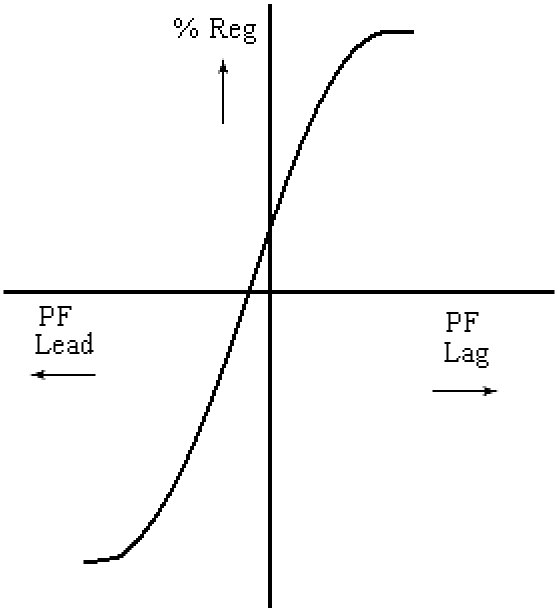
PROCEDURE TO DRAW THE VECTOR DIAGRAM (ASA METHOD)

(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.

MODEL GRAPH

REGULATION GRAPH



PRECAUTIONS:

- The prime mover (DC Motor) field rheostat should be kept at the minimum resistance position while starting.
- An Alternator filed potential divider (1200 Ω / 0.8 A) should be in the minimum voltage position
- Ensure that initially all the switches like DPSTS are in open condition.
- Ensure that there is no loose connection before starting the experiment.
- Check for proper fuse ratings, meter ratings.

PROCEDURE:

- Connections are given as per the ZPF circuit diagram
- Initially the OCC and SCC tests and R_a are found as explained in EMF or MMF method.
- DPST 1 is closed.
- The Prime- Mover is started using DC 3-Point Starter.
- The Prime-Mover field rheostat is kept in minimum position at the time of starting.
- The Prime –Mover rheostat is adjusted to get the rated speed of an alternator.
- DPST 2 is closed and supply is given to an alternator field circuit.
- Load switch is closed.
- Three-Phase inductive load is applied and adjusted till alternator value is equal to its rated value. Note I_f and V_L .
- Bring the rheostats position of prime –mover and alternator to original position.
- Switch Off the Supply.

RESULT:

Thus, the regulation of three-phase alternator has been predetermined by ASA method

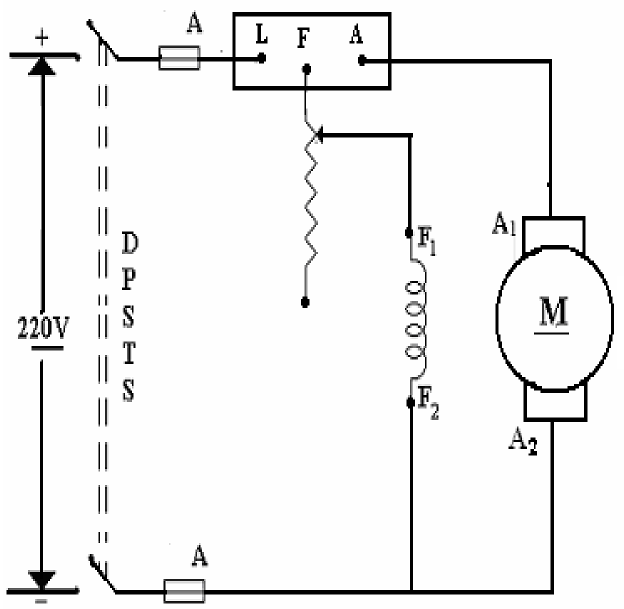
VIVA QUESTION:

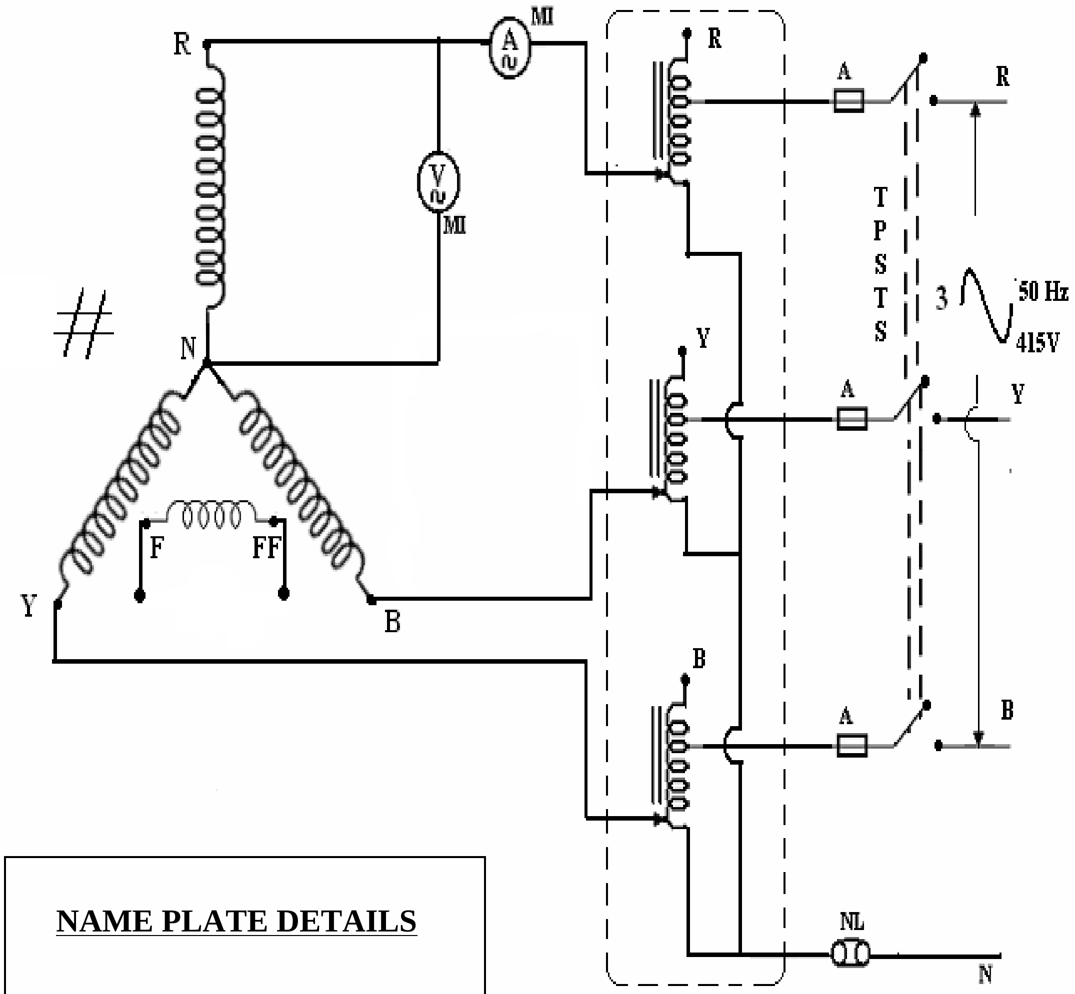
1. What are the various functions of damper winding provided with alternator?
2. Explain why distributed windings are preferred over concentrated windings in making armature windings of synchronous machines.
3. Explain why synchronous machines are designed to have a high ratio of armature reactance to resistance.
4. Explain why the Potier reactance is slightly higher than leakage reactance.
5. Explain the effect of armature flux on the main field flux of a synchronous generator at (i) unity power factor load, (ii) z.p.f lagging load and (iii) z.p.f leading load.
6. What is meant by ZPF Test?
7. What is Potier reactance? How is it determined by Potier triangle?
8. What is meant by armature reaction reactance?
9. What is the significance of the ASA modification of MMF method?
10. What is air gap line in Potier method?

EXPERIMENT – 3

SLIP TEST
ON
3 – PHASE ALTERNATOR

SLIP TEST





FUSE RATING

NAME PLATE DETAILS

EXP. NO.: 3 **DATE:**

REGULATION OF THREE PHASE SALIENT POLE ALTERNATOR BY SLIP TEST.

AIM:

To determine the percentage regulation of the given salient pole alternator by conduction slip test.

APPARATUS REQUIRED:

SI. NO.	Apparatus	Range	Type	Qty

THEORY:

In an alternator we apply excitation to the field winding and voltage gets induced in the armature. But in the slip test, a three phase supply is applied to the armature, having voltage must less than the rated voltage while the field winding circuit is kept open. The alternator is run at a speed close to synchronous but little less than synchronous value.

The three phase currents drawn by the armature from a three phase supply produce a rotating flux. Thus the armature MMF wave is rotating at synchronous speed. Note that the armature is stationary, but the flux and hence MMF wave produced by three phase armature currents is rotating. This is similar to the rotating magnetic field existing in an induction motor.

The rotor is made to rotate at a speed little less than the synchronous speed. Thus armature MMF having synchronous speed, moves slowly past the field poles at a slip speed (n_+ - n) where n is actual speed of rotor. This causes an EMF to be induced in the field circuit.

When the stator MMF is aligned with the d-axis of field poles hen flux ϕ_d per pole is set up and the effective reactance offered by the alternator is X_d. when the stator MMF is aligned with the q-axis of field poles then flux ϕ_q per pole is set up and the effective reactance offered by the alternator is X_q.

TABULATION

Determination of Synchronous Reactnace (X_S)

Speed (N)	Armature Voltage (V_a)		Armature Current (I_a)		Direct Axis Reactance (X_d)	Quadrature Axis reactance (X_q)
	Maximum	Minimum	Maximum	Minimum		
(rpm)	(V)	(V)	(A)	(A)	(Ω)	(Ω)

Determination of Percentage Regulation

Cos φ	δ		No Load Voltage ($E_{0/Ph}$)		% Regulation	
	Lag	Lead	Lag	Lead	Lag	Lead
	degree	degree	(V)	(V)		
0.8						
0.6						
0.4						
0.2						

As the air gap is nonuniform, the reactance offered also varies and hence current drawn by the armature also varies cyclically at twice the slip frequency. The RMS current is minimum when machine reactance is Xd and it is maximum when machine reactance is Xq. As the reactance offered varies due to nonuniform air gap, the voltage drops also varies cyclically. Hence the impedance of the alternator also varies when current and various drops are minimum while voltage at terminals is minimum when current and various drops are maximum.

PRECAUCTIONS:

- At the time of starting the position of three phase variac and field rheostat should be minimum.
- Alternator field should be connected across voltmeter.
- Check proper fuse ratings.
- Ensure there is no loose connection.
- Do not touch the meters and connecting wires when it is connected to supply.

PROCEDURE:

- Connections are given as per the circuit diagram.
- The Prime – Mover field rheostat is connected and kept in minimum resistance position at the time of starting.
- DPST switch is closed and the prime – mover is started using DC 3-point starter and made to run at rated speed of an alternator.
- TPST switch is closed and the variac is adjusted to 20-30% o rated voltage.
- The prime-mover field rheostat is adjusted for different speed slightly above and below the rated speed of an alternator and the readings of an ammeter is noted.

MODEL CALCULATION

FORMULA USED:

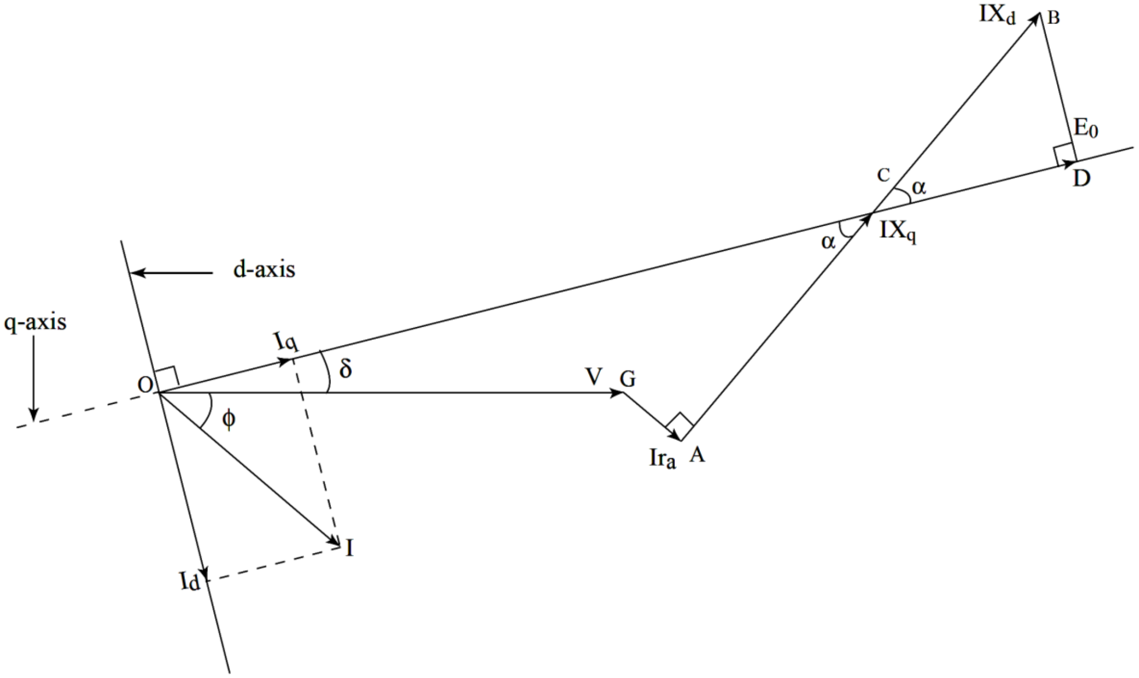
- Direct axis reactance $X_d = V_{max} / I_{min.}$
- Quadrature axis reactance $X_q = V_{min} / I_{max}$
- $\tan \delta = (V_{ph} \cos \Phi + I_a R_a) / (V_{ph} \sin \Phi \pm I_a X_q)$ [Assume $R_a = 3\ \Omega$]
- $E_{o/ph} = \sqrt{ \{ (V_{ph} \cos \Phi + I_a R_a)^2 + (V_{ph} \sin \Phi + I_a X_q)^2 \} } \pm (X_d - X_q) \cos \delta$

  For above formula use Plus symbol for pf lag.

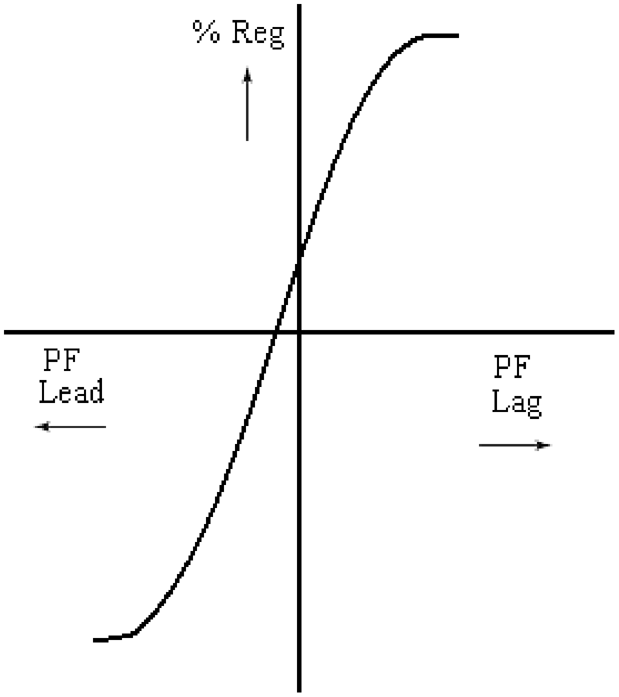
  For above formula use minus symbol for pf lead.

