DMI COLLEGE OF ENGINEERING

PALANCHUR, CHENNAI- 600 123

Department of Electrical and Electronic Engineering

EE6512 Electrical Machines Laboratory – II

Name : ……………………………………

Reg. No. : ……………………………………

Branch : ……………………………………

Year & Semester : ……………………………………

EE6512 ELECTRICAL MACHINES LABORATORY - II LT P C 0 0 3 2

OBJECTIVES:

To expose the students to the operation of synchronous machines and induction motors and give them experimental skill.

LIST OF EXPERIMENTS:

1. Regulation of three phase alternator by emf and mmf methods.
2. Regulation of three phase alternator by ZPF and ASA methods.
3. Regulation of three phase salient pole alternator by slip test.
4. Measurements of negative sequence and zero sequence impedance of alternators.
5. V and Inverted V curves of Three Phase Synchronous Motor.
6. Load test on three-phase induction motor.
7. No load and blocked rotor test on three-phase induction motor (Determination of Equivalent circuit parameters).
8. Separation of No-load losses of three-phase induction motor.
9. Load test on single-phase induction motor.
10. No load and blocked rotor test on single-phase induction motor.
11. Study of Induction motor Starters

TOTAL : 45 PERIODS

OUTCOMES:

- Ability to model and analyze electrical apparatus and their application to power system

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Class/ Semester : III/ V

Sub & Code : **EE6512** - Electrical Machines Laboratory - II

LIST OF EXPERIMENTS

1. LOAD TEST ON 3-PHASE SQUIRREL CAGE INDUCTION MOTOR
2. LOAD TEST ON 3-PHASE SLIP RING INDUCTION MOTOR
3. LOAD TEST ON 1-PHASE INDUCTION MOTOR
4. REGULATION OF ALTERNATOR BY EMF AND MMF METHODS
5. REGULATION OF ALTERNATOR BY ZPF AND ASA METHODS
6. SEPARATION OF NO LOAD LOSSES IN INDUCTION MOTOR
7. NO LOAD AND BLOCKED ROTOR TEST ON 3-PHASE SQUIRREL CAGE INDUCTION MOTOR
8. V AND INVERTED V CURVES OF SYNCHRONOUS MOTOR
9. NO LOAD AND BLOCKED ROTOR TEST ON 1-PHASE SQUIRREL CAGE INDUCTION MOTOR
10. REGULATION OF THREE PHASE SALIENT POLE ALTERNATOR BY SLIP TEST
11. MEASUREMENT OF NEGATIVE SEQUENCE AND ZERO SEQUENCE OF AN ALTERNATOR

STAFF INCHARGE

EE2305 - Electrical Machines Laboratory - II

(ELECTRICAL AND ELECTRONICS ENGINEERING)

NAME OF THE STUDENT :

REGISTER NUMBER :

S.No	Date of Expt.	Name of The Experiment	Marks	Signature
1				
2				
3				
4				
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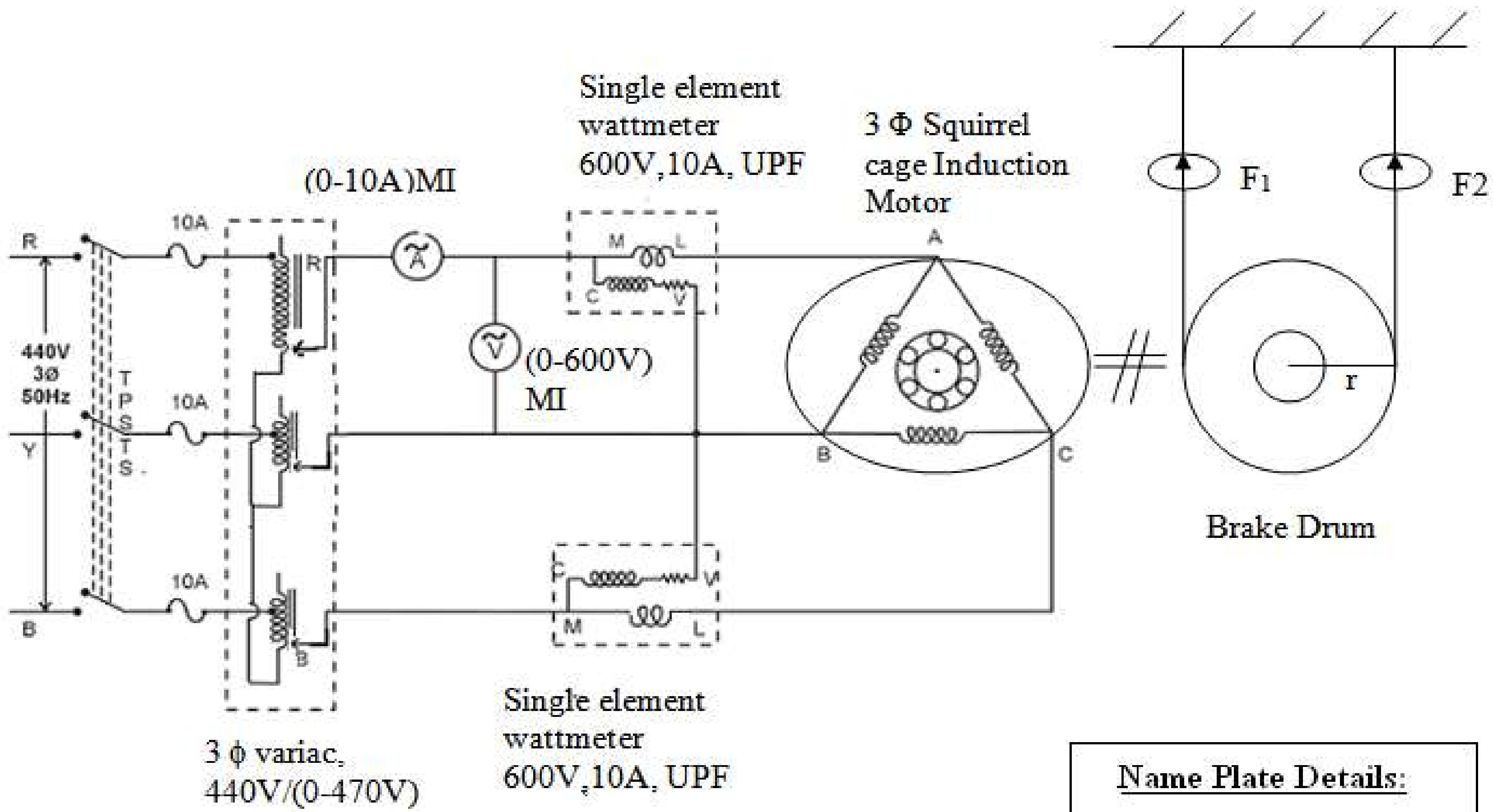
10				
11				

SIGNATURE OF THE STAFF INCHARGE

CIRCUIT DIAGRAM:



Name Plate Details:

Capacity :
Voltage :
Current :
Speed :

Date : **Ex. No: 1**

LOAD TEST ON THREE PHASE INDUCTION MOTOR

AIM:

To conduct the load test on three phase induction motor & to draw its performance & mechanical characteristics.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Type	Quantity
1	Ammeter	(0 – 10A)	MI	1
2	Voltmeter	(0 – 600)V	MI	1
3	Wattmeter	600V,10A,	UPF	2
4	3 Phase auto transformer	415V/ (0-470V	-	1
5	Tachometer	_	Digital	1
6	Connecting Wires	_	_	1 Set

THEORY:

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

FORMULA USED:

1. Torque $T=9.81x(f_1 \sim f_2)$ x r (N-M)
2. Output Power = 2ΠNT / 60
3. Input Power $=W_1+W_2$
4. % Slip $=(N_S\text{-}N) / (N_S)$ x 100
   Where, N_S = Synchronous speed = 1500 rpm.
5. Power factor = Input Power / $\sqrt{3}V_L I_L$
6. Efficiency = (Output Power / Input Power) x 100

OBSERVATION TABULATION:

Sl. No	Line Voltage V_L (Amps)	Line current I_L (Amps)	Wattmeter readings (Watts)				Input Power P_i (W_1 + W_2) Watts	Speed N (rpm)	Spring Balance Reading	
			W_1		W_2				F_1 (kg)	F_2 (kg)
			Reading	Actual	Reading	Actual				

CALCULATION TABULATION:

S.No	Line current I_L (Amps)	P.f	Torque (N-m)	% Slip	Output Power P_0 (Watts)	Input Power P_i (Watts)	% Efficiency η

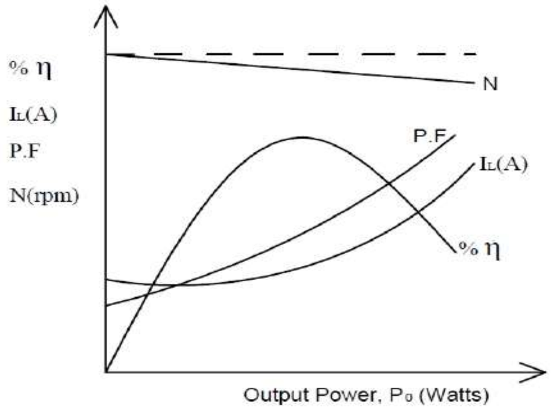
PRECAUTIONS:

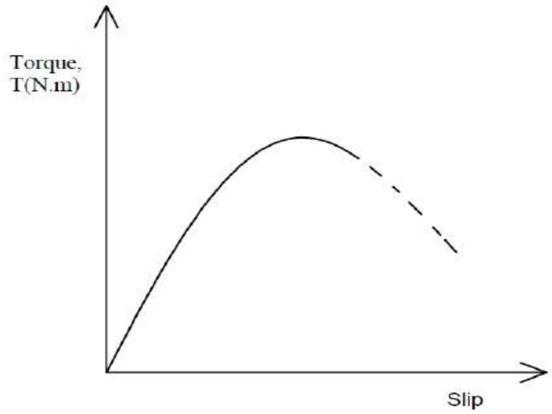
1. Fuses are checked out
2. Initially the motor should be in no load condition
3. Auto transformer should be of minimum position while switch on & off

PROCEDURE

1. Connections are given as per circuit diagram
2. The Supply is switched on
3. Variac is adjusted to provide the rated voltage
4. At no load condition, the line current; line voltage and power are noted. The speed of the motor is accessed by use of tachometer.
5. Load is gradually applied for various of load current, the speed of motor(n) the spring balance reading (f1 & f2) current (I_L), voltage(V_L) & power (W1 & W2) are noted

MODEL GRAPHS:

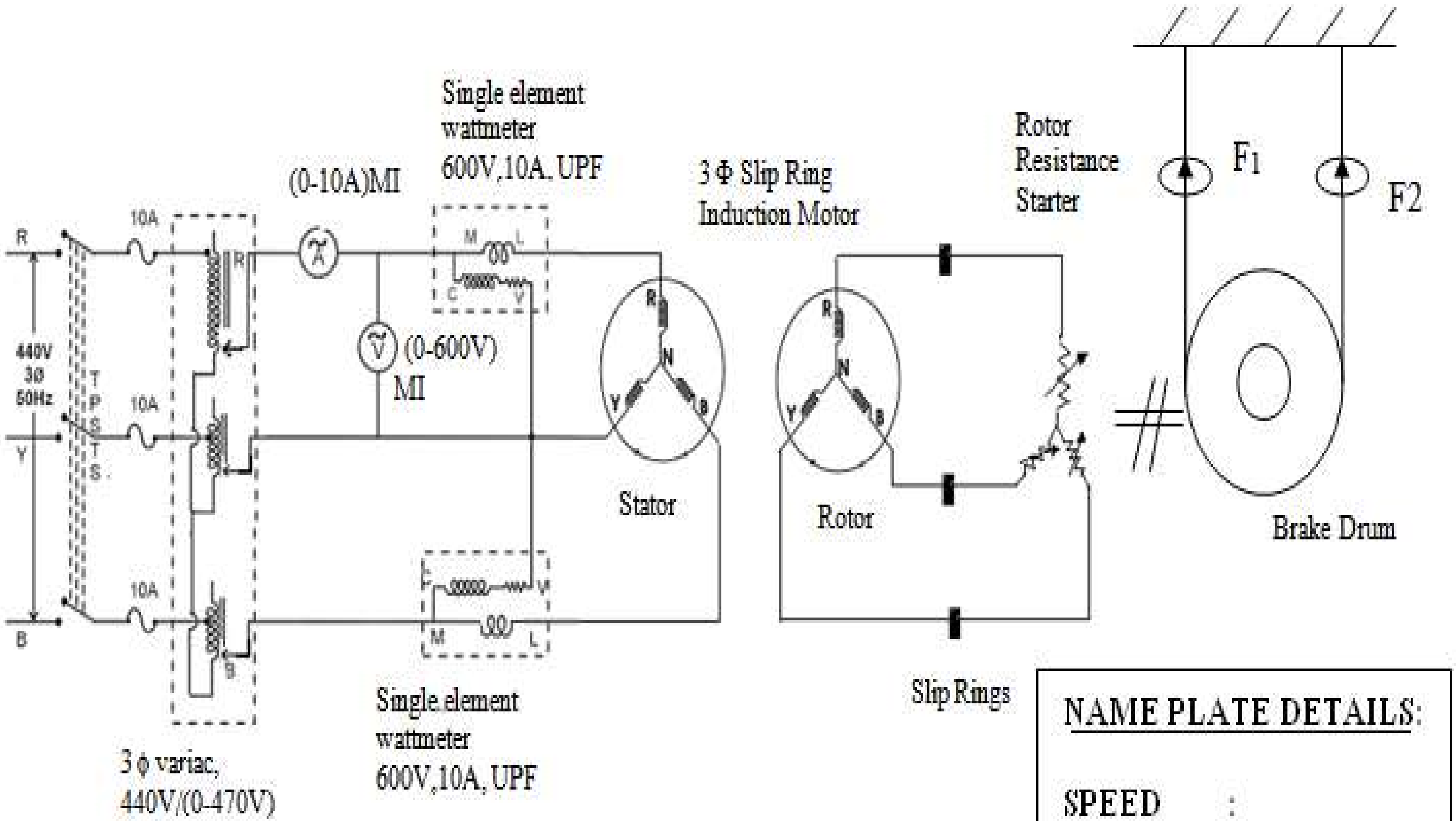




MODEL CALCULATION:

RESULT:

CIRCUIT DIAGRAM:



NAME PLATE DETAILS:

SPEED :
CAPACITY:
VOLTAGE :
CURRENT :

Date: **Ex. No: 2**

LOAD TEST ON THREE PHASE SLIP RING INDUCTION MOTOR

AIM:

To conduct the load test on three phase slip ring induction motor & to draw its performance & mechanical characteristics.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Type	Quantity
1	Ammeter	(0 – 10A)	MI	1
2	Voltmeter	(0 – 600)V	MI	1
3	Wattmeter	600V,10A	UPF	2
4	3 Phase auto transformer	415V/0-470V	-	1
5	Tachometer	_	-	1
6	Connecting Wires	_	_	1 Set

THEORY:

Slip ring induction motor is also called as phase wound motor. The motor is wound for as many poles as the no. of stator poles and always wound 3-Φ even while the stator is wound two-phase. The other three windings are brought out and connected to three insulated slip-rings mounted on the shaft with brushes resting on them. These three brushes are further externally connected to a three phase star connected rheostat. This makes possible the introduction of an additional resistance in the rotor circuit during starting period for increasing starting torque of the motor.

