ST.ANNE'S

COLLEGE OF ENGINEERING AND TECHNOLOGY

ANGUCHETTYPALAYAM, PANRUTI
CUDDALORE DISTRICT-607 110.

EE6512 – ELECTRICAL MACHINES LABORATORY II

LAB MANUAL

NAME :

REGISTER NUMBER :

COURSE :

BRANCH :

YEAR & SEM :

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

CYCLE-1

1. Load test on 3-phase squirrel cage induction motor.
2. Load test on 3-phase slip ring induction motor
3. No load and blocked rotor test on 3phase induction motor.
4. Separation of no load losses of three phase induction motor.
5. Load test on 1-phase induction motor.
6. No load and blocked rotor test on single phase induction motor.
7. Study of Induction motor Starters

CYCLE-2

8. V and inverted V curves of three phase synchronous motor.
9. Regulation of three phase alternator by EMF method.
10. Regulation of three phase alternator by MMF method.
11. Regulation of 3 alternator by ZPF method.
12. Regulation of 3 alternator by ASA method.
13. Regulation of three phase salient pole alternator by slip test.
14. Measurement of negative sequence and zero sequence impedance of an alternator.

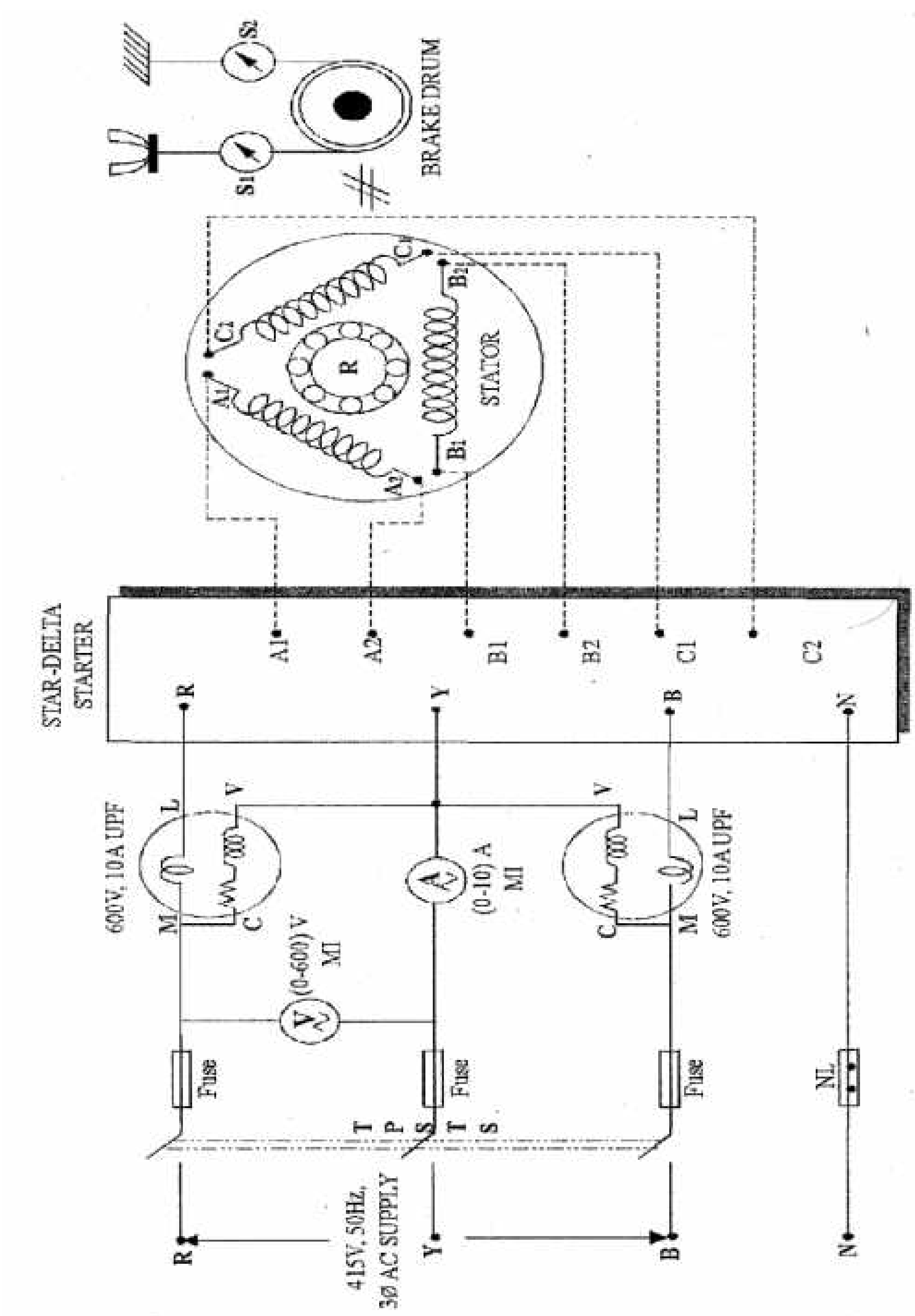
EE6512 - ELECTRICAL MACHINES LABORATORY - II

Name of the Student :

Register Number :

S.No	Date	Name of the Experiment	Marks	Signature

CIRCUIT DIADRAM FOR LOAD TEST ON 3-PHASE SQUIRREL CAGE INDUCTION MOTOR



DATE: **EX.NO.**

LOAD TEST ON 3-PHASE SQUIRREL CAGE INDUCTION MOTOR

AIM :

To determine the performance characteristics of 3-phase squirrel cage induction motor by direct loading.

APPARATUS REQUIRED:

S.NO	APPARATUS REQUIRED	TYPE	RANGE	QUANTITY
1	Volt Meter	MI	(0-600)V	1
2	Ammeter	MI	(0-10)A	1
3	Watt Meter	Double element, UPF	600V,10A	1
4	Connecting Wires			Required.

NAME PLATE DETAILS:

FUSE RATING CALCULATION:

125% of rated current.

FORMULAE USED:

1. Torque,

$$T = (S1 \sim S2)\,(R + t/2) * 9.81 \text{ N-m}$$

S_1, S_2 – Spring balance readings in Kg
R- Radius of the brake drum in m.
t – Thickness of the belt in m

2. Input power

$$P_{in} = W \text{ Watts}$$

W – Wattmeter readings in Watts.

3. Output power,

$$P_{out} = 2\pi NT/60 \text{ watts.}$$

N – Rotor speed in rpm
T – Torque in N-m

TABULATION:

S. No	Load Voltage (V_L)	Load current (I_L)	Wattmeter Readings		Input power (W)	Speed	Spring balance reading			Torque	Output power	Efficiency	Slip s	Power factor
			Obs	Act			S_1	S_2	$S_1 \sim S_2$					
	(V)	(A)	Watts		Watts	rpm	kg			N-m	W	%	%	

4. % Efficiency,

$$\% \eta = P_{out} / P_{in} * 100$$

5. % Slip,

$$\% s = (N_s - N)/N_s * 100$$

N_s – Synchronous speed in rpm

N – Speed of thr motor in rpm

6. Power factor,

$$\cos \varphi = W / (\sqrt{3}\, V_L I_L)$$

PRECAUTION:

1. TPST switch should be at open position.
2. There should be no-load at the time of starting (Loosen the belt on the brake drum)
3. Brake drum should be cooled with water During Loading.

PROCEDURE:
1. The connections are made as per the circuit diagram.
2. Power supply is obtained from the control panel.
3. The TPST switch is closed.
4. Wait till the starter change over from star to delta.
5. The initial readings of ammeter, voltmeter and wattmeter are noted.
6. By increasing the load step by step, the readings of ammeter, voltmeter and wattmeter are noted (till the ammeter shows the rated current of 3-phase induction motor).
8. Decrease the load to no load condition.
9. Switch off the supply.

OBSERVATION:

Circumference of the brake drum =

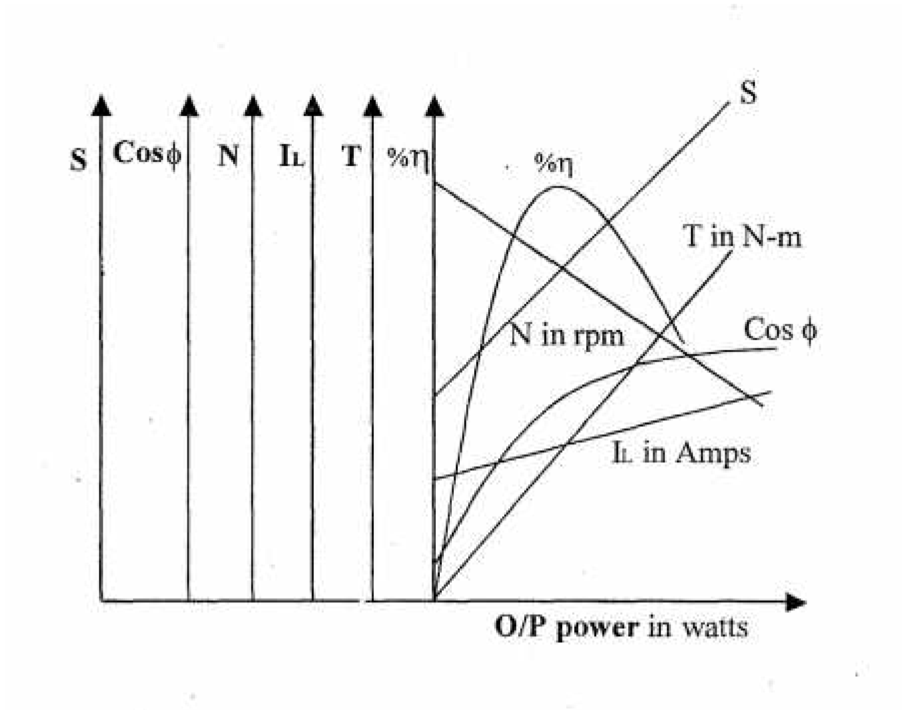
Thickness of the belt =

GRAPH :

The graphs are drawn for

(i) Output power Vs Speed
(ii) Output power Vs Line current
(iii) Output power Vs Torque
(iv) Output power Vs power factor
(v) Output power Vs % Efficiency
(vi) Output power Vs % slip

MODEL GRAPH:

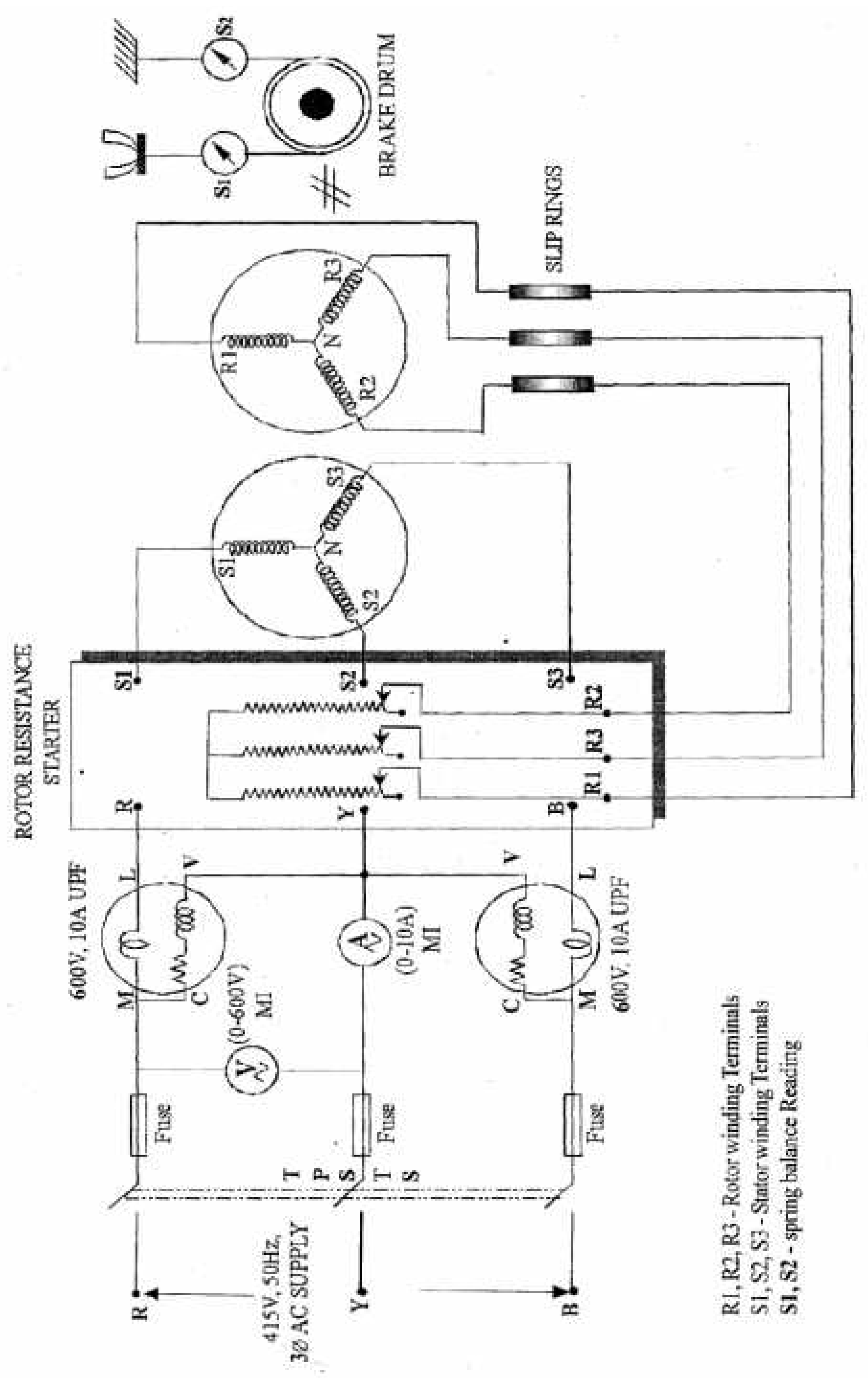


MODEL CALCULATION:

RESULT:

Thus the performance characteristics of 3-phase squirrel cage induction motor by direct loading were determined.

CIRCUIT DIAGRAM FOR LOAD TEST ON THREE PHASE SLIP RING INDUCTION MOTOR



DATE: **EX.NO.**

LOAD TEST ON THREE PHASE SLIP RING INDUCTION MOTOR

AIM:

To conduct the load test on three phase slip ring induction motor and to draw the performance characteristic curves.

APPARATUS REQUIRED:

S.NO	APPARATUS REQUIRED	TYPE	RANGE	QUANTITY
1	Volt Meter	MI	0-600V	1
2	Ammeter	MI	0-10A	1
3	Watt Meter	Double element, UPF	600V,10A	1
4	Connecting Wires			Required.

NAME PLATE DETAILS:

FUSE RATING CALCULATION:

125% of rated current.

FORMULAE USED:

1. Torque,

$$T = (S1 \sim S2)\ (R + t/2) * 9.81 \ \text{N-m}$$

S_1, S_2 – Spring balance readings in Kg
R- Radius of the brake drum in m.
t – Thickness of the belt in m

2. Input power

$$P_{in} = W \text{ Watts}$$

W – Wattmeter readings in Watts.

3. Output power,

$$P_{out} = 2\pi NT/60 \text{ watts.}$$

N – Rotor speed in rpm
T – Torque in N-m

TABULATION:

S. No	Load Voltage (V_L)	Load Current (I_L)	Wattmeter Readings		Input power (W)	Speed	Spring balance reading			Torque	Output power	Efficiency	Slip s	Power factor
			Obs	Act			S_1	S_2	$S_1 \sim S_2$					
	(V)	(A)	Watts		Watts	rpm	kg			N-m	W	%	%	

4. % Efficiency,

$$\% \eta = P_{out} / P_{in} * 100$$

5. % Slip,

$$\% s = (N_s – N)/N_s *100$$

N_s – Synchronous speed in rpm
N – Speed of the motor in rpm

6. Power factor,

$$\cos \varphi = W / (\sqrt{3}\, V_L I_L)$$

PRECAUTION:

1. TPST switch should be at open position.
2. The rotor resistance starter should be in the maximum resistance position while starting.
3. There should be no-load at the time of starting (Loosen the belt on the brake drum)
4. Brake drum should be cooled with water During Loading.

PROCEDURE:

1. The connections are made as per the circuit diagram.
2. Power supply is obtained from the control panel.
3. The TPST switch is closed and the motor is started using rotor resistance starter, where the rotor resistance starter is turned from maximum resistance to minimum resistance position to run at rated speed.
4. At no load the speed, current, voltage are noted
5. By applying the load, for various values of current the above mentioned readings are noted.
6. The load is released. The rotor resistance starter is brought to the original position before switching off the motor.
7. The motor is switched off and the graph is drawn.

OBSERVATION:

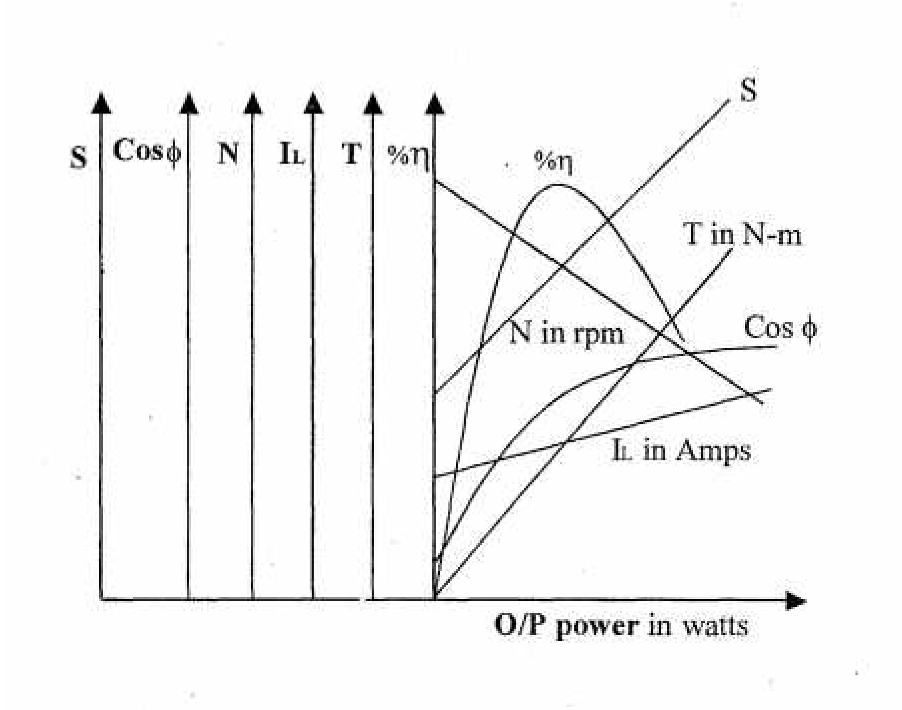
Circumference of the brake drum =
Thickness of the belt =

GRAPH:

The graphs are drawn for

(i) Output power Vs Speed
(ii) Output power Vs Line current
(iii) Output power Vs Torque
(iv) Output power Vs power factor
(v) Output power Vs % Efficiency
(vi) Output power Vs % slip

MODEL GRAPH:

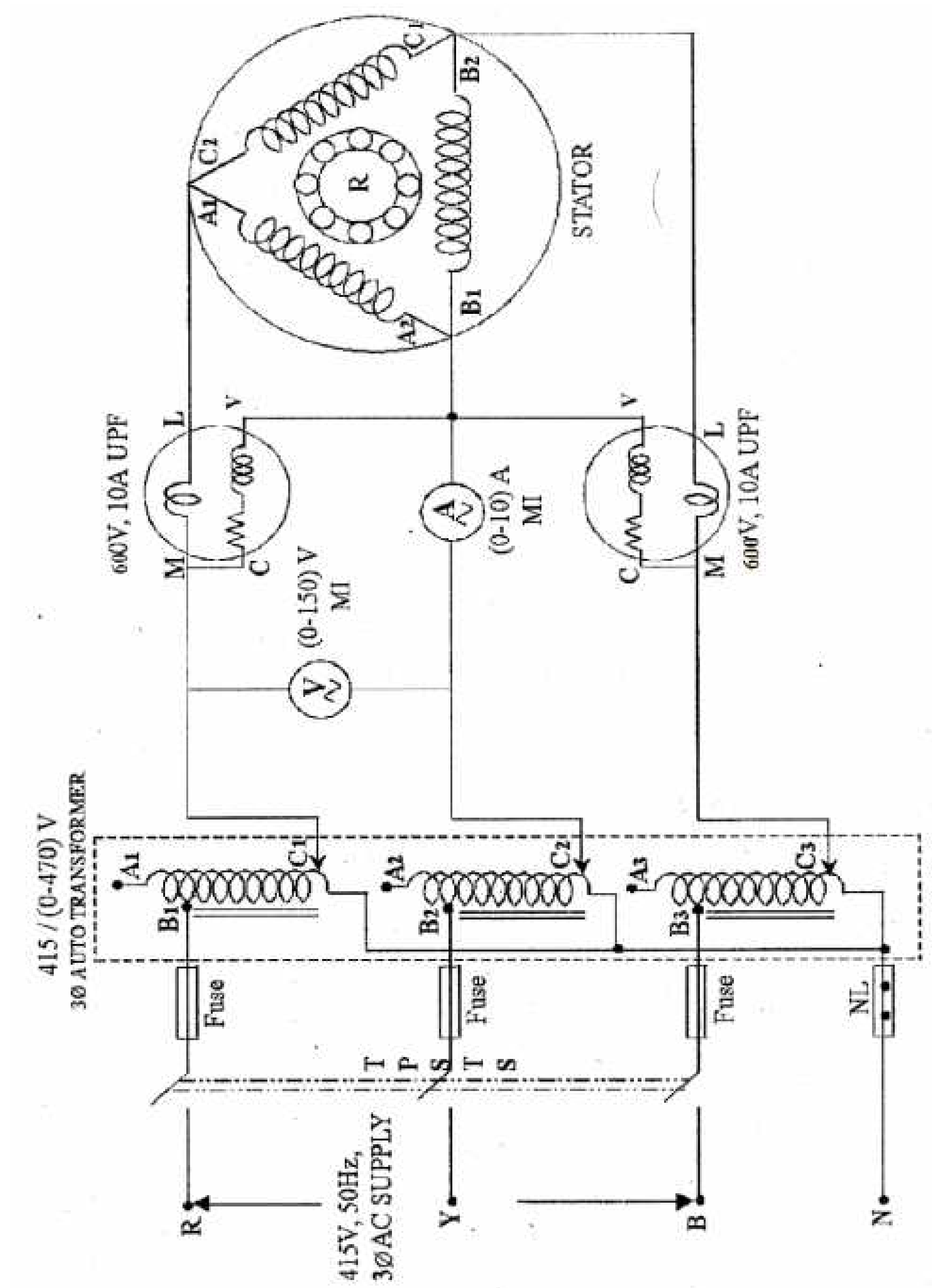


MODEL CALCULATION:

RESULT:

Thus the load test on three phase slip ring induction motor was conducted and the performance characteristic curves were drawn.

CIRCUIT DIAGRAM FOR NO LOAD TEST ON THREE PHASE SQUIRREL CAGE INDUCTION MOTOR



DATE: **EX.NO.**

NO LOAD AND BLOCKED ROTOR TEST ON THREE PHASE SQUIRREL CAGE INDUCTION MOTOR

AIM:

To conduct the No Load test and Blocked Rotor test on three phase squirrel cage induction motor and to draw the equivalent circuit.

APPARATUS REQUIRED:

S.NO	APPARATUS REQUIRED	TYPE	RANGE	QUANTITY
1.	Volt Meter	MI	0-600V	1
2.	Volt Meter	MC	0-50V	1
3.	Ammeter	MI	0-10A	1
4.	Ammeter	MC	0-10A	1
5.	Watt Meter	Double element, UPF	600V,10A	1
6.	Connecting wires			Required

NAME PLATE DETAILS:

FUSE RATING CALCULATION:

125% of rated current.

No-load test - 10% of rated current.