- Percentage regulation $= \{ (E_{o/ph} - V_{ph}) / V_{ph}\} * 100$

MODEL GRAPH



REGULATION GRAPH



RESULT:

Thus, the predetermination of regulation of three- phase alternator by vector diagram was obtained

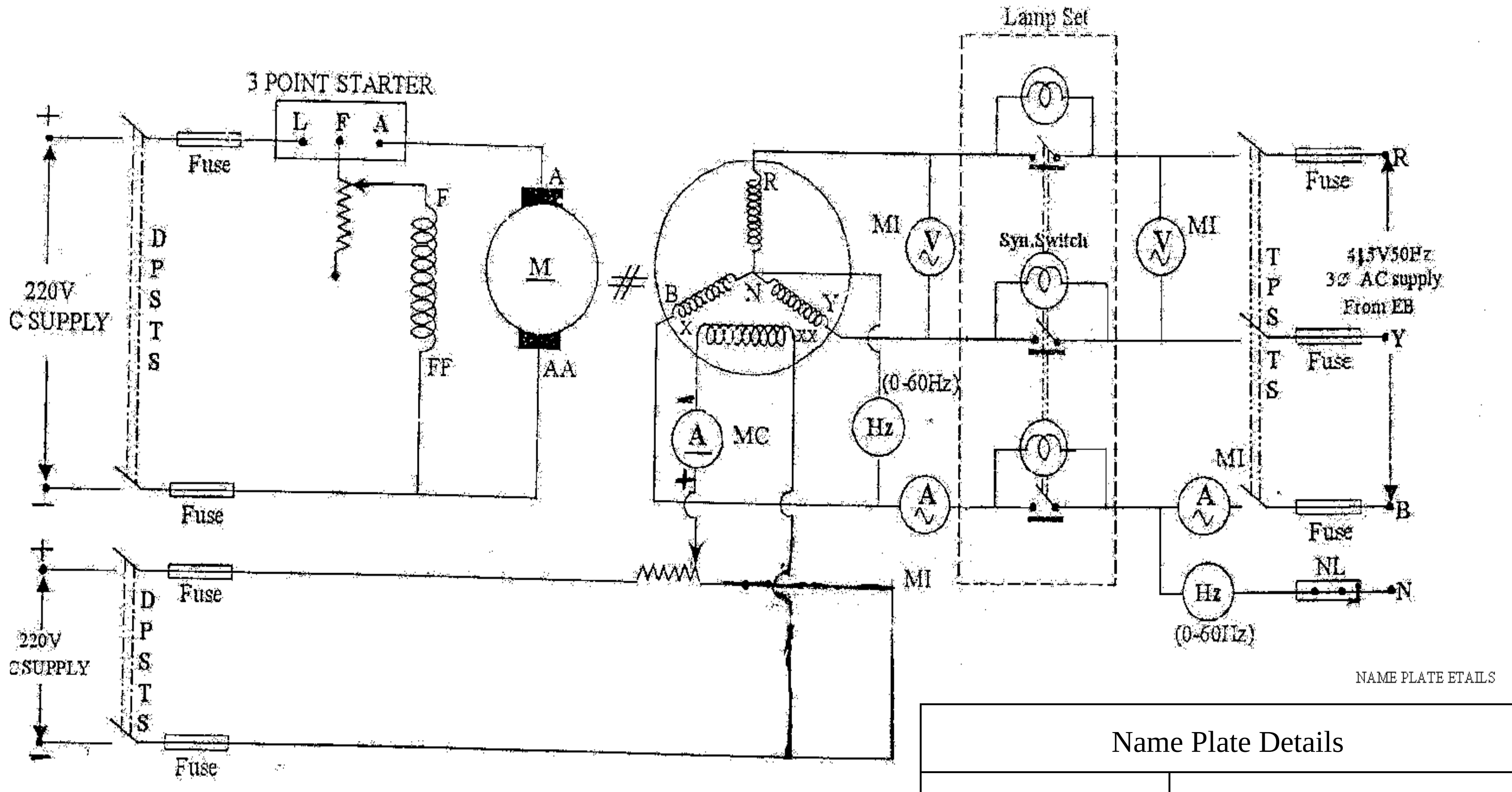
VIVA QUESTION:

1. What is the purpose of slip test on 3 phase alternator?
2. What is meant by direct axis reactance?
3. What is meant by quadrature axis reactance?
4. How is the regulation of alternator predetermined by slip test?
5. What is the difference between salient pole alternator and cylindrical rotor type alternator?
6. Why saliet pole construction is not used for high speed alternator?
7. Define synchronous speed.
8. Explain why efforts are made to generate sinusoidal induced emf in an alternator.
9. The cylindrical rotor theory fails to explain the performance of a salient pole alternator. Explain.
10. Explain why the direct axis synchronous reactance, Xd in a synchronous machine is greater than its quadrature axis synchronous reactance, Xq.

EXPERIMENT – 4

LOAD CHARACTERISTICS OF 3 - PHASE ALTERNATOR BY BUS BAR LOADING

PARALLEL OPERATION OF THREE PHASE ALTERNATORS



NAME PLATE ETAILS

Fuse Rating

Name Plate Details	
DC Shunt Motor	AC Alternator

EXP.NO. 4 **DATE:**

PARALLEL OPERTION OF 3-PHASE ALTERNATOR BY BUS BAR LOADING

AIM:

To synchronize a 3 - phase Alternator in parallel with bus bar arrangement.

APPARATUS REQUIRED:

SI. NO.	Apparatus	Range	Type	Qty

THEORY:

The process of switching of an alternator to another alternator or with a common bus bar without any interruption is called synchronization. To have effective synchronization the following three conditions have to be fulfilled.

1. The terminal voltage of the incoming alternator must be the same as that of bus bar voltage.
2. The frequency of the incoming alternator must be the same as that of bus bar frequency.
3. Phase sequence of both incoming alternator and bus bar must be same.

The above condition can be satisfied by using a voltmeter, synchronizing lamps or synchronoscope. Synchronization by lamps can be done in two ways. (1) Dark Lamp method, (2) Bright Lamp method of the above two methods dark lamp method is preferred.

TABULATION :

Sl. No	Alternator				Busbar		
	Field Current I_f (A)	Voltage (V)	Current (A)	Frequency (Hz)	Voltage (V)	Current (A)	Frequency (Hz)

A supply system with a large number of synchronous machines connected in parallel is referred to as infinite bus bars. Any additional machine, whether to operate as a generator or as a motor is connected in parallel with the bus bars. In this experiment the effect of varying the excitation of a synchronous machine connected to an infinite bus bar is studied.

The variation in excitation will cause a large change in the reactive current supplied by the alternator, and because of armature resistance, there will be a slight change in the power that is receives or delivers to the bus. For all practical purposes it is assumed that variation in excitation causes change in power factor.

If may be noted that when the alternator is over-excited, it operates at lagging power factor and when under excited it operates at leading power factor. When the excitation of an alternator connected to infinite bus-bar and supplying load at lagging power factor is increased, the alternator falls back (i.e load angle decreases), power factor further drops and armature current increases due to reduced power factor, active component being constant.

PRECAUTIONS:

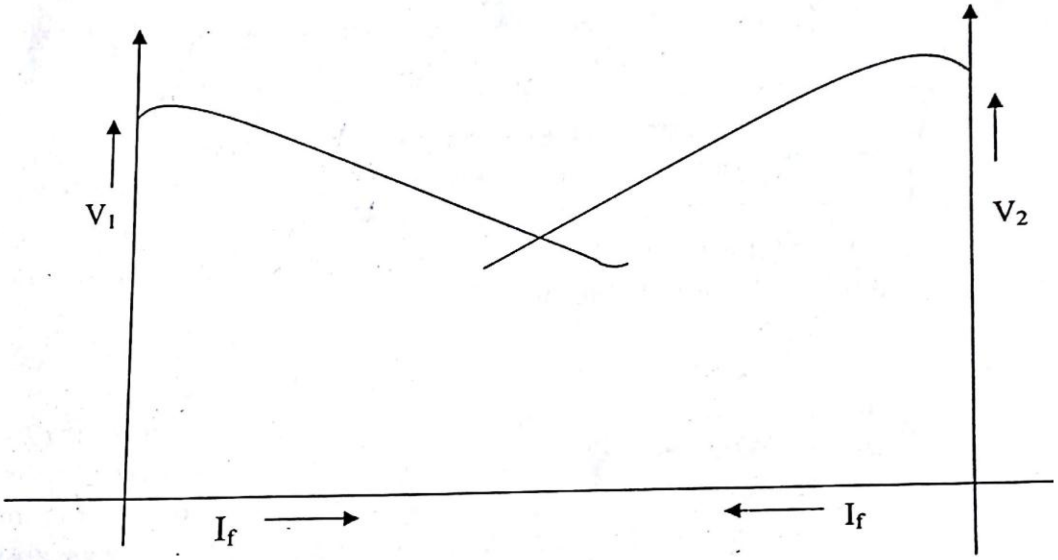
- The motor field rheostat should be in minimum resistance position.
- The Alternator field Potential divider should be at minimum voltage position.
- Initially all switches are in open position.

PROCEDURE:

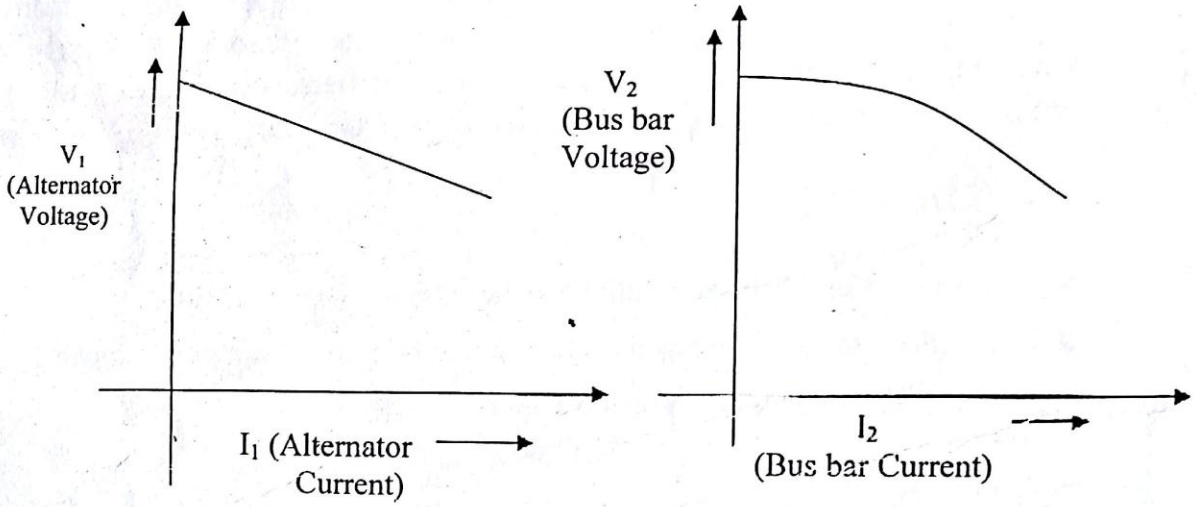
SYNCHRONISATION:

- Note down the name plate details of motor and alternator.
- Connections are made as per the circuit diagram.
- Close the DPST switch.
- Using the 3-point starter start the motor, by varying motor field rheostat set the rated speed.
- By varying the potential divider in the field of the alternator the generated voltage is built up to rated voltage.

MODEL GRAPH



V_1
V_2
I_f →
← I_f



V_1 (Alternator Voltage)
I_1 (Alternator Current) →
V_2 (Bus bar Voltage)
I_2 (Bus bar Current) →

- Now close the TPST switch.
- TPST is closed and by varying the potential divider the field current is varied so that the two voltmeter reads the same rated voltage.
- When TPST is closed the lamps may flicker uniformly.
- If flickering is not uniform then the phase sequences of any two lines are changed.
- Now synchronization switch is closed when lamps are in dark period.
- Now the two sources are synchronized.

NOTE:

Infinite bus bar is one which keeps constant voltage and frequency for minor changes in the load or source.

RESULT:

Thus the 3 phase alternator has been synchronized with the bus bars.

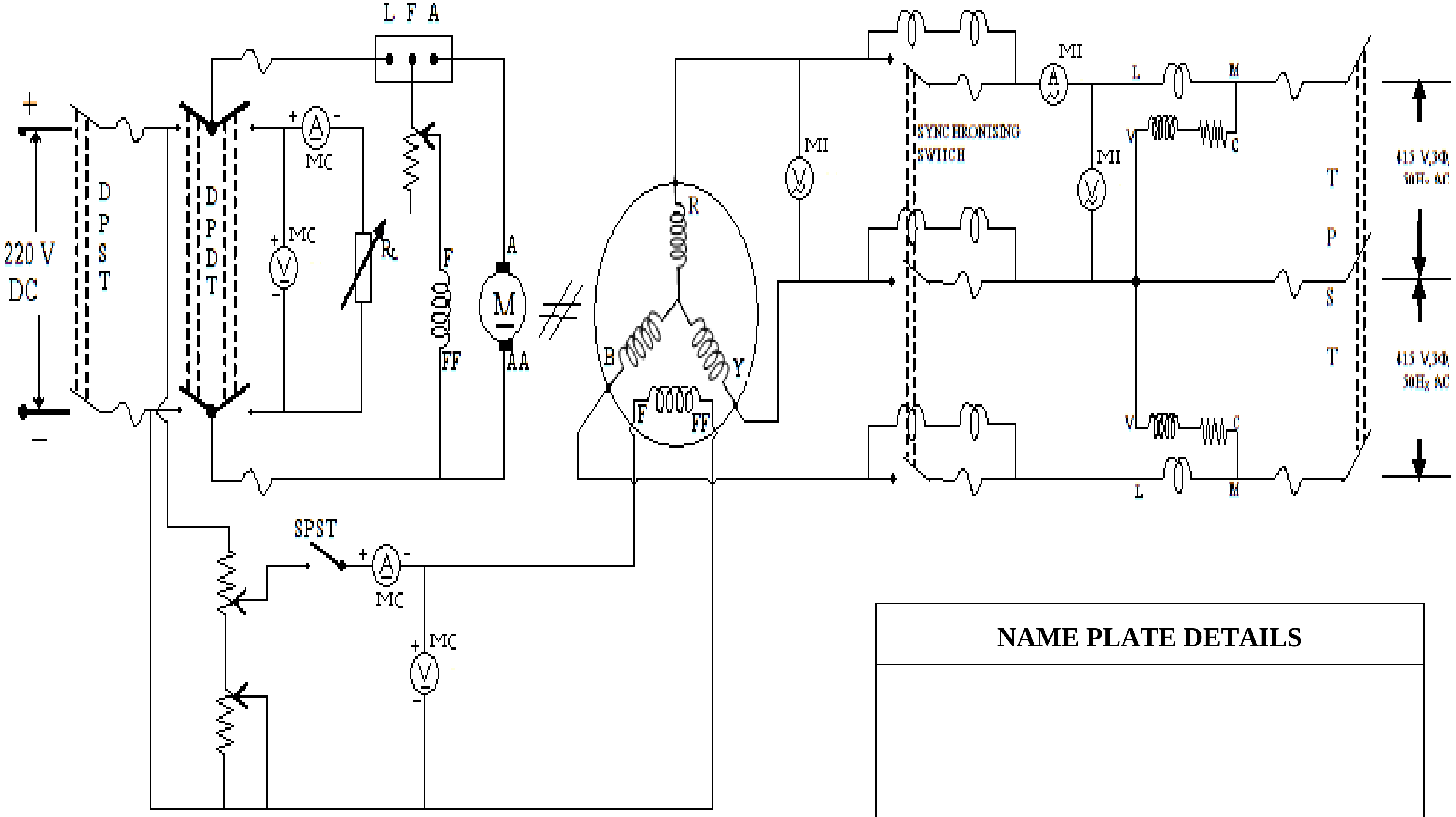
VIVA QUESTIONS:

1. What is meant by synchronization?
2. What are the conditions for synchronization?
3. What is infinite bus?
4. What are the methods of synchronization?
5. How can the voltage and frequency be adjusted?
6. What are the characteristics of infinite bus-bar?
7. What is meant by synchronizing torque?
8. What is the effect of change in excitation?
9. What is load characteristic?
10. What is mean by floating condition in bus bar loading?