FORMULA USED:

1. Torque $T=9.81x(f_1 \sim f_2) \times r$ (N-M)
2. Output Power = $2\Pi NT / 60$
3. Input Power = W_1+W_2
4. % Slip $=(N_S-N) / (N_S) \times 100$

   Where, N_S = Synchronous speed = 1500 rpm.
5. Power factor = Input Power / $\sqrt{3}V_L I_L$
6. Efficiency = (Output Power / Input Power) x 100

OBSERVATION TABULATION:

S. No	Line Voltage V_L (Amps)	Line current I_L (Amps)	Wattmeter readings (Watts)				Input Power P_i (W_1+ W_2) Watts	Speed N (rpm)	Spring Balance Reading	
			W_1		W_2				F_1 (kg)	F_2 (kg)
			Reading	Actual	Reading	Actual				

-

CALCULATION TABULATION:

S.No	Line current I_L (Amps)	p.f	Torque (N.m)	% Slip	Output Power P_0 (Watts)	Input Power P_i	% Efficiency η

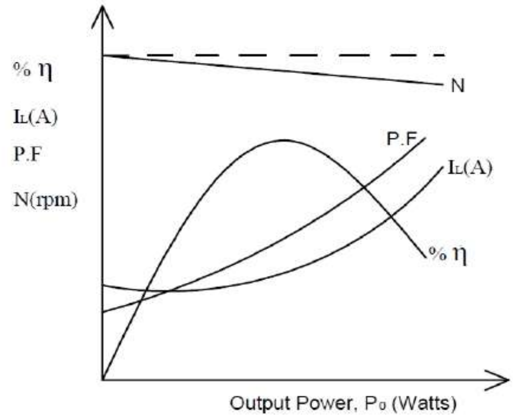
PRECAUTIONS:

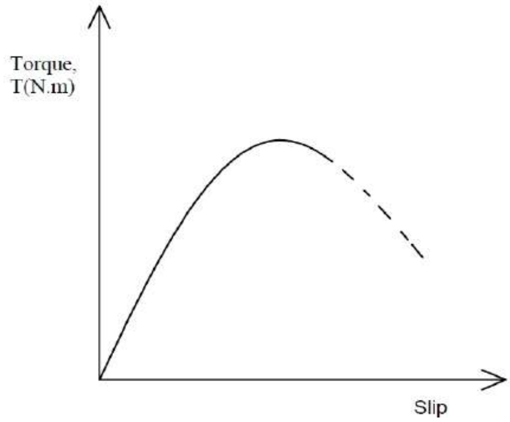
1. Fuses are checked out
2. Initially the motor should be in no load condition
3. Autotransformer should be of minimum position while switch on & off

PROCEDURE:

1. Connections are given as per circuit diagram
2. The Supply is switched on
3. Variac is adjusted to provide the rated voltage
4. Using Rotor resistance starter, slip ring induction motor is started by keeping resistance at maximum position.
5. After attaining rated speed of the motor, the resistance is reduced to minimum position.
6. At no load condition, the line current; line voltage and power are noted. The speed of the motor is accessed by use of tachometer.
7. Load is gradually applied for various of load current, the speed of motor(n) the spring balance reading (f1 & f2) current (I_L), voltage(V_L) & power (W1 & W2) are noted

MODEL GRAPHS:

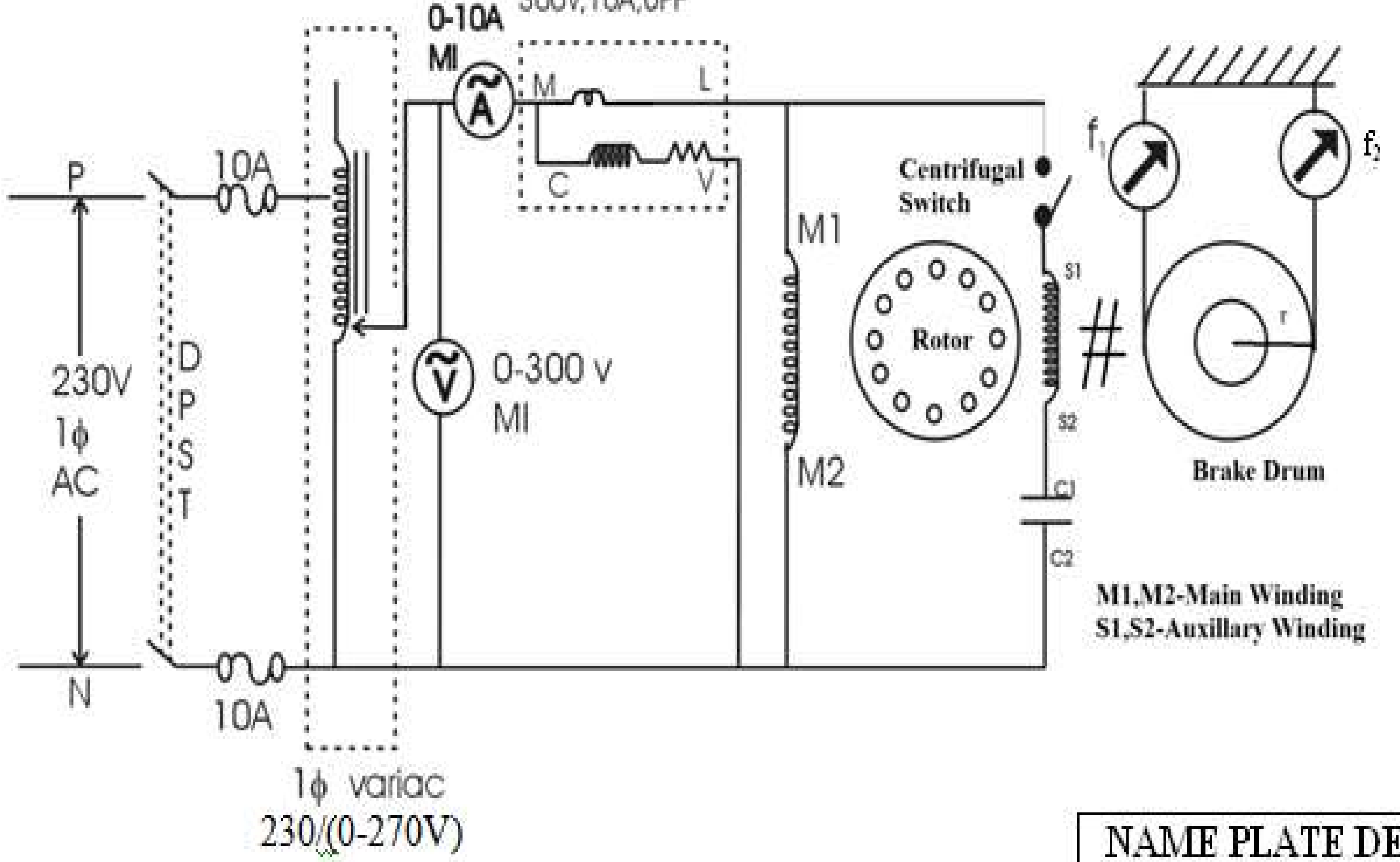




MODEL CALCULATION:

RESULT:

CIRCUIT DIAGRAM



NAME PLATE DETAILS:

CAPACITY:

VOLTAGE:

CURRENT:

SPEED:

Date: **Ex. No: 3**

LOAD TEST ON SINGLE PHASE INDUCTION MOTOR

AIM:

To conduct the load on single-phase induction motor & to draw its performance characteristics.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Type	Quantity
1	Ammeter	(0 – 10A)	MI	1
2	Voltmeter	(0 – 300)V	MI	1
3	Wattmeter	300V,10A	UPF	2
4	1 Phase auto transformer	230V/0-270V	-	1
5	Tachometer	_	-	1
6	Connecting Wires	_	_	1 Set

THEORY:

The single phase induction motor is more or less a polyphase induction motor. The only difference is that is given supply in single phase. This motor connect and motor function without any initial start the motor having some part which is called starter and rotor. These are two types of starting a 1 phase induction motor namely capacitor-start and other is split-phase. These motors are widely used in domestic purpose.

FORMULA USED:

1. Torque $T=9.81x(f_1 - f_2)$ x r (N-M)
2. Output Power = 2ΠNT / 60
3. Input Power $=W_L$ (Wattmeter readings in Watts)
4. % Slip $=(N_S-N) / (N_S)$ x 100

   Where, N_S = Synchronous speed = 1500 rpm.

5. Power factor = Input Power / $V_L I_L$
6. Efficiency = (Output Power / Input Power) x 100

OBSERVATION TABULATION:

Sl. No	Line Voltage V_L(Amps)	Line current I_L(Amps)	Input Power P_i (Watts)		Speed N(rpm)	Spring Balance Reading	
			Reading	Actual		F_1 (kg)	F_2 (kg)

CALCULATION TABULATION.

S.No	Line current I_L(Amps)	p.f	Torque (N.m)	% Slip	Output Power P_0(Watts)	Input Power Pi (Watts)	% Efficiency η

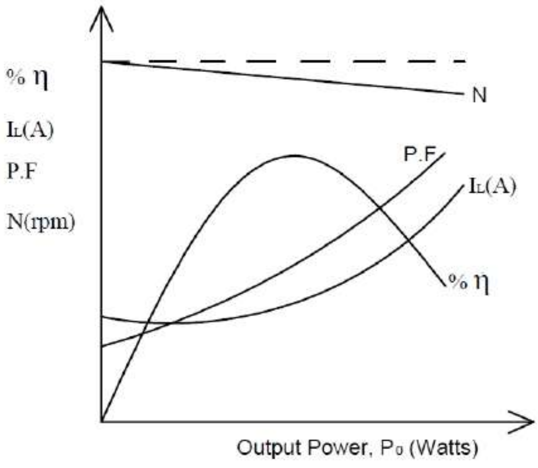
PRECAUTIONS:

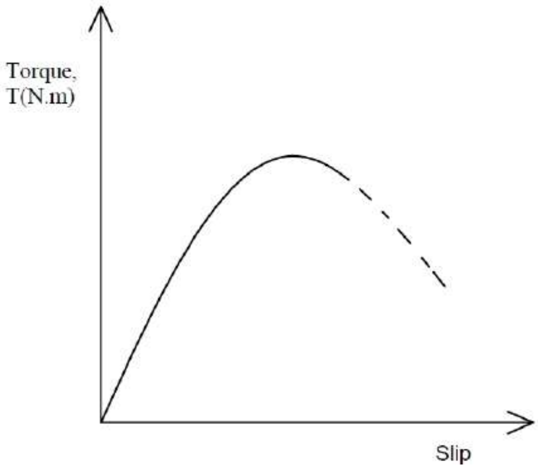
1. Fuses are checked out
2. Initially the motor should be in no load condition
3. The variac should be in minimum position

PROCEDURE:

1. Connections are given as per the circuit diagram
2. The supply is switched on
3. By adjusting the variac, set the rated voltage across the motor
4. By applying the load take various reading until rated load

MODEL GRAPHS:

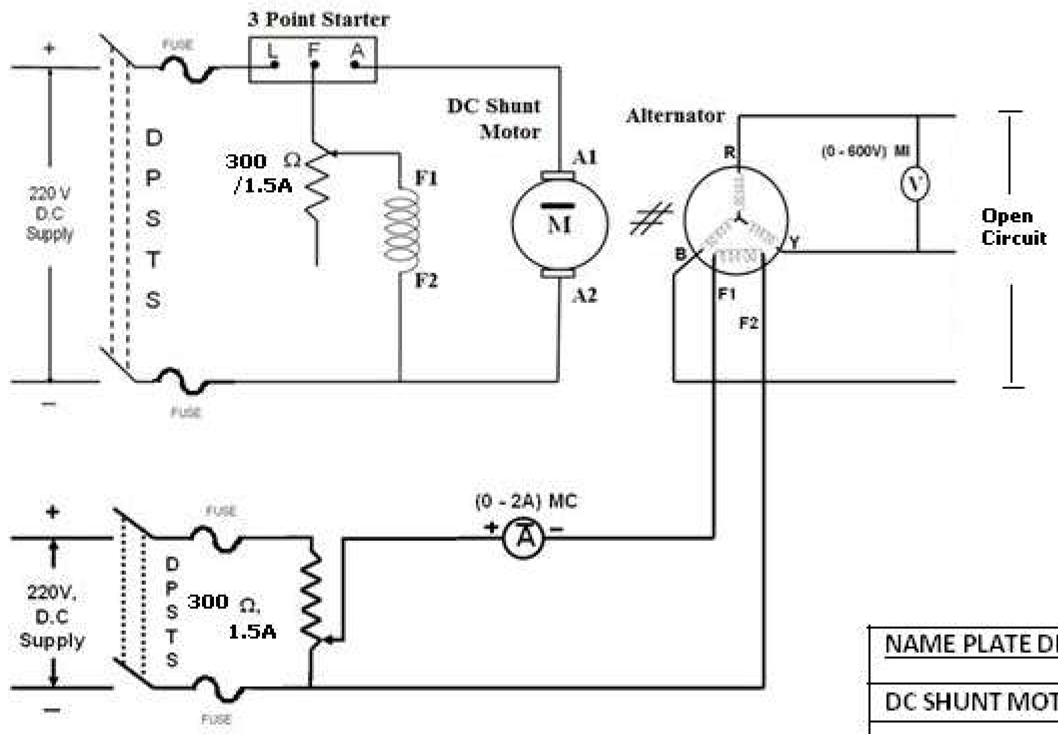




MODEL CALCULATION:

RESULT:

CIRCUIT DIAGRAM



NAME PLATE DETAILS:	
DC SHUNT MOTOR	3- PHASE ALTERNATOR
CAPACITY:	CAPACITY:
VOLTAGE:	VOLTAGE:
CURRENT:	CURRENT:
SPEED:	SPEED:
EXCITATION:	EXCITATION:

Date: **Ex. No: 4**

REGULATION OF THREE PHASE ALTERNATOR BY EMF AND MMF METHOD

AIM:

To predetermine the regulation of three phase alternator by EMF and MMF method.

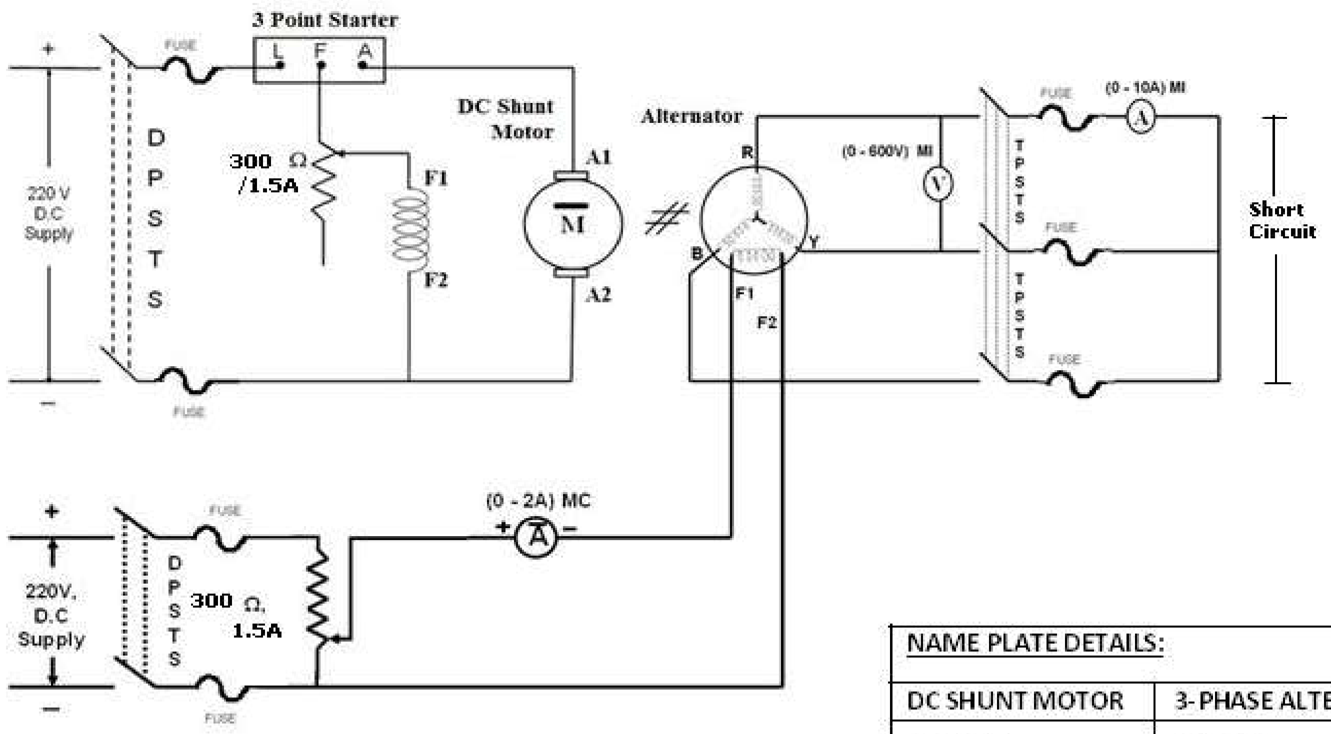
APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Type	Quantity
1	Ammeter	(0 – 10A)	MI	1
2	Ammeter	(0 – 2)A	MC	1
3	Voltmeter	(0 – 600)V	MI	1
4	Rheostat	300Ω,1.5A	_	1
5	Rheostat	300Ω,1.5A	_	1
6	DPST Switch	_	_	1
7	Tachometer	_	_	1
8	Connecting Wires	_	_	1 Set

THEORY:

The regulation of a 3-phase alternator may be predetermined by conducting the Open Circuit (OC) and the Sort Circuit (SC) tests. The methods employed for determination of regulation are EMF or synchronous impedance method, MMF or Ampere Turns method and the ZPF or 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 is much more than the actual value. The MMF method is also called optimistic method as the value of regulation obtained is much less than the actual value. In the MMF method the armature leakage reactance is treated as an additional armature reaction. In both methods the OC and SC test data are utilized.