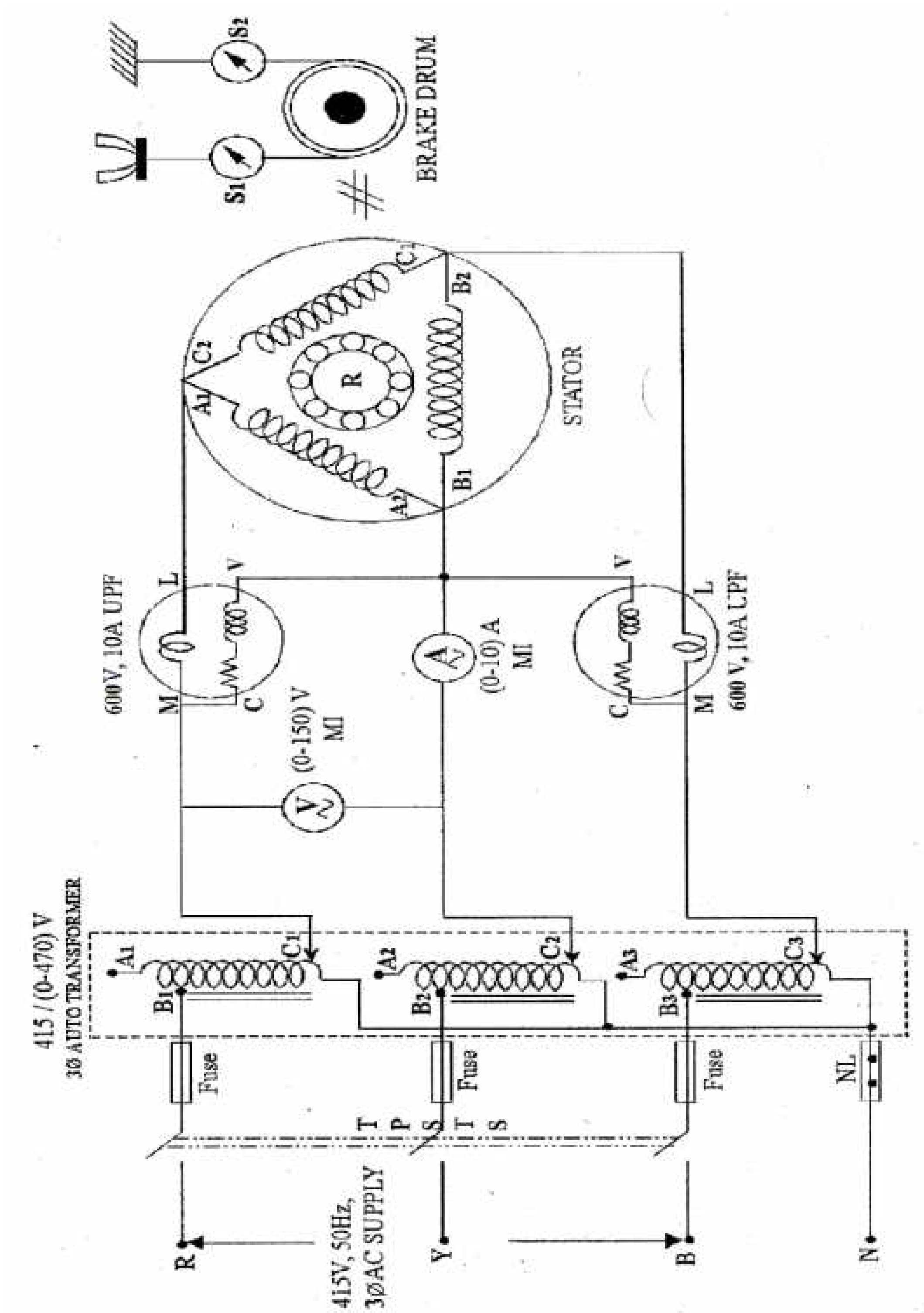
FORMULAE USED:

OC TEST

1. No load power factor, $\cos \varphi_0 = W_0 / V_0 I_0$
   - V_0 – No load voltage per phase in volts
   - I_0 – No load current per phase in amps
   - W_0 – No load power per phase in watts

2. Active Component, $I_c = I_{0(ph)} \cos \varphi_0$

CIRCUIT DIAGRAM FOR BLOCKED ROTOR TEST ON THREE PHASE SQUIRREL CAGE INDUCTION MOTOR



3. Magnetising Component, $I_m = I_{0(ph)} \sin \varphi_0$

4. No load resistance $(R_0) = V_0 / I_c$ Ω

5. No load reactance $(X_0) = V_0 / I_m$ Ω

SC TEST

6. Equivalent impedance referred to stator, $Z_{1e\,(ph)} = V_{SC\,(ph)} / I_{SC(ph)}$ Ω

7. Equivalent resistance referred to stator, $R_{1e\,(ph)} = W_{SC\,(ph)} / [3\, I^2_{SC(ph)}]$ Ω

8. Equivalent reactance referred to stator, $X_{1e(ph)} = \sqrt{[(Z_{1e\,(ph)})^2 - (R_{1e\,(ph)})^2]}$ Ω

9. Rotor resistance referred to stator $(R'_{2\,(ph)}) = R_{1e\,(ph)} - R_1$ Ω

10. Rotor reactance referred to stator $(X'_{2\,(ph)}) = X_{1e(ph)} / 2 = X_1$ Ω
    Where R_1 - stator resistance per phase
    X_1 – stator reactance per phase
    $R_1 = R_{(ac)} = 1.6\, R_{(dc)}$
11. Equivalent load resistance, $R'_L = R'_2\,(1/s - 1)$ Ω
    Where slip, $s = (N_s - N) / N_s$
    N_s – Synchronous speed in rpm
    N – Speed of motor in rpm

PRECAUTION:

1. The auto transformer should be kept in minimum voltage position.

PROCEDURE:

NO LOAD TEST

1. Connections are given as per the circuit diagram
2. By adjusting the auto transformer, rated voltage is applied and the ammeter and wattmeter readings are noted.
3. Initial position of auto transformer is brought back.
4. Supply is switched off.

BLOCKED ROTOR TEST

1. Connections are given as per the circuit diagram
2. Rotor is blocked from rotating.
3. Applied voltage is increased until rated load current flows.
4. Readings of all meters are noted.

TABULATION:

NO LOAD TEST:

S.No	No load voltage (V_0)	No load current (I_0)	No Load Power (W_0)	
			Observed	Actual
	(V)	(A)	Watts	

BLOCKED ROTOR TEST

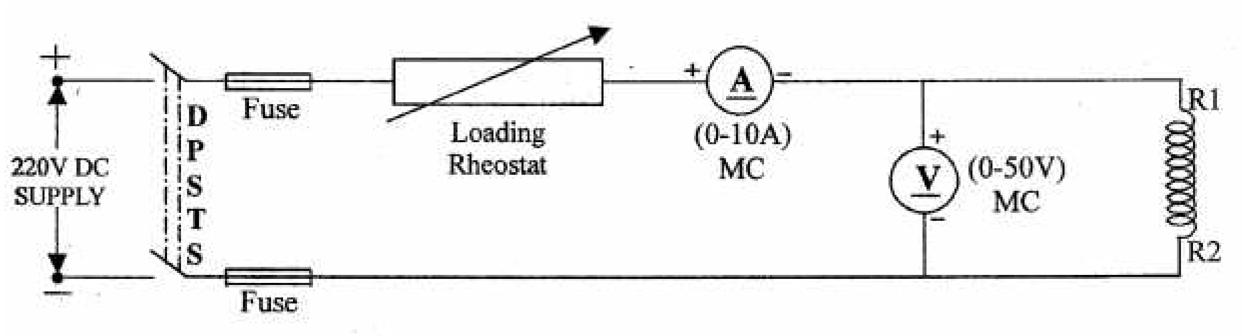
S.No	Short circuit voltage (V_{sc})	Short circuit current (I_{sc})	Short circuit Power (W_{sc})	
			Observed	Actual
	(V)	(A)	Watts	

MEASUREMENT OF STATOR RESISTANCE

1. Connections are made as per the circuit diagram.
2. Supply is given by closing the DPST switch.
3. Readings of voltmeter and ammeter are noted.
4. Stator resistance in ohms is calculated

MODEL CALCULATION:

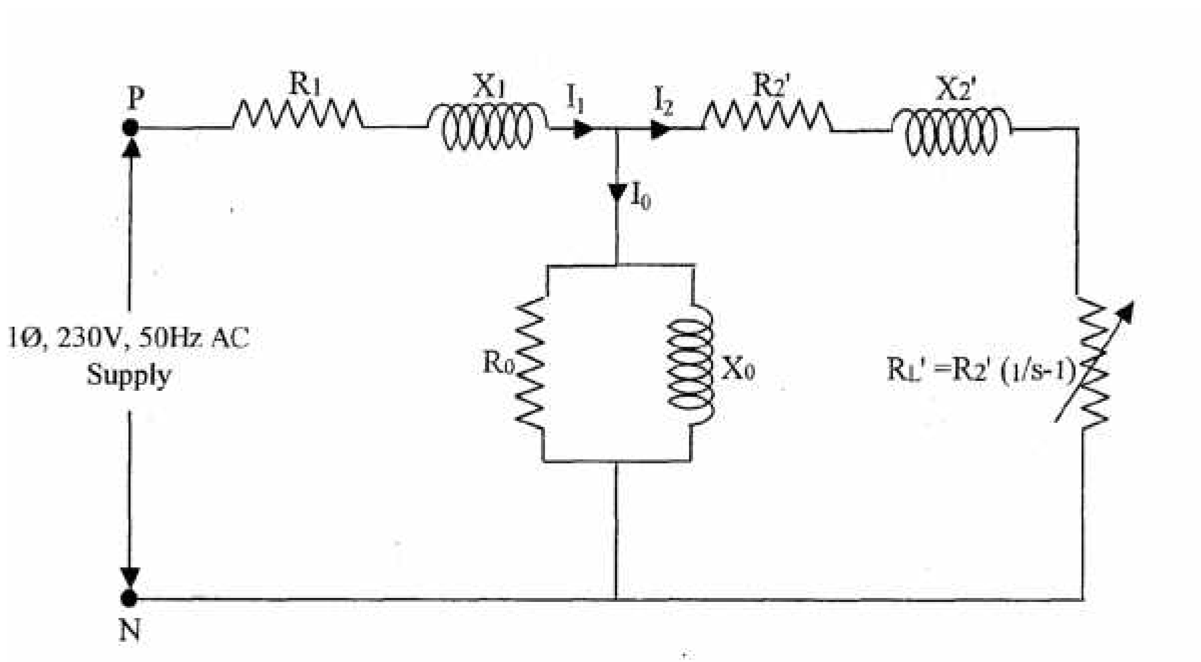
TO FIND OUT THE STATOR RESISTANCE (R_1):



TABULATION TO FIND OUT THE STATOR RESISTANCE (R_1):

S.No	Stator current (I)	Stator Voltage (V)	Stator Resistance R_1 = V/I
	Amps	Volts	Ω

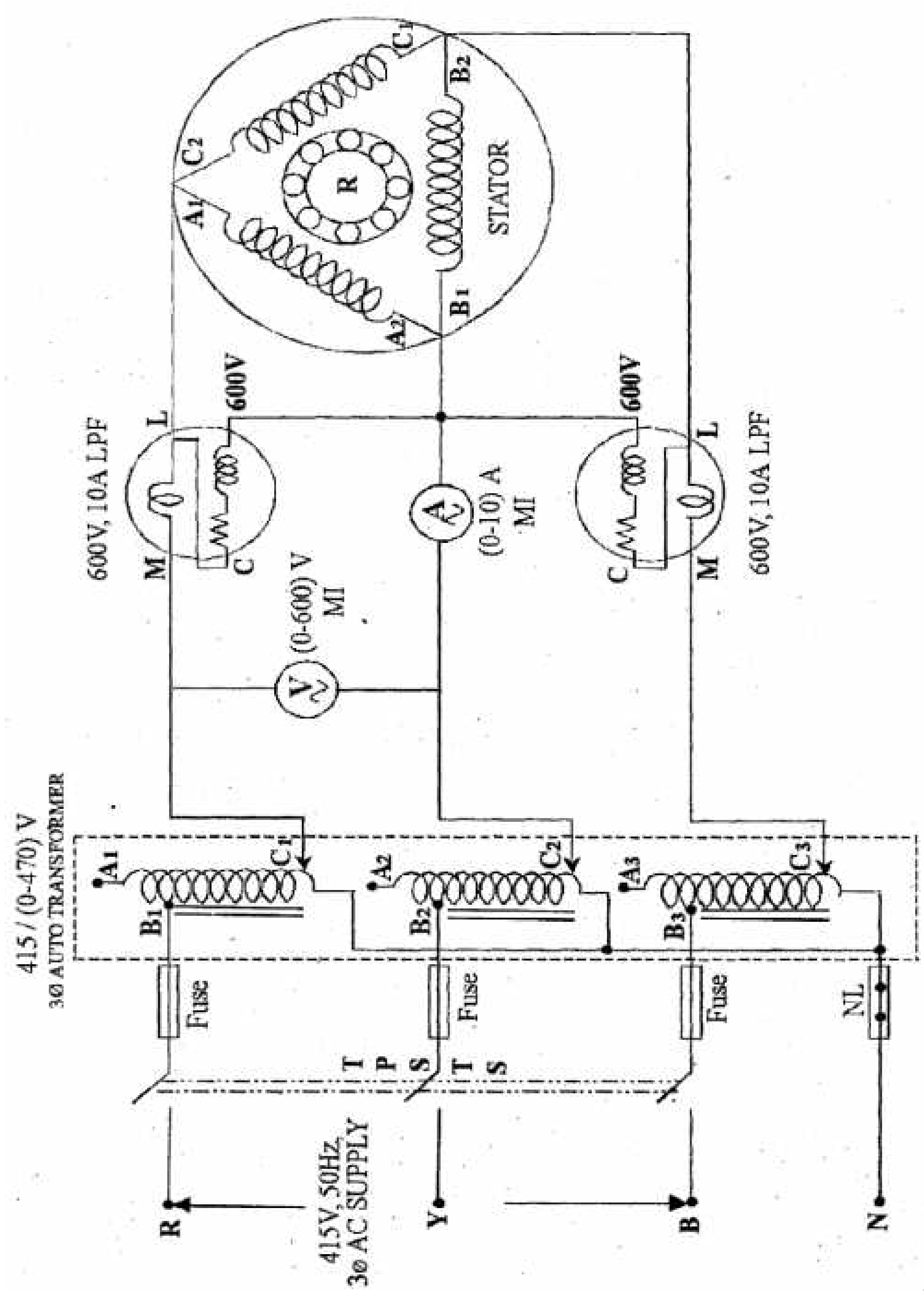
EQUIVALENT CIRCUIT



RESULT:

Thus the No Load test and Blocked Rotor test on three phase squirrel cage induction motor was conducted and the equivalent circuit parameters were determined.

CIRCUIT DIAGRAM FOR SEPARATION OF NO LOAD LOSSES IN THREE PHASE SQUIRREL CAGE INDUCTION MOTOR



DATE: **EX.NO.**

SEPARATION OF NO LOAD LOSSES IN 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	APPARATUS REQUIRED	TYPE	RANGE	QUANTITY
1	Volt Meter	MI	(0-600)V	1
2	Volt Meter	MC	(0-50) V	1
3	Ammeter	MI	(0-10) A	1
4	Ammeter	MC	(0-10) A	1
5	Watt Meter	LPF	600V,10A	2
6	Connecting wires			Required

NAME PLATE DETAILS:

FUSE RATING CALCULATION:

No-load - 10% of rated current.

FORMULAE USED:

1. Input power, W = W watts
2. Stator copper loss = $3 I_0^2 R_s$ Watts
3. Constant Loss / phase, $W_c = (W - 3 I_0^2 R_s) / 3$ watts
4. Core loss / phase, W_i = (constant loss / phase) – mechanical loss
   Here, mechanical loss (W_m) will be the distance from the origin to the point at where the constant loss / phase Vs Voltage curve cuts the Y axis.

TABULATION:

S.No	No Load Voltage (V_0)	No Load current (I_0)	Wattmeter Readings W		Input power	Stator copper Loss	Constant Loss per phase	Core Loss per phase
			Obs	Act				
	(V)	(A)	Watts		Watts	Watts	Watts	Watts

PRECAUTION:

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

PROCEDURE:

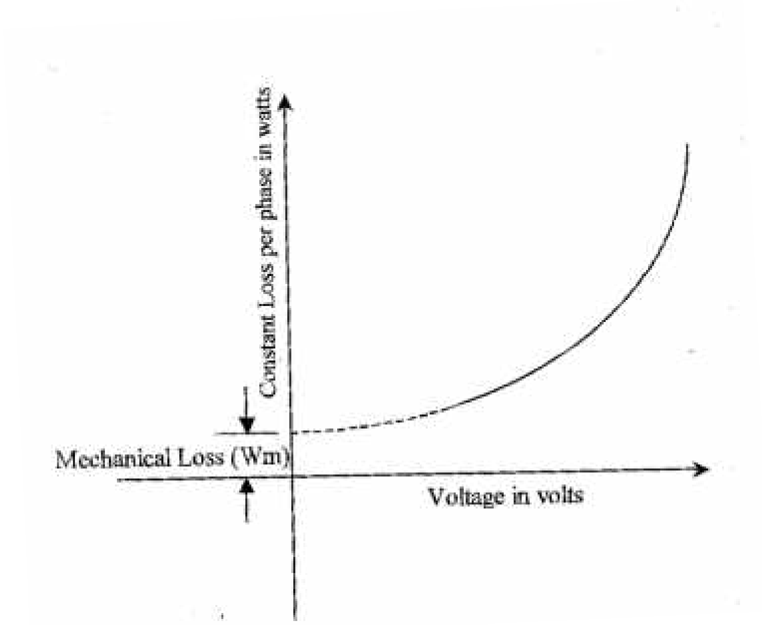
1. Connections are made as per the circuit diagram.
2. By giving the three phase supply through the autotransformer, start the motor.
3. The autotransformer should be varied till the motor attains its rated speed and note the input power, voltage and current.
4. Repeat the same procedure for some more values of the voltage and tabulate the readings.
5. Find the stator copper loss and constant loss by respective formulas.
6. Draw the suitable graph to find the mechanical loss.
7. Obtain the core loss by separating the mechanical loss from the constant loss.

GRAPH:

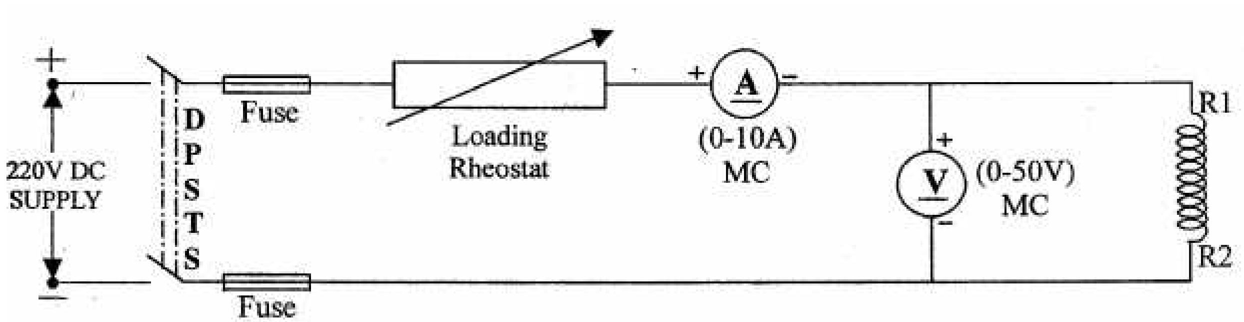
The graph is drawn between constant losses (watts) and input voltage (volts).

MODEL CALCULATION:

MODEL GRAPH:



TO FIND OUT THE STATOR RESISTANCE (R_s):



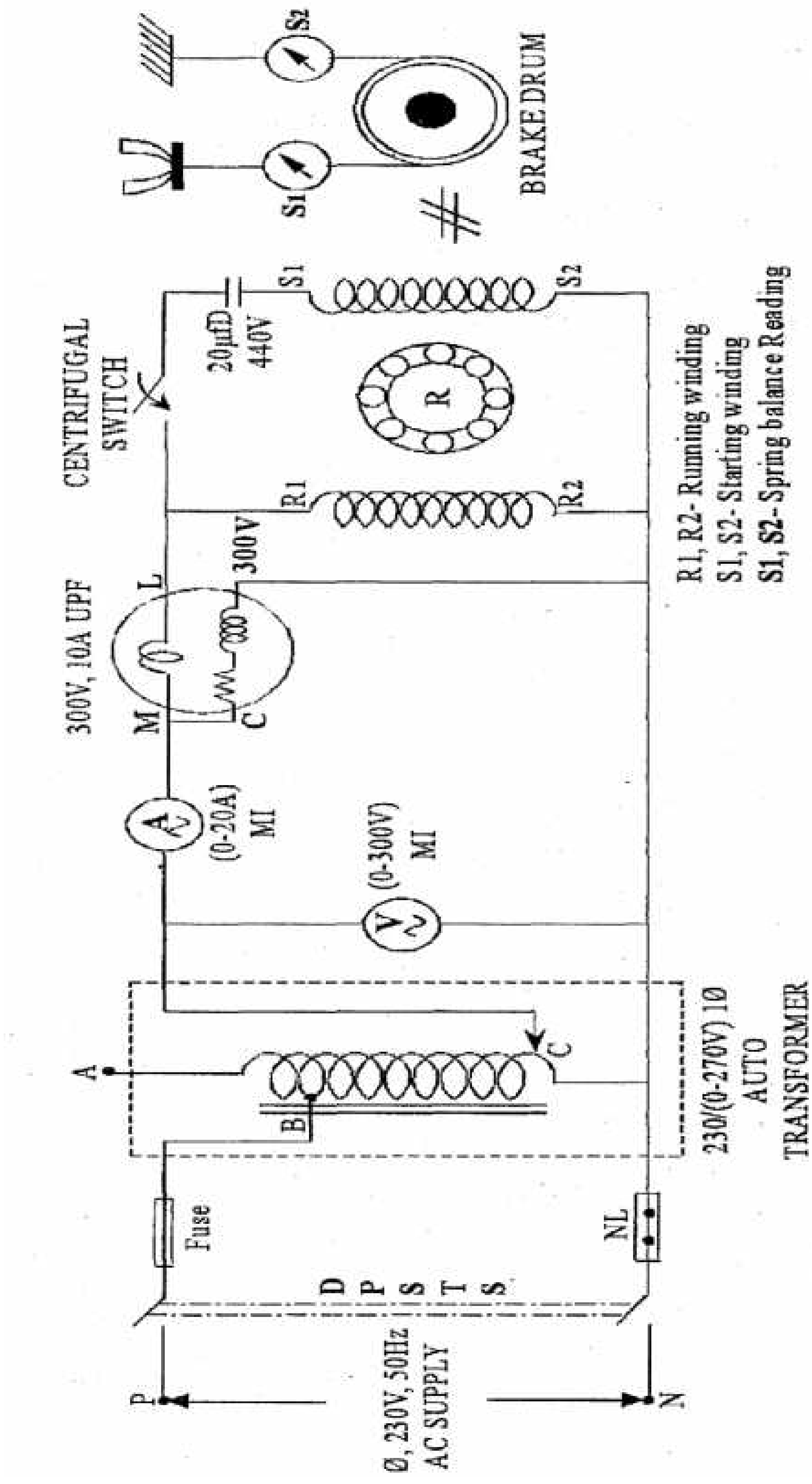
TABULATION TO FIND OUT THE STATOR RESISTANCE (R_s):

S.No	Stator current (I)	Stator Voltage (V)	Stator Resistance R_s = V/I
	Amps	Volts	Ω

RESULT:

Thus the no load losses in three phase squirrel cage induction motor was separated as core loss and mechanical loss.

CIRCUIT DIAGRAM FOR LOAD TEST ON SINGLE PHASE INDUCTION MOTOR



DATE: **EX.NO.**

LOAD TEST ON SINGLE PHASE INDUCTION MOTOR

AIM:

To conduct the load test on single phase induction motor and to draw the performance characteristics.

APPARATUS REQUIRED:

S.NO	APPARATUS REQUIRED	TYPE	RANGE	QUANTITY
1	Volt Meter	MI	(0-300)V	1
2	Ammeter	MI	(0-20)A	1
3	Watt Meter	UPF	300V,10A	1
4	Connecting Wires			Required.

NAME PLATE DETAILS:

FUSE RATING CALCULATION:

125% of rated current.

FORMULAE USED:

1. Torque,

$$T = (S1 \sim S2)\ (R + t/2) * 9.81 \ \text{N-m}$$

S_1, S_2 – Spring balance readings in Kg
R- Radius of the brake drum in m.
t – Thickness of the belt in m

2. Input power

$$P_{in} = W \text{ Watts}$$

W – Wattmeter reading in Watts.

3. Output power,

$$P_{out} = 2\pi NT/60 \text{ watts.}$$

N – Rotor speed in rpm
T – Torque in N-m

TABULATION:

S.No	Load Voltage (V_L)	Load current (I_L)	Wattmeter Readings		Input power	Speed	Spring balance reading			Torque	Output power	Efficiency	Slip s	Power factor
			Obs	Act			S_1	S_2	$S_1 \sim S_2$					
	(V)	(A)	Watts		W	rpm	kg			N-m	W	%	%	

4. % Efficiency,

$$\% \eta = P_{out} / P_{in} * 100$$

5. % Slip,

$$\% s = (N_s – N)/N_s *100$$

N_s – Synchronous speed in rpm
N – Speed of thr motor in rpm

6. Power factor,

$$\cos\varphi = W / (V_L I_L)$$

PRECAUTION:

1. The auto transformer should be kept in minimum voltage position.
2. The motor is started without any load.

PROCEDURE:

1. Connections are given as per the circuit diagram.
2. The DPST switch is closed and the single phase supply is given.
3. By adjusting the variac the rated voltage is applied and the corresponding no load values of speed, spring balance and meter readings are noted down. If the wattmeter readings show negative deflection on no load, switch of the supply & interchange the terminals of current coils (M & L) of the wattmeter. Now, again starting the motor (follow above procedure for starting), take readings.
4. The procedure is repeated till rated current of the motor.
5. The motor is unloaded, the auto transformer is brought to the minimum voltage position, and the DPST switch is opened.
6. The radius of the brake drum is measured.