EXPERIMENT – 5

V AND INVERTED V CURVE OF SYNCHRONOUS MOTORS

V AND INVERTED V CURVE OF THREE PHASE SYNCHRONOUS MOTOR



NAME PLATE DETAILS

FUSE RATING

EXP.NO. 5 **DATE:**

V AND INVERTED V CURVE OF THREE PHASE SYNCHRONOUS MOTOR

AIM:

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

APPARATUS REQUIRED:

SI. NO.	Apparatus	Range	Type	Qty

THEORY:

The operation of a synchronous motor with constant load for different conditions of excitation, neglecting the losses was studied and the following facts were observed.

1. When the motor is operated in under excitation condition armature current increases, power factor decreases and it operates with lagging factor.
2. When the motor is operated in over excitation condition it draws current with leading power factor.
3. The current drawn by the motor will be minimum at unity power factor.

The variation of armature current for different values of field amps in both under excited and over excited condition is shown as V- curves.

The variation of power factor for different values of field amps in both under excited and over excited condition are shown as Λ (inverted V) curves

TABULAR COLUMN

TABLE: 1 (WITH LOAD) M.F = I_{DC} =

Sl.No	Voltage (V)	Field Current I_f (A)	Armature Current (I_a) (A)	Power (W)		Power factor
				Obs	Act	

TABLE: 2 (WITHOUT LOAD) M.F = I_{DC} =

Sl.No	Voltage (V)	Field Current I_f (A)	Armature Current (I_a) (A)	Power (W)		Power factor
				Obs	Act	

PRECAUTION:

- Synchronizing switch in open position.
- Synchronous machine field regulating rheostat should be minimum potential position.
- DC machine field regulating rheostat in minimum position
- DPDT switch is closed to the DC Supply side.
- SPST switch in open position.

PROCEDURE:

(a) PROCEDURE FOR SYNCHRONIZING

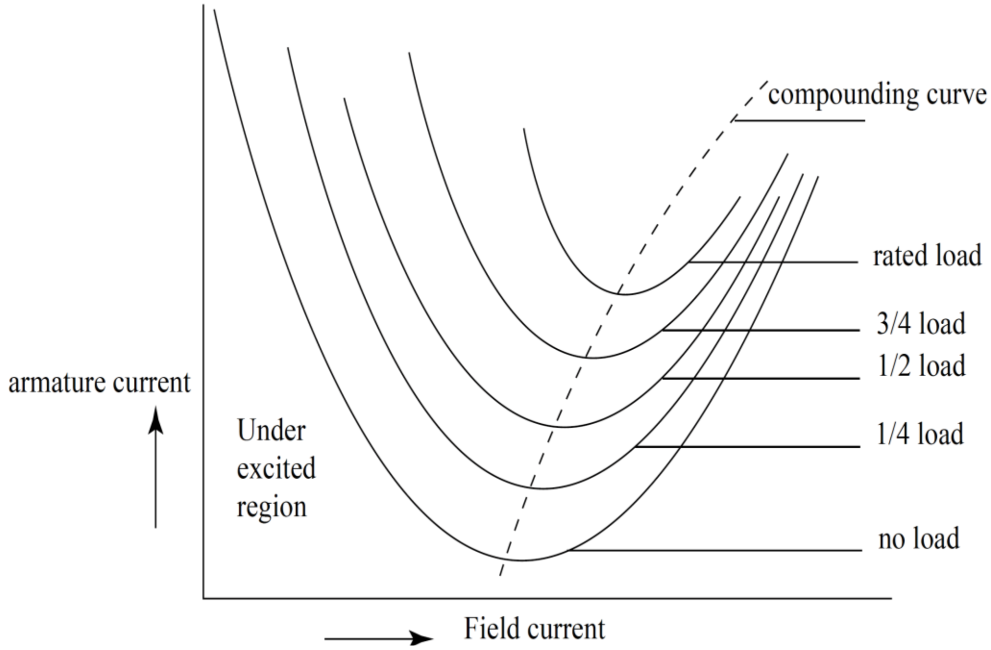
1. Close DPST witch
2. Start dc shunt machine as motor using 3- point starter.
3. By adjusting motor field rheostat, motor should be kept at synchronous speed (Ns).
4. Close TPST switch, note down the voltage.
5. Close SPST switch, increase the field current of the synchronous machine so as to cause its terminal voltage become same as the supply voltage $V_L = V_S$.
6. Watch the manner of glowing of the 3 sets of lamps connected across the synchronizing switch.
7. In case if the 3 sets of lamps become bright & dark one after another, it is an indication of wrong phase sequence. Open TPST switch, bring back the field current of synchronous machine to minimum position open SPST switch and inter change any two terminal connections on the TPST switch. Then follow step 4 to 6.
8. In the 3 sets of lamps become bright & dark simultaneously, it is an assurance of correct phase sequence.
9. Reduce the rate of flickering of the synchronizing switch lamps as low as possible by adjusting the DC motor field regulating rheostat.
10. Close synchronizing switch when all the 3 sets of lamps become dark.
11. Open DPDT switch, the synchronous machine will start working as synchronous motor and DC machine will work as DC shunt generator.

(b) PROCEDURE FOR OBTAINING V AND INVERTED V CURVES AT CONSTANT POWER OUTPUT:

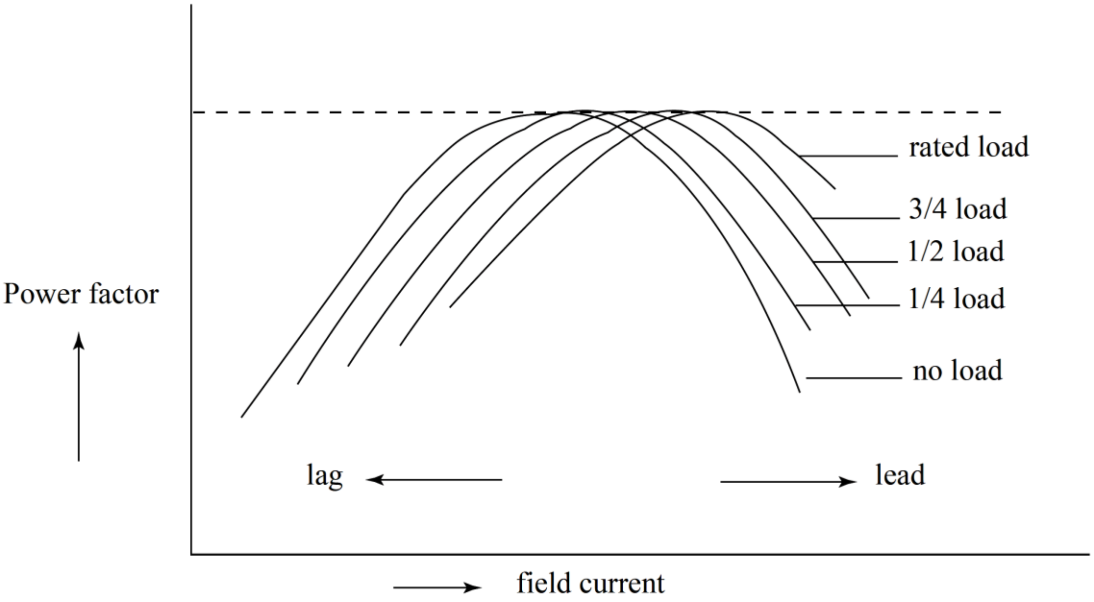
1. With DPDT switch in open position the synchronous motor is made to deliver small mechanical power output to the DC generator to meet its speed losses and field copper loss at constant level.
2. Reduce the field current of the synchronous motor so that its line current reaches around its rated value.
3. Note down the readings of line current, field current, voltage, power and enter them in the tabulation as the first set of readings.
4. Increase the field current of the synchronous motor and that its line ammeter shows as reading less than the previous value.

MODEL GRAPH:

V CURVES



INVERTED V CURVES



5. Note down the readings of field current, line current, voltage, power and enter them in the tabulation as the next set of readings.
6. Repeat steps 4 & 5 till the line current becomes the minimum most reading corresponding to UPF.
7. Increase the field current of the synchronous motor further so that its line ammeter shows a reading higher than the previous value.
8. Note down the readings of line current, field current, voltage, power and enter them in the tabulation as the next set of readings.
9. Repeat the steps 7 & 8 till the line current reaches around its rated value.

GRAPH:

(1) Armature current Vs Excitation current.

(2) Power factor Vs Excitation current.

RESULT:

Thus the V-curves and inverted V-curves of the 3-phase synchronous motor have been drawn.

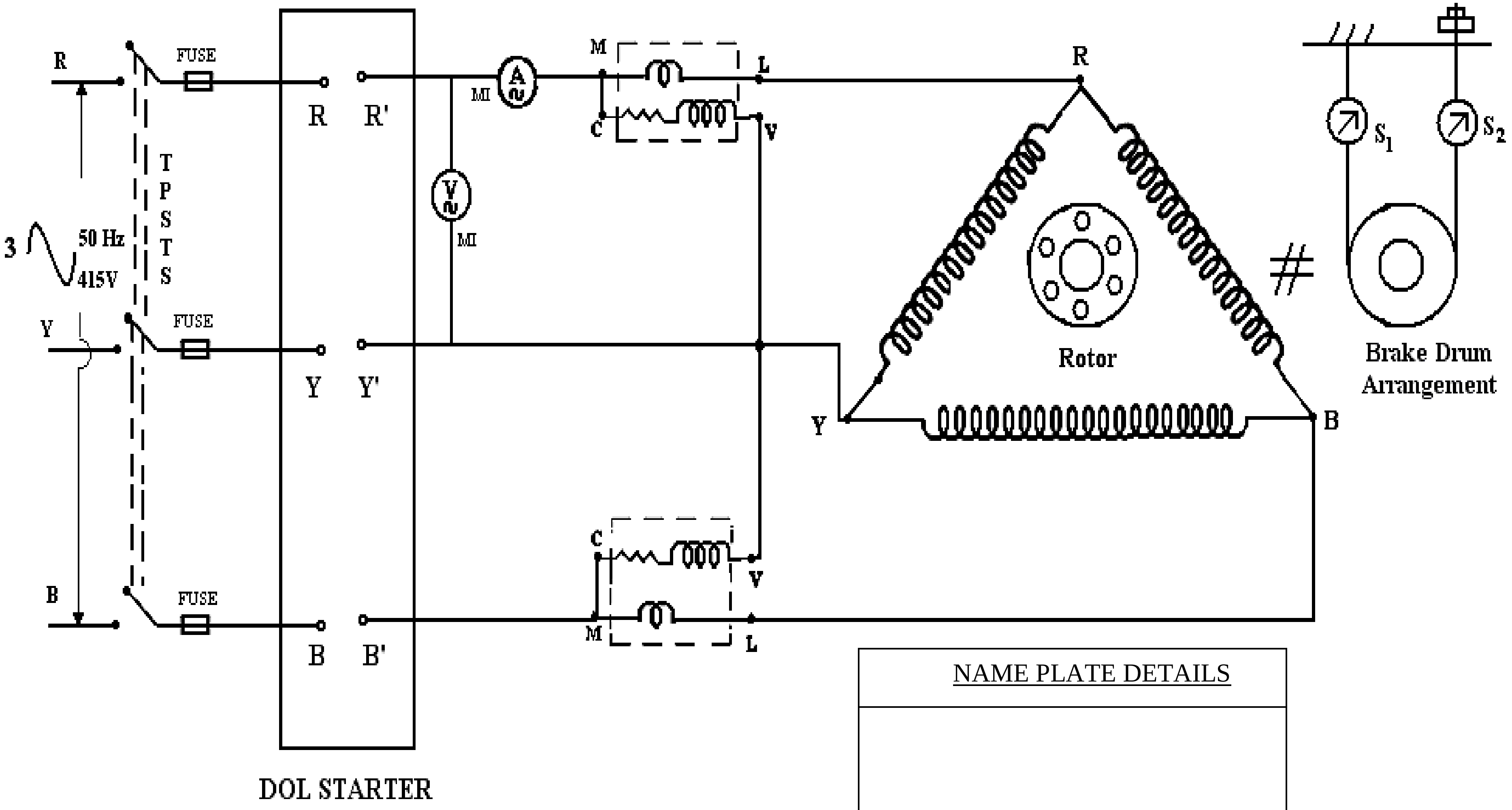
VIVA QUESTIONS:

1. What are the main parts of a synchronous motor?
2. Explain why a synchronous motor has no starting torque.
3. Does change in excitation affect the power factor of the synchronous motor?
4. A synchronous motor always runs at synchronous speed, why?
5. What are V -curves?
6. Mention some specific applications of synchronous motor.
7. What is a synchronous capacitor?
8. Explain what happens when the load on a synchronous motor is changed?
9. What is meant by hunting?
10. What are the uses of damper windings in synchronous motor?

EXPERIMENT – 6

LOAD TEST ON
3 - PHASE
INDUCTION MOTOR

LOAD TEST ON THREE PHASE SQUIRREL CAGE INDUCTION MOTOR



NAME PLATE DETAILS

FUSE RATING:

EXP.NO. 6 **DATE:**

LOAD TEST ON 3-PHASE INDUCTION MOTOR

AIM:

To draw the performance characteristics of 3-phase squirrel cage induction motor by conducting load test.

APPARATUS REQUIRED:

SI. NO.	Apparatus	Range	Type	Qty

THEORY:

Induction motor is one of the most important machines, which is used in Industrial and Domestically applications. These motors are classified in to different types namely (i). Squirrel cage Induction motor (ii). Slip ring Induction motor. Where the first one is most preferable because of its simple construction and its performance characteristics.

This motor has normal starting torque and adjustable speed so that speed control can be achieved easily. Normally direct on-line starter, star-delta starter and autotransformer starter are used to start the motor. It works under the principle of Faraday’s law of electromagnetic induction.

Induction motor is simply an electric transformer whose magnetic circuit is separated by an air gap into two relatively movable portions, one carrying the primary and the other secondary winding. Alternating current supplied to the primary winding from an electric power system induces an opposing current in the secondary winding, when latter short-circuited or closed through external impedance. Relative motion between the primary and secondary is produced by the electromagnetic forces corresponding to the power thus transferred across the air gap by induction.

A 3-phase induction motor consists of stator and rotor with the other associated parts. In the stator, a 3-phase winding is provided. The windings of the three phase are displaced in space by 120º.A 3-phase current is fed to the 3-phase winding. These windings produce a resultant magnetic flux and it rotates in space like a solid magnetic poles being rotated magnetically.

Tabulation for Load Test on Three phase squirrel cage induction motor

Circumference of brake drum =

Radius of the brake drum =

Thickness of the belt =

S.No.	Line Voltage (V_L)	Line Current (I_L)	Input Power		Spring Balance Readings			Torque (T)	Speed (N)	Slip (S)	Output Power	Efficiency (η)	Power factor
			W_1	W_2	S_1	S_2	$S_1 \sim S_2$						
	V	A	W	W	Kg	Kg	kg	Nm	rpm	%	W	%	

PRECAUTIONS:

- TPST switch is kept open initially.
- Autotransformer is kept at min. voltage position.
- There must be no load when starting the load.

PROCEDURE:

1. Connections are given as per circuit diagram.
2. 3-Φ induction motor is started with DOL starter.
3. If the pointer of one of the wattmeter readings reverses, interchange the current coil terminals and take the reading as negative.
4. The no load readings are taken.
5. The motor is loaded step by step till we get the rated current and the readings of the voltmeter, ammeter, wattmeter, spring balance are noted.