CIRCUIT DIAGRAM



NAME PLATE DETAILS:	
DC SHUNT MOTOR	3-PHASE ALTERNATOR
CAPACITY:	CAPACITY:
VOLTAGE:	VOLTAGE:
CURRENT:	CURRENT:
SPEED:	SPEED:
EXCITATION:	EXCITATION:

FORMULA USED:

EMF Method:

1. Synchronous impedance, **Z**s = $\frac{\text{open circuit voltage per phase (E)}}{\text{short circuit current (I)}}$ for same I_f

2. Synchronous reactance, $Xs = \sqrt{Zs^2 - Rac^2}$

3. $Vph = \frac{V_L}{\sqrt{3}}$

4. Rac = 1.6 Rdc (1.6 for skin effect and DC to AC conversion)

5. $\%\ \text{Regulation (down)} = \frac{Eph - Vph}{Vph} \times 100$

For lagging p.f, $Eph = \sqrt{(V_{Ph}\cos\varphi + I_aR_a)^2 + (V_{Ph}\sin\varphi + I_aX_S)^2}$

For leading p.f, $Eph = \sqrt{(V_{Ph}\cos\varphi + I_aR_a)^2 + (V_{Ph}\sin\varphi - I_aX_S)^2}$

For unity p.f, $Eph = \sqrt{(V_{Ph} + I_aR_a)^2 + (I_aX_S)^2}$

Where, Eph is the induced voltage in volts(Calculated from formula)
Vph is the terminal voltage in volts(Rated voltage/√3)

MMF Method:

At Lagging Power factor,

1. $F_R = \sqrt{[(F_0^2) + (F_{AR}^2) - 2 F_0 F_{AR} \cos(90 + \Phi)]}$

At Leading Power factor,

1. $F_R = \sqrt{[(F_0^2) + (F_{AR}^2) - 2 F_0 F_{AR} \cos(90 - \Phi)]}$

   F_0 - Field current corresponds to voltage $V=V_{ph}+I_{aph} R_a \cos\Phi$ (from OCC)

   F_{AR} - Field current corresponds to rated full load current on short circuit (from SC, I_{aph})

   E_{ph} – Voltage corresponding to Field current F_R

2. $\%\ \text{Regulation (down)} = \frac{Eph - Vph}{Vph} \times 100$

Where,

Eph is the induced voltage found from graph ie., Open circuit characteristics curve for the required resultant field current (**F_{AR}**).

Vph is the terminal voltage in volts

OBSERVATION TABULATION

1. O.C TEST:

S.No	Field current I_F (Amps)	No-Load Voltage E_o (Volts)	Phase Voltage $V_{ph}=V_L/\sqrt{3}$ (Volts)

2. S.C.TEST:

S.No	Rated Short circuit current I_{sc} (Amps)	Field current I_f (Amps)

PRECAUTIONS:

1. Fuses are checked out
2. The field Rheostat of the DC motor was kept in minimum position.
3. The field rheostat of the Alternator was kept in maximum position.

PROCEDURE:

Tests to be carried out:

1. Open Circuit Test:
2. Short Circuit Test:
3. Measurement of Stator Resistance

Open Circuit Test:

1. Note down the name plate details of the motor and alternator.
2. Connections are made as per the circuit diagram.
3. Switch ON the supply by closing the DPST switch.
4. Using the Three point starter, start the motor and by adjusting the motor field rheostat, make the motor to run at the rated speed.
5. By varying the potential divider of alternator for various values of field current, tabulate the corresponding Open Circuit Voltage readings.
6. The field current of the alternator was varied in steps until the machine attains its maximum voltage. The corresponding readings were noted down.
7. The system is brought back to its initial position by varying the field rheostat of the alternator.

Short Circuit Test:

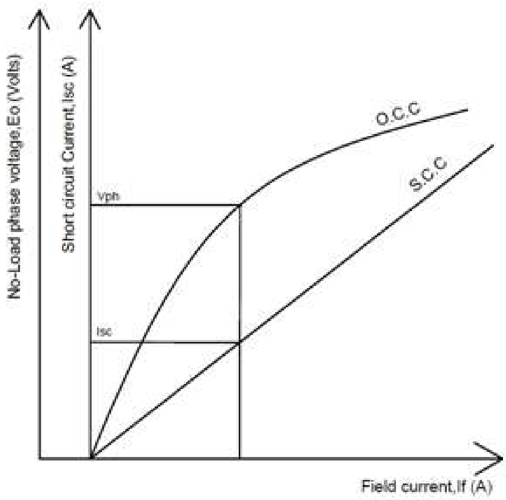
1. Conduct Short Circuit test by closing the TPST switch and adjust the potential divider to set the rated armature current of the alternator and tabulate the corresponding field current.
2. Bring the system to its initial position by varying the field rheostat of the alternator.
3. Reduce the field rheostat of the dc motor.
4. Turn off the input supply to the dc motor.

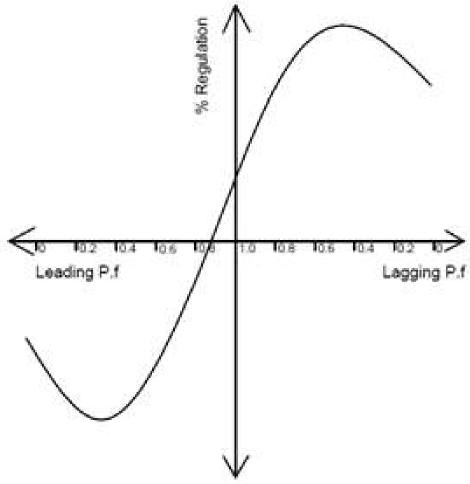
CALCULATION TABULATION:

i).EMF method:

S.No	Power factor cos Ø	sin Ø	No-Load phase voltage, E_0 (volts)		% Regulation	
			Lagging p.f	Leading p.f	Lagging p.f	Leading p.f
1.	0					
2.	0.2					
3.	0.4					
4.	0.6					
5.	0.8					
6.	1.0					

MODEL GRAPHS (EMF METHOD)





MODEL CALCULATION:

PROCEDURE TO DRAW GRAPH FOR EMF METHOD:

1. Draw the Open Circuit Characteristic curve (Generated Voltage per phase VS Field current).
2. Draw the Short Circuit Characteristics curve (Short circuit current VS Field current)
3. From the graph find the open circuit voltage per phase (Eph) for the rated short circuit current (Isc) at the same excitation (I_f).
4. By using respective formulae find the Zs, Xs, Eo and percentage regulation.

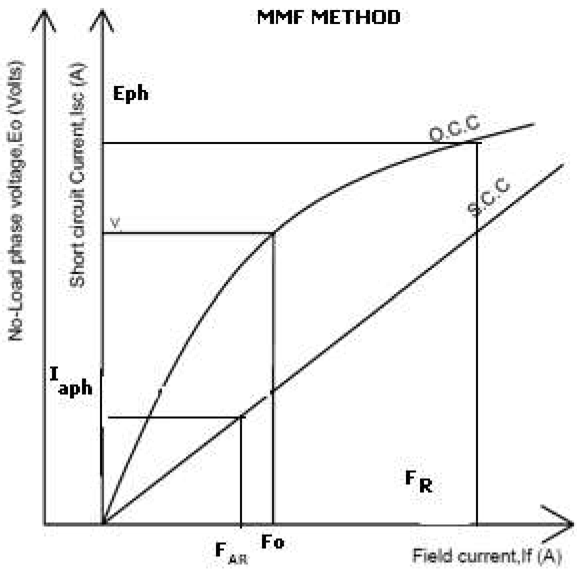
PROCEDURE TO DRAW GRAPH FOR MMF METHOD:

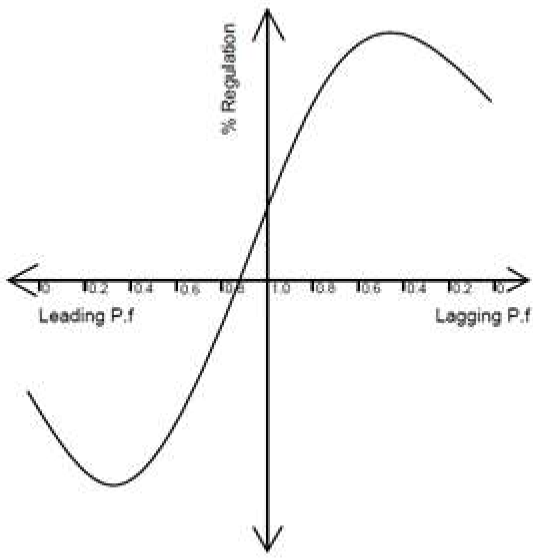
1. Draw the Open Circuit Characteristic curve and Short Circuit Characteristics curve.
2. From the graph. Find
   F_0 - Field current corresponds to voltage $V=V_{ph}+I_{aph} R_a \cos\Phi$ (from OCC)
   F_{AR} - Field current corresponds to rated full load current on short circuit (from SC, I_{aph})
3. F_R is calculated using the given formula for various lagging and leading power factors.
4. For each calculated value of F_R, corresponding values of Eph are noted from the open circuit characteristics(graph)
5. By using respective formulae, calculate percentage regulation.

ii).MMF method:

S.No	Power factor cos Ø	Total field current, I_f (Amps)		No-Load phase voltage, E_o (volts)		% Regulation	
		Lagging p.f	Leading p.f	Lagging p.f	Leading p.f	Lagging p.f	Leading p.f
1.	0						
2.	0.2						
3.	0.4						
4.	0.6						
5.	0.8						
6.	1.0						

MODEL GRAPHS:

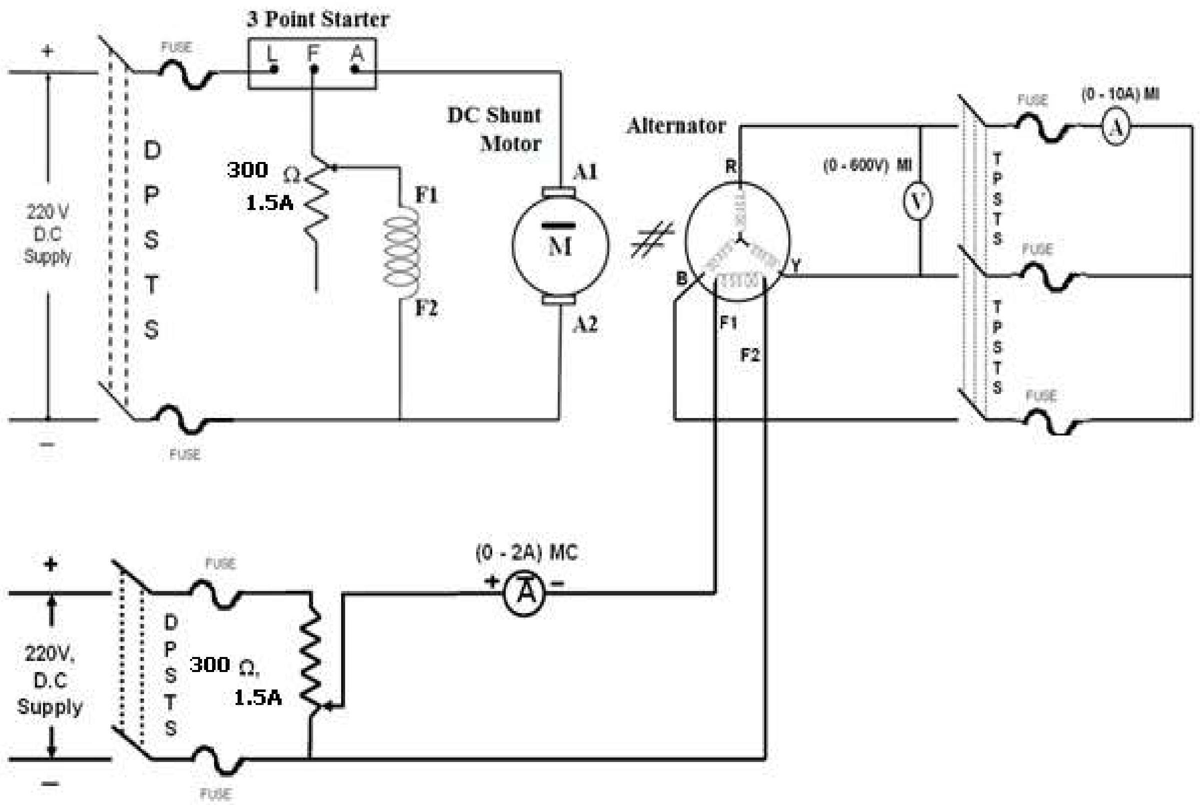




MODEL CALCULATION:

RESULT:

CIRCUIT DIAGRAM:



NAME PLATE DETAILS:	
DC SHUNT MOTOR	3-PHASE ALTERNATOR
CAPACITY:	CAPACITY:
VOLTAGE:	VOLTAGE:
CURRENT:	CURRENT:
SPEED:	SPEED:

Date: **Ex. No: 5**

REGULATION OF THREE PHASE ALTERNATOR BY ZPF AND ASA METHOD

AIM:

To predetermine the regulation of three phase alternator by Zero Power Factor (ZPF) and American Standard Association (ASA) method.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Type	Quantity
1	Ammeter	(0 – 10A)	MI	1
2	Ammeter	(0 – 2)A, (0 – 10)A	MC	1
3	Voltmeter	(0 – 600)V	MI	1
4	Rheostat	300Ω / 1.5A	_	2
5	DPST Switch, TPST Switch	_	_	1 each
6	Tachometer	_	-	1
7	Connecting Wires	_	_	1 Set

THEORY:

ZPF method is based on the separation of armature leakage reactance and armature reaction effects. To determine armature leakage reactance and armature reaction mmf separately, two tests are performed on the alternator.