OBSERVATION:

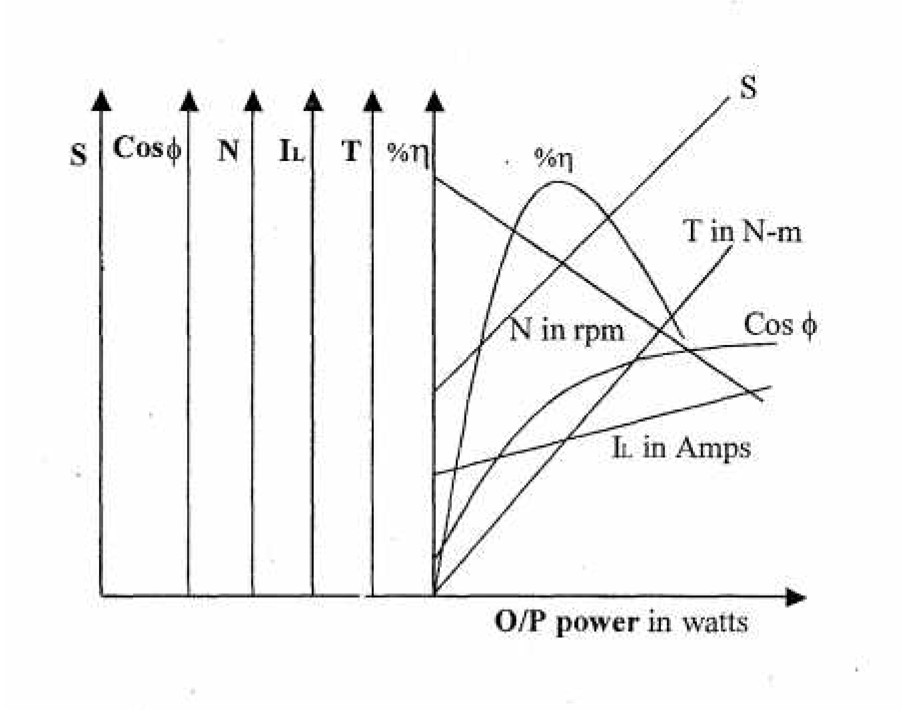
Circumference of the brake drum =
Thickness of the belt =

GRAPH :

The graphs are drawn for

(i) Output power Vs Speed
(ii) Output power Vs Line current
(iii) Output power Vs Torque
(iv) Output power Vs power factor
(v) Output power Vs % Efficiency
(vi) Output power Vs % slip

MODEL GRAPH:

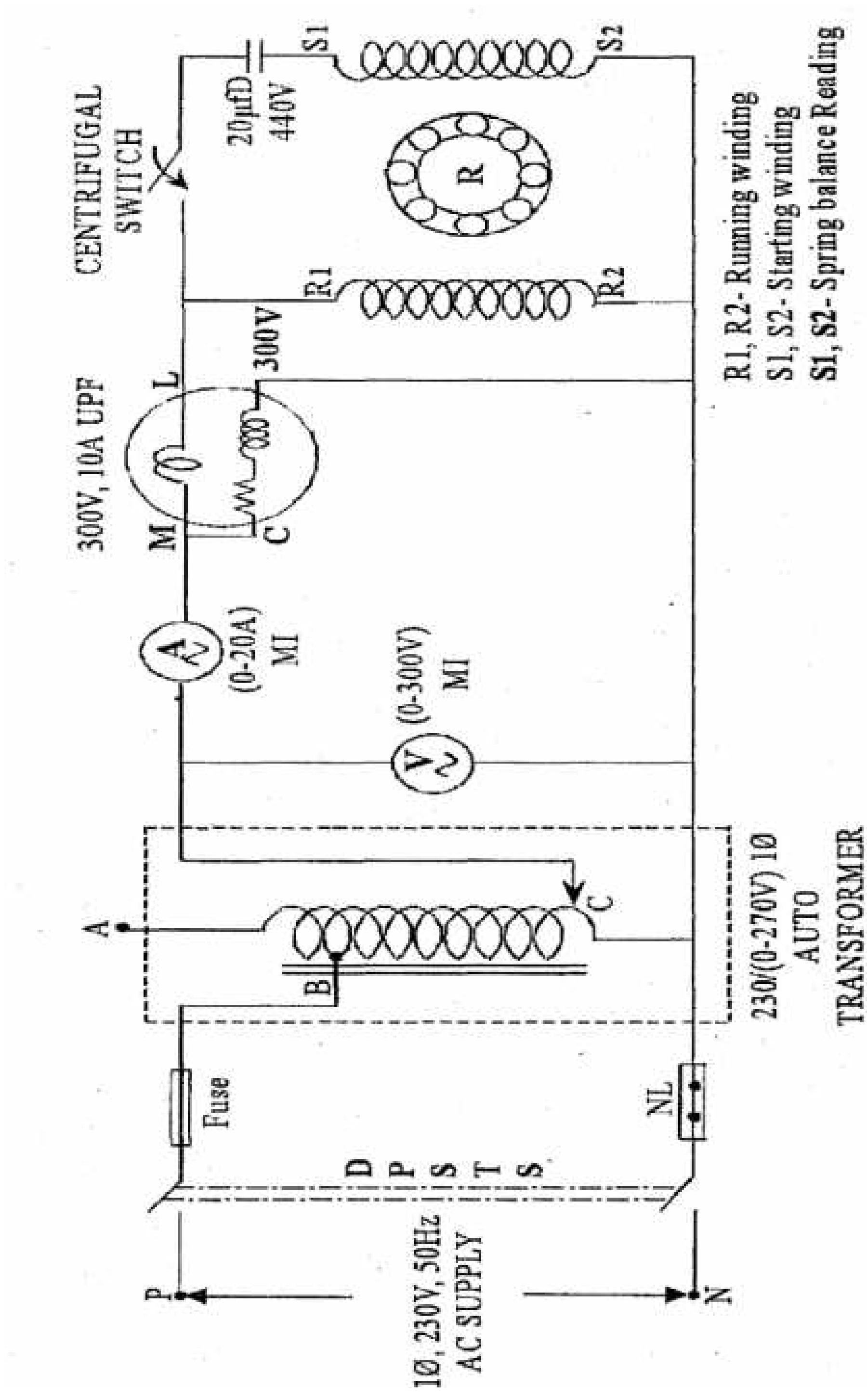


MODEL CALCULATION:

RESULT:

Thus the load test on single phase induction motor was conducted and the performance characteristics were drawn.

CIRCUIT DIAGRAM FOR NO LOAD TEST ON SINGLE PHASE INDUCTION MOTOR



DATE: **EX.NO.**

NO LOAD AND BLOCKED ROTOR TEST ON SINGLE PHASE INDUCTION MOTOR

AIM:

To conduct the No Load test and Blocked Rotor test on single phase squirrel cage induction motor and to draw the equivalent circuit.

APPARATUS REQUIRED:

S.NO	APPARATUS REQUIRED	TYPE	RANGE	QUANTITY
1.	Volt Meter	MI	(0-300) V	1
2.	Volt Meter	MC	(0-50) V	1
3.	Ammeter	MI	(0-20) A	1
4.	Ammeter	MC	(0-10) A	1
5.	Watt Meter	LPF	300V,10A	1
6.	Watt Meter	UPF	150V,10A	1
7.	Connecting wires			Required

NAME PLATE DETAILS:

FUSE RATING CALCULATION:

125% of rated current.

No-load test - 10% of rated current.

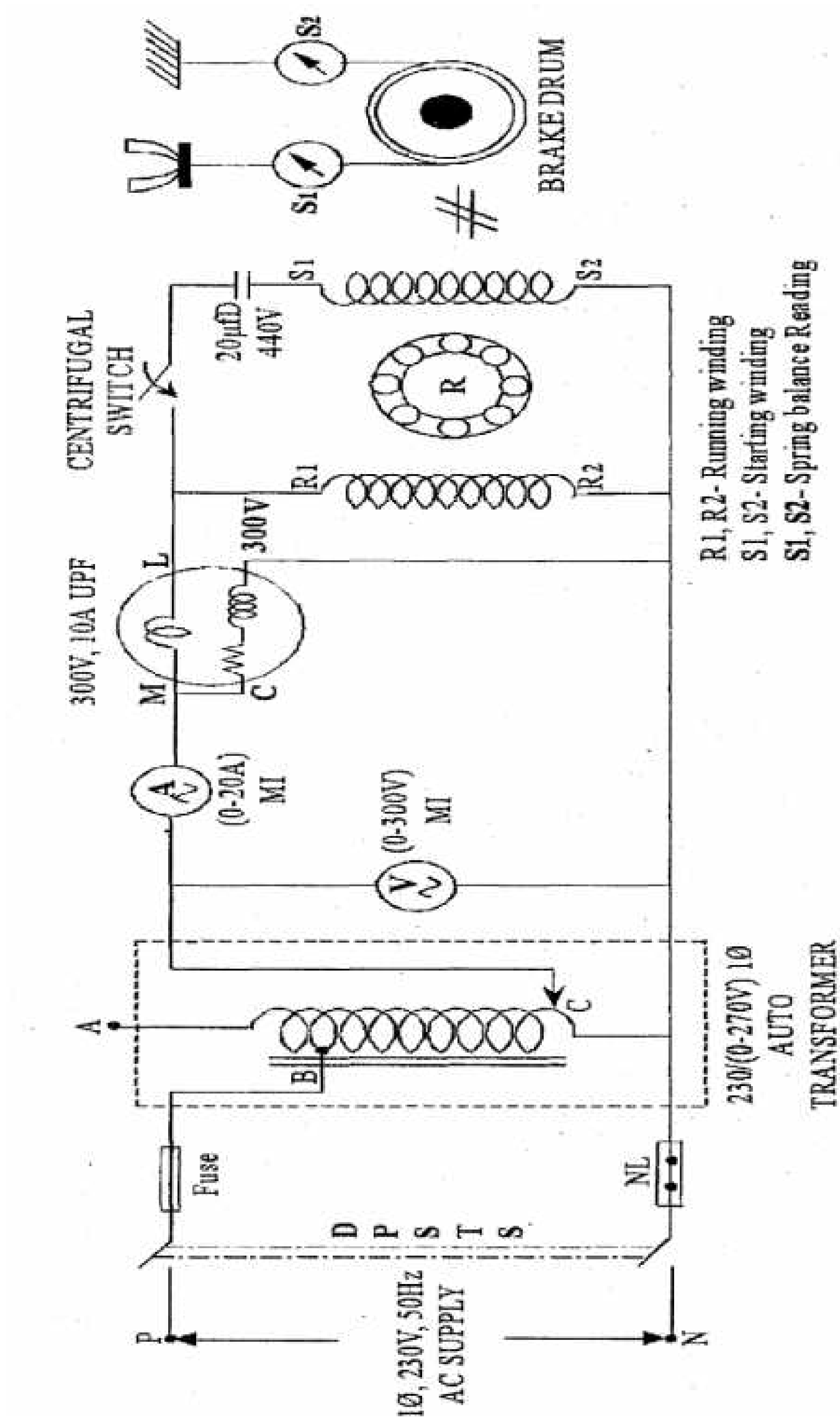
FORMULAE USED:

<u>OC TEST</u>

1. No load power factor, $\cos \varphi_0 = W_0 / V_0 I_0$
   V_0 – No load voltage in volts
   I_0 – No load current in amps
   W_0 – No load power in watts

2. Active Component, $I_c = I_0 \cos \varphi_0$

CIRCUIT DIAGRAM FOR BLOCKED ROTOR TEST ON SINGLE PHASE INDUCTION MOTOR



3. Magnetising Component, $I_m = I_0 \sin \varphi_0$

4. No load resistance $(R_0) = V_0 / I_c \ \Omega$

5. No load reactance $(X_0) = V_0 / I_m \ \Omega$

SC TEST

6. Equivalent impedance referred to stator, $Z_{1e)} = V_{SC} / I_{SC} \ \Omega$

7. Equivalent resistance referred to stator, $R_{1e} = W_{SC} / [I^2_{SC}] \ \Omega$

8. Equivalent reactance referred to stator, $X_{1e} = \sqrt{[(Z_{1e})^2 - (R_{1e})^2]} \ \Omega$

9. Rotor resistance referred to stator $(R'_2) = R_{1e} - R_1 \ \Omega$

10. Rotor reactance referred to stator $(X'_2) = X_{1e} / 2 = X_1 \ \Omega$

    Where R_1 - stator resistance

    X_1 – stator reactance

    $R_1 = R_{(ac)} = 1.6\ R_{(dc)}$
11. Magnetising reactance $(X_m) = 2\ (X_0 - X_1 - X_2' / 2)$
12. Slip, $s = (N_s - N) / N_s$

    N_s – Synchronous speed in rpm

    N – Speed of motor in rpm

PRECAUTION:

The autotransformer should be kept in minimum voltage position.

PROCEDURE:

NO LOAD TEST

1. Connections are given as per the circuit diagram
2. By adjusting the auto transformer, rated voltage is applied and the ammeter and wattmeter readings are noted.
3. Initial position of auto transformer is brought back.
4. Supply is switched off.

BLOCKED ROTOR TEST

1. Connections are given as per the circuit diagram
2. Rotor is blocked from rotating.
3. Applied voltage is increased until rated load current flows.
4. Readings of all meters are noted.

TABULATION:

NO LOAD TEST:

S.No	No load voltage (V_0)	No load current (I_0)	No Load Power (W_0)	
			Observed	Actual
	(V)	(A)	Watts	

BLOCKED ROTOR TEST

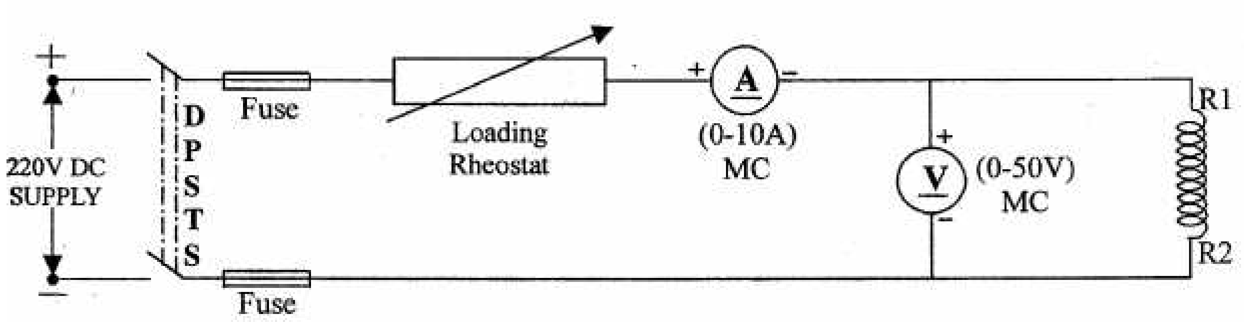
S.No	Short circuit voltage (V_{sc})	Short circuit current (I_{sc})	Short circuit Power (W_{sc})	
			Observed	Actual
	(V)	(A)	Watts	

MEASUREMENT OF STATOR RESISTANCE

1. Connections are made as per the circuit diagram.
2. Supply is given by closing the DPST switch.
3. Readings of voltmeter and ammeter are noted.
4. Stator resistance in ohms is calculated

MODEL CALCULATION:

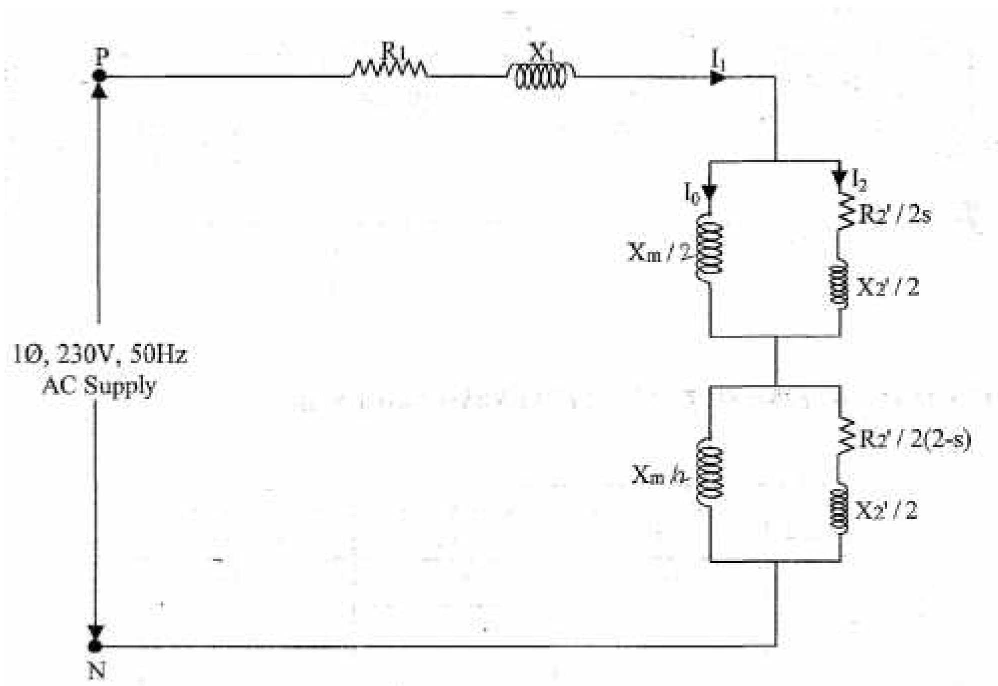
TO FIND OUT THE STATOR RESISTANCE (R_1):



TABULATION TO FIND OUT THE STATOR RESISTANCE (R_1):

S.No	Stator current (I)	Stator Voltage (V)	Stator Resistance R_1 = V/I
	Amps	Volts	Ω

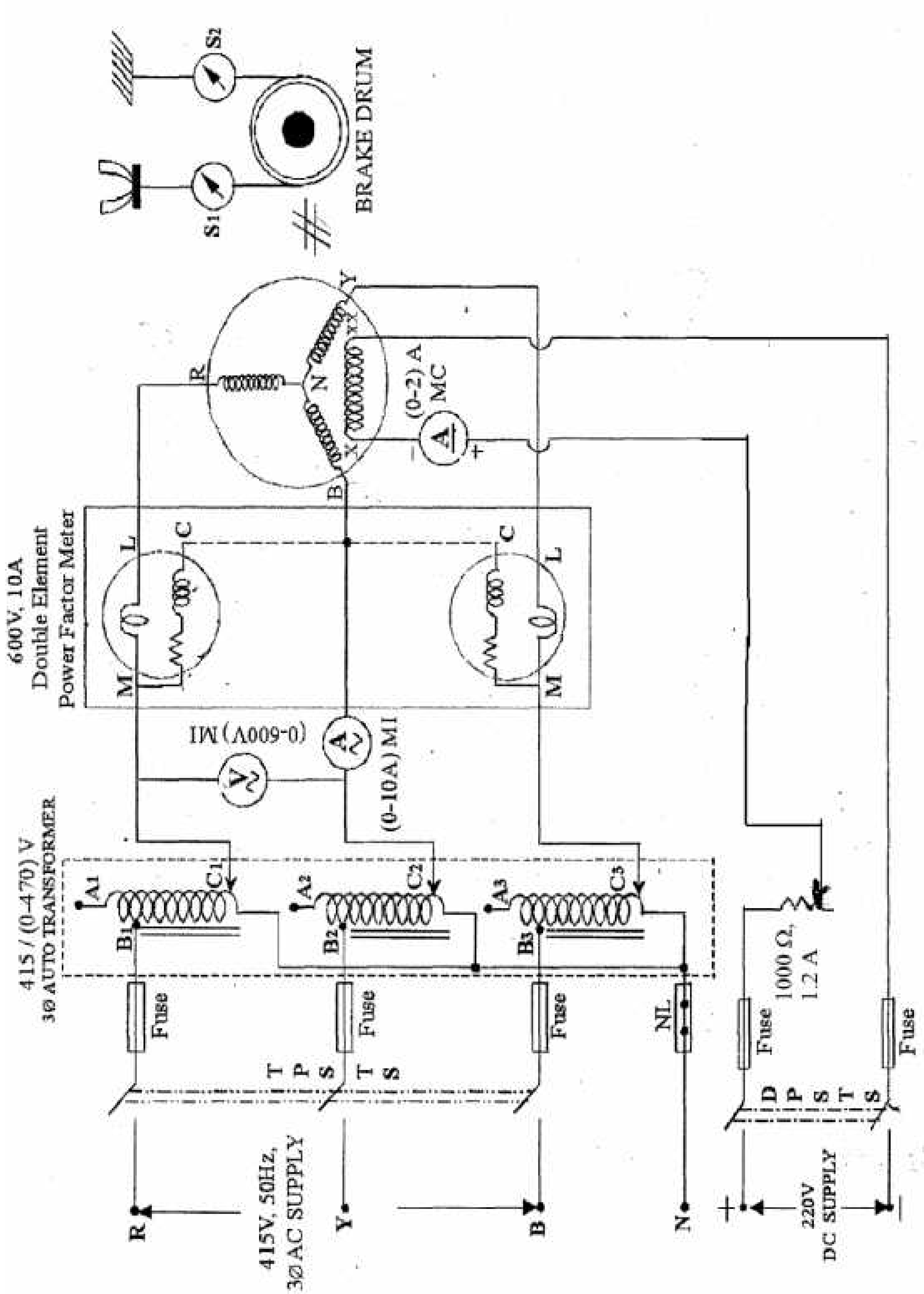
EQUIVALENT CIRCUIT



RESULT:

Thus the No Load test and Blocked Rotor test on single phase squirrel cage induction motor was conducted and the equivalent circuit parameters were determined.

CIRCUIT DIAGRAM FOR V AND INVERTED V CURVES OF THREE PHASE SYNCHRONOUS MOTOR



DATE: **EX.NO.**

V AND INVERTED V CURVES OF THREE PHASE SYNCHRONOUS MOTOR

AIM:

To draw the V and Inverted V curves of three phase Synchronous motor.

APPARATUS REQUIRED:

S.NO	APPARATUS REQUIRED	TYPE	RANGE	QUANTITY
	Volt Meter	MI	(0-600) V	1
	Ammeter	MI	(0-10) A	1
	Ammeter	MC	(0-2) A	1
	Power factor meter	Double Element	600V,10A	1
	Rheostat	Wire wound	1000 Ω,1.2 A	1
	Connecting wires			Required

NAME PLATE DETAILS:

FUSE RATING CALCULATION:

125% of rated current.

For DC Excitation:

For Synchronous Motor:

PRECAUTION:

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

PROCEDURE:

1. Note down the name plate details of motor.
2. Connections are given as per the circuit diagram.
3. Close the TPST switch.

4. By adjusting the auto transformer from minimum position to maximum position the rated supply is given to the motor. The motor starts as an induction motor.

TABULATION:

Armature Voltage:

S. No	Without Load			With Load		
	Excitation Current (I_f)	Armature Current (I_a)	Power Factor (Cos φ)	Excitation Current (I_f)	Armature Current (I_a)	Power Factor (Cos φ)
	Amps	Amps		Amps	Amps	

5. In order to give the excitation to the field winding, for making it to run as synchronous motor, close the DPST switch.
6. By varying the field current with the help of field rheostat from under excitation to over excitation, note down the excitation current, armature current and the power factor.
7. The same process has to be repeated for loaded conditions.
8. Later reduce the load and the motor is switched off after observing the precautions.