FORMULAE USED:

1) % slip= (Ns-N/Ns)*100

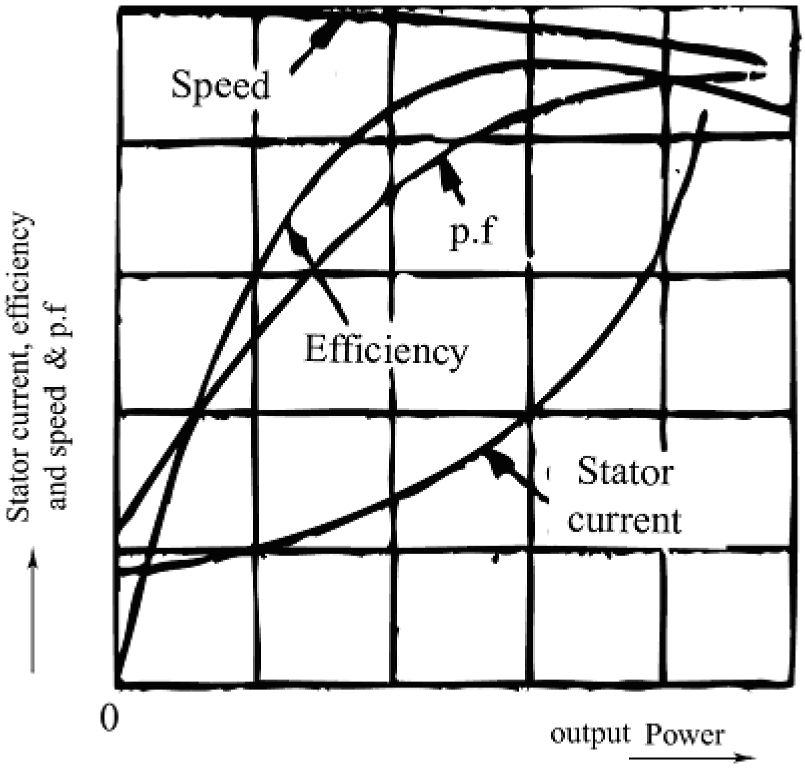
2) Input Power = (W1+W2)watts

3) Output Power = 2∏NT/60 watts

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

5) % efficiency = (o/p power/i/p power)* 100

MODEL GRAPH



MODEL CALCULATION

GRAPHS:

1) Output Power vs Efficiency
2) Output Power vs Power factor
3) Output Power vs Speed
4) Output Power vs stator current

RESULT:

Thus the performance characteristic of a 3-Φ squirrel cage induction motor by conducting load test has been drawn.

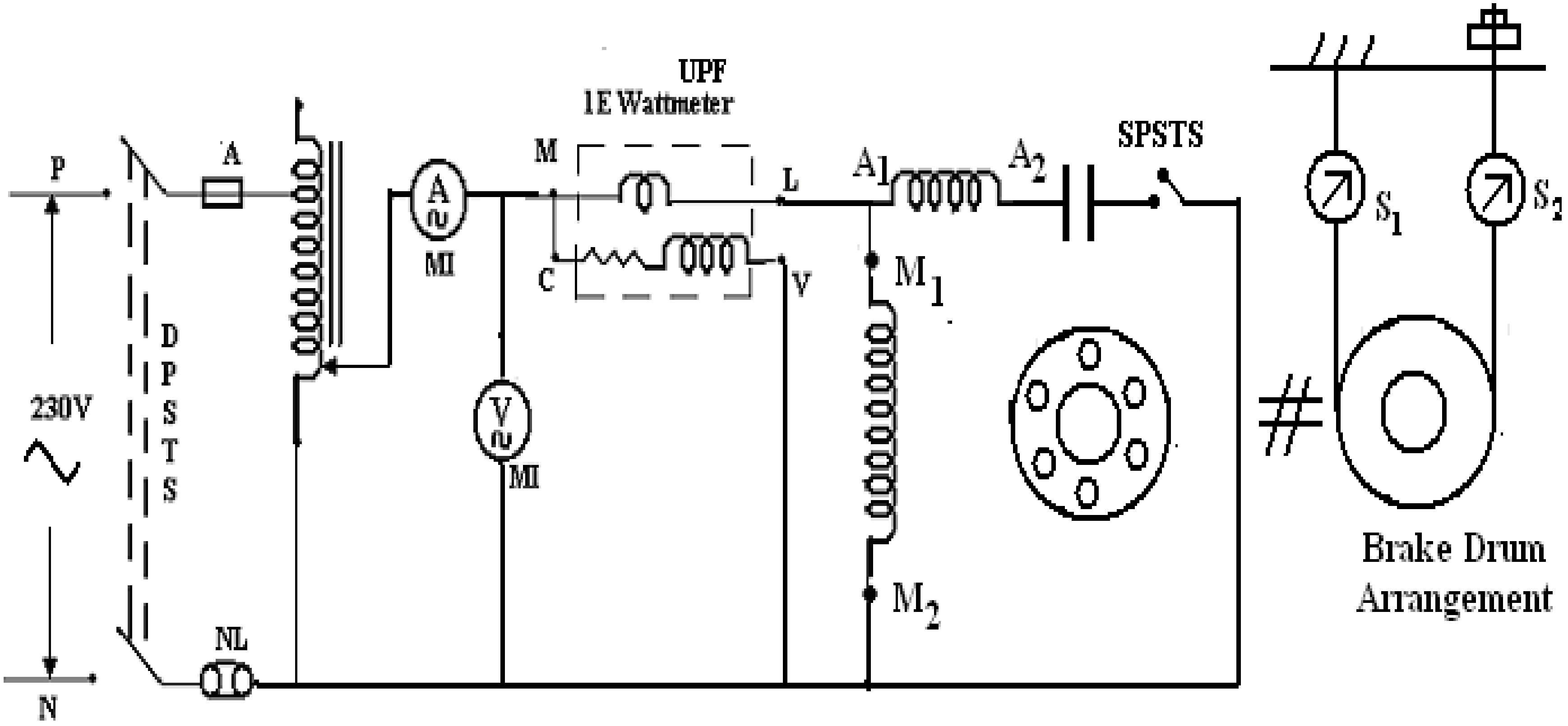
VIVA QUESTIONS:

1. What are the two types of 3 phase induction motors?
2. Why the rotor slots, of a 3φ induction motor are skewed?
3. Why an induction motor is called asynchronous motor?
4. Define slip of induction motor.
5. What is the purpose of end rings in the case of a 3 phase cage induction motor?
6. Give the advantages of a wound rotor motor over a squirrel cage induction motor.
7. State the effect of rotor resistance on starting torque.
8. Explain why the no load current of an induction motor is much higher than that of an equivalent transformer.
9. Explain why the power factor of an induction motor is very low at starting.
10. Why is the efficiency of a 3 phase induction motor less than that of a transformer?

EXPERIMENT – 7

LOAD TEST ON SINGLE PHASE INDUCTION MOTOR

LOAD TEST ON SINGLE PHASE INDUCTION MOTOR



FUSE RATING

NAME PLATE DETAILS

EXP.NO. 7 **DATE:**

LOAD TEST ON SINGLE PHASE INDUCTION MOTOR

AIM:

To determine the performance characteristic of a given single phase capacitor start induction motor by conducting load test.

APPARATUS REQUIRED:

SI. NO.	Apparatus	Range	Type	Qty

THEORY:

The single phase induction motor has two main parts, one rotating and other stationary. The stationary part in single phase induction motor is called Stator while the rotating part is called Rotor. The 3 phase induction motor is a self-starting motor but the single phase induction motor is not self-starting motor because in single phase induction motor is not having rotating magnetic field.

To produce rotating magnetic field, it is necessary to have minimum two alternating fluxes having a phase difference between the two. The interaction of the such 2 fluxes produce a resultant flux which is rotating magnetic flux. Thus production of rotating magnetic field at start is important to make the single phase induction motor is self-starting. This type of motor has single phase stator winding called main winding. In addition to this, stator carries one more winding called auxiliary winding or starting winding.

Tabulation for Load Test on Single phase induction motor

Circumference of brake drum =

Radius of the brake drum =

Thickness of the belt =

S.No.	Line Voltage (V_L)	Line Current (I_L)	Input Power	Spring Balance Readings			Torque (T)	Speed (N)	Slip (S)	Output Power	Efficiency (η)
			W	S_1	S_2	$S_1 \sim S_2$					
	V	A	W	Kg	Kg	kg	Nm	rpm	%	W	%

The auxiliary winding has a centrifugal switch in series with it when the motor gather a speed upto 75 to 80% of the synchronous speed, centrifugal switch gets opened mechanically and in running condition auxiliary winding remains out of the circuit. So motor runs only on the stator winding.

Depending upon the methods of producing rotating stator magnetic flux, the single phase induction motors are classified as,

- Split phase Induction motor
- Capacitor start induction motor
- Capacitor start capacitor run induction motor
- Shaded pole induction motor.

PRECAUTION:

1. Before switching on the supply, the variac is kept in minimum position.
2. Initially these should be on no load while starting the motor.

PROCEDURE:

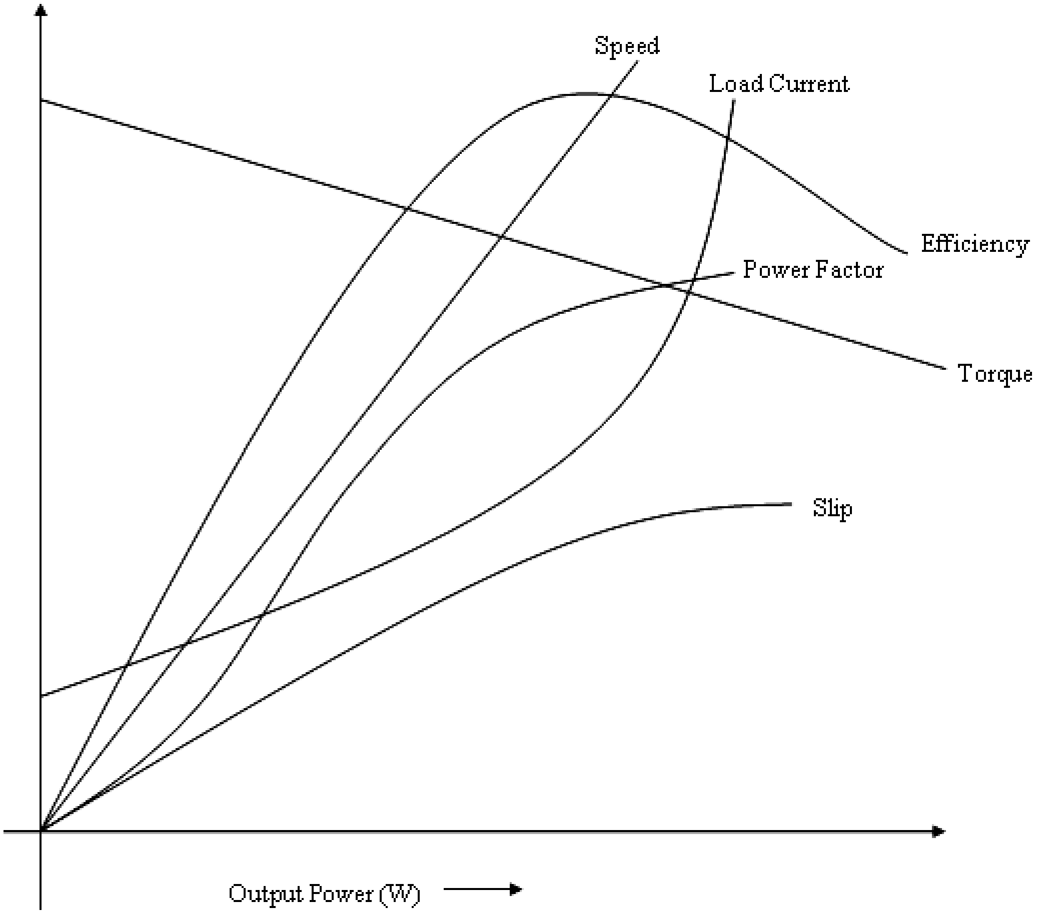
1. Connections are given as per the circuit diagram.
2. Switch on the supply at no load condition.
3. Apply the rotor voltage to the motor using the variac and note down the readings at ammeter and wattmeter for no load readings.
4. Vary the load in suitable steps and note down all the meter readings till fill load condition.

MODEL CALCULATION:

FORMULA USED:

1) Torque ,T = $(S1 \sim S2)*9.81*R$ N.m
2) Output power = $2\pi NT/60$*W
3) Effecting (η%) = 0/P Power/I/p Power*100
4) Slip (%S) = $NS - N/NS*100$
5) Power factor = Cos φ=W/VI

MODEL GRAPH:


Speed
Load Current
Efficiency
Power Factor
Torque
Slip
Output Power (W)

GRAPH:

1) Output Power Vs speed
2) Output power Vs Torque
3) Output power Vs Effecting
4) Output power Vs slip
5) Output power Vs Power factor

RESULT:

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

VIVA QUESTION:

1. What is the rating of the single phase machine? State its applications.
2. A single phase induction motor does not develop a starting torque why?
3. How will you change the direction of rotation of a split phase induction motor?
4. State applications of two-valued capacitor motor.
5. What type of motor is used for ceiling fan?
6. State applications of shaded pole motor.
7. Can a shaded pole motor be reversed?

EXPERIMENT – 8

NO LOAD

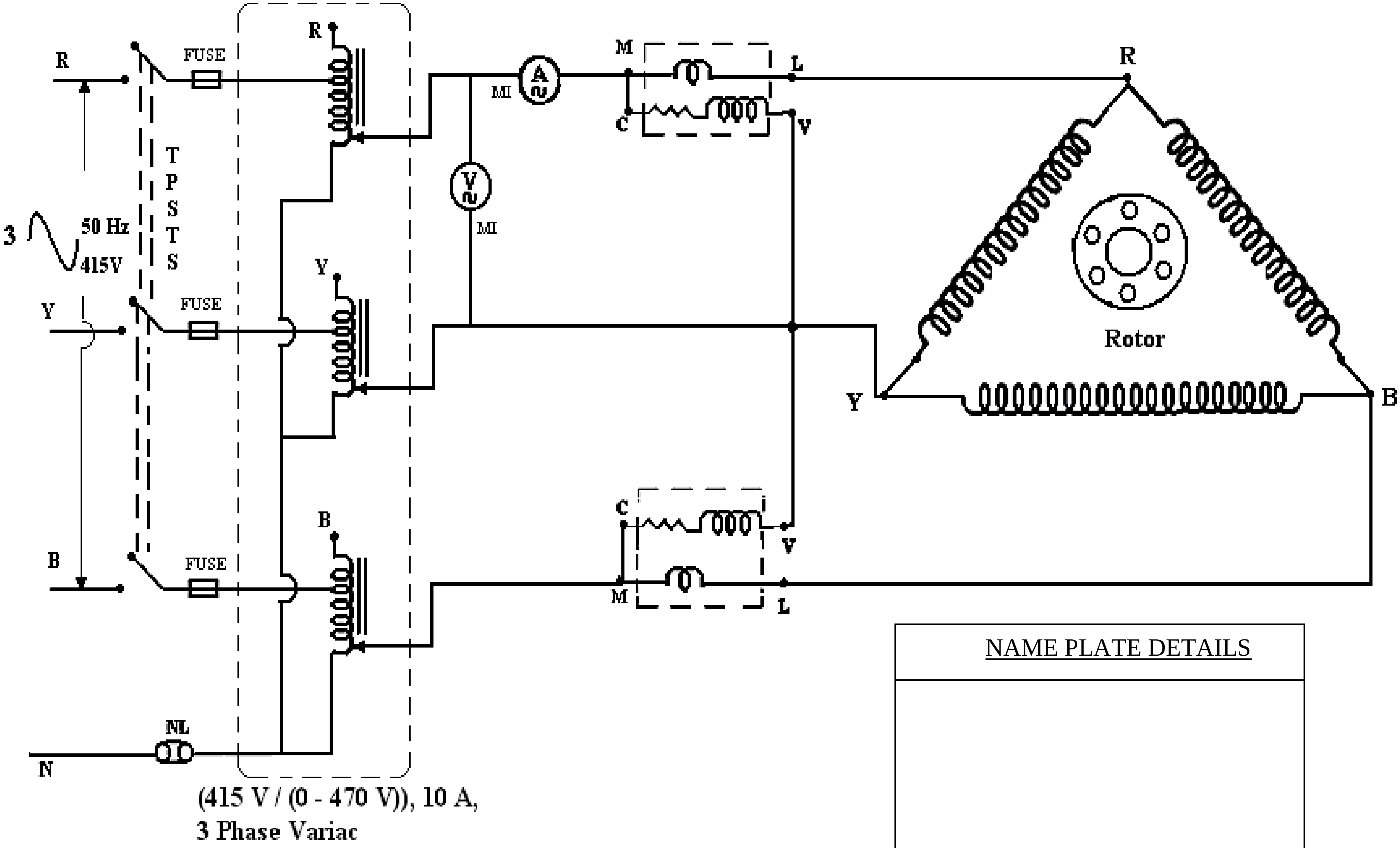
AND

BLOCKED ROTOR

TEST ON THREE PHASE

INDUCTION MOTOR

NO LOAD TEST ON THREE PHASE INDUCTION MOTOR



FUSE RATING:

NAME PLATE DETAILS

EXP. NO.: 8 **DATE:**

NO LOAD AND BLOCKED ROTOR TEST ON THREE PHASE INDUCTION MOTOR

AIM:

To determine the equivalent circuit parameters of a given three phase induction motor by performing no load and blocked rotor test.