The two tests are

1. Open circuit test
2. Short circuit test
3. Zero power factor tests

ASA means American standard Association method. This is a modification of mmf method. In these methods, the magnetic circuit is assumed to be unsaturated. If we consider the saturated magnetic circuit, the resultant excitation is not If, but it is If'. This additional excitation can be obtained by ASA method.

OBSERVATION TABULATION:

1. O.C TEST:

S.No	Field current I_f (Amps)	No-Load Voltage E_O (Volts)

2. S.C.TEST:

S.No	Rated Short circuit current I_{sc} (Amps)	Field current I_f (Amps)

3. ZPF TEST:

S.No	Field current, I_f (Amps)	EMF/Phase, E (Volts)

FORMULA USED:

ZPF Method:

At Lagging Power factor,

1. Open circuit voltage for lagging p.f ,$E_{ph1} = \sqrt{(V_{ph}\cos\Phi + IaRa)^2 + (V_{ph}\sin\Phi + IaX_L)^2}$

   Where Vph = $\mathbf{V_L/\sqrt{3}}$

   Cos φ = 0.8 & Sin φ=0.6

   $Ia = Kva \times 10^3 / (\sqrt{3}\, V_L)$

2. $F_R = \sqrt{[(F_{f1}^2) + (F_{AR}^2) - 2 F_{f1} F_{AR} \cos(90 + \Phi)]}$
3. % Regulation (down) = $\frac{Eph - Vph}{Vph} \times 100$

At Leading Power factor,

1. Open circuit voltage for leading p.f.,$E_{ph1} = \sqrt{(V_{ph}\cos\Phi + IaRa)^2 + (V_{ph}\sin\Phi - IaX_L)^2}$
2. $F_R = \sqrt{[(F_{f1}^2) + (F_{AR}^2) - 2 F_{f1} F_{AR} \cos(90 - \Phi)]}$
3. % Regulation (down) = $\frac{Eph - Vph}{Vph} \times 100$

At Unity Power factor,

1. Open circuit voltage for unity p.f,$E_{ph1} = \sqrt{(V_{ph} + IaRa)^2 + (IaX_L)^2}$
2. $F_R = \sqrt{[(F_{f1}^2) + (F_{AR}^2)}$
3. % Regulation (down) = $\frac{Eph - Vph}{Vph} \times 100$

Eph - Induced voltage considering resistance and leakage reactance drop (Ra, X_L)(Using formula)

Eph - Induced voltage considering resistance, leakage reactance & armature reaction

Vph - Terminal voltage

I_{aph} - Load Current from ZPF test

$I_{aph}X_L$ - Leakage reactance drop obtained from Potier Triangle

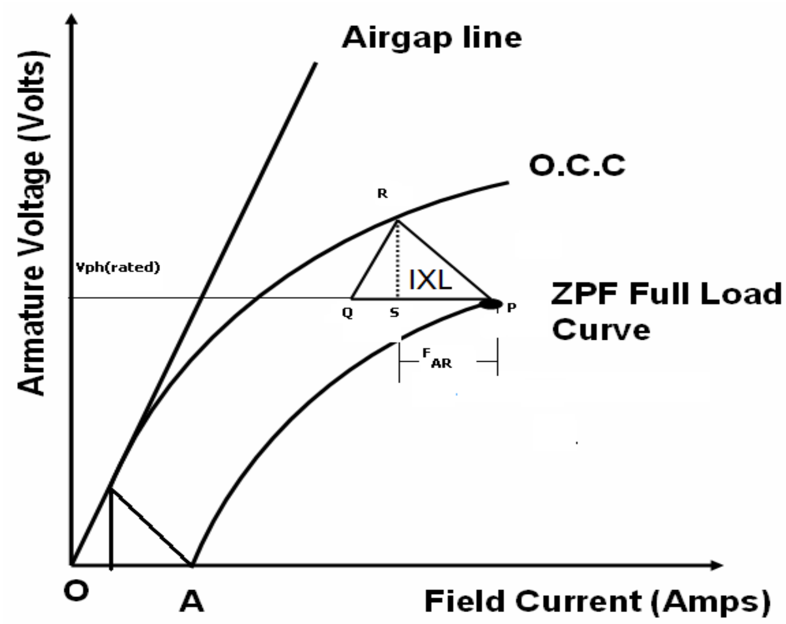
F_{f1}- Field current corresponding to E_{ph1} from OCC

F_{AR}- Field current for balancing Armature reaction , obtained from Potier Triangle(PS)

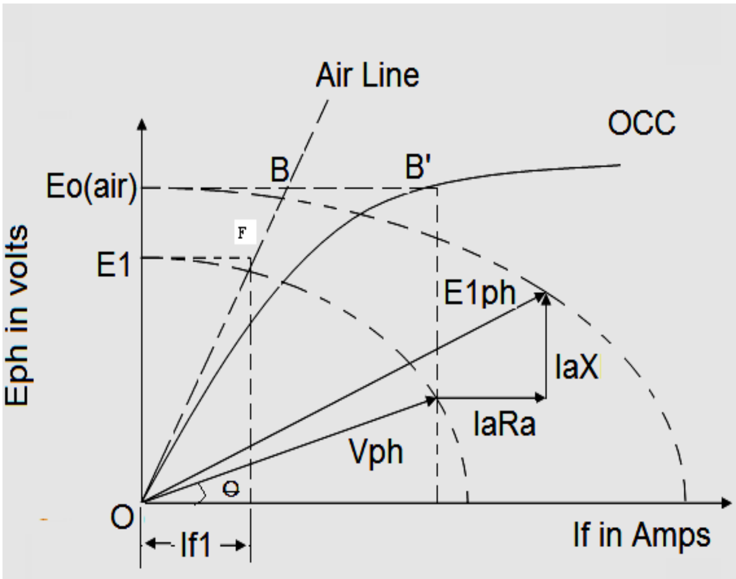
F_{AR}= l(PS) x scale

Model Graph:

i) ZPF Method:



ii) **ASA METHOD:**



Vph = Vph / power scale

PRECAUTIONS:

1. Fuses are checked out
2. The field Rheostat of the DC motor was kept in minimum position.
3. The field rheostat of the Alternator was kept in maximum position.

PROCEDURE:

Tests to be carried out:

1. Open Circuit Test
2. Short Circuit Test
3. ZPF test
4. Measurement of Stator Resistance

Open Circuit Test:

1. Note down the name plate details of the motor and alternator.
2. Connections are made as per the circuit diagram.
3. Switch ON the supply by closing the DPST switch.
4. Using the Three point starter, start the motor and by adjusting the motor field rheostat, make the motor to run at the rated speed.
5. By varying the potential divider of alternator for various values of field current, tabulate the corresponding Open Circuit Voltage readings.
6. The field current of the alternator was varied in steps until the machine attains its maximum voltage. The corresponding readings were noted down.
7. The system is brought back to its initial position by varying the field rheostat of the alternator.

Short Circuit Test:

1. Conduct Short Circuit test by closing the TPST switch and adjust the potential divider to set the rated armature current of the alternator and tabulate the corresponding field current.
2. Bring the system to its initial position by varying the field rheostat of the alternator.
3. Reduce the field rheostat of the dc motor.
4. Turn off the input supply to the dc motor.

ZPF Test:

1. Conduct ZPF test by connecting inductive load to the alternator to obtain Zero Power factor.
2. By varying the potential divider of alternator, set the value of rated voltage.
3. Set a particular value of load current by increasing inductive load.
4. Take a set of readings by decreasing the potential divider , and also maintaining constant load current.

Measurement of Stator Resistance:

1. The Stator resistance per phase is determined by connecting any one phase stator winding of the alternator as per the circuit diagram .
2. Switch ON the supply by closing the DPST switch and give low voltage DC supply.
3. By varying the carbon rheostat, take various values of ammeter and voltmeter readings.

MODEL CALCULATION:

PROCEDURE TO DRAW THE POTIER TRIANGLE (ZPF METHOD):

1. Draw the Open Circuit Characteristics (Generated Voltage per phase VS Field Current)
2. Mark the point A at X-axis, which is obtained for field current 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 P 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 and Mark the 'P' point in ZPF curve corresponding to Vph(rated).
6. Draw the line PQ from P towards Y-axis, which is parallel and equal to OA.
7. Draw the parallel line for the tangent from Q to meet the OCC curve at point R.
8. Join the points P and R also drop the perpendicular line RS to PQ, where the line

RS represents armature leakage reactance drop ($I_{ph}X_L$) an $I_{ph}X_L$ = l(RS) x Power scale

PS represents Field current due to armature reaction excitation (F_{AR}) & F_{AR}= l(PS) x Power scale

9. From armature leakage reactance drop obtained from potier triangle(RS-IX_L), calculate the value of induced voltage considering resistance and leakage reactance drops(IRa, IX_L) using the formula

Open circuit voltage for lagging p.f ,$E_{ph1} = \sqrt{(V_{ph}\cos\Phi + IaRa)^2 + (V_{ph}\sin\Phi + IaX_L)^2}$

Open circuit voltage for leading p.f.,$E_{ph1} = \sqrt{(V_{ph}\cos\Phi + IaRa)^2 + (V_{ph}\sin\Phi - IaX_L)^2}$

Open circuit voltage for unity p.f,$E_{ph1} = \sqrt{(V_{ph} + IaRa)^2 + (IaX_L)^2}$

10. For each value of E_{ph1}, obtain the corresponding value of F_{f1}(excitation w.r.t leakage reactance)from Open circuit characteristic(graph).
11. From the obtained values of F_{f1} (from OCC graph corresponding to E_{ph1}) and F_{AR} (from potier triangle) calculate the value of F_R ie., resultant field current considering leakage reactance and armature reaction reactance using the formula

For lagging p.f $F_R = \sqrt{[(F_{f1}^2) + (F_{AR}^2) - 2 F_{f1} F_{AR} \cos(90 + \Phi)]}$

For leading p.f., $F_R = \sqrt{[(F_{f1}^2) + (F_{AR}^2) - 2 F_{f1} F_{AR} \cos(90 - \Phi)]}$

For unity p.f $F_R = \sqrt{[(F_{f1}^2) + (F_{AR}^2)]}$

For each value of F_R, take the corresponding value of Eph ie., Induced voltage considering resistance , leakage reactance & armature reaction reactance drop ($Ra, X_L X_{ar}$) from OCC(graph)

12. For the obtained value of Eph ,calculate the % regulation using the formula

$$\% \text{ Regulation (down)} = \frac{Eph - Vph}{Vph} \times 100$$

PROCEDURE FOR ASA METHOD:

(All the quantities are in per phase value)

1. Draw the Open Circuit Characteristics (Generated Voltage per phase VS Field Current)
2. Take the values of Armature leakage reactance drop from ZPF method and I_aR_a Drop= I_aR_a / Power Scale
3. Assuming X-axis as current phasor,draw Vph(rated terminal per phase voltage)at an angle Φ to X-axis by choosing appropriate scale.
4. Draw I_aR_a vector inphase with current vector from Vph and I_aX_L vector perpendicular to I_aR_a. And $I_aX_L = I_aX_L$/ Power Scale
5. Addition of $V_{ph}+I_aR_a+I_aX_L$ gives E1ph vector
6. To get the value of E1 from graph,
   With 'O' as centre and Vph as radius, draw an arc to cut the Y-axis at a point E_1.

   From E_1, draw a parallel line to X-axis to cut the airline at a point 'F'.

   The Value of 'OF' corresponding to current scale gives the value of $\mathbf{F_{f1}}$.
7. To get the value of $E_{0(air)}$ from graph,
   With 'O' as centre and E1ph as radius, draw an arc to cut the Y-axis at a point $E_{0\ (Air)}$

   From $E_{0(Air)}$,draw a parallel line to X-axis to cut the airline at a point B and OCC at B'.
8. The Value of **BB'** corresponding to field current scale gives the value of additional excitation for partially saturated magnetic field.
9. Resultant field current without considering the effect of partially saturated magnetic field is
   Calculated using the formula,

   For lagging p.f $F_R = \sqrt{[(F_{f1}^2) + (F_{AR}^2) - 2 F_{f1} F_{AR} \text{Cos}(90 + \Phi)]}$

   For leading p.f., $F_R = \sqrt{[(F_{f1}^2) + (F_{AR}^2) - 2 F_{f1} F_{AR} \text{Cos}(90 - \Phi)]}$

   For unity p.f $F_R = \sqrt{[(F_{f1}^2) + (F_{AR}^2)]}$

   F_{f1} – from ASA graph

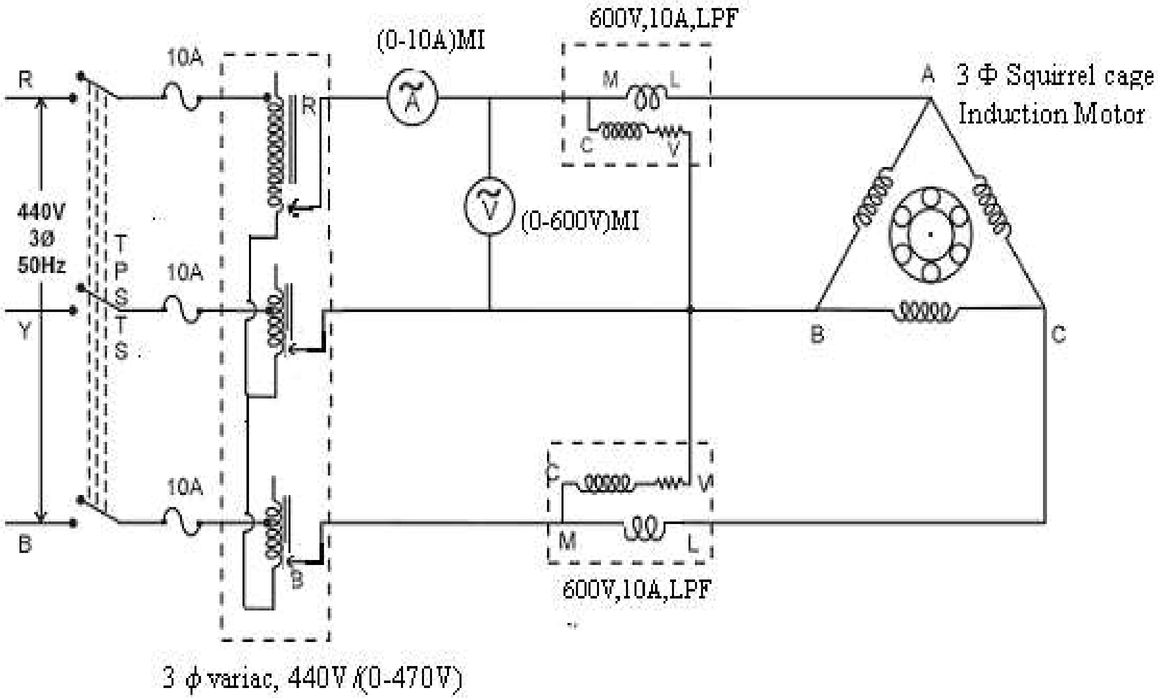
   F_{AR} – from Potier triangle
10. Resultant field current considering the effect of partially saturated magnetic field (I_{fr}')is calculated using the formula,

    $$F_R' = F_R + BB'$$
11. For each value of F_R', corresponding values of E_{ph} is noted from OCC(graph)
12. For the values of E_{ph} ,% regulation is calculated using,

$$\% \text{ Regulation (down)} = \frac{\text{Eph} - \text{Vph}}{\text{Vph}} \times 100$$

RESULT:

CIRCUIT DIAGRAM



NAME PLATE DETAILS:

CAPACITY:
VOLTAGE:
CURRENT:
SPEED:

Date: **Ex. No: 6**

SEPERATION OF NO LOAD LOSSES THREE PHASE SQUIRREL CAGE INDUCTION MOTOR

AIM:

To separate the No load losses in three phase squirrel cage induction motor as core loss and Mechanical loss

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Type	Quantity
1.	Ammeter	(0 – 10)A	MI	2
2.	Voltmeter	(0 – 600)V	MI	1
3.	Wattmeter	600V/10A	LPF	1
4.	3ϕ Autotransformer	415V/ (0- 470V)	–	1
5.	Connecting Wires	_	_	1 Set

THEORY:

The no load losses are the constant losses which include core loss and friction and Windage loss. The separation between the two can be carried out by the no load test conducted from variable voltage, rated frequency supply. When the voltage is decreased below the rated value, the core loss reduces as nearly square of voltage. The slip does not increase significantly the friction and Windage loss almost remains constant.