GRAPH:

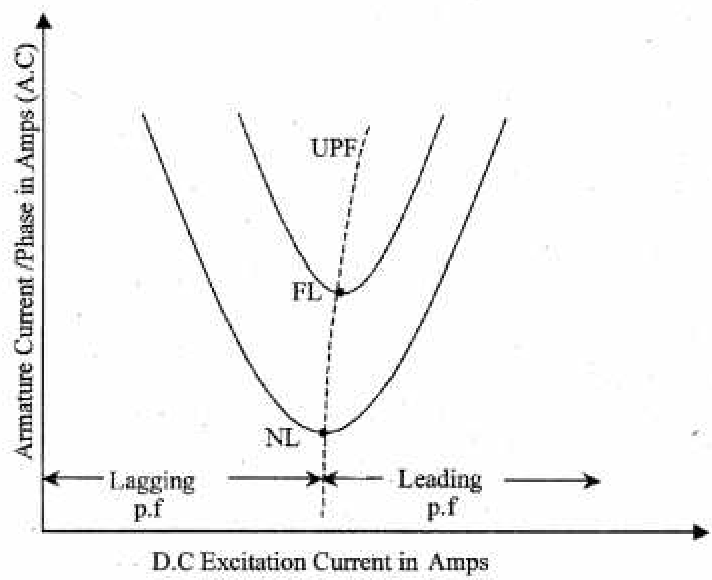
The graph was drawn for

(i) Armature current Vs Excitation current

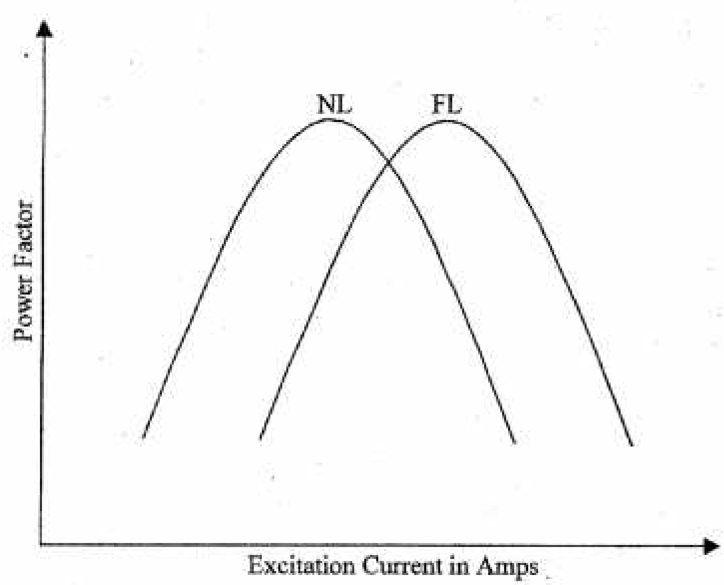
(ii) Power factor Vs Excitation current

MODEL GRAPH:

(A) Excitation Current Vs Armature Current



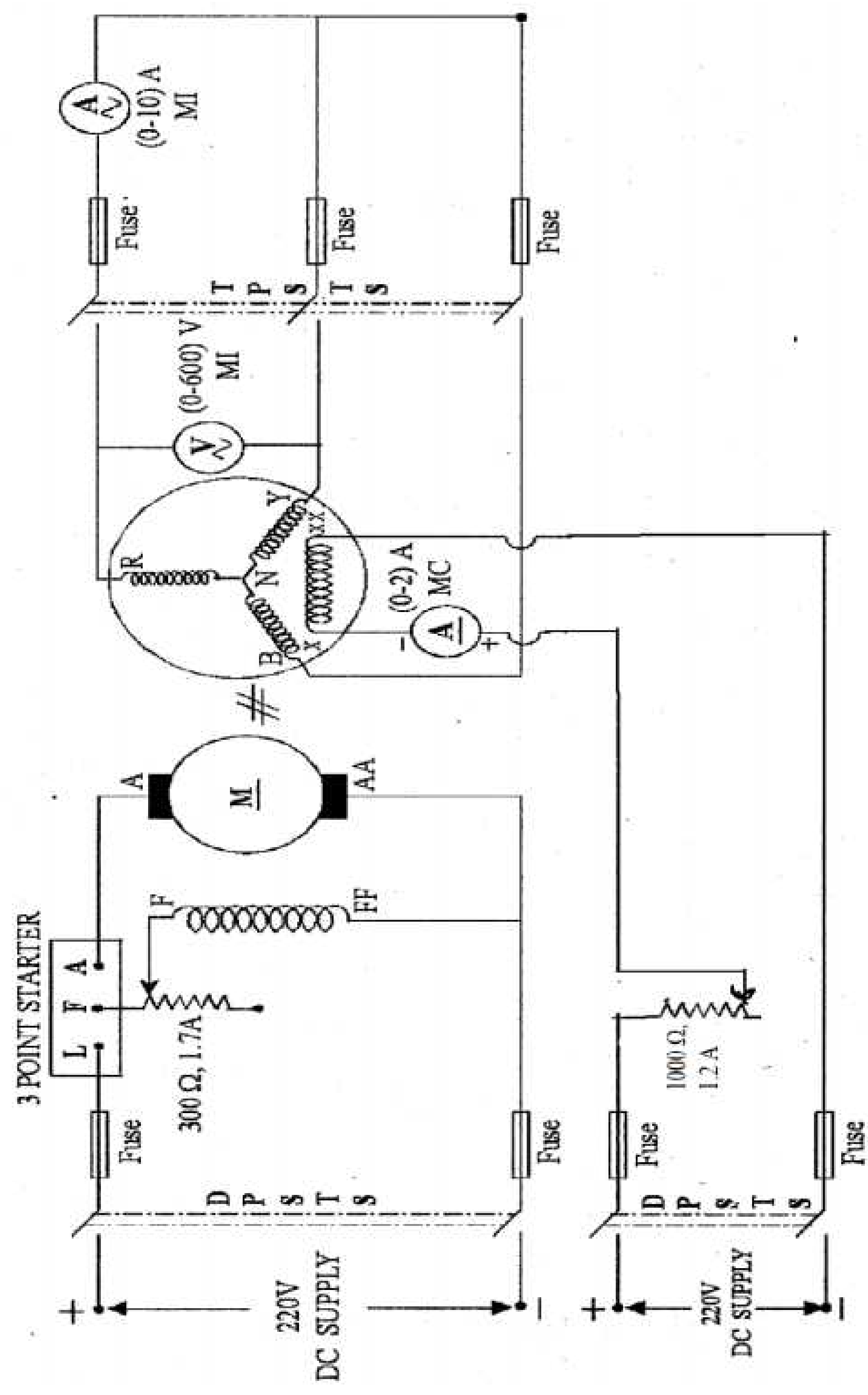
(B) Excitation Current Vs Power Factor



RESULT:

Thus V and inverted V curves of three phase synchronous motor is plotted.

CIRCUIT DIAGRAM FOR REGULATION OF THREE PHASE ALTERNATOR BY EMF METHOD



DATE: **EX.NO.**

REGULATION OF THREE PHASE ALTERNATOR BY EMF METHOD

AIM:

To predetermine the percentage regulation of the given alternator by EMF (Synchronous Impedance Method), by conducting Open Circuit and Short circuit test.

APPARATUS REQUIRED:

S.NO	APPARATUS REQUIRED	TYPE	RANGE	QUANTITY
1	Volt Meter	MI	(0-600) V	1
2	Volt Meter	MC	(0-150) V	1
3	Ammeter	MI	(0-10) A	1
4	Ammeter	MC	(0-10) A	1
5	Ammeter	MC	(0-2) A	1
6	Rheostat	Wire wound	1000 Ω, 1.2 A	1
7	Rheostat	Wire wound	300 Ω, 1.7 A	1
8	Connecting wires			Required

NAME PLATE DETAILS:

FUSE RATING CALCULATION:

125% of rated current.

No-load test - 10% of rated current.

FORMULAE USED:

1. Armature resistance $R_a = 1.6\ R_{dc}$
   R_{dc} – resistance in DC supply
2. Synchronous impedance, $Z_s = \frac{o \quad c \quad v \quad ,E1(p\ )}{s \quad c \quad c \quad ,I!}$ (from graph)
3. Synchronous reactance, $X_s = \sqrt{(Zs^2 - Ra^2)}$ Ω/ph

TABULATION:

OPEN CIRCUIT TEST:

S.No	Field Current (I_f)	Open Circuit Line Voltage $(V_{oc})_L$	Open Circuit Phase Voltage $(V_{oc})_{ph} = (V_{oc})_L / \sqrt{3}$
	Amps	Volts	Volts

SHORT CIRCUIT TEST:

S.No	Field Current (I_f)	Short Circuit Current (I_{sc})
	Amps	Amps

4. No load induced e.m.f per phase,

$$E_{ph} = \sqrt{(Vph\ cos\varphi + IaRa)^2 + (Vph\ sin\varphi \pm IaXs)^2}$$

Where,

V_{ph} – phase value of rated voltage
I_a – phase value of current
Cos φ – p.f. of load
+ ve sign for lagging power factor
-ve sign for leading power factor

5. % regulation = $\frac{(E \quad - V \quad)}{V}$ x 100

PRECAUTION:

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

PROCEDURE:

Open Circuit Test:

1. Connections are made as per the circuit diagram is obtained.
2. Observing the precautions, DPST switch on motor side is closed.
3. Using 3-point starter, the DC motor is started.
4. Varying the field rheostat of DC shunt motor, it is set to run at rated speed as per name plate detail.
5. DPST switch in alternator field circuit is closed.
6. Keeping the TPST switch of alternator side open, the field current is varied using the alternator potential divider.
7. For various values of alternator field current (I_f), the generated AC line voltage (V_{oc}) is noted down and the readings are tabulated.(This should be done upto125% of rated voltage).

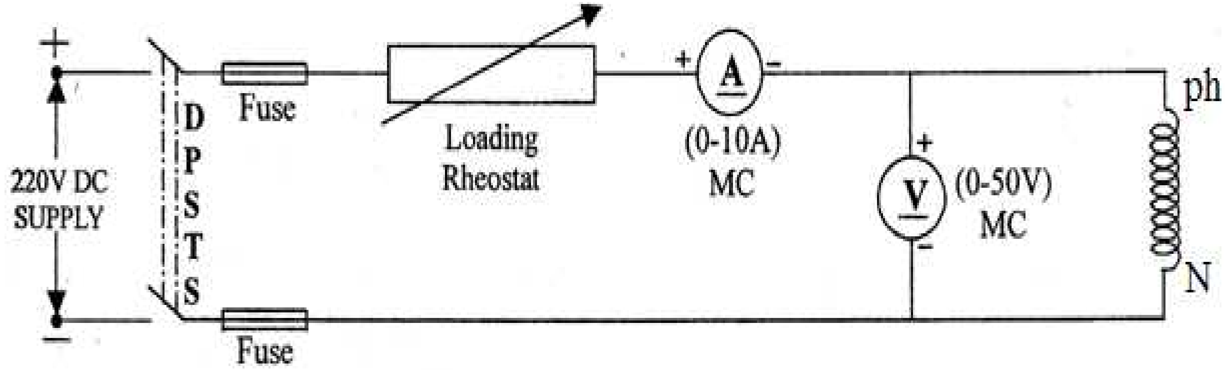
Short circuit Test:

1. TPST switch, on alternator side is closed.
2. Adjust the potential divider to set the rated armature current, tabulate the corresponding field current.
3. Restore the initial conditions.
4. Switch off the supply.

MEASUREMENT OF STATOR RESISTANCE

1. Connections are made as per the circuit diagram.
2. Supply is given by closing the DPST switch.
3. Readings of voltmeter and ammeter are noted.
4. Stator resistance in ohms is calculated

TO FIND OUT THE ARMATURE RESISTANCE (R_a):



TABULATION TO FIND OUT THE ARMATURE RESISTANCE (R_a):

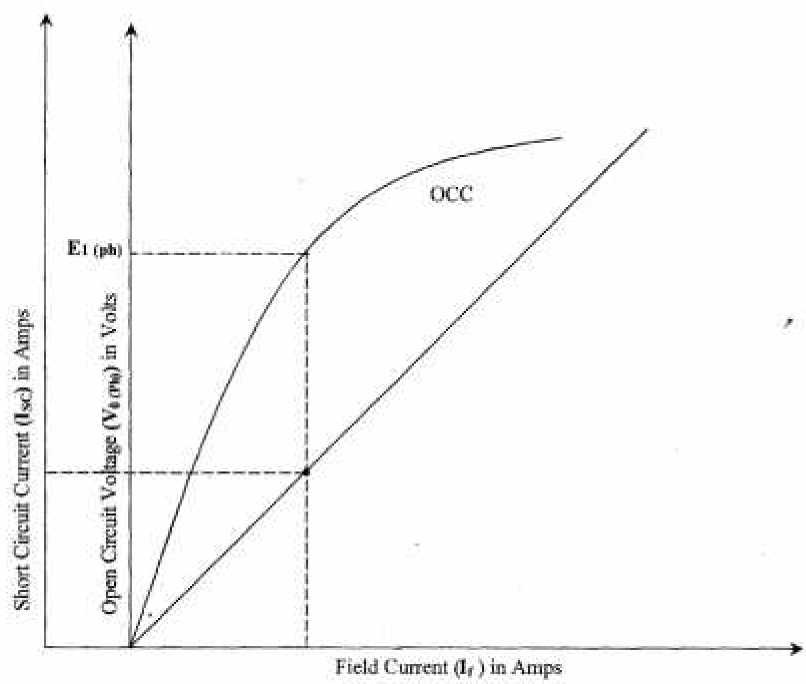
S.No	Armature Current (I)	Armature Voltage (V)	Armature Resistance $R_a = V/I$
	Amps	Volts	Ω

PROCEDURE TO DRAW THE GRAPH:

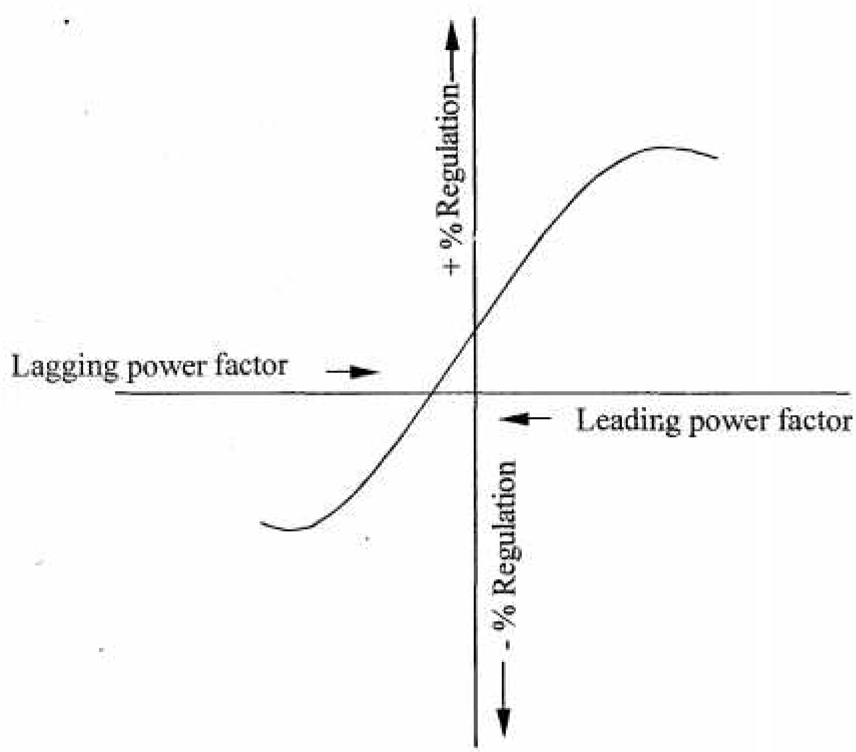
1. Draw the open circuit characteristics curve (generated voltage per phase Vs field current)
2. Draw the short circuit characteristics curve (short circuit current Vs field current)
3. From the graph find the open circuit voltage per phase ($E_{1\ (ph)}$) for the short circuit current I_{sc}.
4. By using respective formulae find Z_s, X_s, E_{ph} and % regulation.

MODEL CALCULATION:

MODEL GRAPH:



MODEL GRAPH FOR % REGULATION:



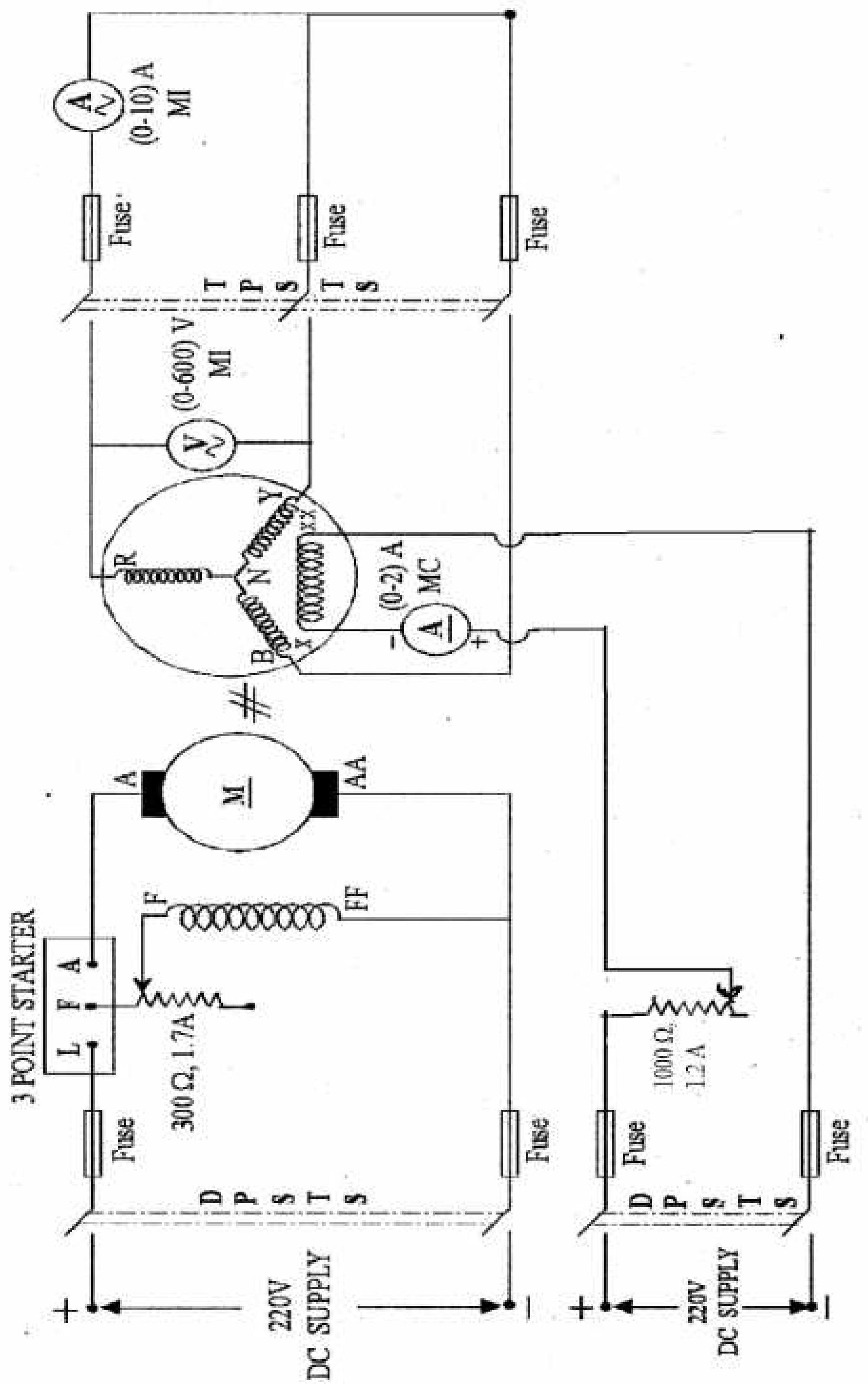
TABULATION FOR % REGULATION:

S.No	Power Factor	E_{ph} (V)		% Regulation	
		Lagging	Leading	Lagging	Leading
1.	0.2				
2.	0.4				
3.	0.6				
4.	0.8				
5.	1.0				

RESULT:

Thus the percentage regulation of the given alternator by EMF (Synchronous Impedance Method), was predetermined by conducting Open Circuit and Short circuit test.

CIRCUIT DIAGRAM FOR REGULATION OF THREE PHASE ALTERNATOR BY MMF METHOD



DATE: **EX.NO.**

REGULATION OF THREE PHASE ALTERNATOR BY MMF METHOD

AIM:

To predetermine the percentage regulation of the given alternator by MMF (Ampere Turns Method), by conducting Open Circuit and Short circuit test.

APPARATUS REQUIRED:

S.NO	APPARATUS REQUIRED	TYPE	RANGE	QUANTITY
1	Volt Meter	MI	(0-600) V	1
2	Volt Meter	MC	(0-150) V	1
3	Ammeter	MI	(0-10) A	1
4	Ammeter	MC	(0-10) A	1
5	Ammeter	MC	(0-2) A	1
6	Rheostat	Wire wound	1000 Ω, 1.2 A	1
7	Rheostat	Wire wound	300 Ω, 1.7 A	1
8	Connecting wires			Required

NAME PLATE DETAILS:

FUSE RATING CALCULATION:

125% of rated current.

No-load test - 10% of rated current.

FORMULAE USED:

1. Find field current $I_{f\,1}$ corresponding to the voltage ($V_{ph} + I_{a\,ph} R_a \text{Cos}\,\varphi$) from open circuit characteristics.
2. Find field current $I_{f\,2}$ required to circulate full load short circuit current I_{sc} from short circuit characteristics.
3. Resultant field current, $I_f^2 = I^2_{f\,1} + I^2_{f\,2} - 2\, I_{f\,1}\, I_{f\,2} \text{Cos}\,(90 \pm \varphi)$

   + for lag; - for lead.

TABULATION:

OPEN CIRCUIT TEST:

S.No	Field Current (I_f)	Open Circuit Line Voltage $(V_{oc})_L$	Open Circuit Phase Voltage $(V_{oc})_{ph} = (V_{oc})_L / \sqrt{3}$
	Amps	Volts	Volts

SHORT CIRCUIT TEST:

S.No	Field Current (I_f)	Short Circuit Current (I_{sc})
	Amps	Amps

4. Obtain E_{ph} corresponding to resultant field current, I_f from open circuit characteristics.
5. % regulation = $\frac{(E \quad - V \quad)}{V}$ x 100

PRECAUTION:

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

PROCEDURE:

Open Circuit Test:

1. Connections are made as per the circuit diagram is obtained.
2. Observing the precautions, DPST switch on motor side is closed.
3. Using 3-point starter, the DC motor is started.
4. Varying the field rheostat of DC shunt motor, it is set to run at rated speed as per name plate detail.
5. DPST switch in alternator field circuit is closed.
6. Keeping the TPST switch of alternator side open, the field current is varied using the alternator potential divider.
7. For various values of alternator field current (I_f), the generated AC line voltage (V_{oc}) is noted down and the readings are tabulated. (This should be done upto125% of rated voltage).

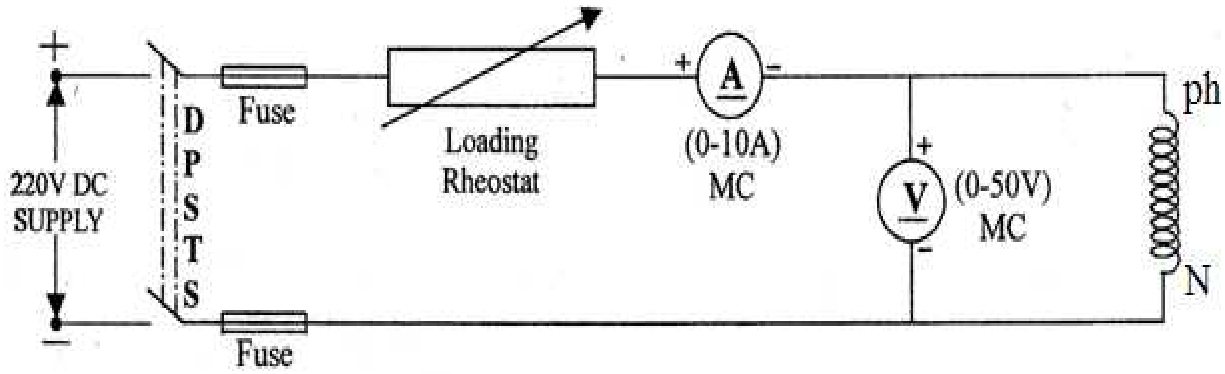
Short circuit Test:

1. TPST switch, on alternator side is closed.
2. Adjust the potential divider to set the rated armature current, tabulate the corresponding field current.
3. Restore the initial conditions.
4. Switch off the supply.

MEASUREMENT OF STATOR RESISTANCE

1. Connections are made as per the circuit diagram.
2. Supply is given by closing the DPST switch.
3. Readings of voltmeter and ammeter are noted.
4. Stator resistance in ohms is calculated

TO FIND OUT THE ARMATURE RESISTANCE (R_a):

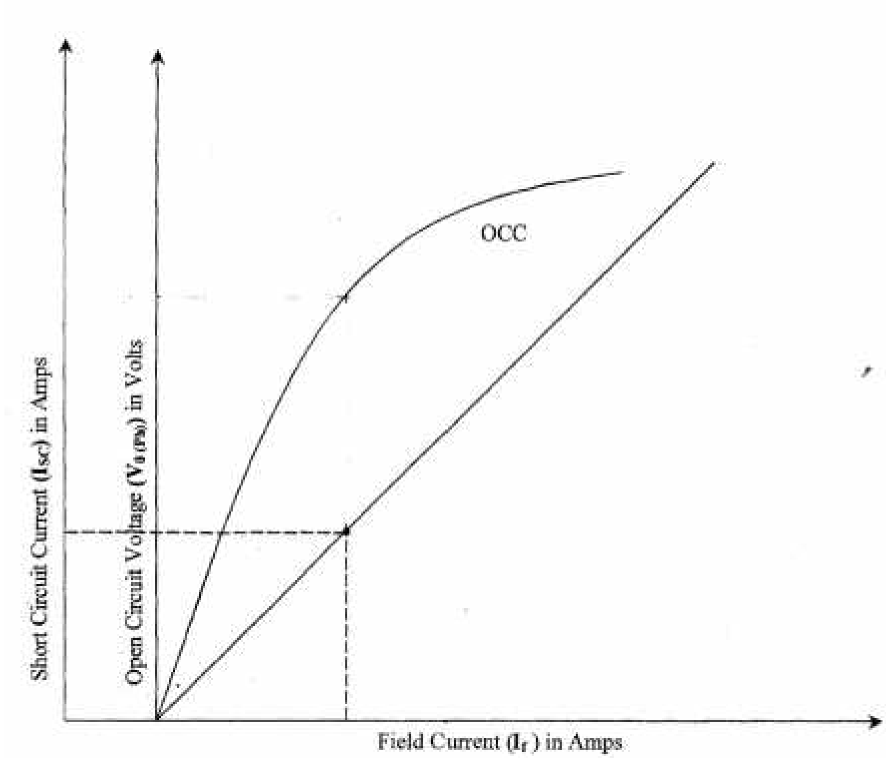


TABULATION TO FIND OUT THE ARMATURE RESISTANCE (R_a):

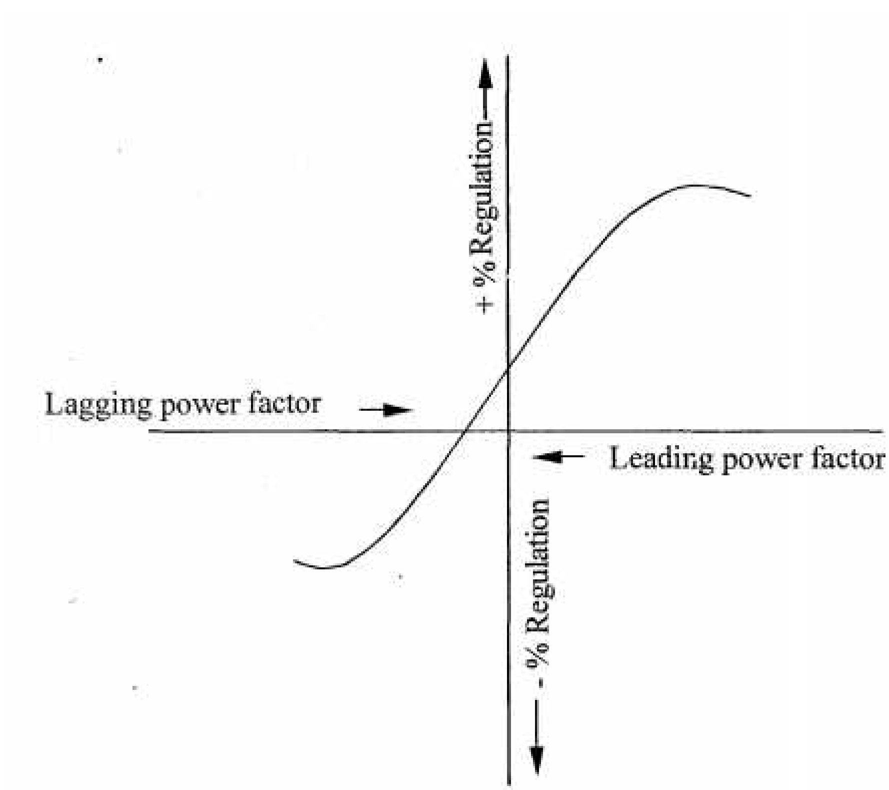
S.No	Armature Current (I)	Armature Voltage (V)	Armature Resistance $R_a = V/I$
	Amps	Volts	Ω

MODEL CALCULATION:

MODEL GRAPH:



MODEL GRAPH FOR % REGULATION:



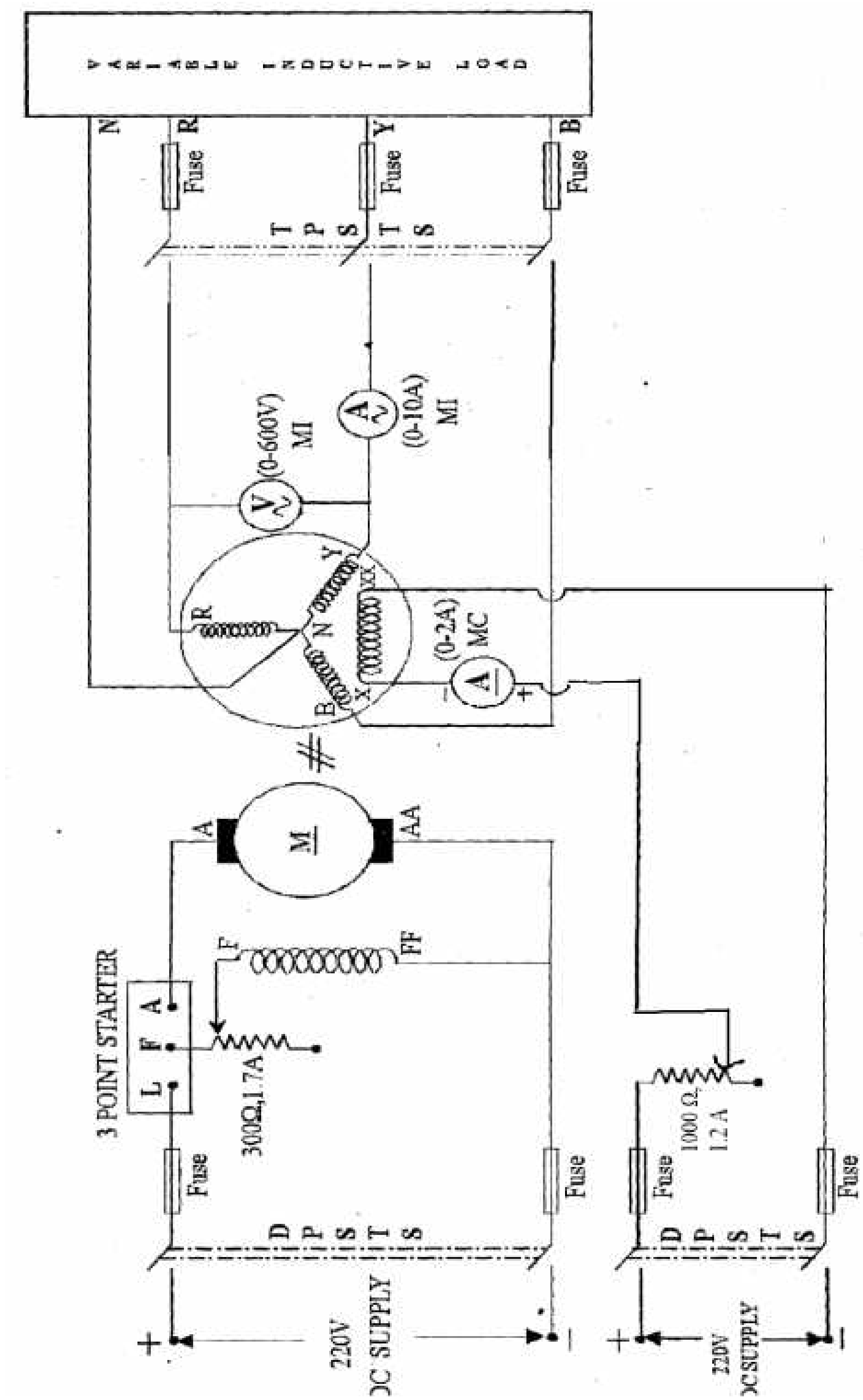
TABULATION FOR % REGULATION:

S. No	Power Factor	$(V_{ph} + I_{a\,ph} R_a \cos\varphi)$	$I_{f\,1}$ (A)	$I_{f\,2}$ (A)	I_f (A)		E_{ph} (V)		% Regulation	
					Lagging	Leading	Lagging	Leading	Lagging	Leading
	0.2									
	0.4									
	0.6									
	0.8									
	1.0									

RESULT:

Thus the percentage regulation of the given alternator by MMF (Ampere Turns Method), was predetermined by conducting Open Circuit and Short circuit test.

CIRCUIT DIAGRAM FOR REGULATION OF THREE PHASE ALTERNATOR BY ZPF METHOD



DATE: **EX.NO.**

REGULATION OF THREE PHASE ALTERNATOR BY ZPF METHOD

AIM:

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

APPARATUS REQUIRED:

S.NO	APPARATUS REQUIRED	TYPE	RANGE	QUANTITY
1	Volt Meter	MI	(0-600) V	1
2	Volt Meter	MC	(0-150) V	1
3	Ammeter	MI	(0-10) A	1
4	Ammeter	MC	(0-10) A	1
5	Ammeter	MC	(0-2) A	1
6	Rheostat	Wire wound	1000 Ω, 1.2 A	1
7	Rheostat	Wire wound	300 Ω, 1.7 A	1
8	Connecting wires			Required

NAME PLATE DETAILS:

FUSE RATING CALCULATION:

125% of rated current.

No-load test - 10% of rated current.

FORMULAE USED:

1. From Potier triangle BCD, the armature leakage reactance drop is *l* (DE)

$$I_{ph} * XL_{ph} = l\text{ (DE) x scale}$$

2. $I_{ph} = KVA/(\sqrt{3}* V_L)$ Ampere

TABULATION:

OPEN CIRCUIT TEST:

S.No	Field Current (I_f)	Open Circuit Line Voltage $(V_{oc})_L$	Open Circuit Phase Voltage $(V_{oc})_{ph} = (V_{oc})_L / \sqrt{3}$
	Amps	Volts	Volts

SHORT CIRCUIT AND ZPF TEST:

	Short Circuit Test		Zero Power Factor Test		
S.No	Field Current (I_f)	Short Circuit Current (I_{sc})	Field Current (I_f)	Rated Armature current (I_a)	Rated Armature Voltage
	Amps	Amps	Amps	Amps	Volts

3. $(E_{1\,ph})^2 = (V_{ph} \cos\varphi + I_{ph} R_{a\,ph})^2 + (V_{ph} \sin\varphi \pm I_{ph} X_{L\,ph})^2$

   + for lag; - for lead.

4. Field excitation $I_{f\,1}$ required to induce $E_{1\,ph}$ is obtained from open circuit characteristics.

5. The field current $I_{f\,2}$ required to balance armature reaction is obtained from Potier triangle.

   $I_{f\,2} = l\,(BE) \text{ x scale}$

6. Resultant field current, $I_f^2 = I^2_{f\,1} + I^2_{f\,2} - 2\, I_{f\,1}\, I_{f\,2} \cos(90 \pm \varphi)$

   + for lag; - for lead.

7. Obtain E_{ph} corresponding to resultant field current, I_f from open circuit characteristics.

8. % regulation = $\frac{(E \quad - V \quad)}{V}$ x 100

PRECAUTION:

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

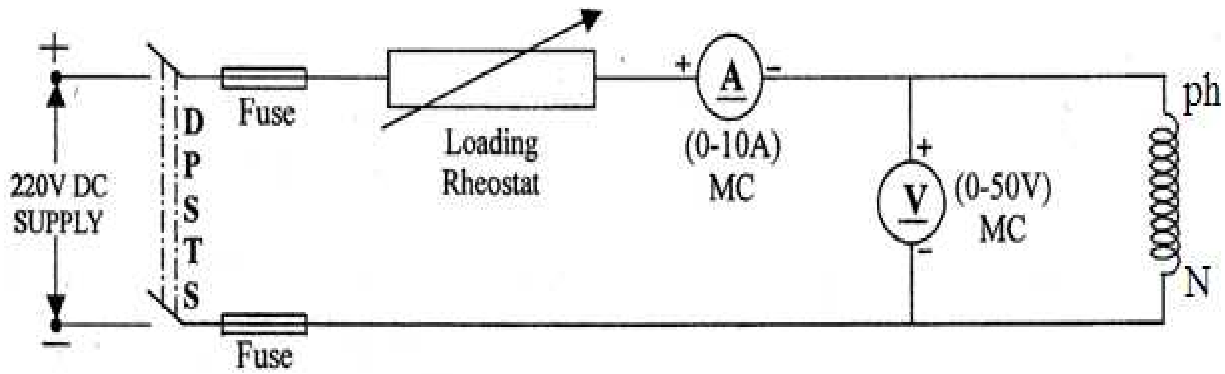
PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Supply is given by closing the DPST switch.
3. Using three point starter, start the motor to run at the synchronous speed by varying the motor field rheostat.
4. Conduct an open circuit test by varying the potential divider for various loads of field current and tabulate the corresponding open circuit voltage readings.
5. Conduct a short circuit test by closing the TPST switch and adjust the potential divider to set the rated armature current and tabulate the corresponding field current.
6. Conduct a ZPF test by adjusting the potential divider for full load current passing through either inductive or capacitive load with zero power and tabulate the readings.
7. Conduct a Stator Resistance test by giving connection as per the circuit diagram and tabulate the voltage and current readings for various resistive loads.

PROCEDURE TO DRAW THE POTIER TRIANGLE:

1. Draw the open circuit characteristics curve (generated voltage per phase Vs field current)
2. Mark the point A at X-axis, which is obtained from short circuit test with full load 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.

TO FIND OUT THE ARMATURE RESISTANCE (R_a):



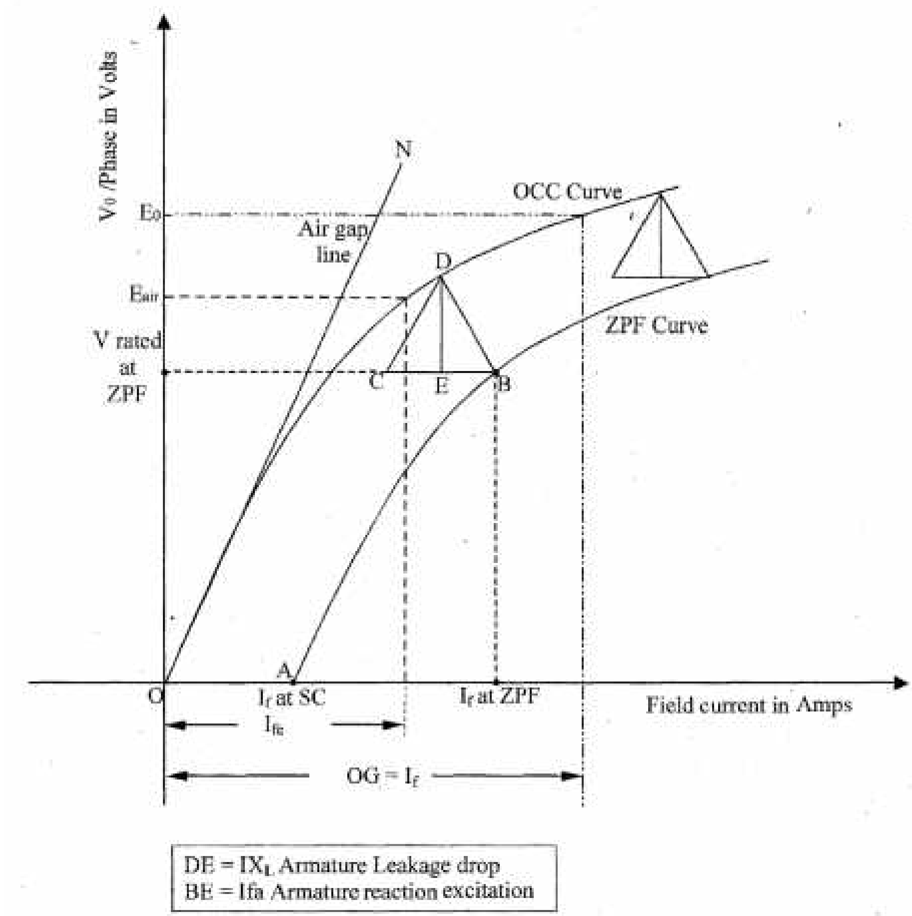
TABULATION TO FIND OUT THE ARMATURE RESISTANCE (R_a):

S.No	Armature Current (I)	Armature Voltage (V)	Armature Resistance $R_a = V/I$
	Amps	Volts	Ω

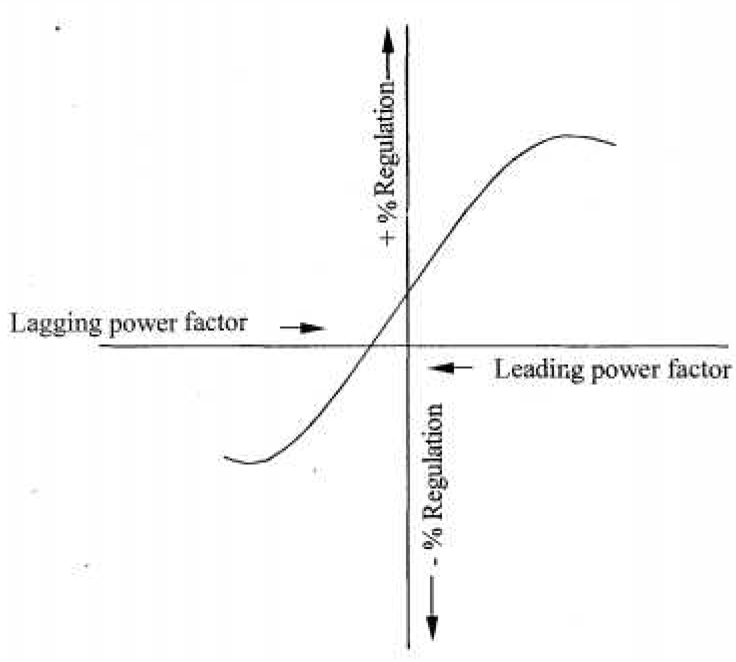
5. Draw the tangent for the OCC from the origin (i.e.,) air gap line.
6. Draw the line BC from B towards Y axis, which is parallel and equal to OA.
7. Draw the parallel line for the tangent from C to the OCC curve.
8. Join the point B and D. Also drop a perpendicular line DE to BC. Line DE represent armature leakage reactance drop (IX_L) and BE represent armature reaction excitation.

MODEL CALCULATION:

MODEL GRAPH:



MODEL GRAPH FOR % REGULATION:



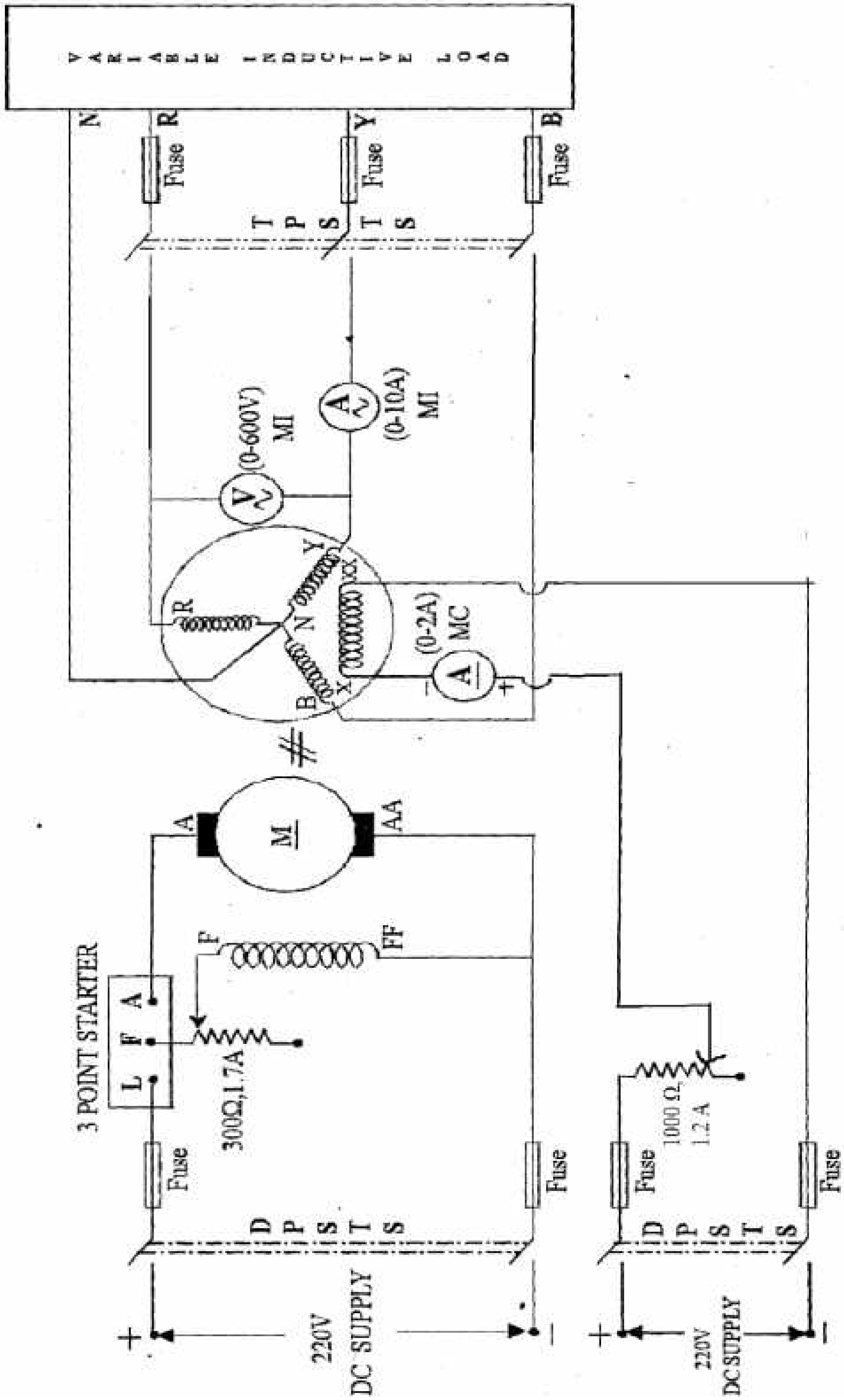
TABULATION FOR % REGULATION:

S. No	Power Factor	$E_{1\,ph}$ Volts		$I_{f\,1}$ (A)		$I_{f\,2}$ (A)	I_f (A)		E_{ph} (V)		% Regulation	
		Lag	Lead	Lag	Lead		Lag	Lead	Lag	Lead	Lag	Lead
	0.2											
	0.4											
	0.6											
	0.8											
	1.0											

RESULT:

Thus the percentage regulation of the given alternator by ZPF (Potier Triangle Method), was predetermined by conducting Open Circuit, Short circuit and ZPF test.

CIRCUIT DIAGRAM FOR REGULATION OF THREE PHASE ALTERNATOR BY ASA METHOD



DATE: **EX.NO.**

REGULATION OF THREE PHASE ALTERNATOR BY ASA METHOD

AIM:

To predetermine the percentage regulation of the given three phase alternator by ASA, by conducting Open Circuit, Short circuit and ZPF test.

APPARATUS REQUIRED:

S.NO	APPARATUS REQUIRED	TYPE	RANGE	QUANTITY
1	Volt Meter	MI	(0-600) V	1
2	Volt Meter	MC	(0-150) V	1
3	Ammeter	MI	(0-10) A	1
4	Ammeter	MC	(0-10) A	1
5	Ammeter	MC	(0-2) A	1
6	Rheostat	Wire wound	1000 Ω, 1.2 A	1
7	Rheostat	Wire wound	300 Ω, 1.7 A	1
8	Connecting wires			Required

NAME PLATE DETAILS:

FUSE RATING CALCULATION:

125% of rated current.

No-load test - 10% of rated current.

FORMULAE USED:

1. From Potier triangle BCD, the armature leakage reactance drop is *l* (DE)

$$I_{ph} \times X_{L\,ph} = l\,(DE) \times \text{scale}$$

2. $I_{ph} = KVA/(\sqrt{3} * V_L)$ Ampere

TABULATION:

OPEN CIRCUIT TEST:

S.No	Field Current (I_f)	Open Circuit Line Voltage $(V_{oc})_L$	Open Circuit Phase Voltage $(V_{oc})_{ph} = (V_{oc})_L / \sqrt{3}$
	Amps	Volts	Volts

SHORT CIRCUIT AND ZPF TEST:

	Short Circuit Test		Zero Power Factor Test		
S.No	Field Current (I_f)	Short Circuit Current (I_{sc})	Field Current (I_f)	Rated Armature current (I_a)	Rated Armature Voltage
	Amps	Amps	Amps	Amps	Volts

3. $(E_{1\,ph})^2 = (V_{ph} \cos \varphi + I_{ph} R_{a\,ph})^2 + (V_{ph} \sin \varphi \pm I_{ph} X_{L\,ph})^2$

   + for lag; - for lead.
4. Field excitation $I_{f\,1}$ required to induce $E_{1\,ph}$ is obtained from open circuit characteristics.

5. The field current $I_{f\,2}$ required to balance armature reaction is obtained from Potier triangle.

   $I_{f\,2} = l\,(BE) \times \text{scale}$

9. Resultant field current, $I_f^2 = I^2_{f\,1} + I^2_{f\,2} - 2\, I_{f\,1} I_{f\,2} \cos(90 \pm \varphi)$

   + for lag; - for lead.

10. Total field excitation $I_f' = I_f + [l\,(BB') \times \text{scale}]$ ….from graph

11. Obtain E_{ph} corresponding to resultant field current, I_f' from open circuit characteristics.

12. % regulation = $\dfrac{(E \quad - V \quad)}{V} \times 100$

PRECAUTION:

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

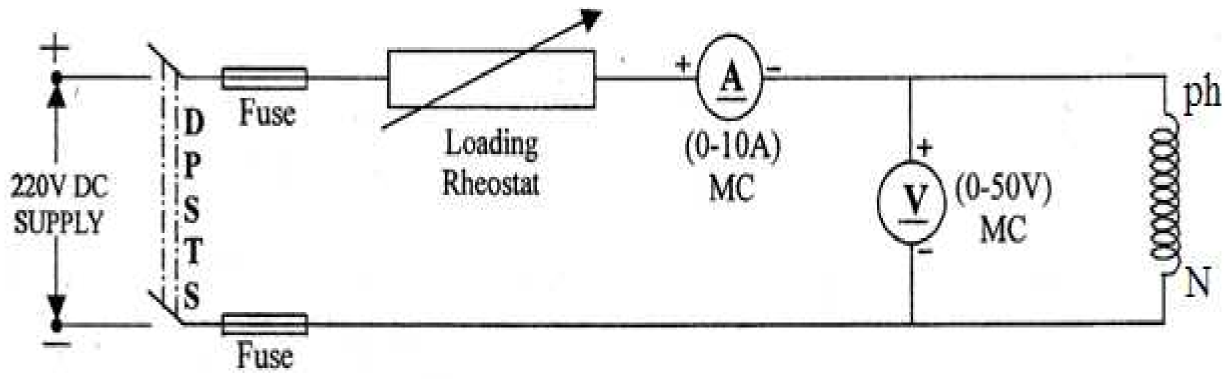
PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Supply is given by closing the DPST switch.
3. Using three point starter, start the motor to run at the synchronous speed by varying the motor field rheostat.
4. Conduct an open circuit test by varying the potential divider for various loads of field current and tabulate the corresponding open circuit voltage readings.
5. Conduct a short circuit test by closing the TPST switch and adjust the potential divider to set the rated armature current and tabulate the corresponding field current.
6. Conduct a ZPF test by adjusting the potential divider for full load current passing through either inductive or capacitive load with zero power and tabulate the readings.
7. Conduct a Stator Resistance test by giving connection as per the circuit diagram and tabulate the voltage and current readings for various resistive loads.

PROCEDURE TO DRAW THE ASA DIAGRAM:

1. Draw the open circuit characteristics curve (generated voltage per phase Vs field current)
2. Mark the point A at X-axis, which is obtained from short circuit test with full load 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.

TO FIND OUT THE ARMATURE RESISTANCE (R_a):



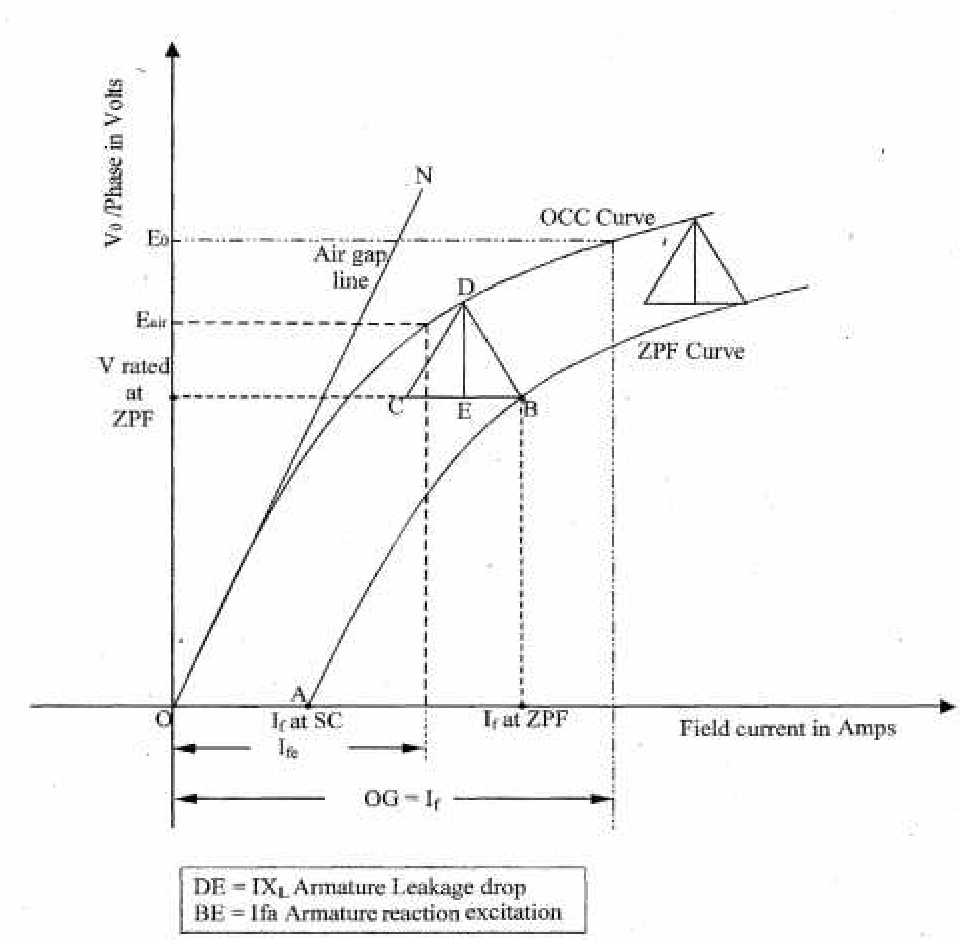
TABULATION TO FIND OUT THE ARMATURE RESISTANCE (R_a):

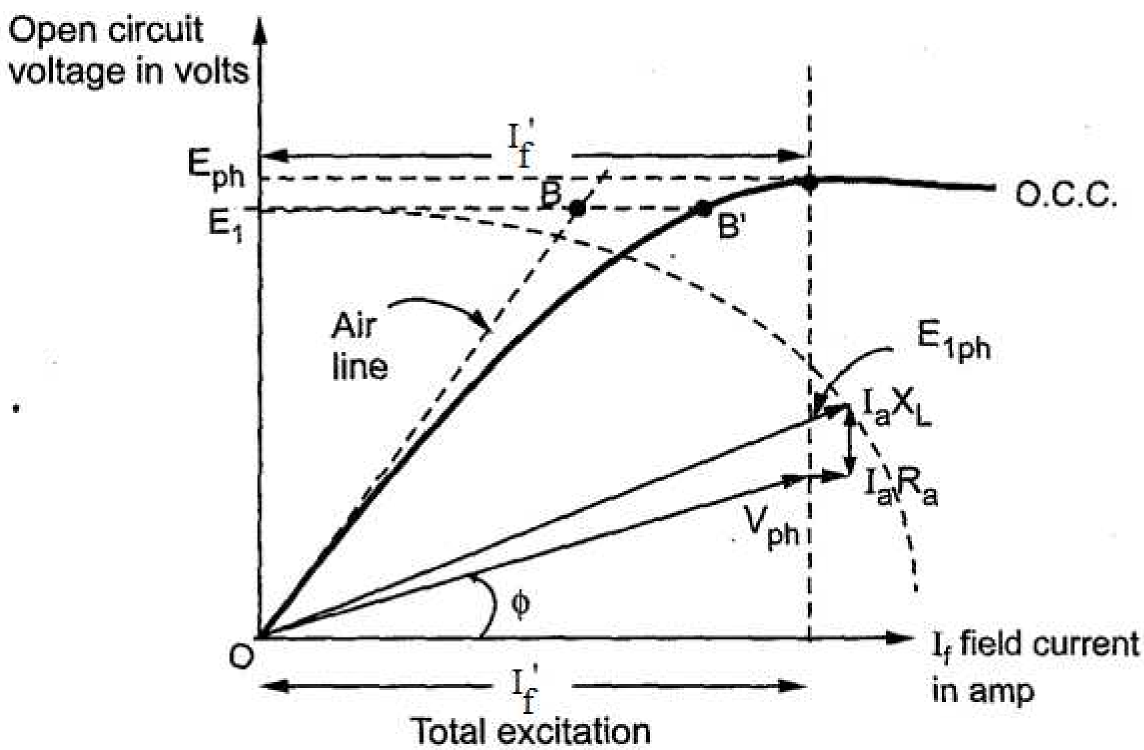
S.No	Armature Current (I)	Armature Voltage (V)	Armature Resistance $R_a = V/I$
	Amps	Volts	Ω

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 from the origin (i.e.,) air gap line.
6. Draw the line BC from B towards Y axis, which is parallel and equal to OA.
7. Draw the parallel line for the tangent from C to the OCC curve.
8. Join the point B and D. Also drop a perpendicular line DE to BC. Line DE represent armature leakage reactance drop (IX_L) and BE represent armature reaction excitation.
9. Draw ASA diagram with X-axis as field current and y-axis as the open circuit voltage.
10. Draw OCC on the ASA diagram.
11. Assume X-axis as current phasor, draw V_{ph} at an angle φ, above the horizontal. The V_{ph} is the terminal voltage.
12. Add I_aR_a in phase with I_a i.e. horizontal and I_aX_L perpendicular to I_aR_a to V_{ph}. This gives the voltage $E_{1\ ph}$.
13. With O as centre and radius $E_{1\ ph}$ draw an arc which will intersect Y-axis at E_1.
14. From E_1, draw horizontal line intersecting both air gap line and OCC at B and B' respectively.
15. The distance between the points BB' corresponding to full current scale gives the additional excitation required to take into account the effect of partially saturated field.
16. Add *l* (BB') to I_f to get the total excitation I_f'.
17. From I_f', the open circuit voltage E_{ph} can be obtained from OCC.

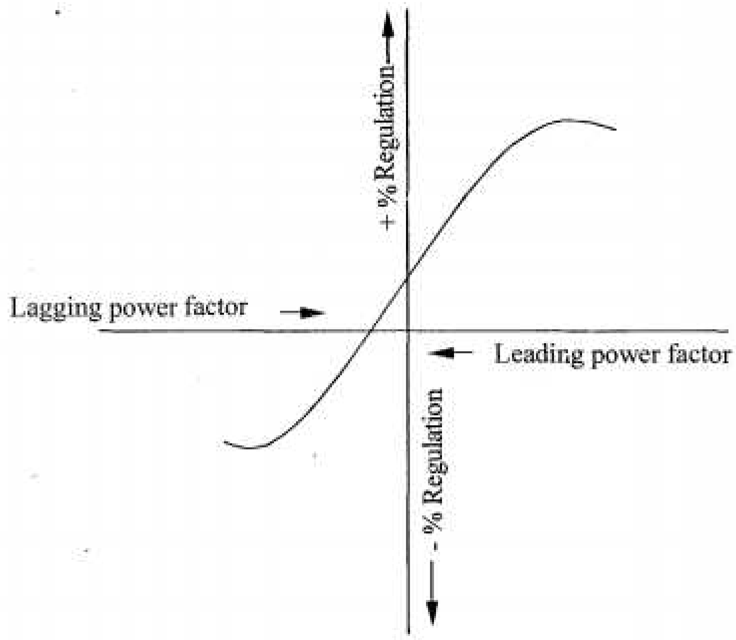
MODEL CALCULATION:

MODEL GRAPH:


V0 /Phase in Volts
N
OCC Curve
E0
Air gap line
D
Eair
V rated at ZPF
C
E
B
ZPF Curve
A
O
If at SC
If at ZPF
Field current in Amps
Ifo
OG = If
DE = IXL Armature Leakage drop
BE = Ifa Armature reaction excitation


Open circuit voltage in volts
If'
Eph
E1
B
B'
O.C.C.
Air line
E1ph
IaXL
IaRa
Vph
φ
O
If field current in amp
If'
Total excitation

MODEL GRAPH FOR % REGULATION:



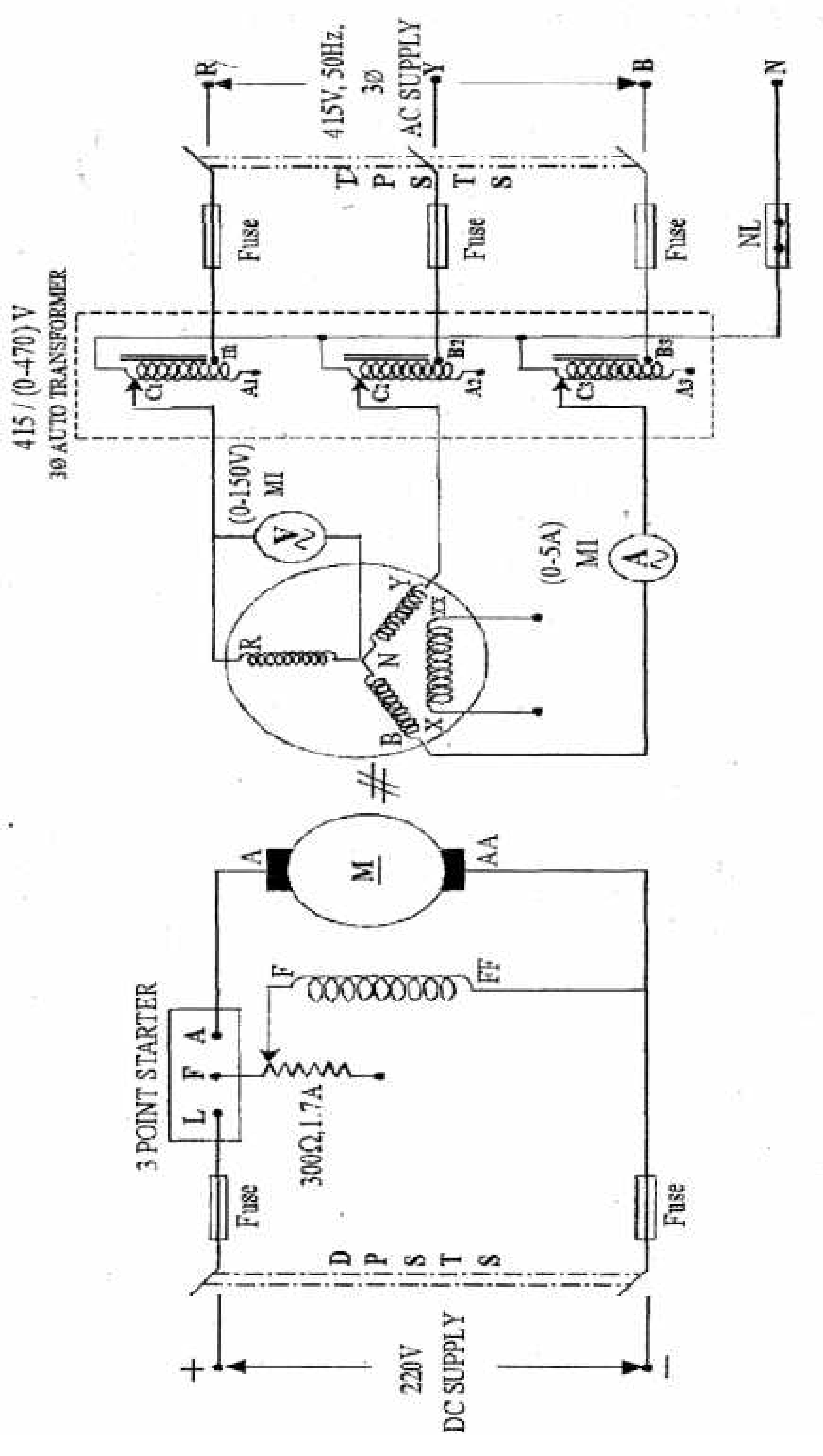
TABULATION FOR % REGULATION:

S. No	Power Factor	$E_{1\,ph}$ Volts		$I_{f\,1}$ (A)		$I_{f\,2}$ (A)	I_f (A)		*I* (BB')		I_f' (A)		E_{ph} (V)		% Regulation	
		Lag	Lead	Lag	Lead		Lag	Lead	Lag	Lead	Lag	Lead	Lag	Lead	Lag	Lead
	0.2															
	0.4															
	0.6															
	0.8															
	1.0															

RESULT:

Thus the percentage regulation of the given alternator by ASA, was predetermined by conducting Open Circuit, Short circuit and ZPF test.

CIRCUIT DIAGRAM FOR REGULATION OF THREE PHASE SALIENT POLE ALTERNATOR BY SLIP TEST



DATE: **EX.NO.**

REGULATION OF THREE PHASE SALIENT POLE ALTERNATOR BY SLIP TEST

AIM:

To conduct the slip test on three phase salient pole alternator and to predetermine the regulation through vector diagrams.

APPARATUS REQUIRED:

S.NO	APPARATUS REQUIRED	TYPE	RANGE	QUANTITY
1	Volt Meter	MI	(0-300) V	1
2	Volt Meter	MC	(0-150) V	1
3	Ammeter	MI	(0-10) A	1
4	Ammeter	MC	(0-5) A	1
5	Rheostat	Wire wound	300 Ω, 1.7 A	1
6	Connecting wires			Required

NAME PLATE DETAILS:

FUSE RATING CALCULATION:

125% of rated current.

No-load test - 10% of rated current.

FORMULAE USED:

1. Armature resistance, $R_a = 1.6 * R_{dc}$ in Ω
R_{dc} is the resistance in DC supply.

2. Direct Axis Impedance per phase, $Z_d = \frac{V}{I_l} = \frac{(V)_{li} \quad (a \;\; m \qquad I_l)}{\sqrt{3}\, I_l \; (m \quad)}$ in Ω

TABULATION:

TO FIND OUT THE DIRECT AXIS REACTANCE (X_d):

Speed of the Alternator:
Minimum Voltage applied to the Stator:
(Nearly 20% to 30% of rated voltage)

S.No	Minimum Current per Phase (I_{min})	Maximum Voltage per phase (V_{max})	Direct Axis Impedance per phase (Z_d)	Direct Axis Reactance per phase (X_d)
	Amps	Volts	Ohms	Ohms

TO FIND OUT THE QUADRATURE AXIS REACTANCE (X_q):

S.No	Maximum Current per Phase (I_{max})	Minimum Voltage per phase (V_{min})	Quadrature Axis Impedance per phase (Z_q)	Quadrature Axis Reactance per phase (X_q)
	Amps	Volts	Ohms	Ohms

3. Quadrature Axis Impedance per phase, $Z_q = \frac{V}{I} = \frac{(V\ )li\ \ (a\ \ m\ \ \ \ I\ )}{\sqrt{3}\, I\ (m\ \ )}$ in Ω

4. Direct Axis Reactance per phase, $X_d = \sqrt{(Zd^2 - Ra^2)}$ in Ω

5. Quadrature Axis Reactance per phase, $X_q = \sqrt{(Zq^2 - Ra^2)}$ in Ω

6. $\psi = \tan^{-1}\left[\frac{V\ s\ \ \ \varphi + I\ X}{V\ c\ \ \ \varphi + I\ R}\right]$

7. $\delta = \psi - \varphi$

8. Direct Axis Current Component, $I_d = I_a \sin \psi$

9. Quadrature Axis Current Component, $I_q = I_a \cos \psi$

10. Total induced emf, $E_f = V_t \cos \delta + I_q R_a + I_d X_d$
    (* in the above relations, φ is taken positive for lagging p.f. For leading p.f., φ must be taken negative)

11. % Regulation = $\frac{(E\ - V\ )}{V}$ x 100

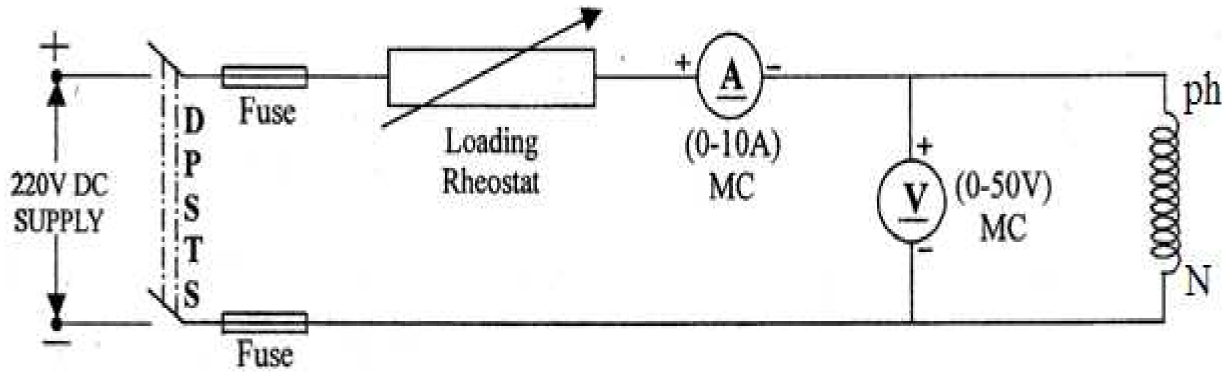
PRECAUTION:

1. The motor field rheostat should be kept in the minimum resistance position.
2. The alternator field should be kept open throughout the experiment.
3. The direction of rotation due to prime mover and due to the alternator run as the motor should be the same.
4. Initially all switches are kept open.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Give the supply by closing the DPST switch.
3. Using three point starter, start the motor to run at the synchronous speed by varying the motor field rheostat. At the same time check whether the alternator field has been opened or not.
4. Apply 20% to 30% of the rated voltage to the armature of the alternator by adjusting the auto transformer.
5. To obtain the minimum and the maximum oscillation of pointers, the speed is slightly reduced lesser than the synchronous speed.
6. Maximum current, minimum current, maximum voltage and minimum voltage are noted.
7. Find out the direct and quadrature axis reactance from formula.

TO FIND OUT THE ARMATURE RESISTANCE (R_a):



TABULATION TO FIND OUT THE ARMATURE RESISTANCE (R_a):

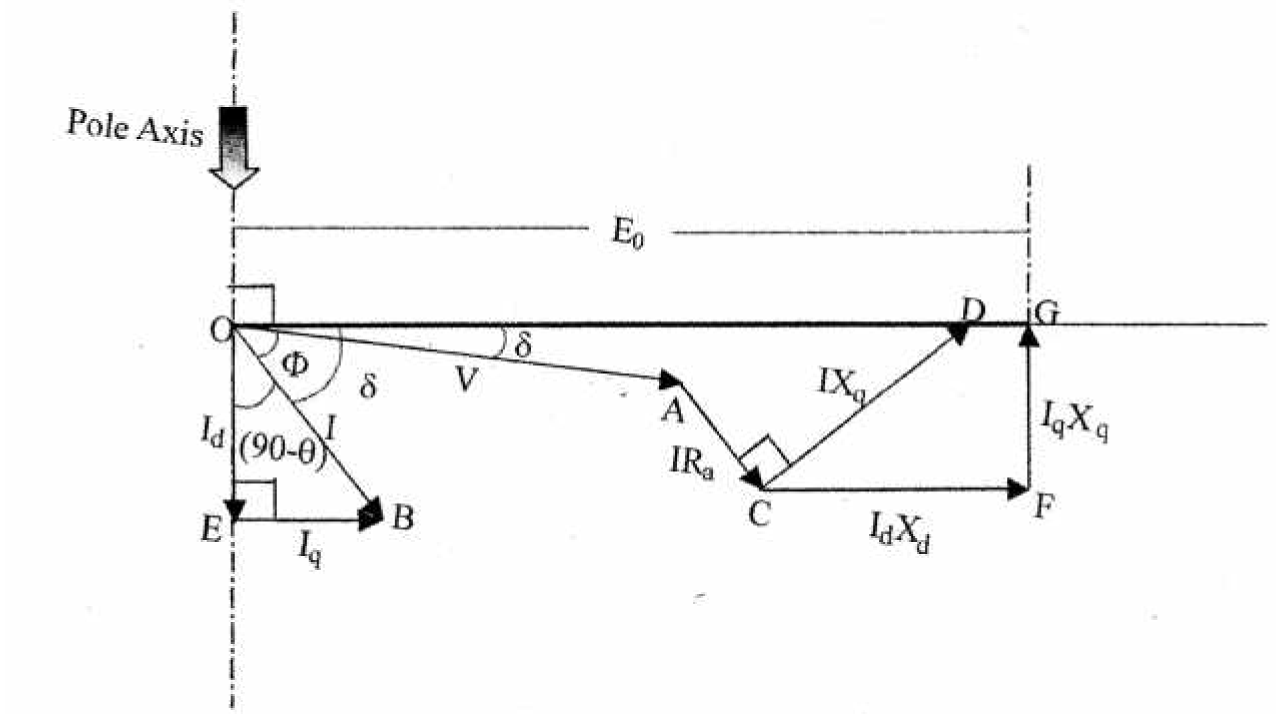
S.No	Armature Current (I)	Armature Voltage (V)	Armature Resistance R_a = V/I
	Amps	Volts	Ω

PROCEDURE TO DRAW THE VECTOR DIAGRAM:

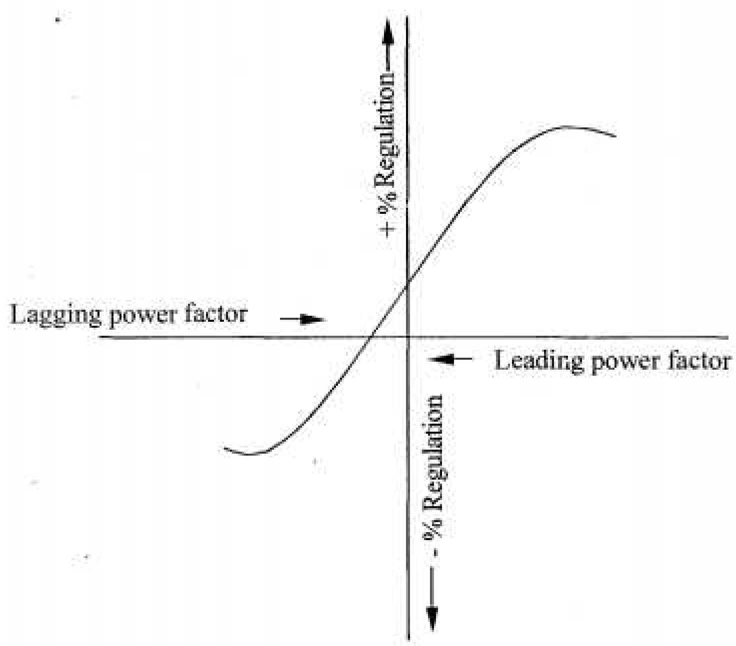
1. Draw the line OA vector that represents the rated voltage V_t.
2. Draw the line OB vector to represent the rated current I_a, which makes an angle φ with the voltage.
3. Draw the line AC vector to represent $I_a R_a$ drop, which is parallel to OB vector.
4. Draw the perpendicular line CD vector to the line AC ($I_a R_a$ drop) that represent $I_a X_q$ drop.
5. Draw the line from the origin through the point D, which consist the no load voltage (E_0).
6. Draw the pole axis through the origin, which should be perpendicular to vector OD.
7. Draw a perpendicular to the pole axis from the same (point E), which should be passed through the point B. [vector OE represents Direct Axis Current (I_d) and vector EB represents Quadrature Axis Current (I_q)].
8. Find out the reactive voltage drops $I_d X_d$ and $I_q X_q$.
9. Draw a parallel line (i.e. perpendicular to I_d) to OD vector from the point C, with the magnitude of the drop $I_d X_d$ (line CF).
10. Draw a parallel line (i.e. perpendicular to I_q) to OE vector from the point F, with the magnitude of the drop $I_q X_q$ (line FG).
11. Let the point at where the $I_q X_q$ drop meets the OD line be G. here the vector OG is representing the no load voltage (E_f).
12. Find out the voltage regulation by using the suitable formula.

MODEL CALCULATION:

VECTOR DIAGRAM:
(for lagging power factor)



MODEL GRAPH FOR % REGULATION:



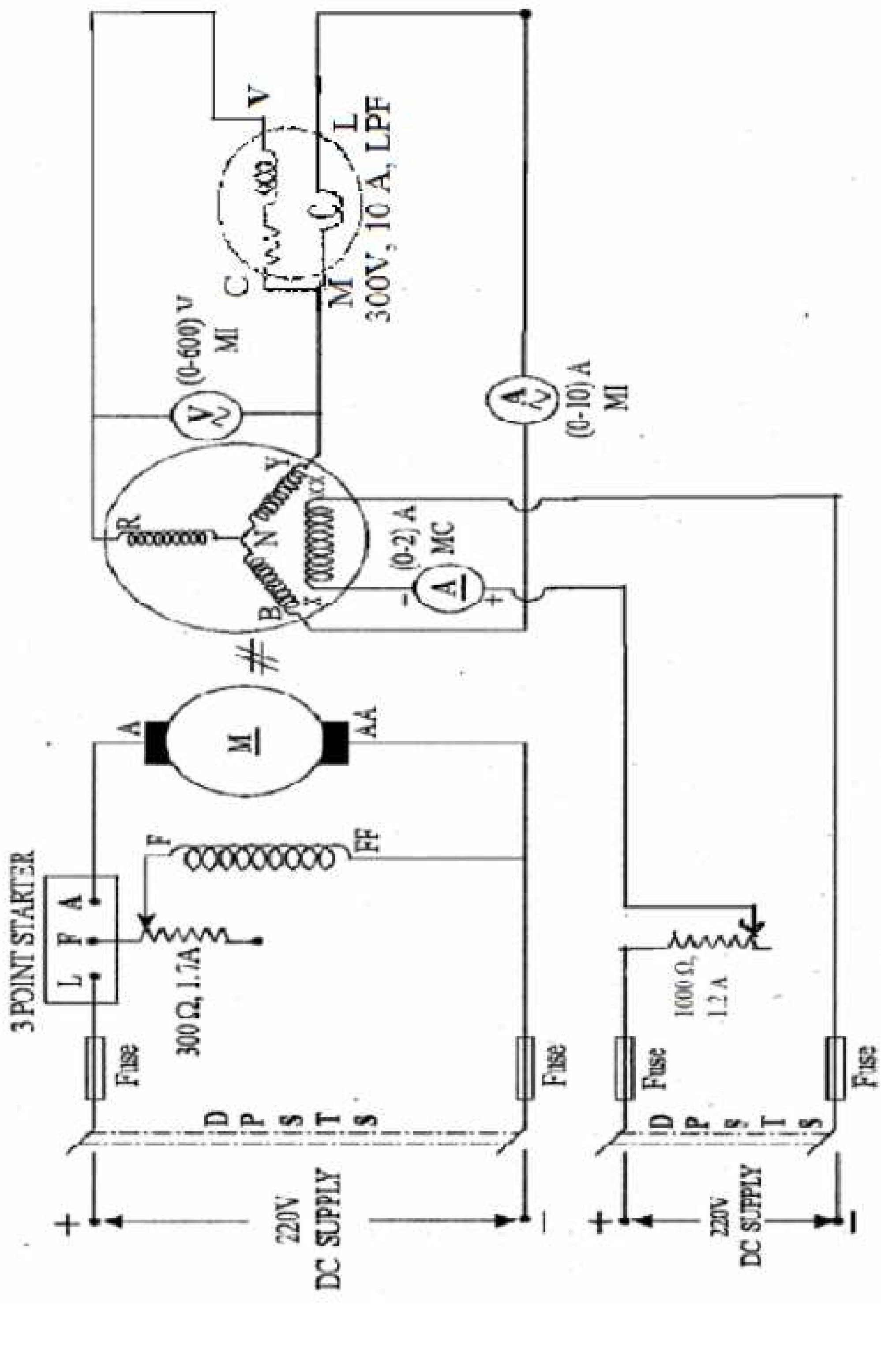
TABULATION FOR % REGULATION:

S. No	Power Factor	ψ		I_d		I_q		δ		E_f		% Regulation	
		Lag	Lead	Lag	Lead	Lag	Lead	Lag	Lead	Lag	Lead	Lag	Lead
	0.2												
	0.4												
	0.6												
	0.8												
	1.0												

RESULT:

Thus the slip test on three phase salient pole alternator was conducted and the regulation was predetermined.

CIRCUIT DIAGRAM FOR FINDING NEGATIVE SEQUENCE IMPEDANCE:



DATE: **EX.NO.**

MEASUREMENT OF NEGATIVE SEQUENCE AND ZERO SEQUENCE IMPEDANCE OF AN ALTERNATOR

AIM:

To determine the negative sequence and zero sequence impedance of an alternator.

APPARATUS REQUIRED:

S.NO	APPARATUS REQUIRED	TYPE	RANGE	QUANTITY
1.	Volt Meter	MI	(0-300) V	1
2.	Ammeter	MI	(0-10) A	1
3.	Ammeter	MC	(0-2) A	1
4.	Wattmeter	LPF	300V, 10A	1
5.	Rheostat	Wire wound	1000 Ω, 1.2 A	1
6.	Variac	Single phase	270 V, 5 A	1
7.	Connecting wires			Required

NAME PLATE DETAILS:

FUSE RATING CALCULATION:

125% of rated current.

FORMULAE USED:

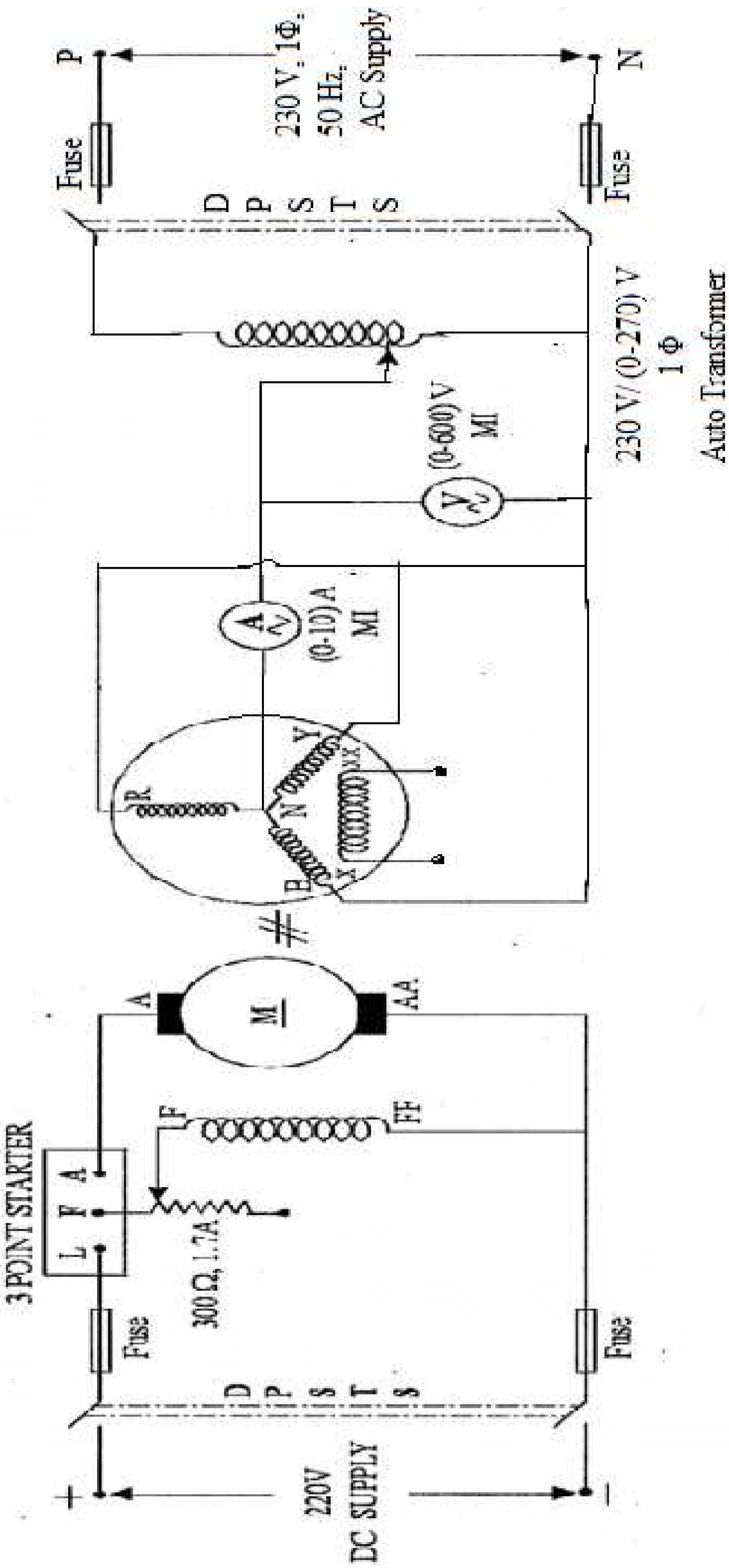
1. Negative Sequence impedance, $Z_2 = V_{RY} / (\sqrt{3} * I_{SC})$ in Ω

   V_{RY} – Line voltage in volts
   I_{SC} – line current in A

2. Negative Sequence Reactance, $X_2 = Z_2 * W / (V_{RY} * I_{SC}) = W / (\sqrt{3}\, I_{SC}^2)$ in Ω

   W – Wattmeter Reading in W

CIRCUIT DIAGRAM FOR FINDING ZERO SEQUENCE IMPEDANCE:



3. Zero Sequence Impedance, $Z_0 = \frac{\text{V} \quad \text{a} \quad \text{t p}}{\text{C} \quad \text{t} \quad \text{e} \quad \text{p}} = \frac{V}{I/3} = \frac{3V}{I}$ in Ω

4. Zero Sequence Reactance, $X_0 = Z_0$ in Ω

PRECAUTION:

1. All the switches should be kept open at the time of starting the experiment.
2. The D. C. motor field rheostat should be kept at minimum resistance position at the time of starting the experiment.
3. The generator field potential divider should be kept at minimum potential position.
4. The auto transformer should be kept at minimum potential position.

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.

B. **For Zero Sequence**

1. Make connection as shown in circuit diagram.
2. Set the Variac output to zero volts and switch on the supply.
3. Gradually increase Variac 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.

TABULATION:

FOR NEGATIVE SEQUENCE

S.NO	Voltage V_{RY} (V)	Current I_{SC} (A)	Power W (Watts)	Negative Sequence Impedance Z_2 (Ω)	Negative Sequence Reactance X_2 (Ω)	Average X_2 (Ω)

FOR ZERO SEQUENCE

S.NO	Voltage V (V)	Current I (A)	Zero Sequence Impedance Z_0 (Ω)	Zero Sequence Reactance X_0 (Ω)	Average X_0 (Ω)

MODEL CALCULATION:

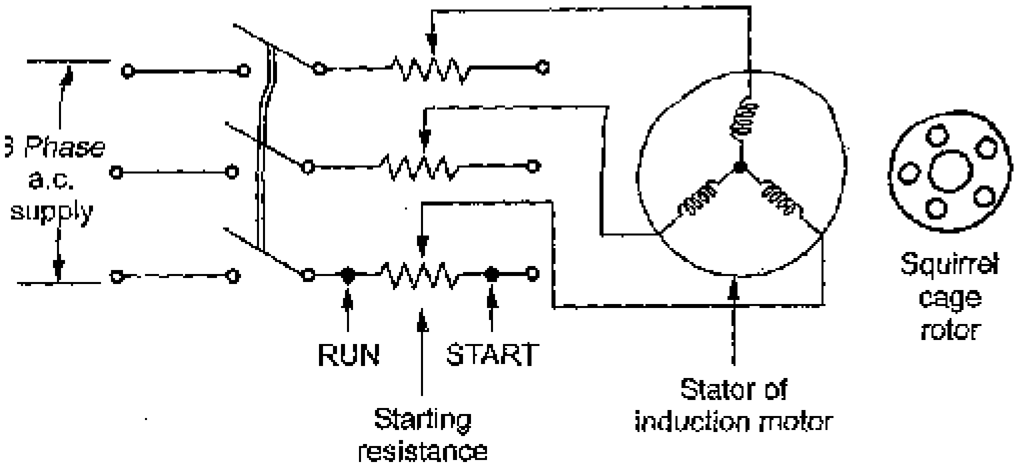
RESULT:

Thus the negative sequence and zero sequence impedance of an alternator were determined.

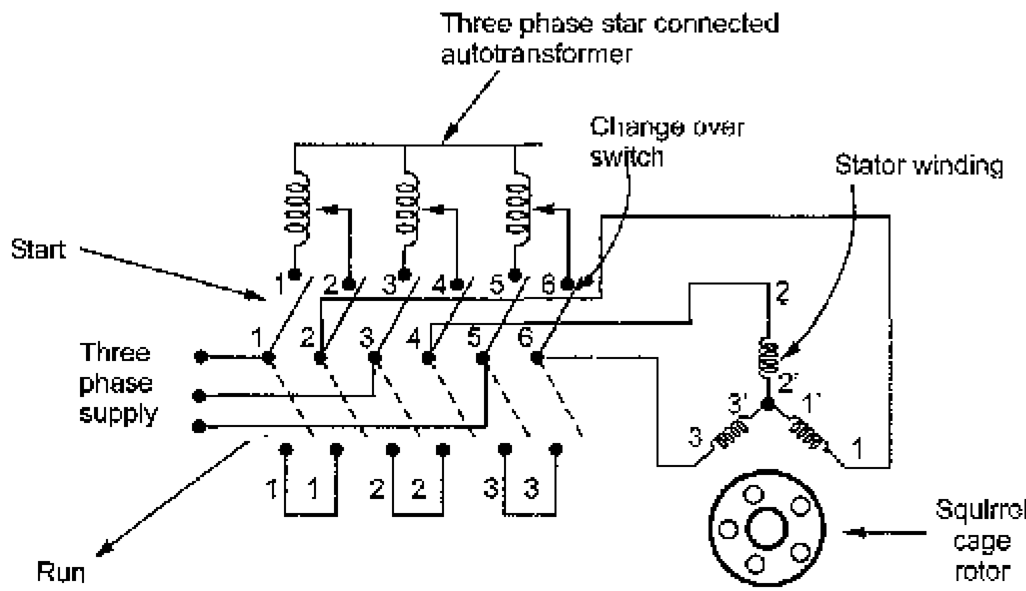
Negative Sequence Reactance X_2 = Ω

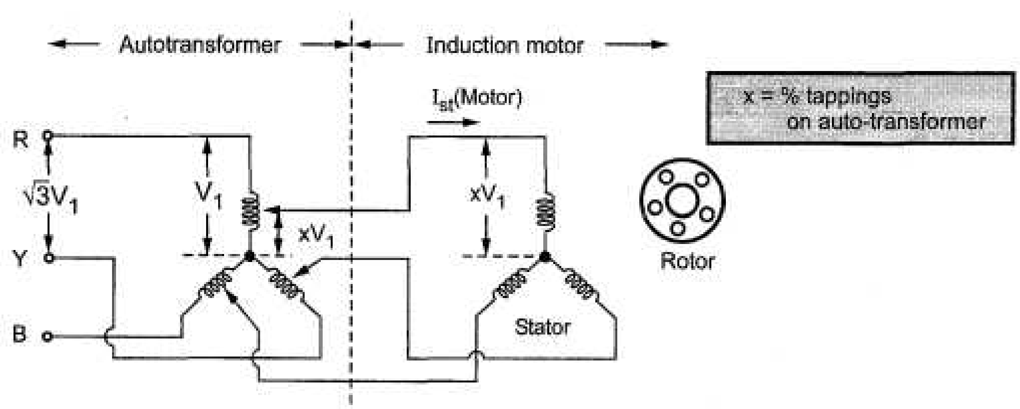
Zero Sequence Reactance X_0 = Ω

STATOR RESISTANCE STARTER



AUTOTRANSFORMER STARTER





DATE: **EX.NO.**

STUDY OF INDUCTION MOTOR STARTERS

AIM:

To Study the Induction motor starters.

NECESSITY OF STARTER:

In a three phase induction motor, the magnitude of an induced e.m.f. in the rotor circuit depends on the slip of the induction motor. This induced e.m.f. effectively decides the magnitude of the rotor current. The rotor current in the running condition is given by,

$$I_{2r} = \frac{s \quad 2}{\sqrt{(R2^2 - (s \quad 2)^2)}}$$

But at start, the speed of the motor is zero and slip is at its maximum i.e. unity. So magnitude of rotor induced e.m.f. is very large at start. As rotor conductors are short circuited, the large induced e.m.f. circulates very high current through rotor at start.

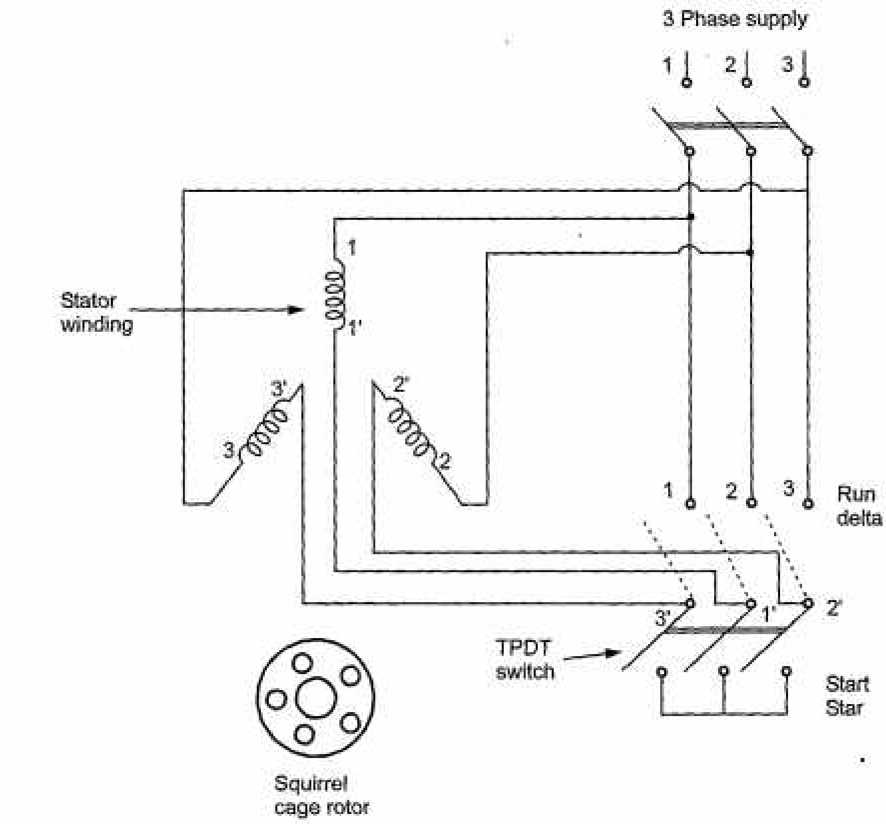
The condition is exactly similar to a transformer with short circuited secondary. Such a transformer when excited by a rated voltage circulates very high current through short circuited secondary. As secondary current is large, the primary also draws very high current from the supply.

Similarly in a three phase induction motor, when rotor current is high, consequently the stator draws a very high current from the supply. This current can be of the order of 5 to 8 times the full load current, at start.

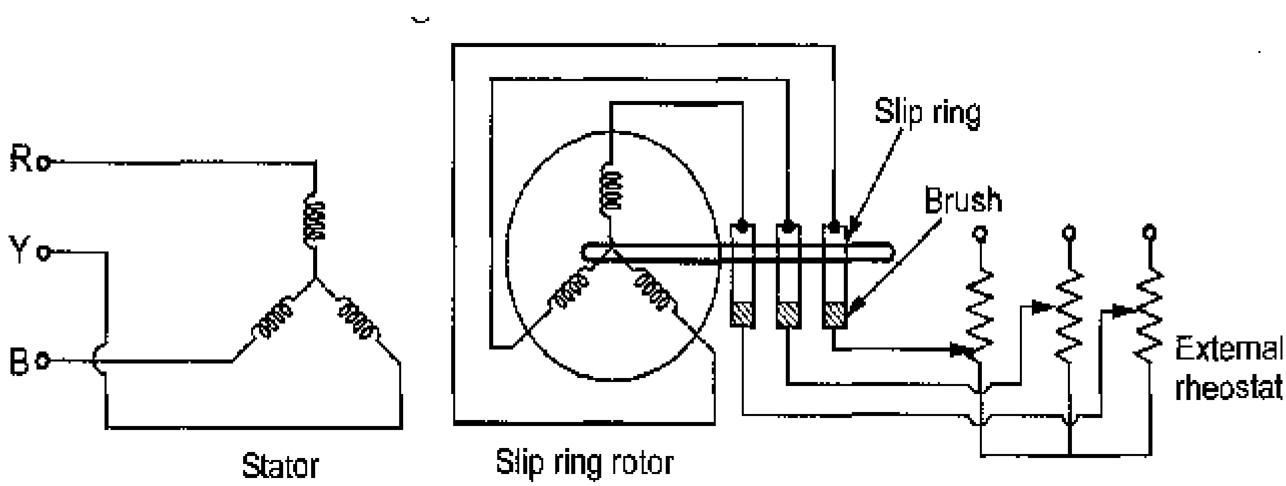
Due to such heavy inrush of current at start there is possibility if damage of the motor winding. Similarly such sudden inrush of current causes large line voltage drop. Thus other appliances connected to the same line may be subjected to voltage spikes which may affect their working. To avoid such effects, it is necessary to limit the current drawn by the motor at start. The starter is a device which is basically used to limit high starting current by supplying reduced voltage to the motor at the time of starting. Such a reduced voltage is applied only for short period and once rotor gets accelerated, full normal rated voltage is applied.

Not only the starter limits the starting current but also provides the protection to the induction motor against overt loading and low voltage situations. The protection against single phasing is also provided by the starter. The induction motors having rating below 5 h.p. can withstand starting currents hence such motors can be started directly on line. But such motors also need overload, single phasing and low voltage protection which is provided by a starter.

STAR-DELTA STARTER



ROTOR RESISTANCE STARTER



Types of Starters for Three Phase Induction Motor

The various types of starters based on the methods of reducing the starting current are,

1. Stator resistance starter
2. Autotransformer starter
3. Star-delta starter
4. Rotor resistance starter
5. Direct on line starter

1. Stator Resistance Starter

In order to apply the reduced voltage to the stator of the induction motor, three resistances are added in series with each phase of the stator winding. Initially the resistances are kept maximum in the circuit. Due to this, large voltage gets dropped across the resistances. Hence a reduced voltage gets applied to the stator which reduces the high starting current. The schematic diagram showing stator resistances is shown in the Fig. When the motor starts running, the resistances are gradually cut-off from the stator circuit. When the resistances are entirely removed from the stator. circuit i.e. rheostats in RUN position then rated voltage gets applied to the stator. Motor runs with normal speed. The starter is simple in construction and cheap. It can be used for both star and delta connected stator. But there are large power losses due to resistances. Also the starting torque of the motor reduces due to reduced voltage applied to the stator.

2. Autotransformer Starter

A three phase star connected autotransformer can be used to reduce the voltage applied to the stator. Such a starter is called an autotransformer starter. The schematic diagram of autotransformer starter is shown in the Fig.

When the switch is in the start position, the stator winding is supplied with reduced voltage. This can be controlled by tappings provided with autotransformer. The reduction in applied voltage by the Fractional percentage tappings x, used for an autotransformer is shown in the Fig.

When motor gathers 80 % of the normal speed, the change over switch is thrown into run position.

Due to this, rated voltage gets applied to stator winding. The motor starts rotating with normal speed. Changing of switch is done automatically by using relays. The power loss is much less in this type of starting. It can be used for both star and delta connected motors. But it is expensive than stator resistance starter.

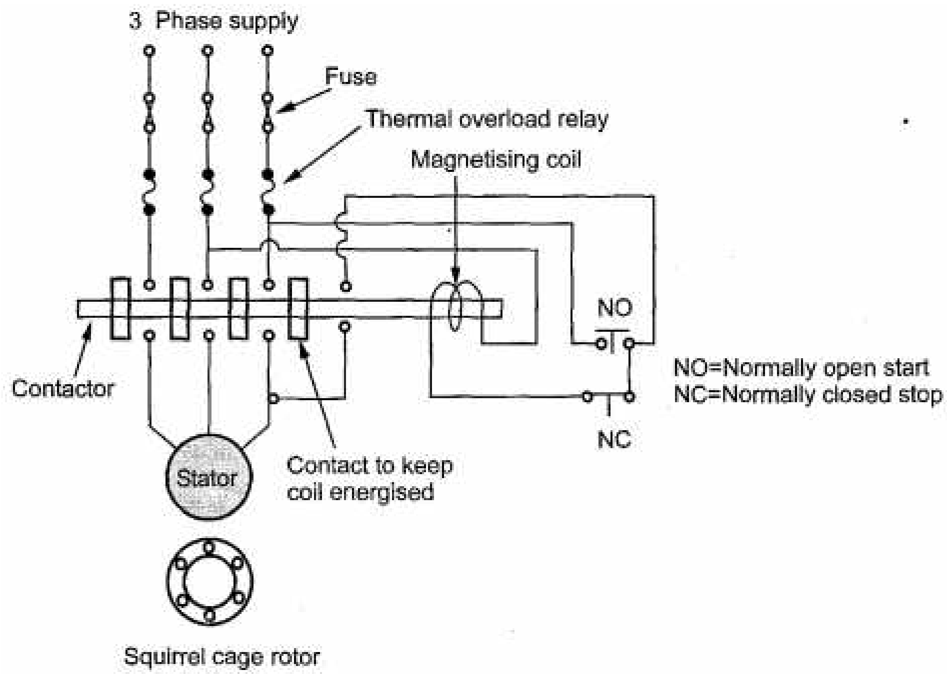
3. Star-Delta Starter

This is the cheapest starter of all and hence used very commonly for the induction motors. It uses Triple Pole Double Throw (TPDT) switch. The switch connects the stator winding in star at start. Hence per phase voltage gets reduced by the factor $1/\sqrt{3}$. Due to this reduced voltage, the starting current is limited.

When the switch is thrown on other side, the winding gets connected in delta, across the supply. So it gets normal rated voltage. The windings are connected in delta when motor gathers sufficient speed. The arrangement of star-delta starter is shown in the Fig.

The operation of the switch can be automatic by using relays which ensures that motor will not start with the switch in Run position. The cheapest of all and maintenance free operation are the two important advantages of this starter. While its limitations are, it is suitable for normal

DIRECT ON LINE STARTER



delta connected motors and the factor by which voltage changes is 1/√3 which cannot be changed.

4. Rotor Resistance Starter

To limit the rotor current which consequently reduces the current drawn by the motor from the supply, the resistance can be inserted in the rotor circuit at start. This addition of the resistance in rotor is in the form of 3 phase star connected rheostat. The arrangement is shown in the Fig.

The external resistance is inserted in each phase of the rotor winding through slip ring and brush assembly. Initially maximum resistance is in the circuit. As motor gathers speed, the resistance is gradually cut off. The operation may be manual or automatic.

We have seen that the starting torque is proportional to the rotor resistance. Hence important advantage of this method is not only the starting current is limited but starting torque of the motor also gets improved. The only limitation of the starter is that it can be used only for slip ring induction motors as in squirrel cage motors; the rotor is permanently short circuited.

5. Direct On Line Starter (DO.L)

In case of small capacity motors having rating less than 5 h.p., the starting current is not very high and such motors can withstand such starting current without any starter. Thus there is no need to reduce applied voltage, to control the starting current. Such motors use a type of starter which is used to connect stator directly to the supply lines without any reduction in voltage. Hence the starter is known as direct on line starter.

Though this starter does not reduce the applied voltage, it is used because it protects the motor from various severe abnormal conditions like over loading, low voltage, single phasing etc.

The NO contact is normally open and NC is normally closed. At start, NO is pushed for fraction of second due to which coil gets energised and attracts the contactor. So stator directly gets supply. The additional contact provided, ensures that as long as supply is ON, the coil gets supply and keeps contactor in ON position. When NC is pressed, the coil circuit gets opened due to which coil gets de-energised and motor gets switched OFF from the supply.

Under over load condition, current drawn by the motor increases due to which there is an excessive heat produced, which increases temperature beyond limit. Thermal relays get opened due to temperature, protecting the motor from overload conditions.

VIVA QUESTIONS

1. What are synchronous machines?

The machines generating ac emf are called alternating or synchronous generators. While the machine accepting input from ac supply to produce mechanical output are called synchronous motors. Both these machines work at a specific constant speed called synchronous speed and hence in general called synchronous machines.

2. Define voltage regulation. Name two methods used to determine voltage regulation of

$\%Reg = (E-V_{rated} / V_{rated})*100$

Where,

E = No load voltage, V_{rated} = Rated voltage

3. Two methods to determine voltage regulation:

a)EMF method

b)MMF method

4. What are the two types of alternators?

a)Non salient pole alternator

b)Salient pole alternator.

5. State the principle of alternator.

When the rotor is rotated by the prime mover, the stator windings or conductors are cut by the magnetic flux hence an emf is induced in the stator conductors. (Faraday's law of electromagnetic induction)

6. Is EMF method an accurate method?

No, it is not an accurate method because the value of synchronous impedance found is always more than the original value.

7. Write the emf equation of an alternator.

$$E = 4.44f\,\Phi T K_c K_d \text{ volts}$$

Where,

f = frequency in hertz, Φ = flux per pole, T = Number of turns in stator windings

K_c = Pitch factor, K_d = Distribution factor

8. What is known as Armature reaction?

The effect of armature flux on main flux is called as armature reaction.

9. What is meant by synchronous reactance?

$$\text{Synchronous reactance } X_s = X_L + X_a$$

Where,

X_L = leakage reactance, X_a = Armature reactance

10. Can a DC generator be converted into an alternator? How?

Yes, by providing two collector rings on end of the armature and connecting these two rings to two points in the armature windings 180 degree apart.

11. Why is the field system of an alternator made as a rotor?

The field system of an alternator is made rotating to avoid interaction of mechanical and electrical stress. So with rotating field system, it is easier to collect currents at very high voltages from stationary member. The insulation required is less; the problem of sparking is avoided.

12. Define the terms distribution factor and pitch factor.

The factor by which there is a reduction in the emf due to distribution of coils is called distribution factor, denoted by K_d.

The factor by which induced emf gets reduced due to short pitching of coil is called pitch factor, denoted by K_c.

13. Potier method is also called Potier reactance method. Why?

It is based on the separation of armature leakage reactance and armature reaction effects. The armature leakage reactance XL is called Potier reactance in this method, hence this method is also called as Potier reactance method.

14. What are the experimental data required for Potier method?

i). Data's obtained from open circuit test to draw the OCC curve

ii). Field current required to obtain the zero armature voltage and the field current to obtain the rated armature current. These two field currents are required to draw the ZPF curve.

15. What is ASA method?

This is American Standard Association method. Both the EMF and MMF method is capable of giving the reliable values of the voltage regulation, the error is present. So to rectify that a modification of MMF method is introduced called as ASA method. It includes the additional excitation.

16. Whether the results obtained by ASA method is reliable for salient pole machines.

Yes, it is reliable for salient pole and Non salient pole machines.

17. Compare EMF method and Potier method.

Sl.No	EMF METHOD	POTIER METHOD
1.	Regulation of alternator of any load condition and power factor condition can be determined.	Separate curves foe every load condition are to be plotted if regulation at various load condition is required.
2.	It is also called as pessimistic method.	It is also called as Potier reactance method.

18. State the reason of errors in EMF and MMF method

a) The magnetic circuit is assumed to be unsaturated. This assumption is unrealistic.

b) 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.

19. Compare MMF method and Potier method.

Sl.No	MMF METHOD	POTIER METHOD
1.	This method which gives regulation lower than actual, hence called optimistic method.	The results obtained are nearer to reality.
2.	Energy is not wasted.	Energy is wasted.

20. What are the different methods available to determine the voltage regulation of an alternator?

a)Direct loading method

b)Synchronous Impedance method or EMF method

c)Ampere Turn method or MMF method

d)Zero Power Factor method or Potier method

e)ASA method

f)Two reaction theory

21. What is meant by salient pole type rotor?

The rotor poles projecting out from the rotor core of large diameter but small length. This is used in low and medium speed (engine driven alternator)

22. What is the necessity of damper winding?

Most of the alternators have the pole shoes slotted for receiving copper bars of a grid or damper winding. They are useful in preventing the hunting in generators and are needed in synchronous motors to provide the starting torque.

23. What is meant by Two Reaction theory?

The method of analysis of the distributing effects caused by salient pole construction is called Two Reaction theory.

24. State Two Reaction theory.

The armature mmf can be divided into two components as

i). Component acting along the pole axis called direct axis (d)

ii). Component acting along at right angles to the pole axis called quadrature axis (q).

25. What is d axis and q axis?

The reluctance offered to the mmf wave is lowest when it is aligned with the field pole axis. This axis is called direct axis of pole.

The reluctance offered is highest when the mmf wave is oriented at 90 to the field pole axis which is called quadrature axis.

26. What is meant by magnetizing and cross magnetizing component?

The component along direct axis can be magnetizing and the component acting along the quadrature axis is called cross magnetizing component.

27. What is called slip test?

The method used to determine X_d and X_q, the direct and quadrature axis reactance's is called slip test.

28. What is meant by power angle?

The angle d between E_o and V is called the power angle.

29. Compare salient pole and Non salient pole rotor.

S.no	SALIENT POLE ROTOR	NON SALIENT POLE ROTOR
1.	Large diameter and small axial length.	The diameter of the rotor is reduce, to reduce the peripheral velocity of rotor
2.	It is employed with hydraulic turbines or diesel engines.	Used in high speed turbine like steam turbines.

30. What is meant by Auto – Transformer?

It is a transformer with one winding only, part of this being common to both primary and secondary. In this transformer the primary and secondary are not electrically isolated from each other.

31. Define V and Inverted V curves.

The magnitude of armature current varies with excitation. If graph of armature current drawn by the motor against field current is plotted then we get V curves. If the power factor is plotted against field current then the shape of the graph looks like an inverted V and are called as Inverted v curves.

32. When Synchronous motor is is said to receive 100% excitation?

The value of excitation for which back emf is equal to the applied voltage is known as 100% excitation or when the power factor of the synchronous motor is unity.

$E_b = V$ (or) $\cos\Phi = 1$

33. Define critical excitation.

When the excitation is changed, the power factor changes. The excitation for which the power factor of the motor is unity is called critical excitation.

34. What do you mean by under excitation and over excitation?

When the excitation is adjusted in such a way that the magnitude of induced emf is less than the applied voltage the excitation is called under excitation (lagging power factor)

When the excitation is adjusted in such a way that the magnitude of induced emf is greater than the applied voltage the excitation is called over excitation (leading power factor).

35. What is synchronous capacitor?

When synchronous motor is over excited it takes leading power factor current. This characteristic is similar to a normal capacitor which always takes leading power factor current. Hence over excited synchronous motor operating on no load condition is called as synchronous condenser or synchronous capacitor. This is the property due to which synchronous motor is used as a phase advancer or as a power improvement device.

36. What is hunting?

When synchronous motor is on no load, the stator and rotor pole axis coincide with each other. When motor is loaded, the rotor pole axis falls back with respect to stator. If the load connected to motor is suddenly changed by a large amount, the rotor tries to take its new equilibrium position. But due to inertia of rotor, it cannot achieve equilibrium instantaneously while achieving new position, it passes beyond its final position corresponding to new load. This will produce more torque than demanded. So the load angle is reduced and rotor swings in other direction. Such oscillations of the rotor about its new equilibrium position, due to sudden application or removal of load is called hunting.

37. Mention some application of synchronous motor.

a)Constant speed load service
b)Reciprocating compressor drives
c)Power factor correction
d)Voltage regulation of transmission lines

38. What could be the reasons if a synchronous motor fails to start?

It is usually due to the following reasons

a) Voltage may be to low
b) Some faulty connections in auxiliary apparatus
c) Too much starting load
d) Open circuit in one phase or short circuit
e) Field excitation may be excessive.

39. A synchronous motor starts as usual but fails to develop its full torque. What could be due to?

a)Exciter voltage may be too low
b)Field spool may be reversal
c)There may be either open or short circuit in the field

40. What are the various methods of starting synchronous motor?

a)Pony motor method starting
b)Auto induction starting
c)DC exciter starting
d)Damper winding method of starting

41. What significant characteristic of a synchronous motor is revealed by its V-curves?

The V curves of synchronous motor reveals the fact that its power factor is controllable by means of its excitation.

42. What is the function of slip rings and brush assembly in three phase induction motor?

Slip rings are used to connect external stationary circuit to the internal rotating circuit. Hence in induction motor, the external resistances can be added with the help of brushes and slip ring arrangement in series with each phase of rotor winding.

43. List the difference between squirrel cage rotor and slip ring rotor

S.no	SLIP RING ROTOR	SQUIRREL CAGE ROTOR
1.	Rotor consists of winding similar to the stator winding.	Rotor consists of bars which are short circuited at the ends with the help of end rings.
2.	Resistances can be added externally.	External resistances cannot be added.

44. Define the term slip

Slip of the induction motor is defined as the difference between the synchronous speed and actual speed of rotor expressed as a fraction of the synchronous speed.

45. How the direction of rotation of three phase induction motor can be reversed?

The direction of rotation of three phase induction motor can be reversed by interchanging any two terminals of the three phase windings while connecting to the three phase supply.

46. Under what condition, the slip in an induction motor is zero, one, negative and greater than one.

a) Zero: when N = Ns, S=0 which is not possible for an induction motor.
b) One: when N = 0, S=1. At start motor is at rest and hence its speed N is zero.
c) Negative: When the rotor is running at a speed above synchronous speed, slip is negative.
d) Greater than one: When the motor is rotated in opposite direction to that of rotating field,
e) Slip is greater than 1. When slip is greater than one, the machine works in breaking mode.

47. What are the fundamental characteristics of a rotating magnetic field?

a)The resultant of three alternating fluxes separated from each other by 120 degree has constant amplitude of 1.5 Φ_m, where Φ_m is maximum amplitude of an individual flux due to any phase.

b)The resultant always keeps on rotating with certain speed in space, and the speed is given by Ns = 120f / P

48. What is induction generator?

When run faster than its synchronous speed, an induction motor runs as a generator called as induction generator. Slip is negative.

49. What is the effect of slip on frequency, induced emf, current, power factor, Reactance, Impedance?

a). $F_r = Sf$ b).$E_{2r} = S\,E_2$ c).$X_{2r} = S\,X_2$ d).$I_{2r} = E_{2r} / Z_{2r}$

e).$\cos\Phi_{2r} = R_2 / Z_{2r}$ f).$Z_{2r} = \sqrt{R_2^2 + (SX_2)^2}$

50. What are the types of three phase induction motor?

a)Squirrel cage induction motor
b)Slip ring induction motor

51. Can N = Ns in three phase induction motor?

When rotor starts rotating it tries to catch the speed of rotating magnetic field. If it catches the speed of rotating magnetic field, the relative motion between rotor and RMF will vanish. In fact the relative motion is the main cause for the individual emf the rotor. So induced emf will vanish and hence there cannot be rotor current and rotor flux which is essential to produce the torque on the rotor. Eventually motor will stop. The induction motor never rotates at synchronous speed.

52. Enumerate the possible reasons if a three phase motor fails to start?

a) One or more fuses may be blown
b) Voltage may be too low
c) The starting load may be too heavy

d) Worn bearings due to which the armature may be touching field laminate, thus introducing excessive friction.

53. What happens if single phasing occurs when the motor is running? And when it is stationary?

a) If already running and carrying half load or less, the motor will continue running as single phase motor on the remaining single phase supply, without damage because half loads do not blow normal fuses.

b) If motor is very heavily loaded, then it will stop under single phasing and since it caneither restart nor blow out the remaining fuses, the burn out prompt.

c) A stationary motor will not start with one line broken. In fact due to heavy standstill current, it is likely to burn out quickly unless immediately disconnected.

54. What is meant by plugging?

Plugging means stopping a motor by instantaneously reversing it till it stops.

55. What are the starters used in three phase induction motor?

a)Primary resistance starter
b)Auto transformer starter
c)Direct on line starter
d)Star Delta starter
e)Rotor resistance starter

56. What are the different methods of speed control of three phase induction motor?

a). Control from stator side:

i).By changing the supply voltage
ii).By changing the supply frequency
iii).By changing the number of poles

b). C o n t r o l from Rotor side:

i).Rotor rheostat control
ii).By operating two motors in cascade or concatenation
iii).By injecting an emf in the rotor circuit

57. What is meant by crawling?

Induction motor particularly the squirrel cage type, sometimes exhibit a tendency to run stably at speeds as low as one seventh of their synchronous speed. This phenomenon is known as crawling.

58. What is meant by cogging or magnetic locking?

The rotor of a squirrel cage induction motor sometimes refuses to start at all, particularly when the voltage is low. This happens when the number of stator teeth is equal to the number of rotor teeth and is due to the magnetic locking between the stator and rotor teeth. That is why this phenomenon is also called as teeth locking.

59. What are the advantages of skewing?

a)It reduces magnetic humming.
b)It helps in reducing the locking tendency of the rotor. ie, the tendency of the rotor teeth to remain under the stator teeth due to the magnetic attraction between the two.

60. What is jogging?

Jogging means inching a motor ie, make it to move a little at a time by constant starting and stopping.

61. What are the indications of winding faults in an induction motor?

a)Excessive and unbalanced starting currents
b)Some peculiar noises and
c)Over heating

62. Mention the losses that occur in induction motor.

a)Stator core loss
b)Stator copper loss
c)Rotor Copper loss
d)Mechanical losses

63. What are the no load losses?

The no load losses are the constant losses which include core loss and friction and windage loss.

64. In which type of induction motor can resistance be introduced in the rotor circuit?

In slip ring induction motor the resistance can be introduced in the rotor circuit.

65. The squirrel cage rotor is also known as short circuited rotor. Why?

In squirrel cage rotor, the copper bars are placed in the slots. These bars are short circuited at each end with the help of conducting copper ring called end ring. The entire rotor resistance is very small. Hence this rotor is also called as short circuited rotor.

66. Why air gap length is minimum in an induction motor?

The air gap length is kept minimum in induction motor
a)To reduce the magnetizing current which is required to set up the flux
b)To improve the power factor.

67. Define operating torque, starting torque and breakdown torque. Which of these is the largest?

Operating Torque : Torque from light load to full load
Starting Torque : Torque at start ie, speed = 0 or slip = 1
Breakdown Torque : Maximum torque that motor can develop.

If loaded beyond this torque the motor will decelerate and come to standstill. Breakdown torque is the largest among these for normal induction motor.

68. Why do induction motor runs at low power factor when lightly loaded?

At no load an induction motor draws large magnetizing current to create flux in the air gap. This current has very low power factor of the order 0.2 lag. The power is mainly drawn to provide for core loss. As the motor is loaded, it draws a load component of current with much higher power factor. Therefore the power factor of the net current drawn from main increases with load. It rises to 0.8 - 0.85 at full load. At light load the power factor will be slightly more than that at no load.

69. Why an induction motor is not operated under conditions of maximum load?

Maximum power output condition corresponds to matching of the load resistance in the circuit model to the circuit impedance as seen by the load resistance. This condition corresponds to much larger than the normal operating slip and hence larger current than the full load value. As copper loss is proportional to square of motor current, the motor efficiency under condition of maximum power output is well below 50% which is unacceptable for a power device. Acceptable efficiencies are about 85% or higher.

70. Why an induction motor is called asynchronous motor?

Since the induction motor runs always at a speed lesser than the synchronous speed, it is called asynchronous motor.

71. Why is the efficiency of a three phase induction motor less than that of a transformer?

In induction motor, there are mechanical losses due to the rotation of the rotor. Hence the efficiency of an induction motor is less than that of the transformer.

72. A single phase induction motor is not self starting. Why?

When a single phase supply is connected across a single phase winding, a pulsating magnetic field is produced. The force experienced by the upper conductors of the rotor will be downward and the force experienced by the lower conductors will be directed upward. The two sets of force will cancel and the rotor will experience no torque. Hence the rotor will not rotate.

73. What is the rating of single phase machines? State its applications.

The rating of the single phase machine is from 1/8 to ¾ hp range. They are widely used for fans, washing machines, refrigerators, blowers, centrifugal pumps etc.

74. How will you change the direction of rotation of a split phase induction motor?

The direction of rotation of a split phase induction motor can be changed by changing the direction of current either in the starting winding or in the running winding.

75. What type of motor is used for ceiling fans?

Permanent magnet capacitor motor is used for ceiling fans.

76. Why single phase induction motor has low power factor?

The current through the running winding lags behind the supply voltage by a very large angle. Hence the power factor is low in single phase induction motor.

77. What is the use of shading coil in the shaded pole motor?

The copper shading coil is used to produce rotating magnetic field moving from the unshaded to shaded portion of the pole. Hence the motor produces a starting torque.

78. Why are centrifugal switches provided on many single phase inductions motor?

The centrifugal switches are provided on many single phase induction motors, because when the motor is running at 75% of the synchronous speed, the centrifugal switch connected in the auxiliary winding operates and disconnect the auxiliary winding from the supply.

79. What could be the reasons if a split phase motor runs too slow?

a)Wrong supply voltage and frequency
b)Overload
c)Grounded starting and running windings
d)Short circuited or open winding in field circuit

80. What could be the reasons if a split phase motor fails to start and hums loudly?

It could be due to the starting windings being grounded or burnt out.

81. What is universal motor?

Universal motor is a series motor of rating less than 1Kw which is designed to operated on both dc and ac supply. They are widely used for food mixers, vaccum cleaners, hair driers, electric shavers, portable drills, sewing machines etc.

82. What is the function of capacitor in a single phase induction motor?

Capacitor is used to improve the power factor of the motor. Due to the capacitor connected in series with the auxiliary winding, the capacitive circuit draws a leading current which increases the split phase angle a between the two current I m and Ist.

83. Define double field revolving theory.

According to this theory, any alternating quantity can be resolved into two rotating components which rotates in opposite directions and each having magnitude as half of the maximum magnitude of the alternating quantity.

84. What are the classifications of single phase induction motor based on the method of starting?

a)Split phase motor
b)Capacitor start motor
c)Capacitor run motor
d)Capacitor start Capacitor run motor
e)Shaded pole motor

85. **What design features are incorporated in a split phase motor to make it starting?**

The split phase motor is provided with windings, main winding and auxiliary winding. These two windings are excited from the same voltage. The currents in the two windings can be made out of phase by adjustment of the impedance of the auxiliary winding in relation to the main winding. As a result the mmf of main winding and mmf of auxiliary winding constitute an unbalanced field set with 90 degree electrical space phase relationship. The two symmetrical components now being unequal the forward rotating field is made stronger than the backward rotating field, which results in the net production of starting torque. Thus the two windings with phase difference make the split phase motor self starting.

86. **What is the advantage of a capacitor start motor over a resistance split phase motor?**

In case of capacitor start, it is possible to have the phase angle between the two currents. Therefore this type of motor has high starting torque as compared to resistance split phase motor and used for heavy loads such as compressors, conveyors, pumps, certain machine tools, refrigerators and air conditioning equipment.

87. In which direction does a shaded pole motor runs?

It runs from the unshaded to the shaded part.

88. Give the function performed by induction motor starter.

a) To improve the starting torque

b) To limit the initial in rush of current during starting conditions, which would otherwise produce larger line voltage drop affecting equipments connected to the same line.

89. What do you mean by synchronous condenser?

A single machine which is available to convert ac to dc is known as synchronous converter or rotary converter. A synchronous converter combines the function of a synchronous motor and a dc generator.

90. What type of motor is used in computer drives and wet grinders?

For computer drives – Permanent magnet dc motors

Wet grinders – Universal motor

91. What is the difference between the dc motors and single phase induction motor?

An important difference between the two is that the dc motors are self starting while single phase induction motors are not self starting.