APPARATUS REQUIRED:

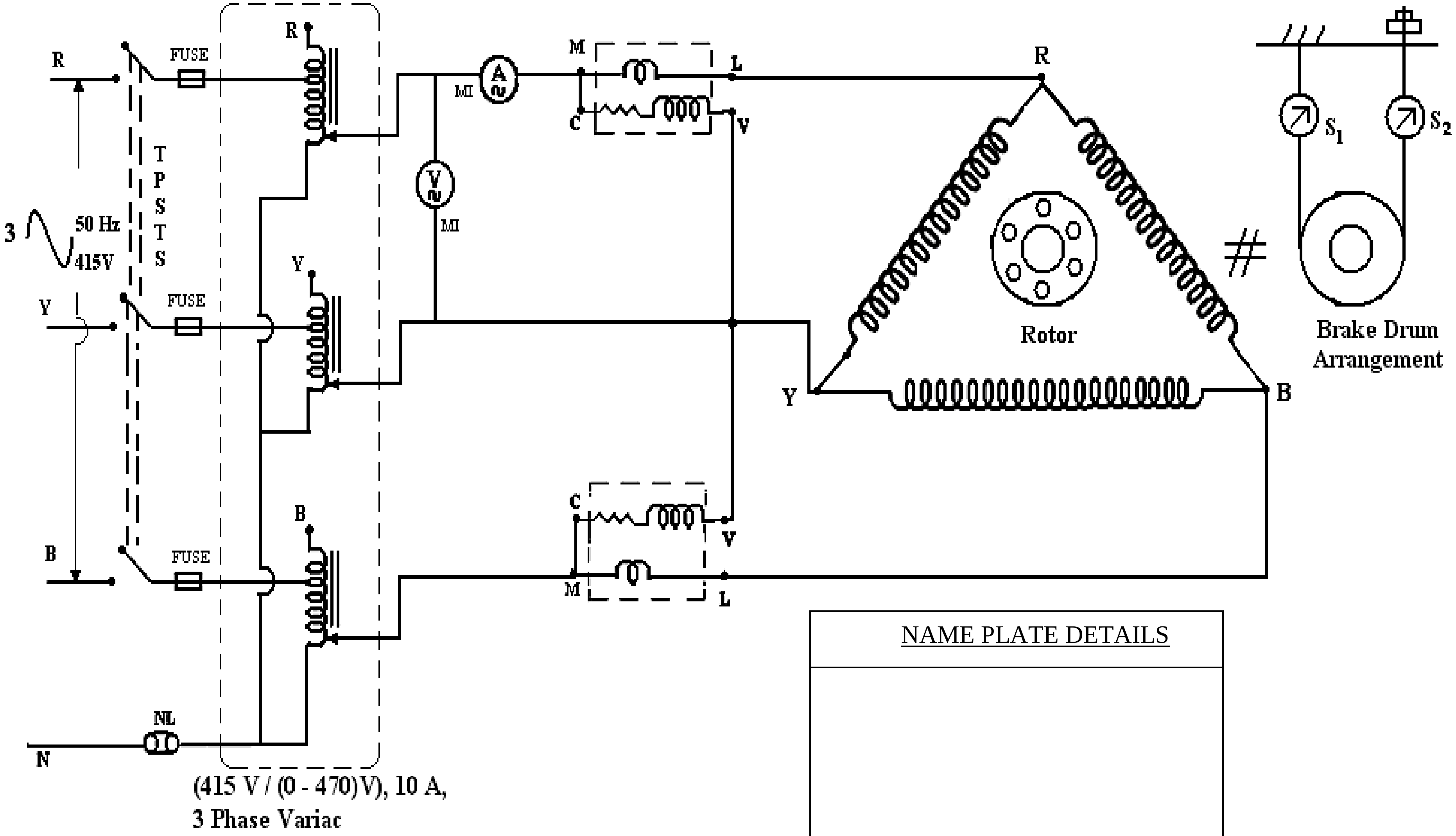
SI. NO.	Apparatus	Range	Type	Qty

THEORY:

The induction motor can b treated as generalized transformer. Transformer works on the principle of electromagnetic induction. The induction motor also works on the same principle. The energy transfer from stator to rotor of the induction motor takes place entirely with the help of a flux mutually linking the two. Thus stator acts as a primary while the rotor acts as a rotating secondary when induction motor is treated as a transformer.

A 3 - phase induction motor consists of stator, rotor & other associated parts. In the stator 3- phase winding (provided) are displaced in space by 120. A 3 - phase current is fed to the winding so that a resultant rotating magnetic flux is generated. The rotor starts rotating due to the induction effect produced due the relative velocity between the rotor Winding & the rotating flux.

BLOCKED ROTOR TEST ON THREE PHASE INDUCTION MOTOR



FUSE RATING:

NAME PLATE DETAILS

PRECAUTIONS:

- The three phase auto transformer kept at minimum position, when the motor is starting or stopping time.
- If wattmeter reading shows negative, switch off the supply and interchange the wattmeter terminal M & L connections.
- For no load test ensure that there is no load in brake drum For blocked rotor test, the belt should be tightened to prevent the rotation of rotor.

PROCEDURE:

NO – LOAD TEST:

- Connections are given as per the circuit diagram.
- Close the TPST switch.
- At the time of starting the three phase auto transformer is kept at the minimum position.
- Adjust the three phase auto transformer to get the rated voltage.
- Note down the readings of ammeter, voltmeter and wattmeters and tabulated.
- Bring the three phase auto transformer is brought to original position.
- Open the TPST switch.

BLOCKED ROTOR TEST:

- Connections are given as per the circuit diagram.
- At the time of starting the three phase variac is kept in minimum position
- The rotor is locked by tightening the belt over the brake drum.
- Supply is given by using the TPST switch.
- The three phase variac is adjusted to get the full load or rater current in the stator.
- Note down the readings of ammeter, voltmeter and wattmeters and tabulated.
- The three phase variac is brought to the original position.
- Open the TPST switch
- Switch off the power supply.

TABULAR COLUMN:

NO LOAD TEST:

Multiplication factors: MF_1 = MF_2 =

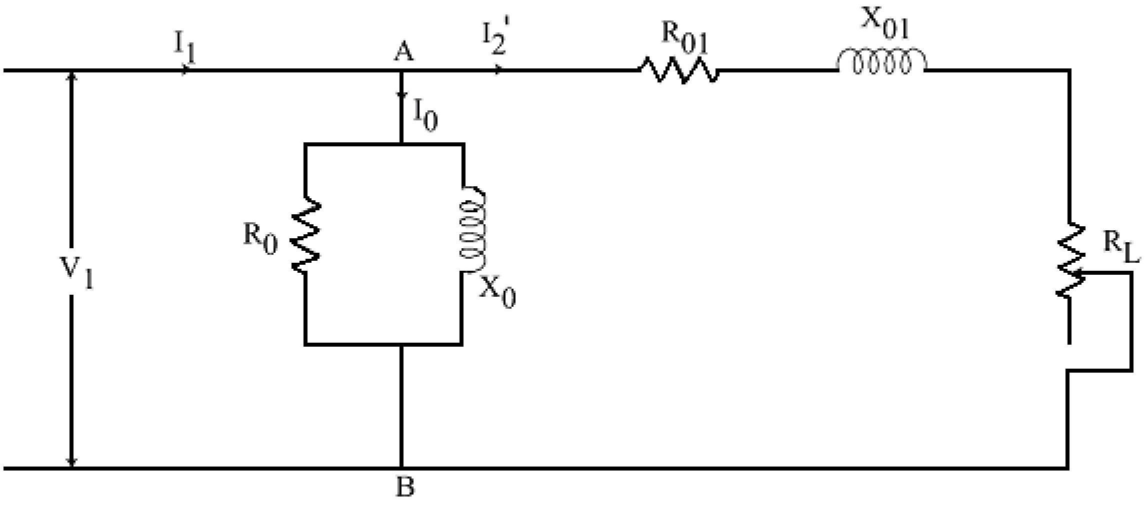
SI. NO.	No Load Line Voltage (V_{OL})	No Load current (I_L)	No Load Power (W_0)				
			Observe value		Actual value		$W_0 = W_1 + W_2$
			W_1	W_2	$MF_1 * W_1$	$MF_2 * W_2$	
	(Volt)	(Amp)	(Watt)	(Watt)	(Watt)	(Watt)	(Watt)

BLOCKED LOAD TEST:

Multiplication factors: MF_1 = MF_2 =

SI. NO.	Short circuit Voltage (V_{SC})	Short circuit current (I_{SC})	Short circuit Power (W_{SC})				
			Observe value		Actual value		$W_{SC} = W_1 + W_2$
			W_1	W_2	$MF_1 * W_1$	$MF_2 * W_2$	
	(Volt)	(Amp)	(Watt)	(Watt)	(Watt)	(Watt)	(Watt)

EQUIVALENT CIRCUIT FOR A THREE PHASE INDUCTION MOTOR:



FORMULA USED:

1. $\cos\phi_0 = \frac{W_0}{\sqrt{3} I_L V_{0L}}$

2. $I_\omega = {I_L \cos\phi_0}/{\sqrt{3}}$

3. $I_\mu = {I_L \sin\phi_0}/{\sqrt{3}}$

4. $\phi_0 = \cos^{-1}\left(\frac{W_0}{\sqrt{3} I_L V_{0L}}\right)$

5. $R_0 = \frac{V_{0L}}{\sqrt{3} I_L \cos\phi_0}$

6. $X_0 = \frac{V_{0L}}{\sqrt{3} I_L \sin\phi_0}$

7. $R_{01} = \frac{W_{SC}}{3 I_{SC}^2}$

8. $Z_{01} = \frac{V_{SC}}{\sqrt{3} I_{SC}}$

9. $X_{01} = \sqrt{(Z_{01})^2 - (R_{01})^2}$

10. $R_2^1 = R_{01} - R_1$

11. $R_L = \frac{R_2^1 (1 - S)}{S}$

Here Stator Resistance (R_1) & Slip (S) is given.

MODEL CALCULATION:

RESULT:

Thus the No load and Blocked rotor test on three phase induction motor is performed and its equivalent circuit parameters are determined.

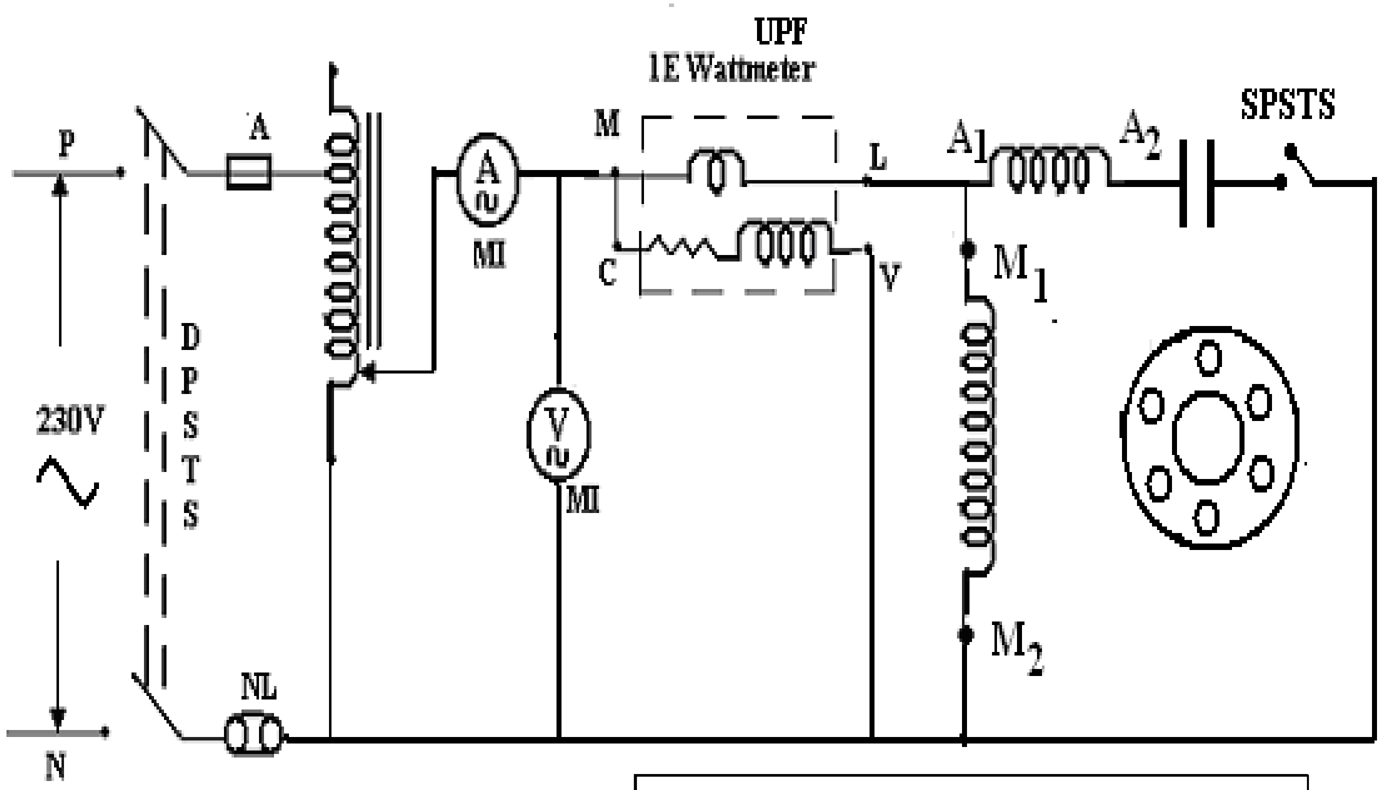
VIVA QUESTIONS:

1. What are the advantages of the cage motor?
2. The air gap length is kept minimum in induction motor. Why?
3. What is an induction generator?
4. What are the losses that take place in induction motor?
5. State two specific applications of double cage induction motor.
6. List out the tests necessary to draw the circle diagram of 3 phase induction motor?
7. How does the slip vary with load in 3-phase induction motor?
8. What is the reason for inserting additional resistance in the rotor circuit of a slip ring induction motor?
9. On what factors does the speed of an induction motor depend?
10. Is it possible to add an external resistance in the rotor circuit of a 3-phase cage induction motor? Give reason for your answer.

EXPERIMENT – 9

EQUIVALENT CIURCUIT AND PRE-DETERMINATION OF PERFORMANCE CHARACTERISTICS OF SINGLE PHASE INDUCTION MOTOR

NO LOAD TEST ON SINGLE PHASE INDUCTION MOTOR



FUSE RATING

NAME PLATE DETAILS

EXP.NO. 9 **DATE:**

EQUIVALENT CIURCUIT AND PRE-DETERMINATION OF PERFORMANCE CHARACTERISTICS OF SINGLE PHASE INDUCTION MOTOR

AIM:

To draw the performance characteristics of a single-phase induction motor by conducting the no-load and blocked rotor test.