The voltage is continuously decreased, till the machine slip suddenly begins to increase and the motor tends to stall. At no load this takes place at a sufficiently reduced voltage. The graph showing no load losses versus voltage is extrapolated to V =0 which gives friction and Windage loss as iron or core loss is zero at zero voltage.

FORMULA USED :

1. Input power(W_i) = $W_1 + W_2$ watts
2. Stator Copper loss = 3 Ia^2 Ra watts
3. Constant loss/phase(W_c) = (W-3 Ia^2 Ra)/3 Watts
4. Core Loss/phase (W_i) = Constant loss/phase – Mechanical Loss
5. Stator Resistance/phase ,R_s = 1.6 x 1.2 x Rdc

TABULATION:

Sl.No	No Load Voltage, V_0 (Volts)	No Load current, I_0 (Amps)	W1(Watts)		W2(Watts)		No Load Input Power, W=W1+W2 (Watts)	Constant Loss	Core Loss	Stator copper loss
			Reading	Actual	Reading	Actual				

MODEL CALCULATION:

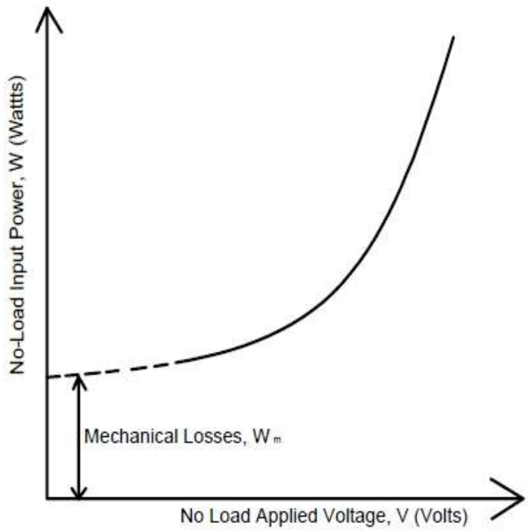
PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Adjust the voltage applied to the induction motor in convenient steps, note down the wattmeter readings.
3. Repeat this procedure up to rated voltage and slightly above the rated voltage.

Procedure for Separation of No Load Losses:

1. From no load test, Plot a graph W and V as shows.
2. For rated voltage read W. This represents the iron and mechanical losses, as stator Cu loss on no load is negligible. Note it as W_o
3. Extend the graph so that it intercepts the y axis. This y axis intercept represents the
4. Mechanical losses of the IM. Note this as W_m.

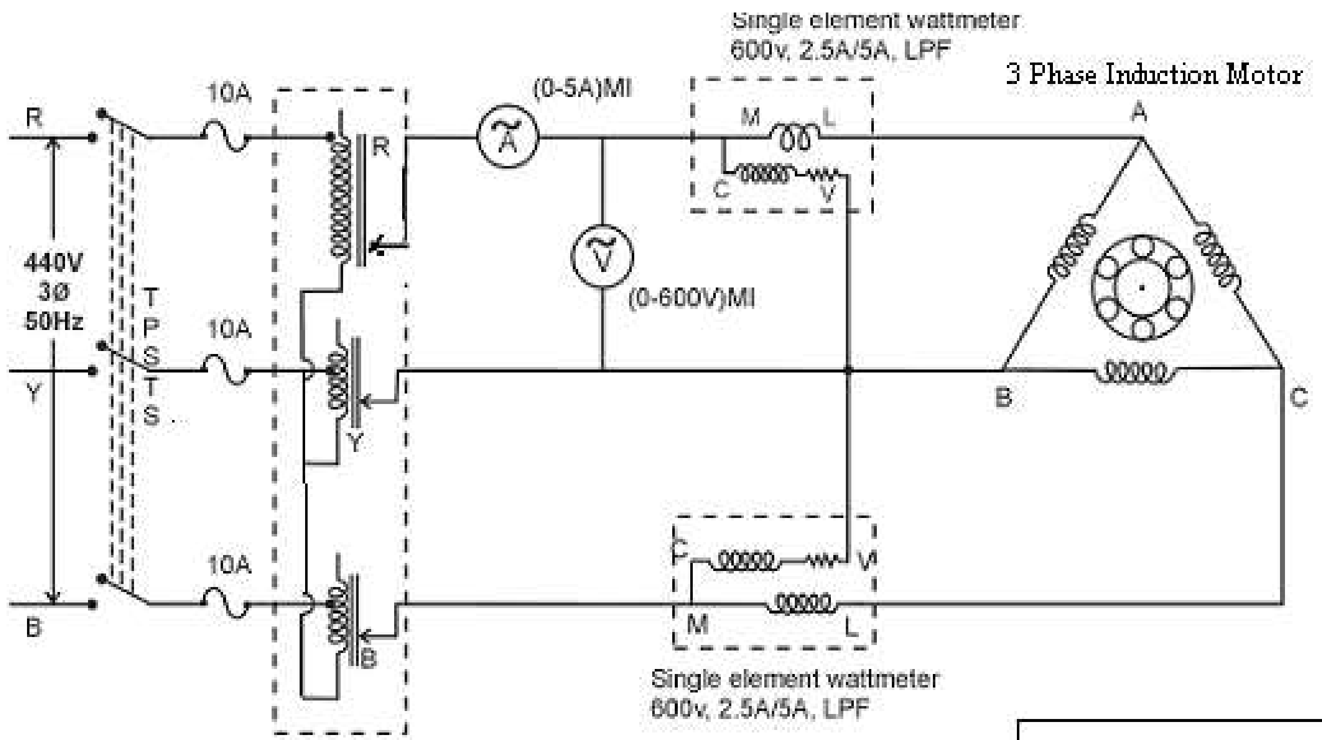
MODEL GRAPHS:



RESULT:

CIRCUIT DIAGRAM

NO LOAD TEST :



NAME PLATE DETAILS:
CAPACITY:
CURRENT:
VOLTAGE:
SPEED:

Date: **Ex. No: 7**

NO LOAD AND BLOCKED ROTOR TEST ON 3Φ INDUCTION MOTOR

(Circle Diagram & Equivalent Circuit)

AIM:

To predetermine the performance characteristics using circle diagram and also to draw the equivalent circuit of three phase Squirrel Cage induction motor by conducting no load and blocked rotor test.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Type	Quantity
1	Ammeter	(0-5A), (0-10A)	MI	1
2	Voltmeter	(0-150V),(0-600V)	MI	1
3	Wattmeter	600V,2.5/5A 150V,10A	LPF UPF	2
4	3 φ Auto Transformer	415V/0-470V	-	1
5	Carbon rheostat	25A,1 Ohms		
6	Tachometer	_	-	1
7	Connecting Wires	_	_	1 Set

THEORY:

An 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 the secondary winding. Alternating current supplied to the primary winding induces an opposing current in the secondary winding, when later is short circuited or closed through an external impedance. Relative motion between the primary and secondary i.e., stator and rotor is produced by the electromagnetic forces corresponding to the power thus transferred across the air gap by induction.

NO LOAD TEST (OR) OPEN CIRCUIT TEST:

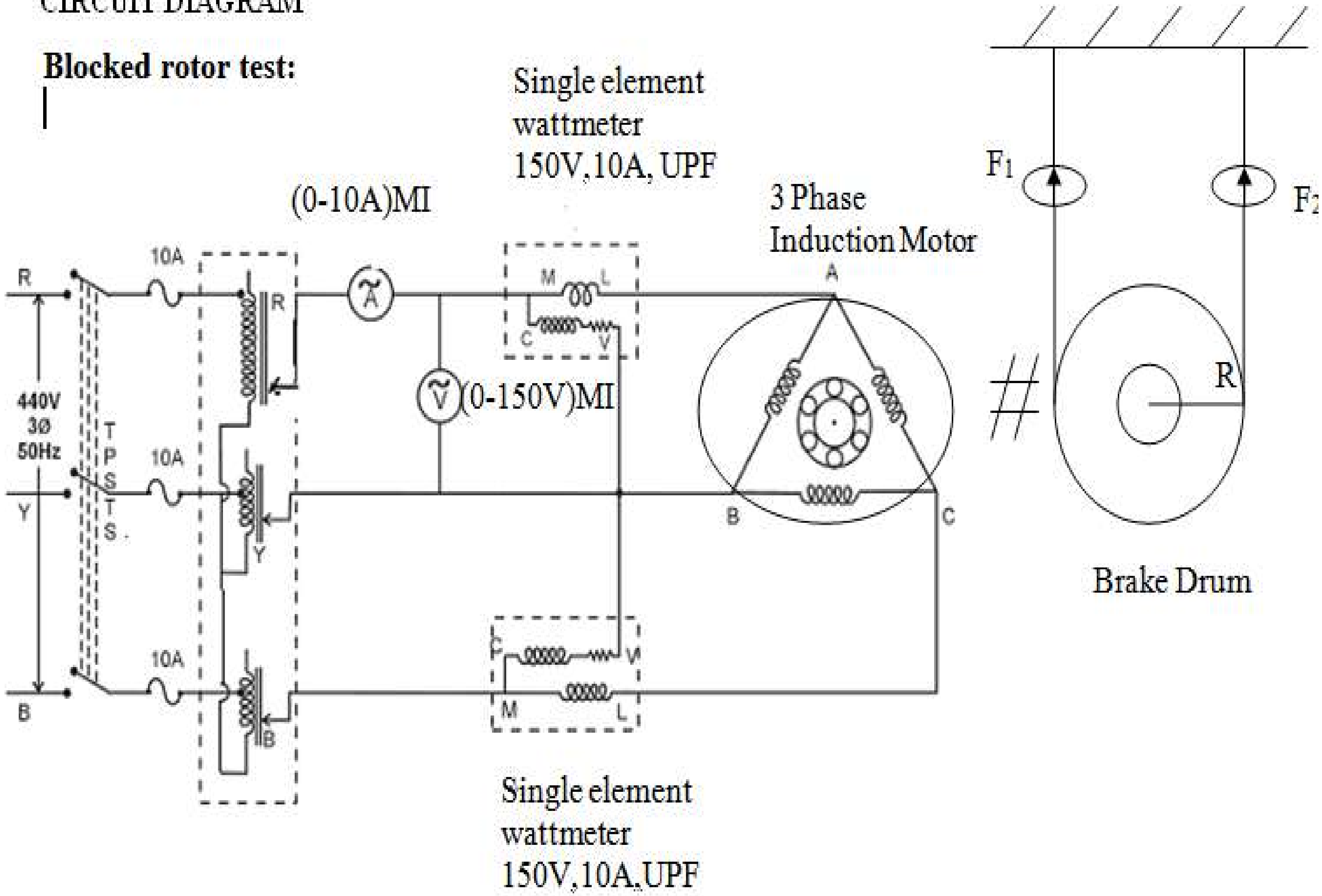
No load test is performed to determine the no load current, no load power factor, Windage and friction losses, no load input and no load resistance and reactance. Since there is no power output on no load, the power supplied to the stator furnishes its core loss and the friction and wind age losses in the rotor.

BLOCKED ROTOR TEST (OR) SHORT CIRCUIT TEST:

It is also known as locked rotor or short circuit test. This test is used to find the short circuit current with normal voltage applied to stator, power factor on short circuit, total leakage reactance and resistance of the motor as referred to stator and full load copper loss.

CIRCUIT DIAGRAM

Blocked rotor test:



FORMULA USED:

From no load test

1. No load Power factor $\cos\phi_0 = W_0 / \sqrt{3}\, V_0 I_0$

   Where $W_0 = \sqrt{3}\, V_0 I_0 \cos\phi_0$

2. Active Component of no load current $I_c = I_0 \cos\phi_0$
3. Magnetising component of no load current $I_m = I_0 \sin\varphi_0$
4. No load Branch resistance $R_0 = \dfrac{V_0 / \sqrt{3}}{I_c}$
5. No load Branch Reactance $X_0 = \dfrac{V_0 / \sqrt{3}}{I_m}$

From blocked rotor test:

1. Short Circuit Power factor $\cos\phi_{SC} = W_{SC} / (\sqrt{3}\, V_{SC} I_{SC})$
2. Equivalent Resistance referred to stator $R_{01} = \dfrac{W_{SC}}{3 I^2_{SC}}$
3. Equivalent Impedance referred to stator $Z_{01} = \dfrac{V_{SC} / \sqrt{3}}{I_{SC}}$
4. Equivalent Reactance referred to stator $X_{01} = \sqrt{Z^2_{01} - R^2_{01}}$

OBSERVATION TABULATION

1. NO LOAD TEST:

S.No	No-Load applied voltage, V_o (Volts)	No-Load Current, I_o (Amps)	W_1		W_2		Total No-load input Power, W_0 (Watts)
			Reading	Actual	Reading	Actual	
1.							

2. BLOCKED ROTOR TEST:

S.No	Blocked Rotor applied voltage, Vsc(Volts)	Blocked Rotor Current, Isc (Amps)	Total Blocked Rotor input Power, Wsc (Watts)	
			Reading	Actual
1.				

CALCULATION:

PRECAUTIONS

1. Variac should be kept in minimum position while switch on & switching off.
2. LPF wattmeter for no load test & UPF wattmeter for blocked rotor test

PROCEDURE

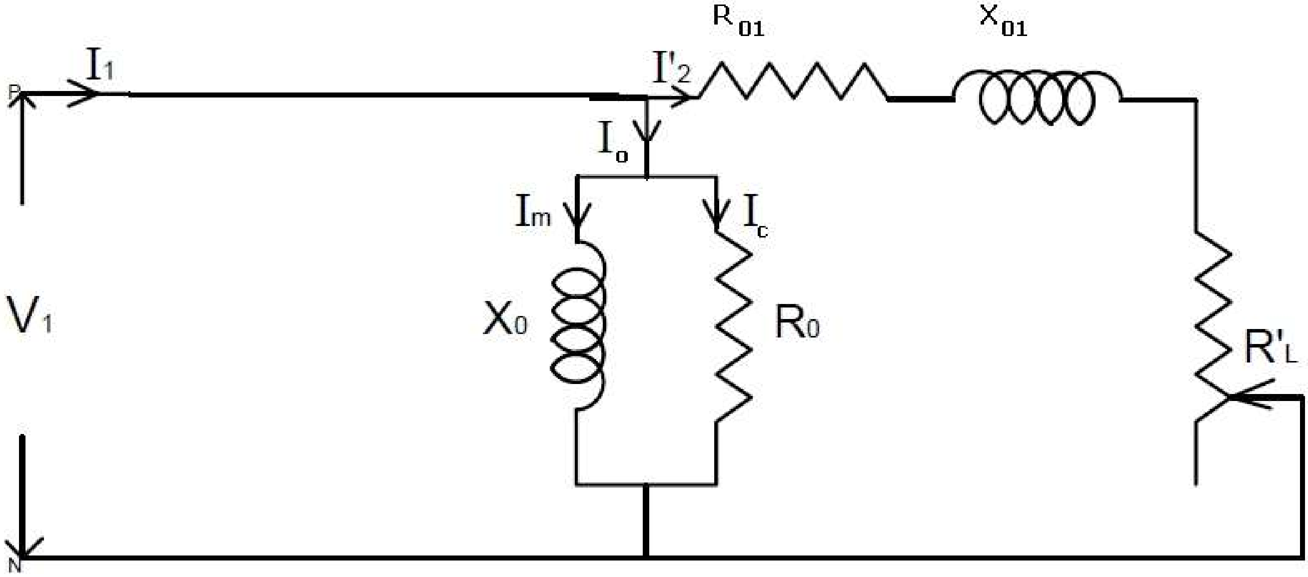
No load test

1. Connections are made as per the circuit diagram.
2. Check whether the rotor of the three phase induction motor is kept at no load condition.
3. Supply is switched on.
4. The variac is adjusted to provide the rated voltage(V_0) to the stator of the three phase induction motor.
5. The corresponding current (I_0) & power (W_{01} & W_{02}) are noted.