APPARATUS REQUIRED:

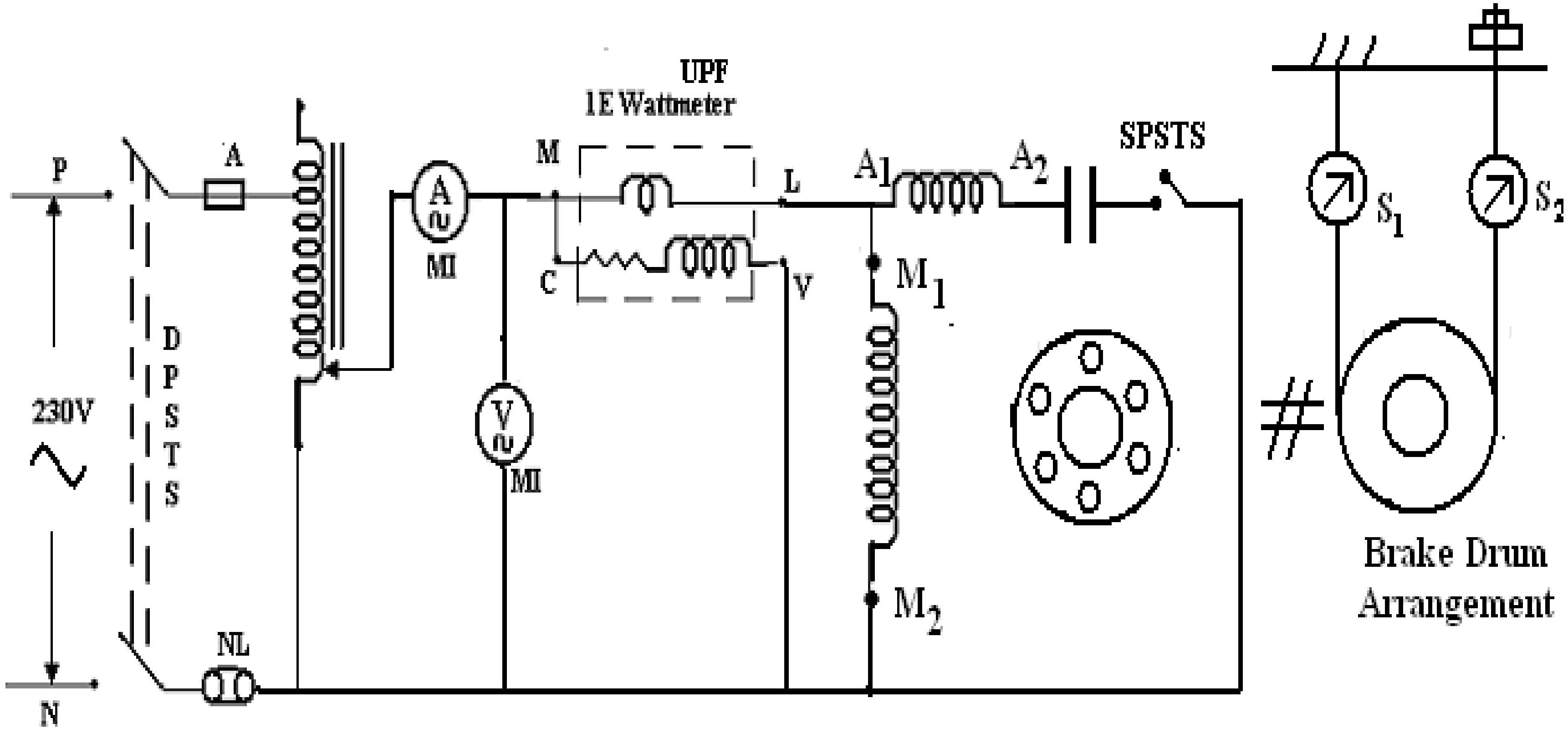
SI. NO.	Apparatus	Range	Type	Qty

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 of a 1- Φ winding(provided) are displaced in space by 120º.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.

Reff = 1.5*Rdc

BLOCKED ROTOR TEST ON SINGLE PHASE INDUCTION MOTOR



FUSE RATING

NAME PLATE DETAILS

PRECAUTIONS:

NO LOAD TEST:

- Initially TPST Switch is kept open.
- Autotransformer is kept at minimum potential position.
- The machines must be started on no load.

BLOCKED ROTOR TEST:

- Initially the TPST Switch is kept open.
- Autotransformer is kept at minimum potential position.
- The machine must be started at full load (blocked rotor).

PROCEDURE:

NO LOAD TEST:

1. Connections are given as per the circuit diagram.
2. Precautions are observed and the motor is started at no load.
3. Autotransformer is varied to have a rated voltage applied.

BLOCKED ROTOR TEST:

1. Connections are given as per the circuit diagram.
2. Precautions are observed and motor is started on full load or blocked rotor position.
3. Autotransformer is varied to have rated current flowing in motor.
4. Meter readings are the noted.

TABULAR COLUMN:

NO LOAD TEST:

MF =

S.No.	No Load Voltage (V_{OL})	No Load current (I_L)	No Load Power (W_O)	
	(V)	(A)	OBS (W)	ACT (W)

BLOCKED LOAD TEST:

MF =

S.No.	Short circuit Voltage (V_{SC})	Short circuit current (I_{SC})	Short circuit Power (W_{SC})	
	(V)	(A)	OBS (W)	ACT (W)

MODEL CALCULATION:

FORMULAE:

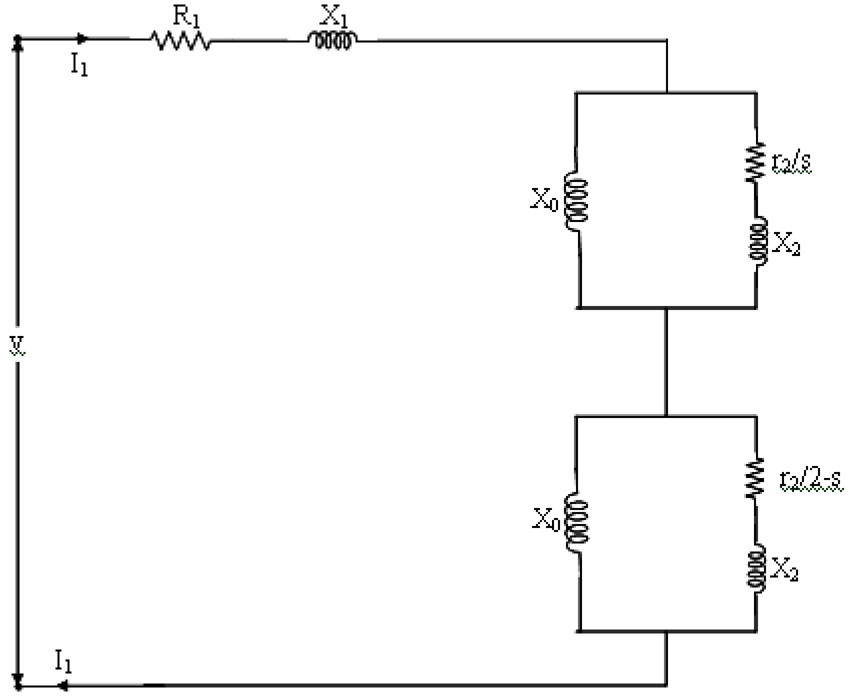
NO LOAD TEST:

- $\cos \Phi = W_o / V_o I_o$
- $I_w = I_o \cos\Phi$
- $I_m = I_o \sin \Phi$
- $R_o = V_o / I_w$
- $X_o = V_o / I_m$

BLOCKED ROTOR TEST:

- $Z_{sc} = V_{sc} / I_{sc}\ \Omega$
- $R_{sc} = W_{sc} / I_{sc}2\ \Omega$
- $X_{sc} = \sqrt{(Z_{sc}^2 - R_{sc}^2)}\ \Omega$

EQUIVALENT CIRCUIT



RESULT:

Thus the no load and blocked rotor test on the single-phase induction motor has been conducted and the equivalent circuit has been drawn.

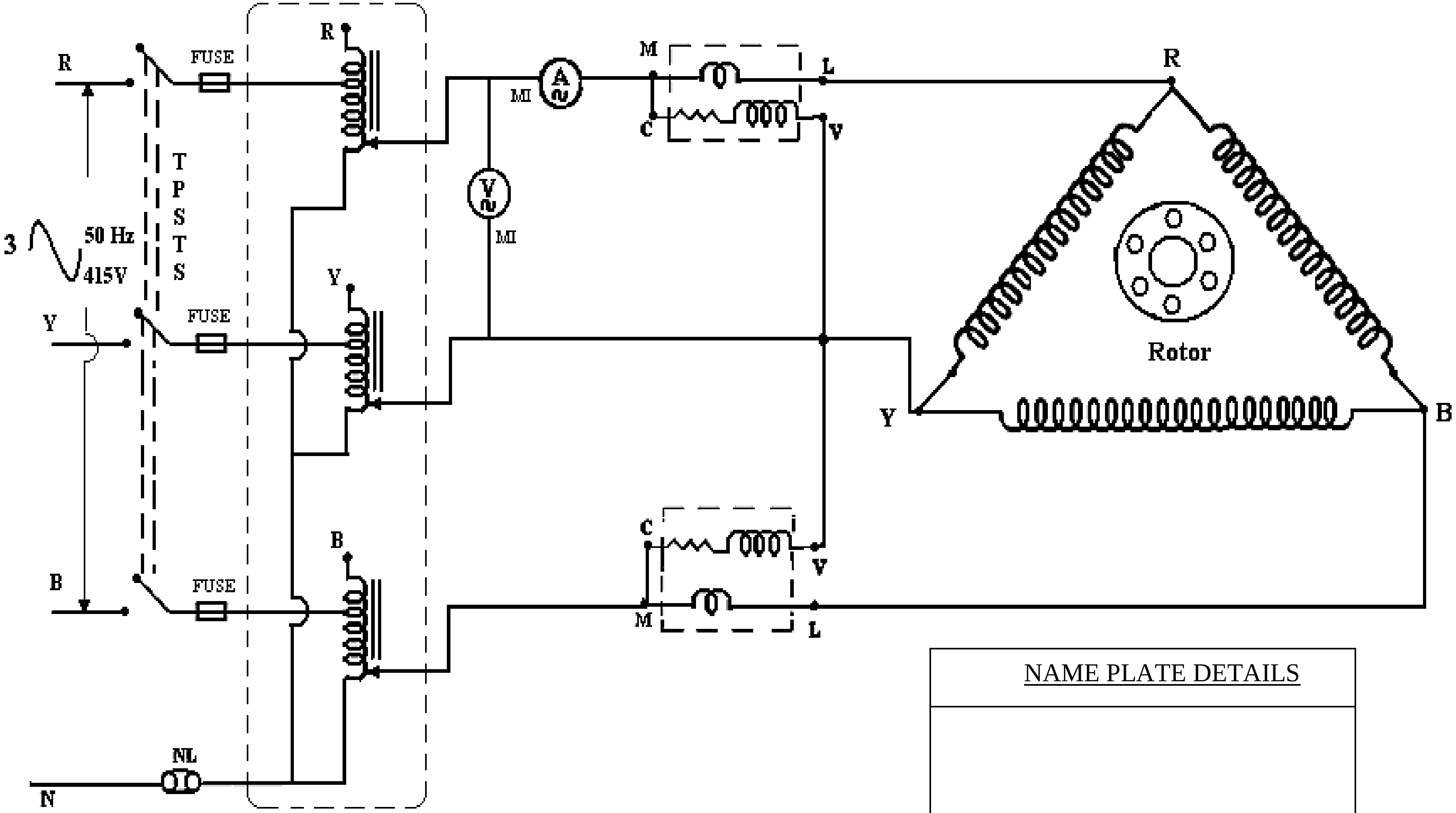
VIVA QUESTIONS:

1. Why single-phase induction motor has low power factor?
2. What is a universal motor?
3. State the applications of universal motor.
4. How is the universal motor different from dc series motor?
5. What is a stepper motor? State its applications?

EXPERIMENT – 10

SEPARATION OF LOSSES IN THREE PHASE INDUCTION MOTOR

SEPARATION OF LOSSES IN THREE PHASE SQUIRREL CAGE INDUCTION MOTOR



(415 V / (0 - 470 V)), 10 A,
3 Phase Variac

NAME PLATE DETAILS

FUSE RATING:

EXP.NO. 10 **DATE:**

SEPARATION OF LOSSES IN THREE PHASE SQUIRREL CAGE INDUCTION MOTOR

AIM:

To separate the no load losses of a 3 phase squirrel cage induction motor as iron losses and mechanical losses.

APPARATUS REQUIRED:

SI. NO.	Apparatus	Range	Type	Qty

THEORY:

We find the losses in the single-phase induction motor using this experiment. we separate the losses from the induction motor using the test. the losses are classified as (i) constant losses and (ii) Variable losses.

CONSTANT LOSSES:

These can be further classified as core losses and mechanical losses. We using this experiment only find out the constant losses.

Core losses occur in stator core and rotor core. These are also called iron losses. These losses include eddy current losses and hysteresis losses. The eddy current losses are minimized by using laminated construction while hysteresis losses are minimized by selecting high-grade silicon steel as the material for stator and rotor.

The iron losses depend on the frequency. The stator frequency is always supply frequency hence stator iron losses are dominant. As against this in rotor circuit, the frequency is very very small which is slip times the supply frequency. Hence, rotor iron losses are very small and hence generally neglected, in the running condition.

The mechanical losses include frictional losses at the bearings and windage losses. The friction changes with speed but practically the drop in speed is very small hence, these losses are assumed to be the part of the constant losses.

TABULAR COLUMN

S.No.	Voltage (V)		Current (I)	W_1	W_2	$W_0=W_1\pm W_2$	Copper Loss	W_0-W_i
	V_L	V_{Ph}						
	V	V	A	W	W	W	W	W

MODEL CALCULATION

PRECAUTIONS:

1. The autotransformer should be kept in minimum voltage position.
2. The motor should not be loaded throughout the experiment.

PROCEDURE:

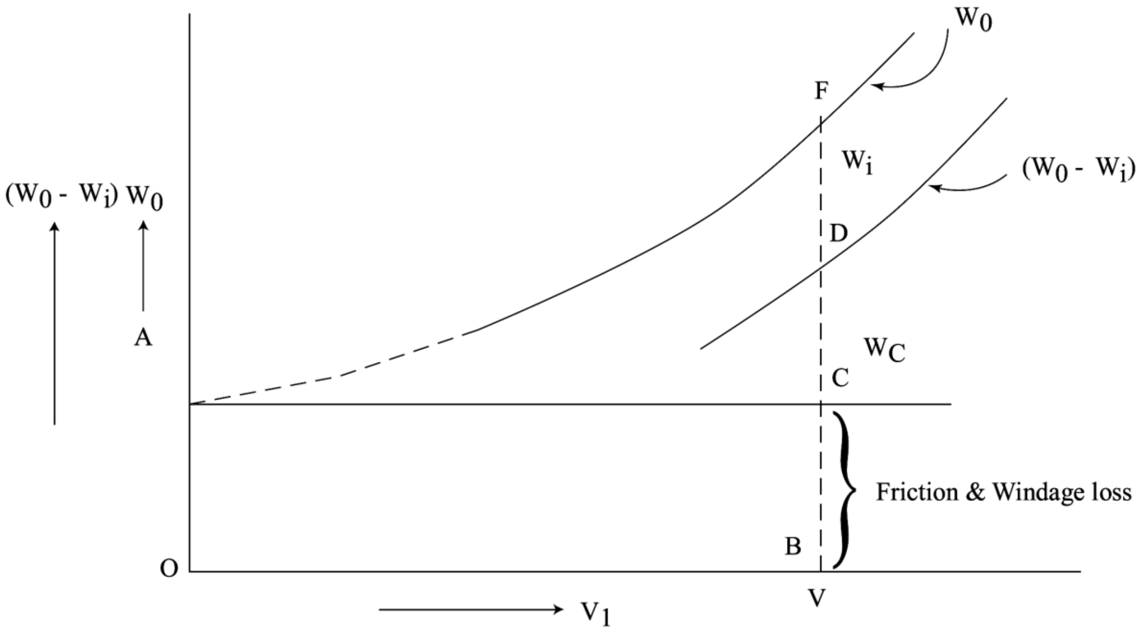
1. Connections should be made as per the circuit diagram.
2. By giving three phase supply, start the motor.
3. Vary the autotransformer till rated speed and note the input power, voltage and current.
4. Repeat the same procedure and tabulate the reading.
5. Find the stator copper loss and constant loss by respective formulas.
6. Draw the suitable graph to find the mechanical losses.
7. Obtain the core loss by separating the mechanical loss from constant losses.

FORMULA REQUIRED:

1. Input power (W) =(W1+W2)in watts
2. Stator copper loss =3I2Rs in watts
3. Constant loss/phase (Wc)= (W-3I2Rs)/3 in watts

4 Core loss/phase (Wi)= (constant loss/phase)-mechanical loss

MODEL GRAPH:



GRAPH:

The graph drawn between constant losses (watts) and input voltage (volts).

RESULT:

Thus the no load losses of 3-phase squirrel cage induction motor was separated as core losses and mechanical losses.

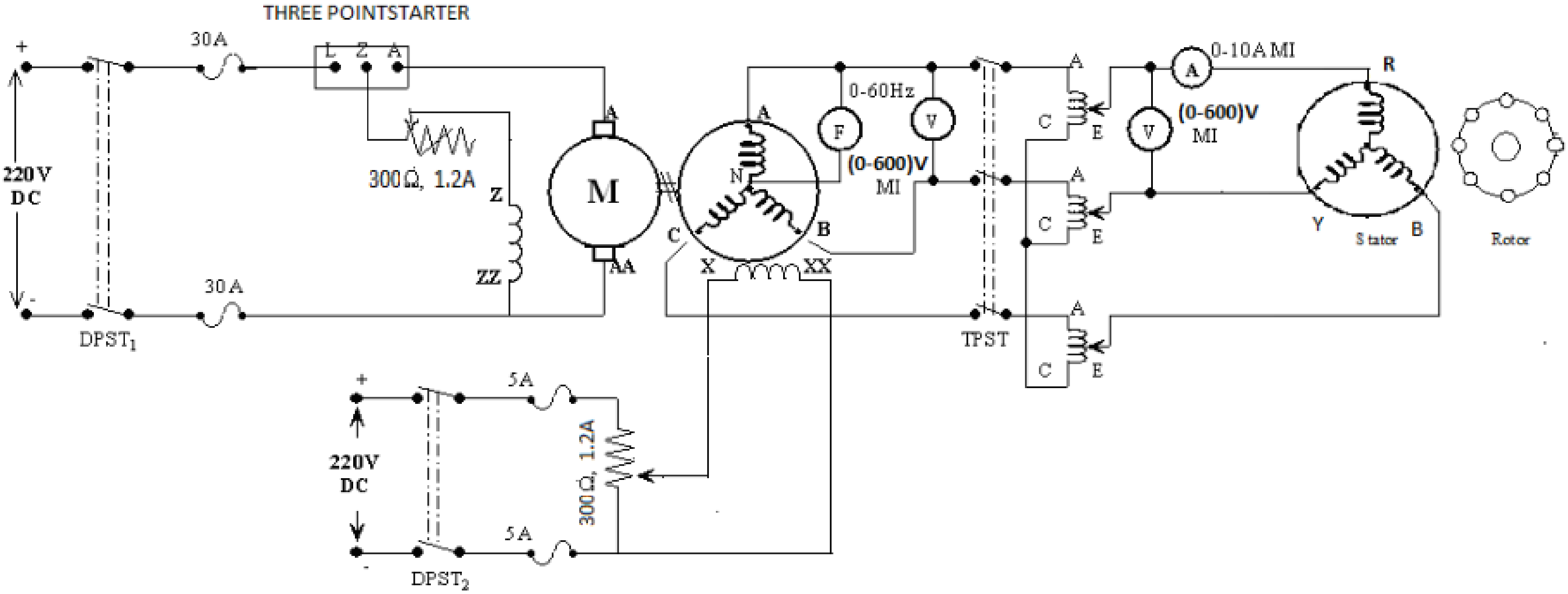
VIVA QUESTIONS:

1. What are the losses arrived in single-phase induction motor?
2. What is mean by constant loss?
3. What is mean by variable loss?
4. What are the types of constant loss?
5. What is mean by hysteresis and core loss?
6. What is mean by core loss?
7. Where will be the windage loss come?
8. Which factor will affect the variable loss?

EXPERIMENT – 11

SPEED CONTROL OF THREE PHASE INDUCTION MOTOR

SPEED CONTROL OF THREE PHASE INDUCTION MOTOR



FUSE RATING:

NAME PLATE DETAILS

EXP. NO : 11 **DATE :**

SPEED CONTROL OF THREE PHASE INDUCTION MOTOR

AIM :

To control the speed of the 3 phase induction motor by changing the supply frequency and to plot the speed Vs frequency curve.

APPARATUS REQUIRED:

SI. NO.	Apparatus	Range	Type	Qty

THEORY :

The synchronous speed of induction motor is given by

$$N_s = \frac{120\,f}{P}$$

where f is frequency of supply and P is number of poles. The synchronous speed and thereby the speed of induction motor can be controlled by controlling the supply frequency. We know that V/f is proportional to flux, therefore if we decrease the frequency while keeping voltage constant the flux in the air-gap will increase thereby causing saturation. To avoid this frequency is not decreased beyond a particular value. The frequency of the alternator output can be varied by varying the prime mover's (dc motor) speed.

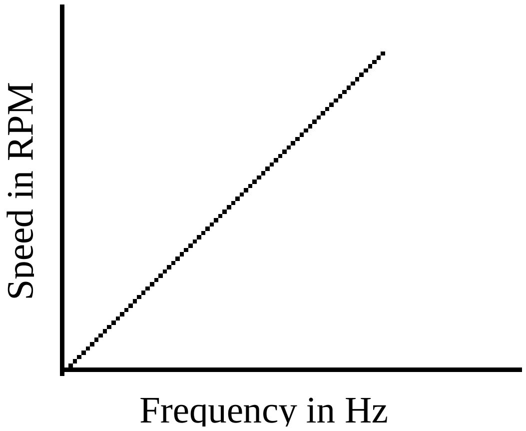
PRECAUTIONS:

1. TPST in open position
2. DPST1 and DPST2 in open position
3. Motor field rheostat in minimum position
4. Potential divider in minimum voltage position
5. Autotransformer at minimum voltage position

TABULATION

Induction motor on no load				
Line voltage In volts				
Frequency In Hz				
Speed of IM In rpm				

MODEL GRAPH :



PROCEDURE:

1. Make the connections as shown in diagram.
2. Switch on the DC supply to the DC motor by closing the switch DPST1. Start the DC shunt motor using 3-point starter. Adjust the field rheostat of the alternator and bring it to rated speed.(1500rpm).
3. Now, DC supply is given to the alternator field winding and adjust the potential divider so that the generated voltage is rated value (410V).
4. Close the TPST switch. Increase the autotransformer. Induction motor starts running on no load. Apply rated voltage by adjusting autotransformer. Note down the frequency, voltage and speed of the induction motor. Now, decrease the frequency. Decrease the voltage and frequency in proportion and note down the frequency, voltage and speed of the induction motor each time. This procedure is continued till frequency decreases to 48Hz.Switch off the supply after bringing the motor to no load.

RESULT :

Thus the speed control characteristics of three phase Induction motor by V/f control method are done.

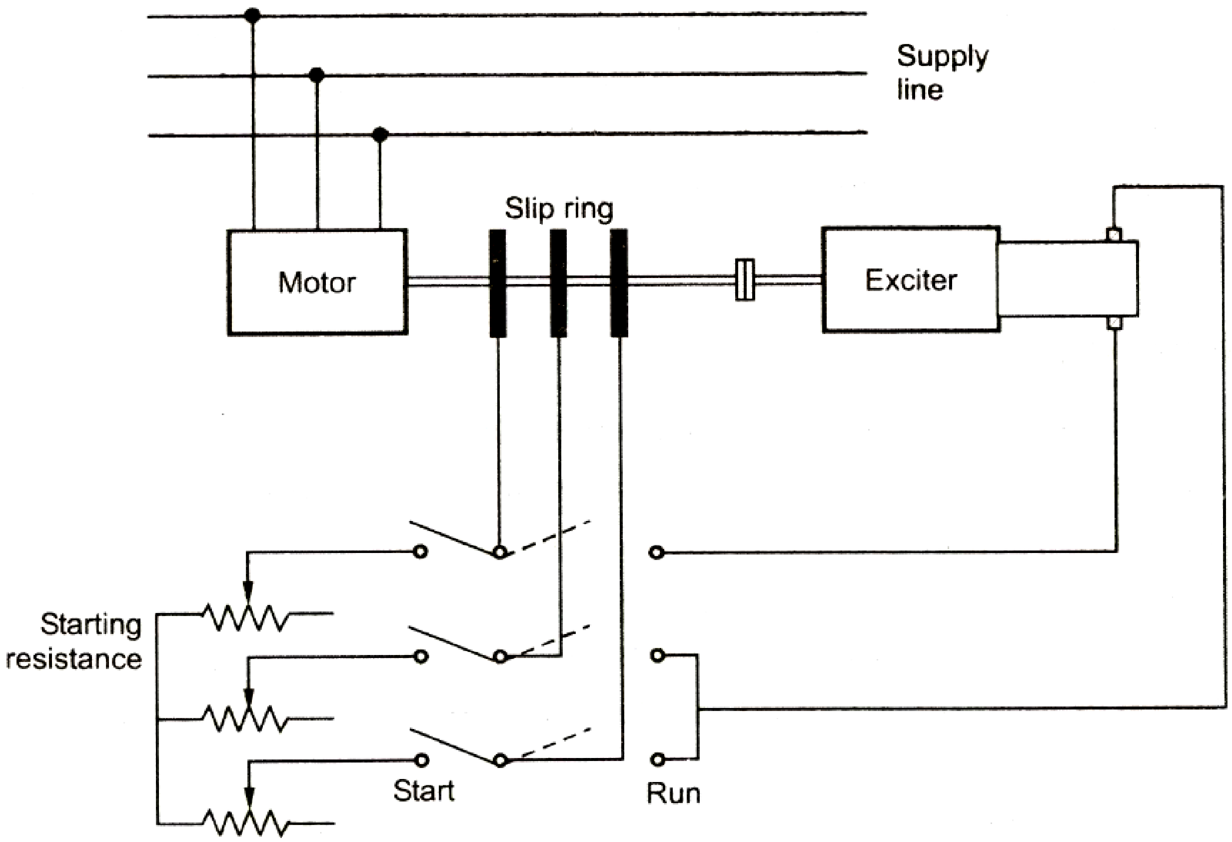
VIVA QUESTIONS:

1. What does happen to the induction motor if supply frequency is reduced keeping the Supply voltage constant?
2. Name some applications of speed control of induction motor?
3. When does the induction motor behave as induction generator?
4. What is single phasing in induction motor?
5. What are the main feature of v/f control?

EXPERIMENT – 12

STUDY OF LINEAR INDUCTION MOTOR & SYNCHRONOUS INDUCTION MOTOR

THE NORMAL SLIP RING INDUCTION MOTOR HAVING THREE PHASE WINDING ON THE ROTOR



EXP. NO.: 12 **DATE:**

STUDY OF LINEAR INDUCTION MOTOR & SYNCHRONOUS INDUCTION MOTOR

A) STUDY OF SYNCHRONOUS INDUCTION MOTOR

AIM:

To study the synchronous induction motor.

THEORY:

In the applications where high starting torque and constant speed are desired then synchronous induction motors can be used. It has the advantages of both synchronous and induction motors. The synchronous motor gives constant speed whereas induction motors can be started against full load torque.

Consider a normal slip ring induction motor having three phase winding on the rotor as shown in figure. The motor is connected to the exciter which gives DC supply to the rotor through slip rings. One phase carries full DC current while the other two carries half of the full DC current as they are in parallel. Due to this DC excitation, permanent poles (N and S) are formed on the rotor.

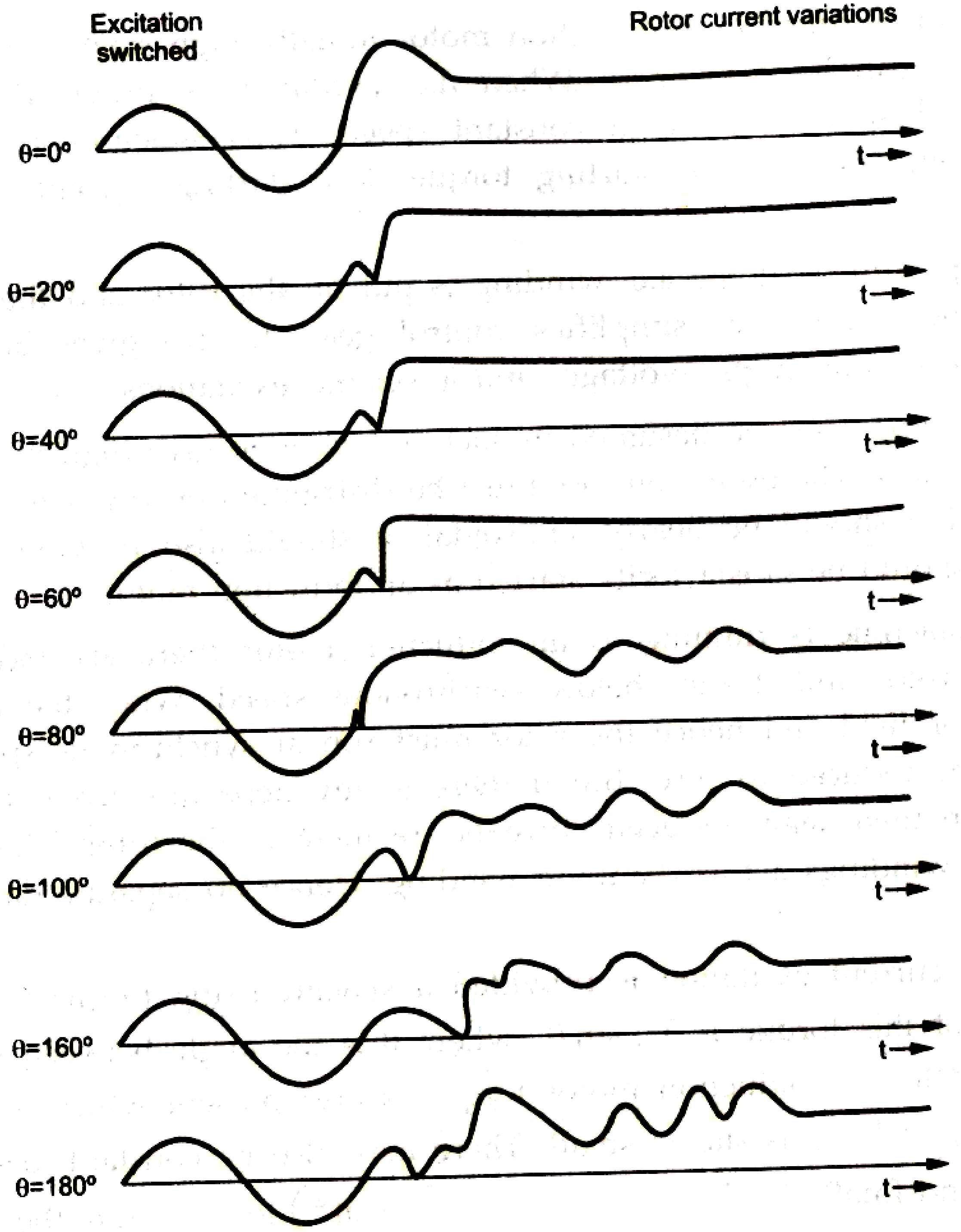
Initially it is run as an slip ring induction motor with the help of starting resistances. When the resistance is cut out the motor runs with a slip. Now the connections are changes and the exciter is connected in series with the rotor windings which will remain in the circuit permanently.

As the motor is running as induction motor initially high starting torque (upto twice full load value) can be developed. When DC excitation is provided it is pulled into synchronism and starts running at constant speed. Thus synchronous induction motor provides constant speed, large starting torque, low starting current and power factor correction.

It may be possible that the AC winding is put on the rotor and DC excitation is provided on the stator. This simplifies control gear. It also gives better facilities for insulation which permits higher voltages and lower DC excitations.

The DC winding must be designed in such a way as to give high mmf with moderate DC excitation power. The excitation loss must be distributed evenly over the winding. The mmf distribution should be nearly sinusoidal. It should also provide damping against hunting and it should be satisfactorily started as an induction motor.

THE OSCILLOGRAMS OF ROTOR CURRENT ON APPLICATION OF EXCITATION FOR VARIOUS VALUES OF θ



When the machine is running as an induction motor there are induced alternating currents in the rotor and it runs below synchronous speed. When the rotor carries DC currents the rotor field and hence the rotor must run at synchronous speed. This means that slip must be reduced to zero. But if there is any departure from this speed during normal operation then again induced currents are there I the rotor. The rotor is of low resistance so its windings act as damping winding. Hence no separate damping windings are required.

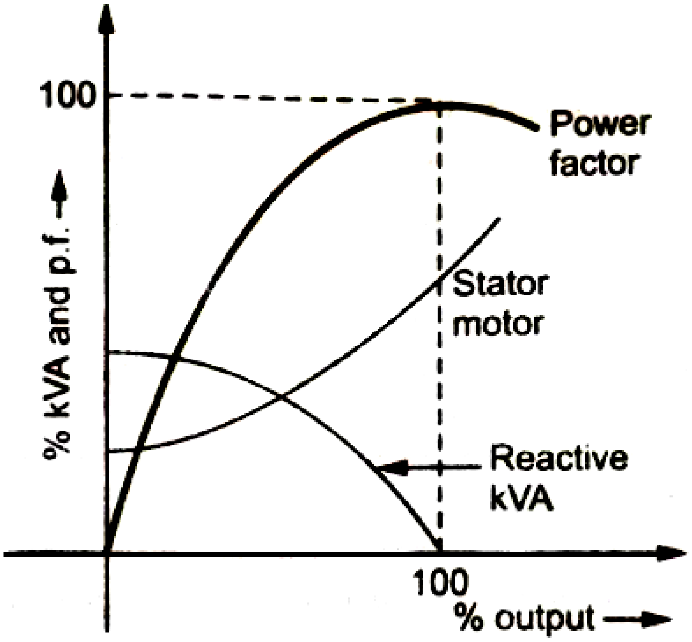
When DC excitation is provided a synchronizing torque is quickly set up. The magnitude of this torque is $T_m \sin \theta$ where θ is the angle between stator and rotor field. In addition to this induction motor torque is also present which is proportional to the slip ($d\theta / dt$), so long as slip is small. There may also be constant load torque if it is started on load and finally it requires torque $J (d^2\theta / dt^2)$ to accelerate the rotor.

It can be seen that as long as $\theta < \pi$ the synchronizing torque acts in opposite direction to that of load torque which tends to reduce the angular velocity $d\theta / dt$ of the slip motion. When $\pi < \theta < 2\pi$ then synchronizing torque acts in conjunction with load torque to increase the slip that is nothing but angular velocity $d\theta / dt$ and the motor fails to synchronize.

As the slip motion is irregular, the motor s subjected to mechanical strains. Also there may be oscillations in current and power factor. Hence it is desired that the motor should synchronize as quickly as possible after switching DC excitation. It requires that synchronizing torque should be sufficiently larger than load torque and it should be opposite of load torque. The angle θ obtained at the instant of switching DC excitation also affects pulling into step. The oscillograms of rotor current on application of excitation for various values of θ as shown in figure. When the excitation is delayed beyond 60 degree it is seen that the rotor fails to synchronize as the induction motor torque and the synchronizing torque work in conjunction and the torque will have pulsating value.

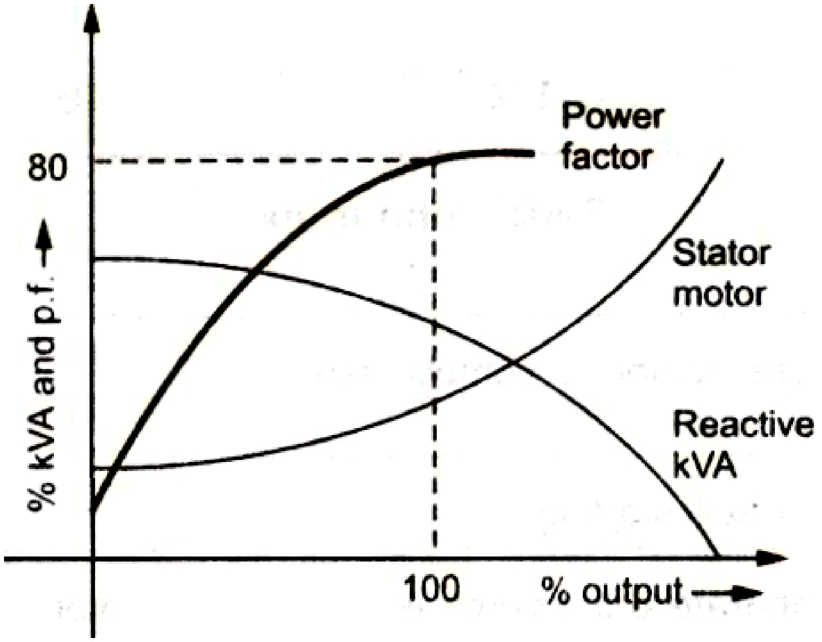
Thus the motor can be pulled into the synchronism if excitation is applied at a position that the rotor will occupy when both stator and rotor fields are synchronized.

THE CHARACTERISTICS CURVES FOR SYNCHRONOUS INDUCTION MOTOR OPERATING AT FULL LOAD UNITY POWER FACTOR



Unity p.f.

THE CHARACTERISTICS CURVES FOR SYNCHRONOUS INDUCTION MOTOR OPERATING AT FULL LOAD 0.8 POWER FACTOR LEADING



0.8 p.f. Leading

PERFORMANCE CHARACTERISTICS OF SYNCHRONOUS INDUCTION MOTORS:

While studying the performance characteristics of synchronous induction motor, three different types of torques are to be considered. These are viz. the starting torque which indicates capacity of motor to start against load, pull in torque which indicates the ability of the motor to maintain operation during change over from induction motor to synchronous motor, pull out torque which represents the running of motor synchronously at peak load. The first two torques are closely related with each other and are the characteristics of the machine running as induction motor. The pull out torque is characteristics when it is running synchronously. The characteristics curves for synchronous induction motor operating at full load unity power factor and at 0.8 power factor leading is shown in figure.

When the load exceeds the synchronous pull out torque, the machine looses synchronism and runs as an induction motor with fluctuation in torque and slip due to DC excitation. With reduction in load torque the motor is automatically resynchronized.

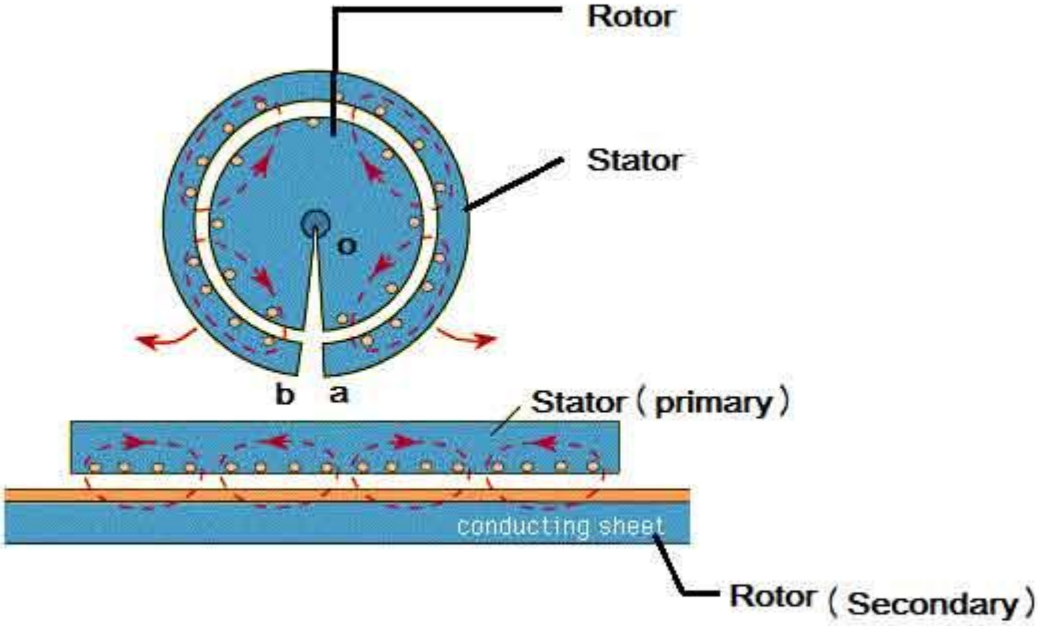
APPLICATIONS OF SYNCHRONOUS INDUCTION MOTOR:

The applications where mechanical load is to be driven along with phase advancing properties of synchronous motors are to be used then use of synchronous induction motor is better option. Also the applications where in load torque is remaining nearly constant, this motor can be used.

RESULT:

Thus the synchronous induction motor was studied.

Construction of a Linear Induction Motor



B) LINEAR INDUCTION MOTOR

AIM:

To study the Linear induction motor.

THEORY

Linear Induction motor abbreviated as LIM, is basically a special purpose motor that is in use to achieve rectilinear motion rather than rotational motion as in the case of conventional motors. This is quite an engineering marvel, to convert a general motor for a special purpose with more or less similar working principle, thus enhancing its versatility of operation. Let us first look into the construction of a LIM.

Construction of a Linear Induction Motor

Construction wise a LIM is similar to three phase induction motor in more ways than one as it has been depicted in the figure below.

If the stator of the poly phase induction motor shown in the figure is cut along the section aob and laid on a flat surface, then it forms the primary of the LIM housing the field system, and consequently the rotor forms the secondary consisting of flat aluminum conductors with ferromagnetic core for effective flux linkage.

There is another variant of LIM also being used for increasing efficiency known as the double sided linear induction motor or DLIM, as shown in the figure.

Which has a primary winding on either side of the secondary, for more effective utilization of the induced flux from both sides.

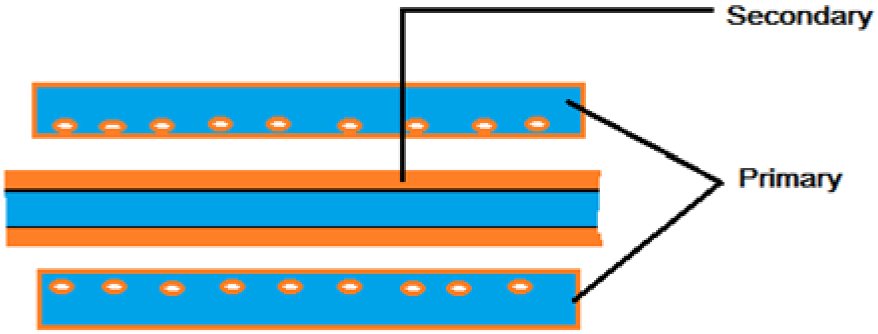
Working of a Linear Induction Motor

When the primary of an LIM is excited by a balanced three phase power supply, a traveling flux is induced in the primary instead of rotating 3 φ flux, which will travel along the entire length of the primary. Electric electric current is induced into the aluminum conductors or the secondary due to the relative motion between the traveling flux and the conductors. This induced electric current interacts with the traveling flux wave to produce linear force or thrust F. If the secondary is fixed and the primary is free to move, the force will move the primary in the direction of the force, resulting in the required rectilinear motion.

When supply is given, the synchronous speed of the field is given by the equation :

$$n_s = \frac{2f_s}{p}$$

Dual Linear Induction Motor



Where,

f_s is supply frequency in Hz,

p = Number of poles,

n_s is the synchronous speed of the rotation of magnetic field in revolutions per second.

The developed field will results in a linear traveling field, the velocity of which is given by the equation,

$$V_s = 2tf_s \ m/sec$$

Where, v_s is velocity of the linear traveling field, and t is the pole pitch.

For a slip of s, the speed of the LIM is given by

$$V = (1 - s)V_s$$

Application of Linear Induction Motor

A linear induction motor is not that widespread compared to a conventional motor, taking its economic aspects and versatility of usage into consideration. But there are quite a few instances where the LIM is indeed necessary for some specialized operations.

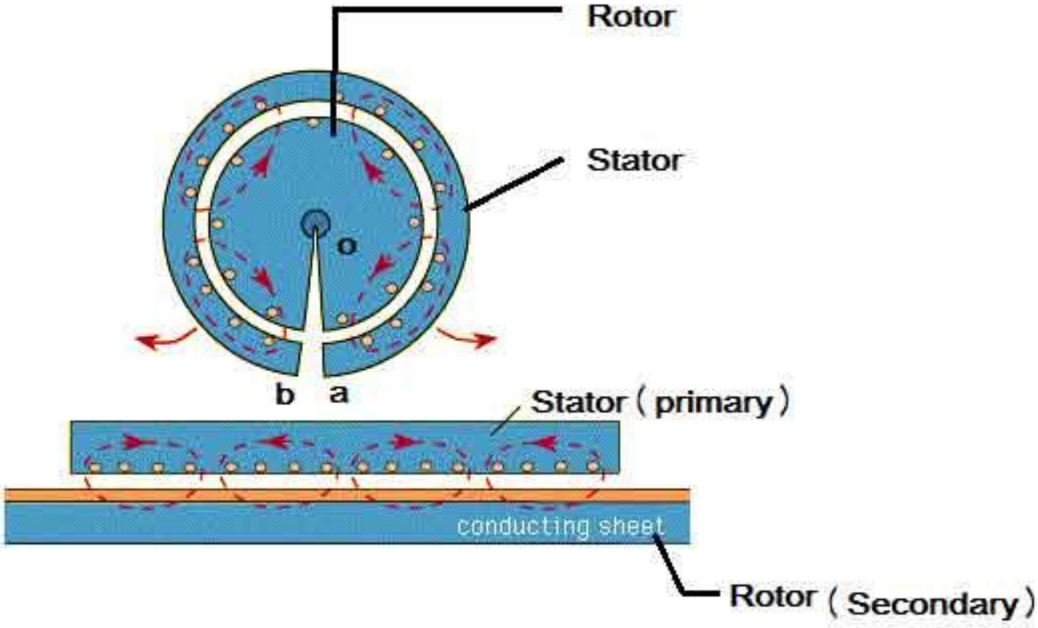
Few of the applications of a LIM have been listed below.

1. Automatic sliding doors in electric trains.
2. Mechanical handling equipment, such as propulsion of a train of tubs along a certain route.
3. Metallic conveyor belts.

RESULT:

Thus the linear induction motor was studied.

Construction of a Linear Induction Motor



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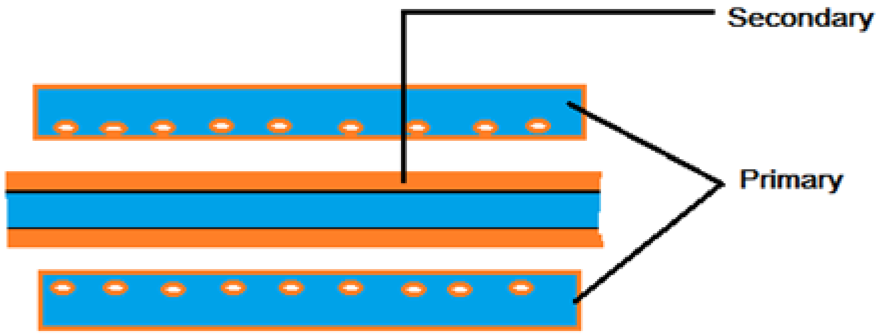

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