Blocked rotor test

1. Connection are made as per the circuit diagram
2. Check whether the rotor side of the motor is locked such that it will not rotate.
3. Supply is switched on.
4. The variac is adjusted to provide the rated full load current (I_{SC}) to the stator of three phase induction motor.
5. The corresponding voltage (V_{SC}) & power (W_{SC1} & W_{SC2}) are noted.

EQUIVALENT CIRCUIT:



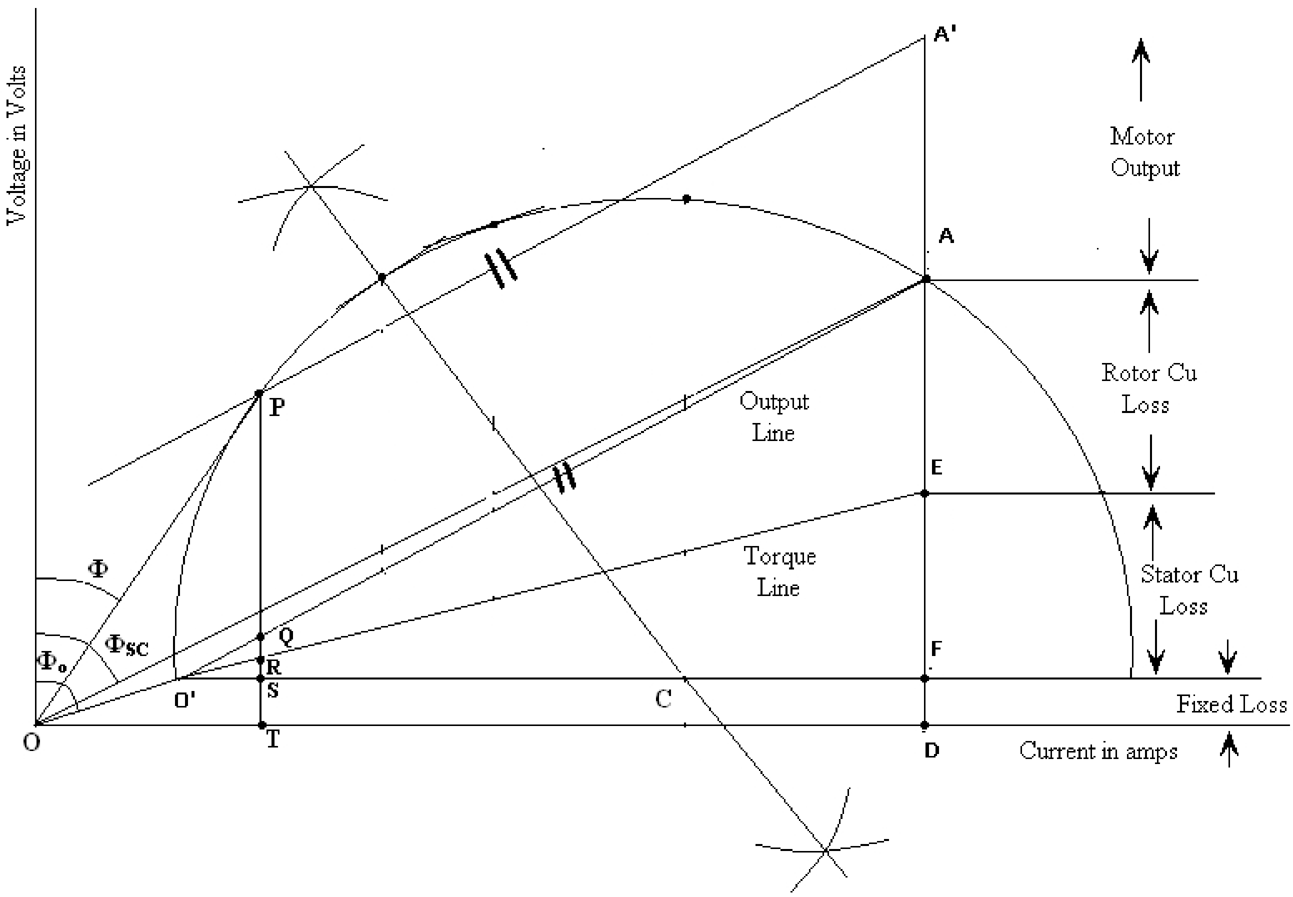
PROCEDURE TO DRAW THE CIRCLE DIAGRAM:

1. Take reference phasor Voltage as Y axis and phasor Current as X axis.
2. Select suitable current scale ie) diameter is 20 to 30 cm.
3. From No load test I_o and φ_o are obtained. Draw vector Io lagging V by angle φ_o. This is the line OO'.
4. Draw horizontal line wrt X axis and mark the point 'B'.
5. Draw the current I_{SN} lagging V by angle φ_o from the origin 'O' and join OA & OA'. OA' line is called as Output line. ie.) $I_{SN} = (V_L / V_{sc}) \times I_{sc}$
6. Draw a perpendicular bisector of O'A and extend it to meet line at X axis at point 'C'.
7. Draw a semi circle with centre as C and radius as O'C.
8. Draw perpendicular line at X axis and it should touch the point 'A' and the corresponding point in X axis is 'D' and point in base line is 'F'. Measure the length of AD [l(AD)].
9. Find AA'= Full load O/P power in watts / Power scale.

   Where Power scale = W_{SN}/ l(AD)
10. Draw the parallel line from point P to the output line ie.) line PA'.
11. Draw the Torque line(O'E) from O' to intersect point of AF.
12. Draw perpendicular line at X axis and it should touch the point 'P' and the corresponding point in X axis is 'T', point in o/p line is 'Q', point in Torque line is 'R' and point in base line is 'S'.

MODEL GRAPH:

CIRCLE DIAGRAM :(DO DRAW IN GRAPH SHEET)



PERFORMANCE PARAMETERS FROM CIRCLE DIAGRAM:

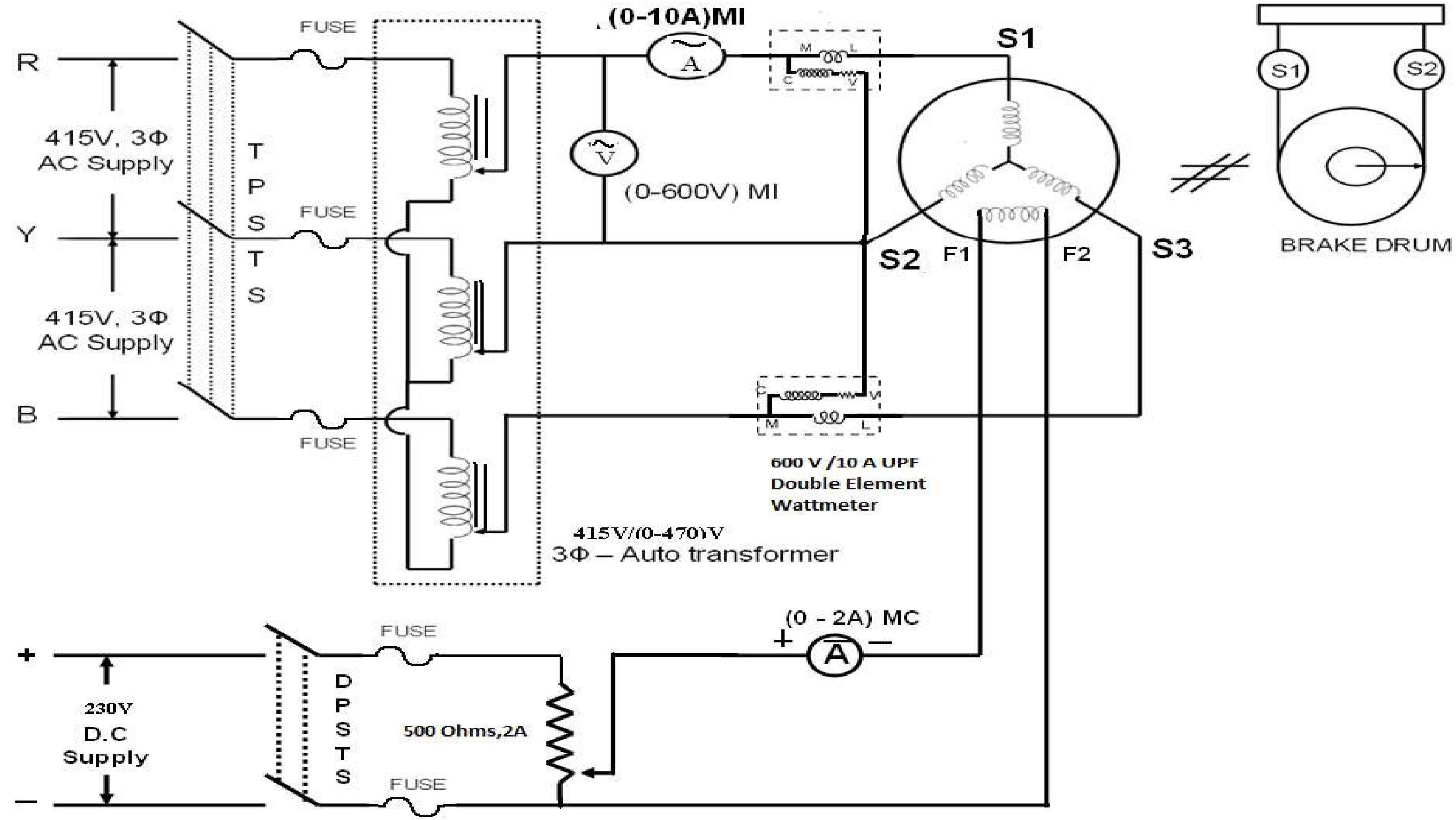
1. Full load line current = l(OP) x current scale
2. Total motor input = PT x Power scale
3. Fixed loss = ST x Power scale
4. Rotor Copper loss = QR x Power scale
5. Stator Copper loss = RS x Power scale
6. Total losses = QT x Power scale
7. Rotor Input = PR x Power scale
8. Rotor Output = PQ x Power scale
9. Rotor Efficiency = (PQ/ PR) x 100
10. Motor Efficiency = (PQ/ PT) x 100
11. Slip = Rotor copper loss / Rotor Input =QR / PR
12. Power factor Cos φ = PT / OP

PERFORMANCE PARAMETERS FROM CIRCLE DIAGRAM:

CALCULATION:

RESULT:

CIRCUIT DIAGRAM



NAME PLATE DETAILS:

CAPACITY :
VOLTAGE :
CURRENT :
SPEED :

Date: **Ex. No: 8**

V AND INVERTED V-CURVES OF 3 ϕ SYNCHRONOUS MOTOR

AIM:

To draw the V and inverted V-curves of three phase Synchronous Motor.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Type	Quantity
1	Ammeter	(0 – 10)A	MI	1
2	Ammeter	(0 – 2)A	MC	1
3	Voltmeter	(0 – 600)V	MI	1
4	Rheostat		_	1
5	3ϕ - Autotransformer	415V/ (0-470V)	_	1
6	Tachometer	_	Digital	1
7	DPST Switch	_	_	1
8	Connecting Wires	_	_	1 Set

THEORY:

Synchronous motor is constant speed motor which are not self starting in nature, so that we have to start this motor by any one of the following starting methods,

1. Pony motor method starting
2. Auto induction starting
3. DC exciter starting
4. Damper winding method of starting

By construction there is no difference between synchronous generator and synchronous motor. It is capable of being operated under wide range of power factor; hence it can be used for power factor correction.

The value of excitation for which back emf is equal to applied voltage is known as1005 excitation. The other two possible excitations are over excitations and under excitation if the back emf is more or less to the applied voltage respectively.

The variations of armature current with field current are in the form of V curves and the variation of power factor with field current are in the form of Inverted V curves.

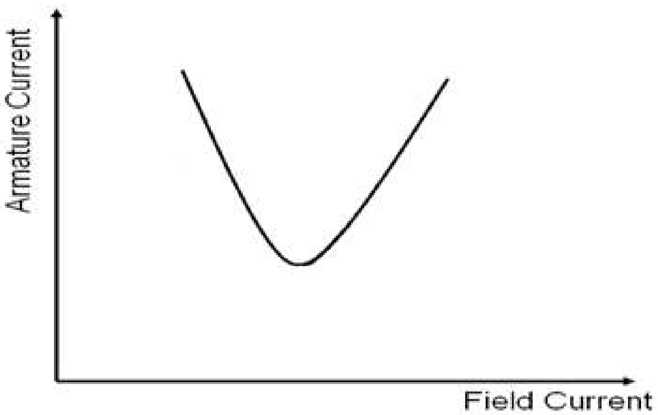
FORMULA USED:

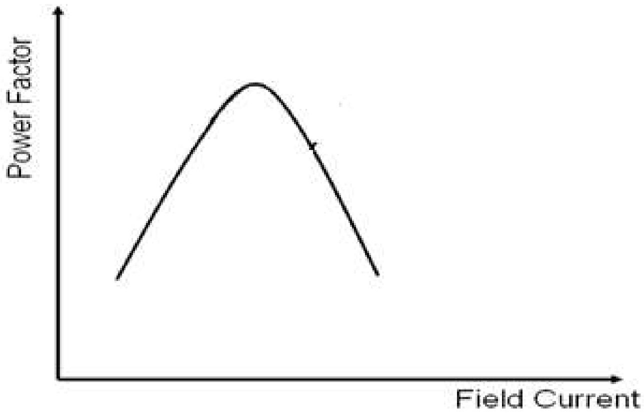
Power Factor, $\cos \varphi = P / \sqrt{3} V_L I_L$

OBSERVATION TABULATION:

S.No	Line Voltage V_L (Amps)	Line current Ia (Amps)	Input Power Pi (Watts)		Field current If (Amps)	Power factor cosφ
			Reading	Actual		

MODELGRAPH





MODEL CALCULATION:

PRECAUTIONS:

1. The Potential divider should be in maximum position.
2. The motor should be started without load .
3. Initially TPST switch is in open position.

PROCEDURE:

1. Connections were made as per the circuit diagram.
2. Close the TPST switch and vary the Auto transformer and start the motor.
3. Apply 50% of the rated voltage to the motor, now close the DPST switch and give DC supply to the field windings.
4. Apply the rated voltage to the motor and the motor runs at synchronous speed now apply load to the motor, vary the field rheostat and change the field current to the motor.
5. Note down the corresponding Voltmeter and Ammeter readings for various field current.

Graph:

The graph is drawn for-

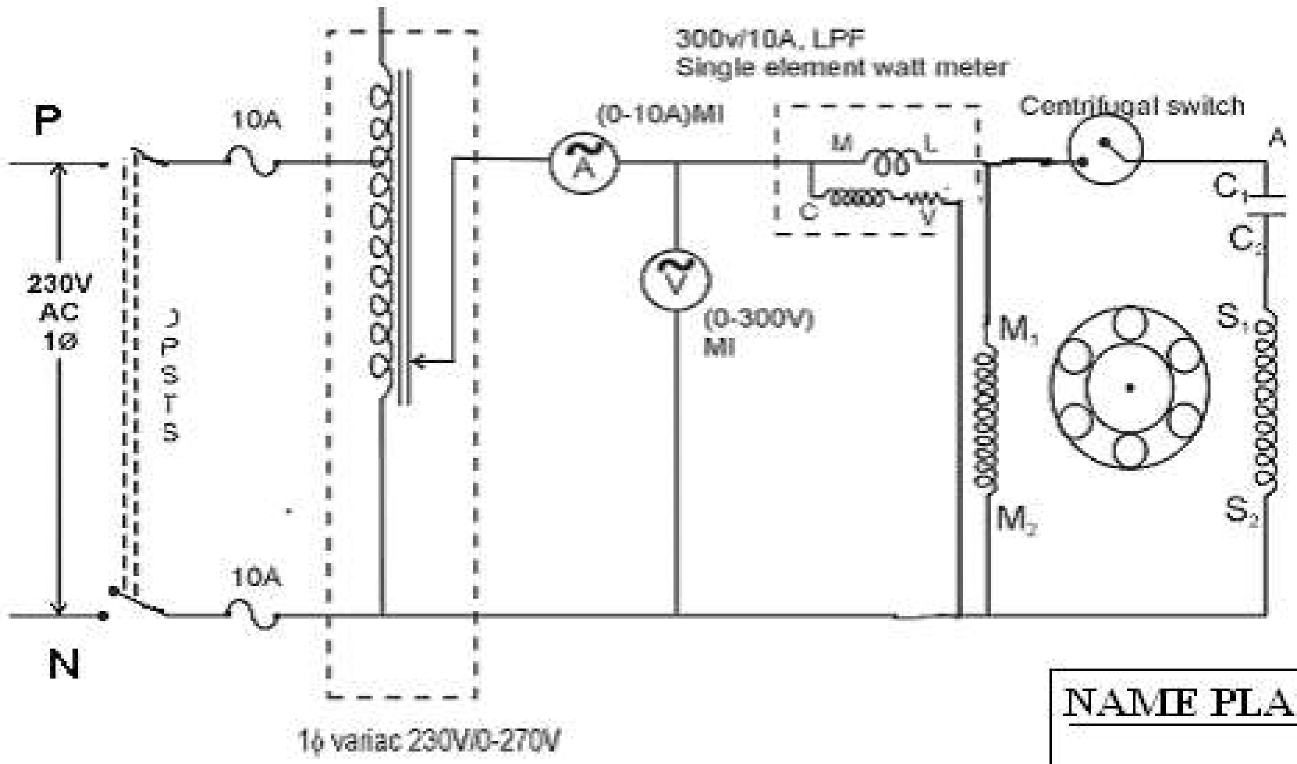
(1) Armature current Vs Excitation current.

(2) Power factor Vs Excitation current.

RESULT:

CIRCUIT DIAGRAM:

No load test



NAME PLATE DETAILS:

CAPACITY:
VOLTAGE:
CURRENT:
SPEED:

Date: **Ex. No: 9**

NO LOAD AND BLOCKED ROTOR TEST OF SINGLE PHASE INDUCTION MOTOR (Equivalent Circuit)

AIM:

To draw the equivalent circuit of single-phase induction motor by conducting no load and blocked rotor test.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Type	Quantity
1	Ammeter	(0 – 10A)	MI	1
2	Voltmeter	(0 – 300)V (0-75V)	MI	1
3	Wattmeter	300V,10A 75V,10A	LPF UPF	1 1
4	1 Phase auto transformer	230V/0-270V	-	1
5	Carbon rheostat	25A,1 Ohms	-	1
6	Tachometer	_	-	1
7	Connecting Wires	_	_	1 Set

THEORY:

The equivalent circuit of a single phase induction motor can be developed by using double field revolving theory. By using the equivalent circuit the performance of the single phase induction motor can be obtained. The single phase induction motor can be visualized to be made of single stator winding and two imaginary rotors. The developing torques of the induction motor is forward torque and backward torque. When the single phase induction motor is running in the direction of forward revolving field at a slip S, then the rotor currents induced by the forward field has frequency sf. The rotor mmf rotates at slip speed with respect to the rotor but at synchronous speed with respect to the stator. The resultant forward stator flux and the rotor flux produce a forward air gap flux. This flux induces the voltage in rotor. Thus due to the forward flux, the rotor circuit referred to stator has an impedance of $R2'/2s + jX2'/2$.

NO LOAD TEST OR OPEN CIRCUIT TEST:

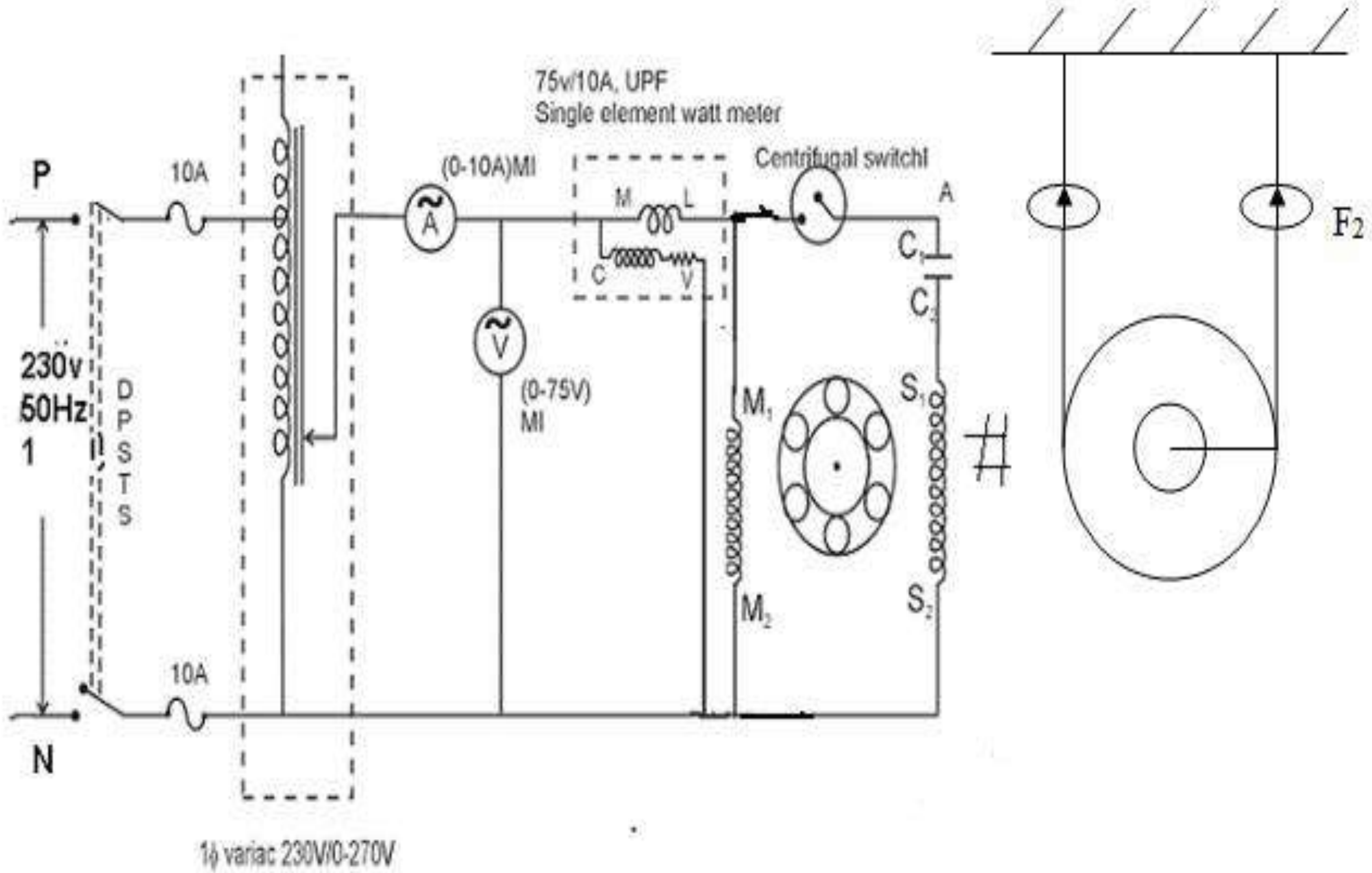
No load test is performed to determine the no load current, no load power factor, wind age and friction losses, no load input and no load resistance and reactance. Since there is no power output on no load, the power supplied to the stator furnishes its core loss and the friction and wind age losses in the rotor.

BLOCKED ROTOR TEST OR SHORT CIRCUIT TEST:

It is also known as locked rotor or short circuit test. This test is used to find the short circuit current with normal voltage applied to stator, power factor on short circuit, total leakage reactance and resistance of the motor as referred to stator and full load copper loss.

CIRCUIT DIAGRAM

Blocked rotor test



FORMULA USED:

i) No Load Test:

1. No load power factor ($Cos\Phi_0$) = $W_0 / V_0 I_0$
   Where W_0 = No load power in watts
   V_0 = No load voltage in volts.
   I_0 = No load current in amps
2. Working component current (I_W) = $I_0 \, Cos\Phi_0$ amps
3. Magnetizing component current (I_m) = $I_0 \, Sin\Phi_0$ amps
4. No load resistance $R_0 = V_0 / I_W$ ohm
5. No load reactance $X_0 = V_0 / I_m$ ohm

ii) Blocked rotor test:

1. Short Circuit Resistance $R_{SC} = W_{SC} / I^2_{SC}$

2. Short Circuit Impedance $Z_{SC} = V_{SC} / I_{SC}$

3. Short Circuit Reactance $X_{SC} = \sqrt{Z^2_{SC} - R^2_{SC}}$

OBSERVATION TABULATION:

NO LOAD TEST:

Sl.No.	No-Load Voltage V_0 (Volts)	No-Load Current I_0 (Amps)	No-Load Power, P_0 (Watts)	
			Reading	Actual
1.				

BLOCKED ROTOR TEST:

Sl.No.	Blocked Rotor Voltage V_1 (Volts)	Blocked Rotor Current I_1 (Amps)	Blocked Rotor Power, P_1 (Watts)	
			Reading	Actual
1.				

MODEL CALCULATION:

PRECAUTIONS:

1. Variac should be kept in minimum position while switch on & switching off.
2. LPF watt meter for no load test & UPF watt meter for blocked rotor test.

PROCEDURE :

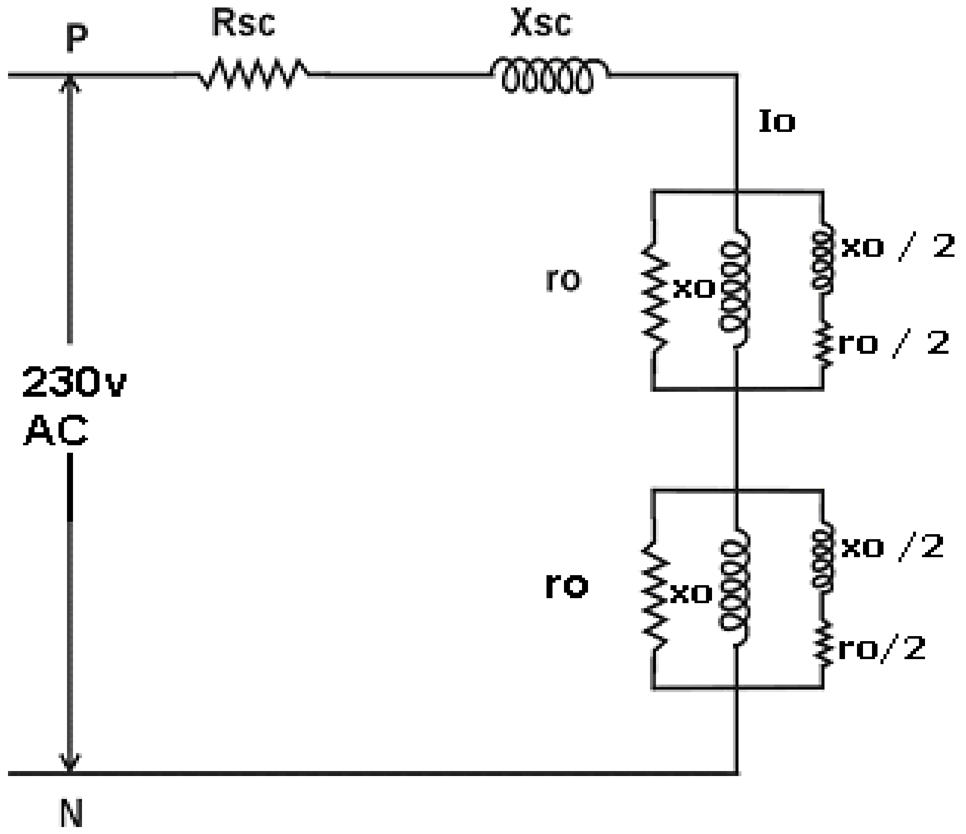
No load test

1. Connections are made as per circuit diagram
2. Check whether the rotor of the single phase induction motor is kept at no load condition
3. Supply is switched on.
4. The variac is adjusted to provide rated voltage (V_0) to the stator of the single phase induction motor.
5. The corresponding current (I_0) & power(W_0) are noted.

Blocked rotor test

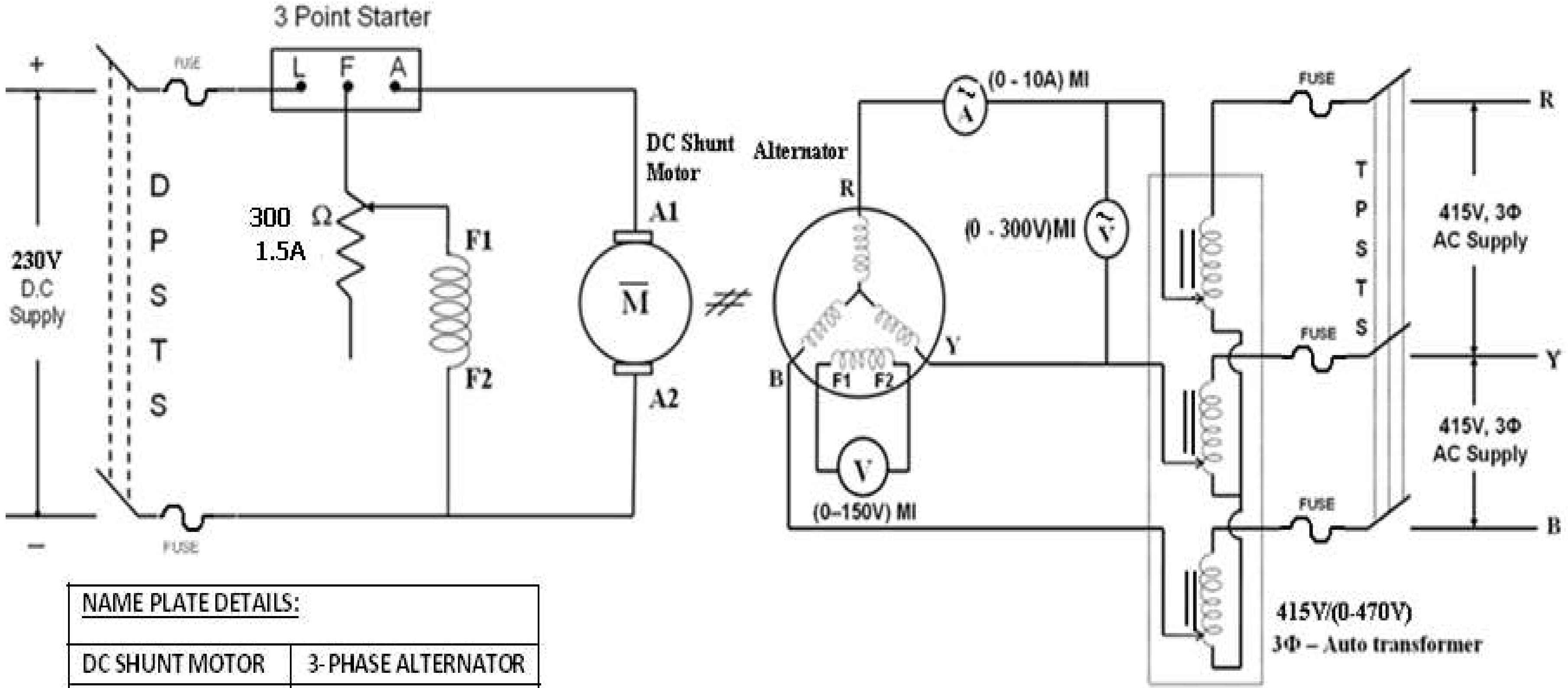
1. Connections are made as per the circuit diagram.
2. Check whether the rotor of the motor is locked such that it will not rotate.
3. Supply is switched on.
4. The variac is adjusted to provide the full load current (I_{SC}) to the stator of the single phase induction motor.
5. The corresponding voltage (V_{SC}) & power (W_{SC}) are noted.

EQUIVALENT CIRCUIT:



RESULT:

CIRCUIT DIAGRAM



NAME PLATE DETAILS:	
DC SHUNT MOTOR	3- PHASE ALTERNATOR
CAPACITY:	CAPACITY:
VOLTAGE:	VOLTAGE:
CURRENT:	CURRENT:
SPEED:	SPEED:
EXCITATION:	EXCITATION:

Date: **Ex. No: 10**

REGULATION OF 3 ϕ SALIENT POLE ALTERNATOR BY SLIP TEST

AIM:

To conduct slip test on a three phase salient pole alternator, and to determine Direct axis Reactance X_d, Quadrature Axis reactance X_q and % regulation.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Type	Quantity
1	Ammeter	(0 – 10)A	MI	1
2	Ammeter	(0 – 10)A	MC	1
3	Voltmeter	(0 – 30)V	MC	1
4	Voltmeter	(0 – 150)V	MI	1
5	Voltmeter	(0 – 300)V	MI	1
6	3ϕ - Autotransformer	415V/(0-470V)	–	1
7	Rheostat	300, 1.1A	–	1
8	Tachometer	–	Digital	1
9	Connecting Wires	–	–	1 Set

THEORY:

In non salient pole alternators air gap length is constant and reactance is also constant. Due to this the mmf of armature and field act upon the same magnetic circuit all the time hence can be added vector ally. But in salient pole alternators the length of the air gap varies and reluctance also varies. Hence the armature flux and field flux cannot vary sinusoid ally in the air gap. So the reluctance of the magnetic circuit on which mmf act is different in case of salient pole alternators. This can be explained by two reaction theory.

FORMULA USED:

1. Direct axis Reactance $X_d = V_{Max} / I_{Min}$, Ω
2. Quadrature axis Reactance $X_q = V_{Min} / I_{Max}$, Ω
3. Direct axis Impedance $Z_d = V_{Min} / I_{Max}$, Ω
4. Quadrature axis Impedance $Z_q = V_{Max} / I_{Min}$, Ω

OBSERVATION TABULATION:

Sl.No	V_{max} (V)	V_{min} (V)	I_{max} (A)	I_{min} (A)	$Z_d = \frac{V_{min}}{I_{max}}$ (Ω)	$Z_q = \frac{V_{max}}{I_{min}}$ (Ω)
1.						

CALCULATION:

PRECAUTIONS:

1. Fuses are checked out
2. The field Rheostat of the DC motor was kept in minimum position.
3. Autotransformer was kept in minimum position.

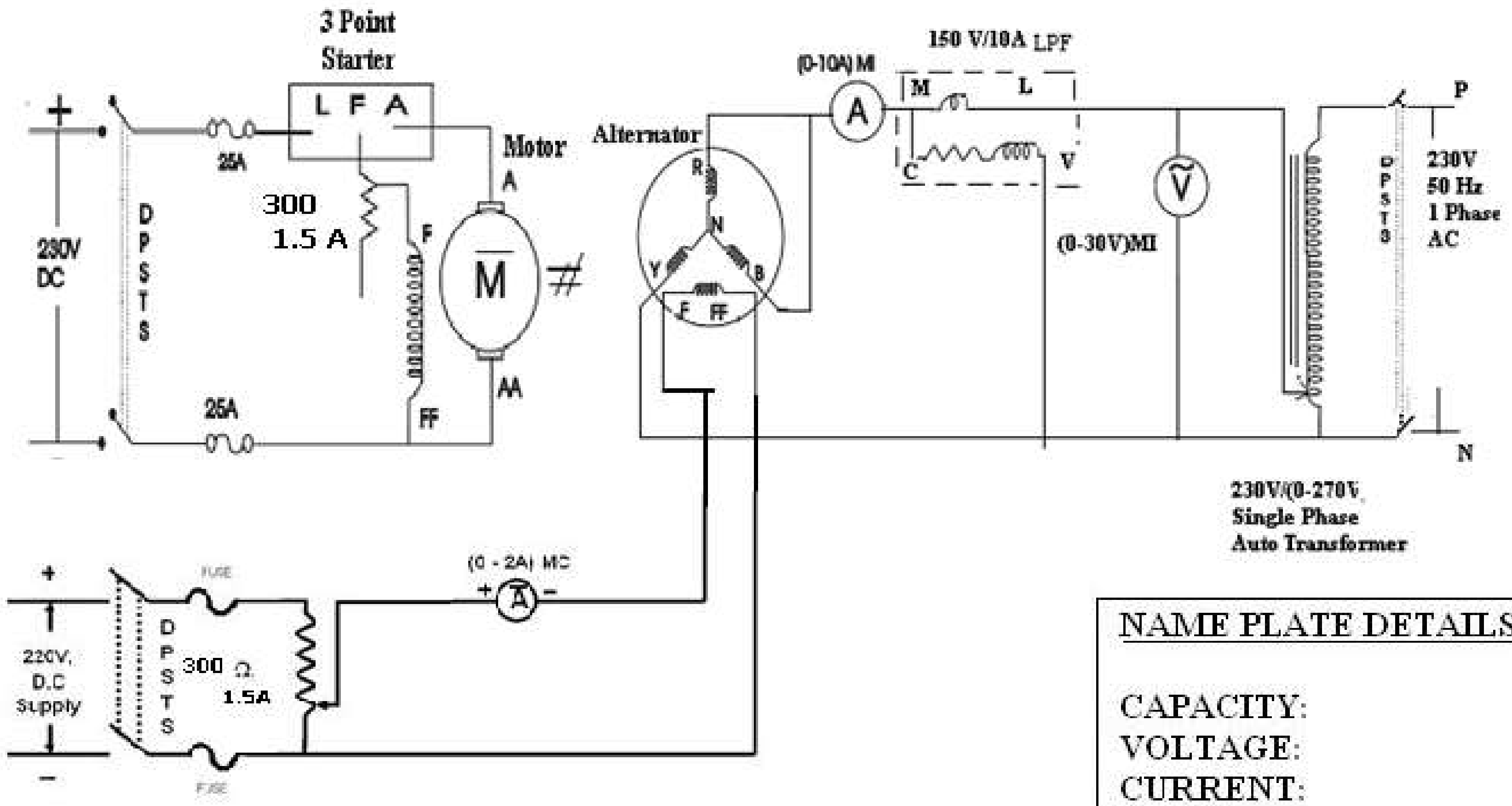
PROCEDURE:

1. Connections were made as per the circuit diagram.
2. The DC motor is started using three-point starter.
3. Vary the Field rheostat of the motor and make to run at synchronous speed.
4. Close the TPST switch.
5. Apply 30% of rated voltage to the armature of the alternator by adjusting the Auto Transformer.
6. To obtain slip and maximum oscillation of pointer, the speed is reduced slightly less than the synchronous speed.
7. Note down the maximum current, maximum voltage and minimum current, minimum voltage.
8. Find out the direct and Quadrature axis impedance using the formula.

RESULT:

CIRCUIT DIAGRAM

NEGATIVE SEQUENCE IMPEDANCE (X2):



NAME PLATE DETAILS:

CAPACITY:
VOLTAGE:
CURRENT:
SPEED:

Date: **Ex. No: 11**

MEASUREMENT OF NEGATIVE SEQUENCE AND ZERO SEQUENCE IMPEDANCE OF ALTERNATOR

AIM:

Determination of negative sequence and zero sequence Impedance of a synchronous generator.

APPARATUS REQUIRED:

SL.NO	Name of the Apparatus	Type	Range	Quantity
1	Ammeter	MI	(0-5)A	1
2	Ammeter	MC	(0-2)A	1
3	Voltmeter	MC	(0-300)V	1
4	Voltmeter	MC	(0-75)V	1
5	Dimmer Stat	1 phase	230V	1
6	Wattmeter		150V,5A	1
7	Tachometer	Digital	--	1

THEORY:

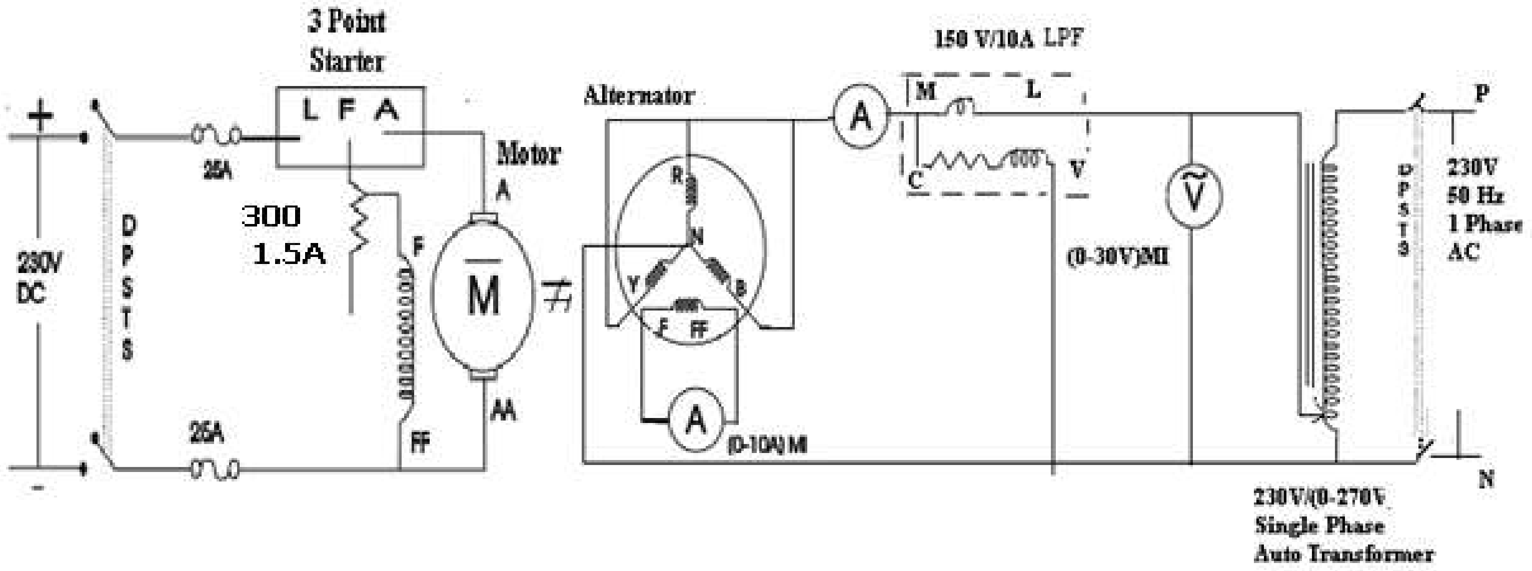
When a synchronous generator is carrying an unbalanced load its operation may be analyzed by symmetrical components. In a synchronous machine the sequence current produce an armature reaction which is stationary with respect to reactance and is stationary with respect to field poles. The component currents therefore encounter exactly same as that by a balanced load as discussed. The negative sequence is produced and armature reaction which rotates around armature at synchronous speed in direction to that of field poles and therefore rotates part the field poles at synchronous speed. Inducing current in the field damper winding and rotor iron. The impendence encountered by the negative sequence is called the –ve sequence impedance of the generator. The zero sequence current produce flux in each phase but their combined armature reaction at the air gap is zero. The impedance encountered by their currents is therefore different from that encountered by +ve and –ve sequence components and is called zero sequence impedance of generator.

Negative sequence:

The –ve sequence impedance may be found by applying balanced –ve sequence voltage to the armature terminals. While the machine is drive by the prime mover at its rated synchronous speed with the field winding short circuited. The ratio of V/ph and Ia/ph gives –ve sequence Z/ph. The reading of the wattmeter gives I2 R losses. This loss /ph divided by Iph required gives the –ve sequence R/ph from the impedance and reactance/ph. –ve sequence can be calculated. Another method of measuring –ve sequence reactance is found to be connect the arm terminals. The machine is driven at synchronous speed and field current adjusted until rated current flows in the phases shorted through armature and current coil of wattmeter respectively

CIRCUIT DIAGRAM:

ZERO SEQUENCE IMPEDANCE (XO):



$$z = \frac{v}{\sqrt{3}\, I}$$

$$X_2 = \frac{W}{\sqrt{3} I^2}$$

$$R_2 = \sqrt{(Z_a{}^2 - X_a{}^2}$$

Zero sequence:

The sequence impedance may be determined by the connecting the armature windings of the three phases in series and then connecting them to the single phase source of power. If the machine is driven at synchronous speed with field winding shorted, then Z_0=V/3I practically the same results will be obtained with rotor stationary. If windings are connected in parallel, then

$$z_0 = \frac{v_0}{\sqrt{3}\, I_0}$$

$$X_0 = \frac{W_0}{\sqrt{3} I_0{}^2}$$

$$R_2 = \sqrt{(Z_0{}^2 - X_0{}^2}$$

PROCEDURE

A. **For Negative Sequence**

(1) Make connection as shown in circuit diagram.

(2) Run DC motor with synchronous speed.

(3) Keeping the speed constant, vary the excitation and measure the voltmeter, ammeter and wattmeter reading.

(4) Take 3-4 readings for different excitation.

(5) The excitation should not be increased beyond the rated capacity of synchronous machine i.e. 4.2 A

B. **For Zero Sequence**

(1)Make connection as shown in circuit diagram.

(2)Set the dimmer stat output to zero volts and switch on the supply.

(3) Gradually increase dimmer stat output and note the ammeter reading for suitable voltage applied.

(4) Repeat reading for suitable voltage applied.

(5) It should be kept in mind that the ammeter reading should not exceed the rated current Capacity of the machine i.e. 4.2 A.

<u>TABULATION</u>:

Negative sequence Impedance

<table>
<tr><th rowspan="2">S.N</th><th rowspan="2">Voltage (V)</th><th colspan="2">Wattmeter Reading(W)</th><th rowspan="2">Armature Current (A)</th><th rowspan="2">Impedance (Z_2)</th><th rowspan="2">Reactance (X_2)</th><th rowspan="2">Resistance (R_2)</th></tr>
<tr><th>Reading</th><th>Actual</th></tr>
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Zero sequence Impedance

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<tr><th rowspan="2">S.N</th><th rowspan="2">Voltage (V)</th><th colspan="2">Wattmeter Reading(W)</th><th rowspan="2">Armature Current (A)</th><th rowspan="2">Impedance (Z_2)</th><th rowspan="2">Reactance (X_2)</th><th rowspan="2">Resistance (R_2)</th></tr>
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RESULT: