ELECTRICAL MACHINES-2 LABORATORY MANUAL

DEPARTMENT OF ELECTRICAL ENGINEERING

Rajiv Gandhi University of Knowledge Technologies-Basar

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ELECTRICAL TECHNOLOGY LABORATORY

SAFETY RULES

1. Do not touch any terminals (or) Switch without ensuring that it is dead.
2. Wearing shoes with rubber sole is desirable.
3. Use a fuse wire of proper rating.
4. Use sufficient long connecting leads rather than joining two or there small ones, because in case any joint is open it could be dangerous.
5. Make sure that all the electrical connections are correct before switching on any circuit. Wrong connections may cause large amount of current which results damage of equipment.
6. The circuit should be de-energized while changing any connection.
7. In case of emergency or fire switch-off the master switch on the main panel board.
8. Keep away from all the moving parts as for as possible.
9. Do not renew a blown fuse until you are satisfied to the cause and rectified problem.
10. Do not touch an electric circuit when your hands are wet or bleeding from a cut.
11. Do not disconnect plug by pulling a flexing cable when the switch is on.
12. Do not throw water on live electrical equipment in case of fire.
13. Do not test the circuit with bear fingers.
14. Do not use loose garments while working in Laboratory.
15. Do not open (or) close a switch (or) fuse slowly or hesitatingly. Do it quickly and positively.

ELECTRICAL MACHINES-II LABARATORY

LIST OF EXPERIMENTS

1. NO LOAD AND BLOCKED ROTOR TEST ON A 3- ϕ INDUCTION MOTOR

AIM:

To determine the equivalent circuit of a 3- ϕ induction motor and calculate various parameters of induction motor with the help of circle diagram.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-600)V	1 no
2	Ammeter	MI	(0-10)A	1 no
3	Wattmeter	Electro dynamo meter type	10A/600V UPF 10A/600V LPF	1 no 1 no
4	Tachometer	Digital	(0-10000)RPM	1 no
5	Connecting Wires		(0-20)A	Required

NAME PLATE DETAILS:

Power rating 5Hp

Voltage 400V

Current 6.8A

Speed (RPM) 150

Frequency 50Hz

PF Lagging

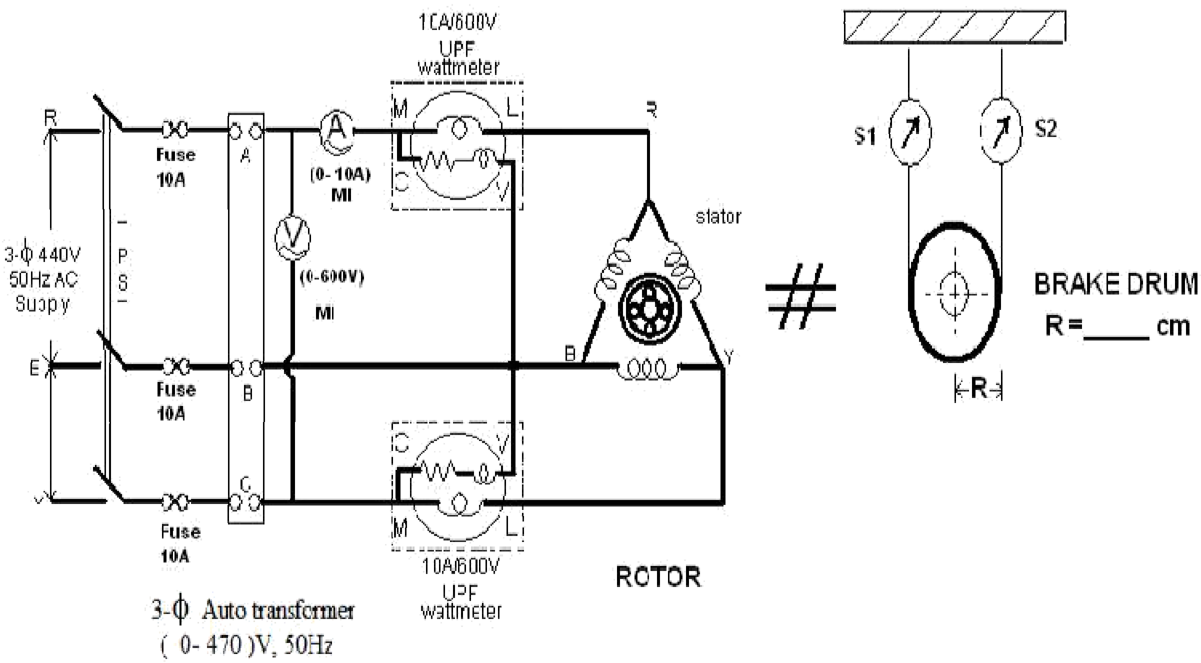
3- ϕ Auto transformer Details:

Input Voltage: _____415_____________ (Volt)

Output Voltage: ___(0-470)_______________ (Volt)

Current:_____________________ (Amp.)

CIRCUIT DIAGRAM:



PROCEDURE:

NO- LOAD TEST:

1. Connections are made as per the circuit diagram.
2. Ensure that the 3- ϕ variac is kept at minimum output voltage position and belt is freely suspended.
3. Switch ON the supply. Increase the variac output voltage gradually until rated voltage is observed in voltmeter. Note that the induction motor takes large current initially, so, keep an eye on the ammeter such that the starting current current should not exceed 7 Amp.
4. By the time speed gains rated value, note down the readings of voltmeter, ammeter, and wattmeter.

5. Bring back the variac to zero output voltage position and switch OFF the supply.

BLOCKED ROTOR TEST:

1. Connections are as per the circuit diagram.
2. The rotor is blocked by tightening the belt.
3. A small voltage is applied using 3- ϕ variac to the stator so that a rated current flows in the induction motor.
4. Note down the readings of Voltmeter, Ammeter and Wattmeter in a tabular column.
5. Bring back the Variac to zero output voltage position and switch OFF the supply.

OBSERVATIONS:

No Load Test:

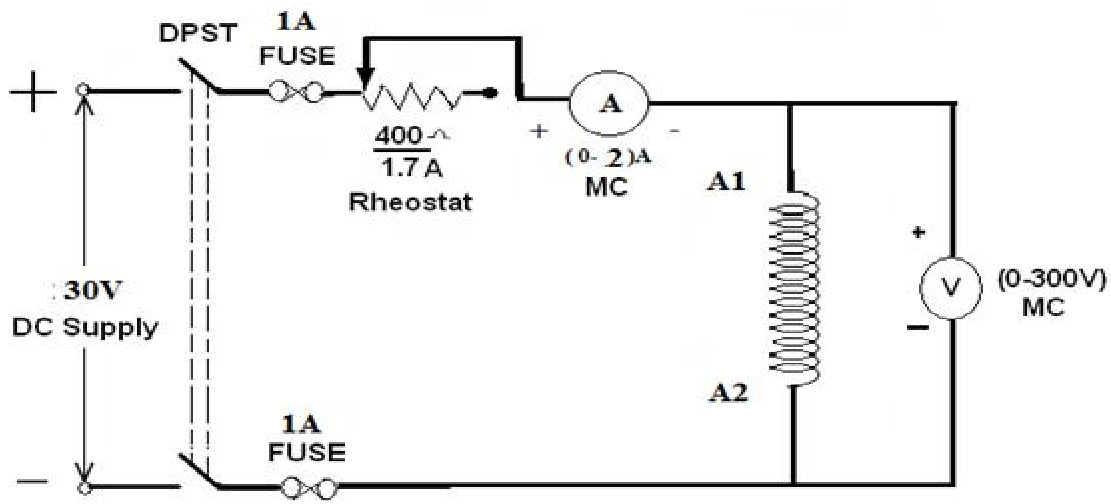
S No.	Voltmeter reading V_{nl} (V)	Ammeter reading I_{nl} (A)	Wattmeter reading		W_{nl} (P_{nl}) (W)
			W_1 (W)	W_2 (W)	W_1+W_2
1	420	1	60	98	158*2=316

Blocked Rotor Test

S No.	Voltmeter Reading V_{br}	Ammeter reading I_{br}	Wattmeter reading		W_{br} (P_{br}) W_1+W_2
			W_1 (W)	W_2 (W)	
1	38.5	8	56	64	120*2=240

Measurement of stator winding resistance (r_1):

CIRCUIT DIAGRAM:



TABULAR COLUMN:

S no.	Voltage (v)	Ammeter (I)	Resistance (R)

Procedure to find r_1:

1. Connections are made as per the circuit diagram
2. Switch ON the supply. By varying the rheostat, take different readings of ammeter and voltmeter in a tabular column.
3. From the above readings, average resistance r_1 of a stator is found

Measurement of Stator resistance

1. Connect the circuit as per the circuit diagram shown in fig (2).
2. Keeping rheostat in maximum resistance position switch on the 220 V Dc supply.
3. Using volt-ammeter method measure the resistance of the stator winding.
4. After finding the stator resistance, R_{dc} must be multiplied with 1.6 so as to account for skin effect i.e. $R_{ac} = 1.6\ R_{dc}$.

MODEL CALCULATIONS:

$G=W_0/3V_2$, $Y_0=I_0/V$, $B_0=Y_0^2-G_0^2$

$Z_{01}=V_{sc}/I_{sc}$, $R=W_{sc}/3xI_{sc}^2$, $X_{01}=\sqrt{Z_{01}^2-R_{01}^2}$

For circle diagrm:

$\cos\Phi_0=W_0/\sqrt{3}\ V_0I_0$, $\Phi_0=\cos^{-1}(W_0/\sqrt{3}\ V_0I_0)$

$\cos\Phi_{sc}=W_{sc}/\sqrt{3}\ V_{sc}I_{sc}$, $I_{sn}=I_{sc}(V/V_{sc})$;

PRECAUTIONS:

1. Connections must be made tight
2. Before making or breaking the circuit, supply must be switched off

RESULT:

No load and blocked rotor tests are performed on 3-Φ Induction motor.

VIVA Questions:

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

2. BRAKE TEST ON 3- ϕ SQUIRREL CAGE INDUCTION MOTOR

AIM:

To determine the efficiency of 3- ϕ induction motor by performing load test. To obtain the performance curves for the same.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-600)V	1 no
2	Ammeter	MI	(0-10)A	1 no
3	Wattmeter	Electro dynamo meter type	10A/600V UPF 10A/600V LPF	1 no 1 no
4	Tachometer	Digital	0-9999 RPM	1 no
5	Connecting Wires	*****	*****	Required

NAME PLATE DETAILS:

Power rating	5HP
Voltage	400V
Current	6.8A
Speed(RPM)	1450rpm

Frequency	50Hz
PF	lagging

3- ϕ Auto transformer Details:

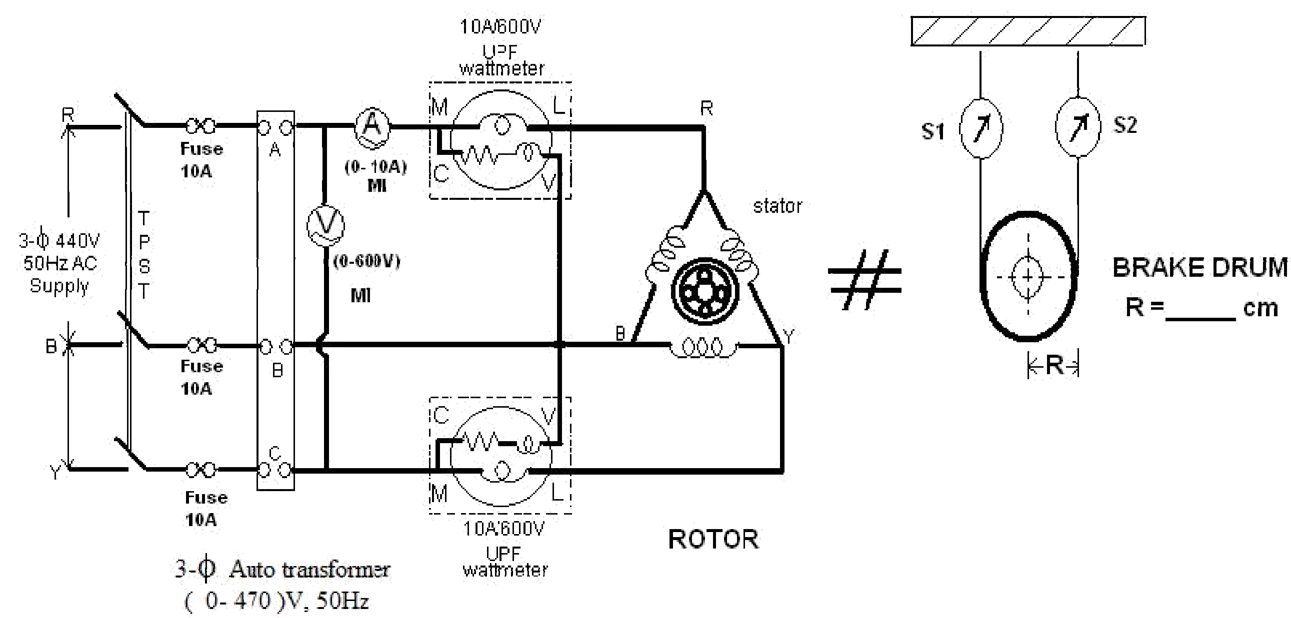
Input Voltage: _________415_________ (Volt)

Output Voltage: ________(0-470)__________ _(Volt)

Current:_______________________(Amp.)

Freq.:_____________50Hz______________(Hz)

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Ensure that the 3- ϕ variac is kept at minimum output voltage position and belt is freely suspended.

3. Switch ON the supply. Increase the variac output voltage gradually until rated voltage is observed in voltmeter. Note that the induction motor takes large current initially, so, keep an eye on the ammeter such that the starting current current should not exceed 7 Amp.

4. By the time speed gains rated value, note down the readings of voltmeter, ammeter, and wattmeter at no-load.

5. Now the increase the mechanical load by tightening the belt around the brake drum gradually in steps.

6. Note down the various meters readings at different values of load till the ammeter shows the rated current.

7. Reduce the load on the motor finally, and switch OFF the supply.

TABULAR COLUMN:

S.NO.	Voltage(V)	Current(A)	Wattmeter reading W1	Wattmeter reading W2	I/P power W1+W2	Spring balance (kg) S1	Spring balance (kg) S2	Spring balance (kg) (S1-S2)	Speed (N) rpm	% Slip	Power factor cosΦ= w_1+w2 /√3vi	Torque (Nm)	Pout(W)	%η
1	400	1.2	240	240	480	0	0	0	1498	0.13	0.57	0	0	0
2	400	2.2	880	240	1160	1.5	6.5	5	1485	1	0.76	5.49	853.74	76.31
3	400	3	1120	480	1600	2.5	10	7.5	1454	3.06	0.76	8.24	1254.64	78.41
4	400	3.6	1440	640	2080	3.5	14	10.5	1424	5.06	0.83	11.53	1720.85	827.3
5	400	4	1600	720	2320	4.5	16.5	12	1398	6.8	0.83	13.18	1929.52	83.16
6	400	5	1960	880	2840	5.5	19	13.5	1382	7.8	0.81	14.83	2146.23	75.57
7	400	6	2000	960	2960	6.0	20	14	1268	7.54	0.7	15.38	2093.76	70.23

MODEL CALCULATIONS:

Input power drawn by the motor W = ($W_1 \pm W_2$) watts

Shaft Torque, $T_{sh} = 9.81\ (S_1 \sim S_2)\ R$ N-m   R → Radius of drum in meters.

Output power in watts = $\dfrac{2\pi N T_{sh}}{60}$ *watts*

$$1.\ efficiency = \frac{output\ power\ in\ watts}{Input\ power\ in\ watts}\ x\ 100$$

Calculations:

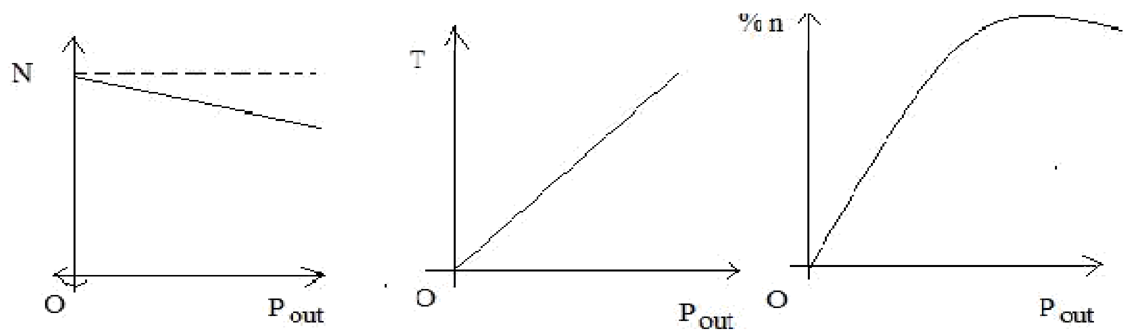
% Slip = (Ns-N)/NS*100

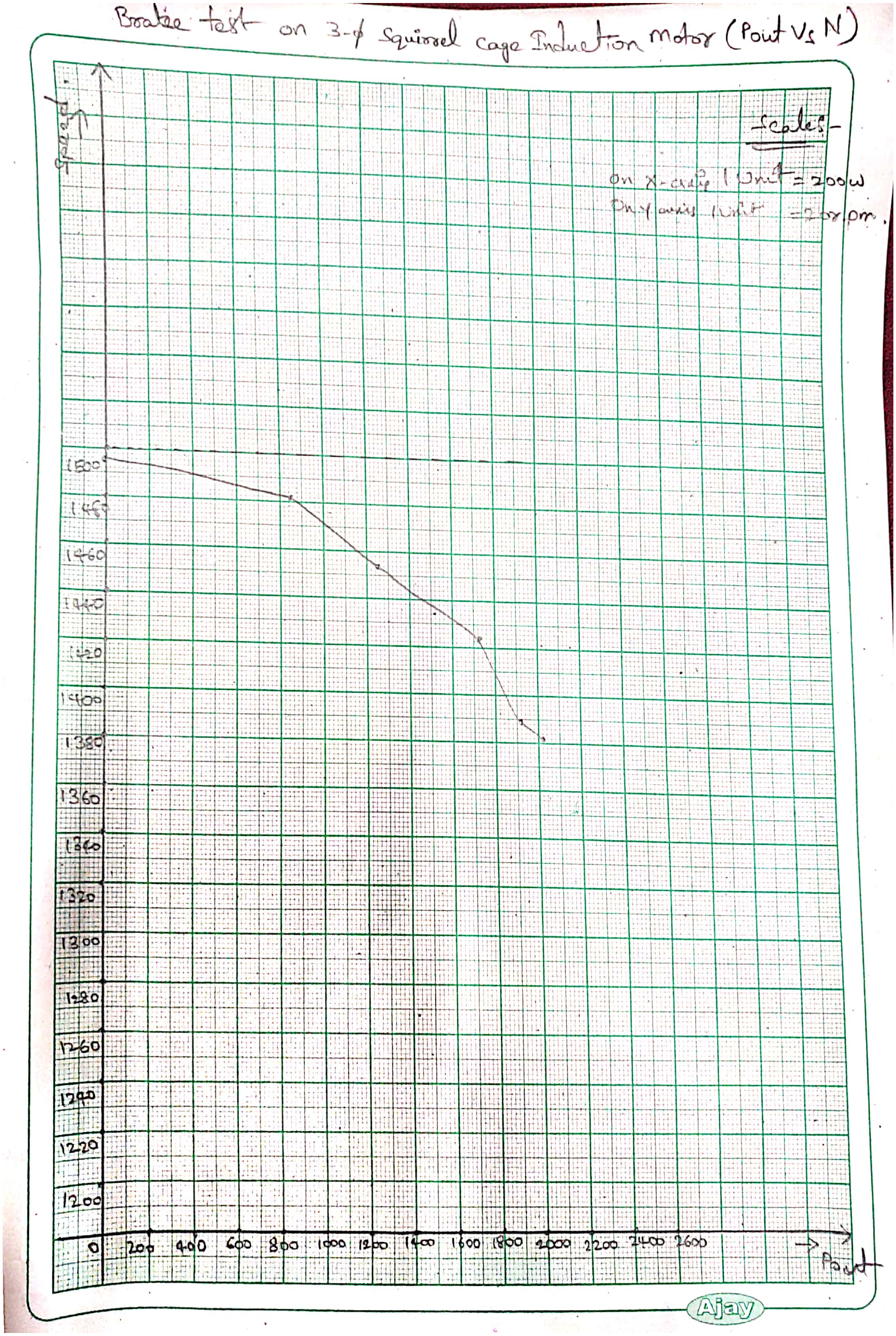
=120f/P

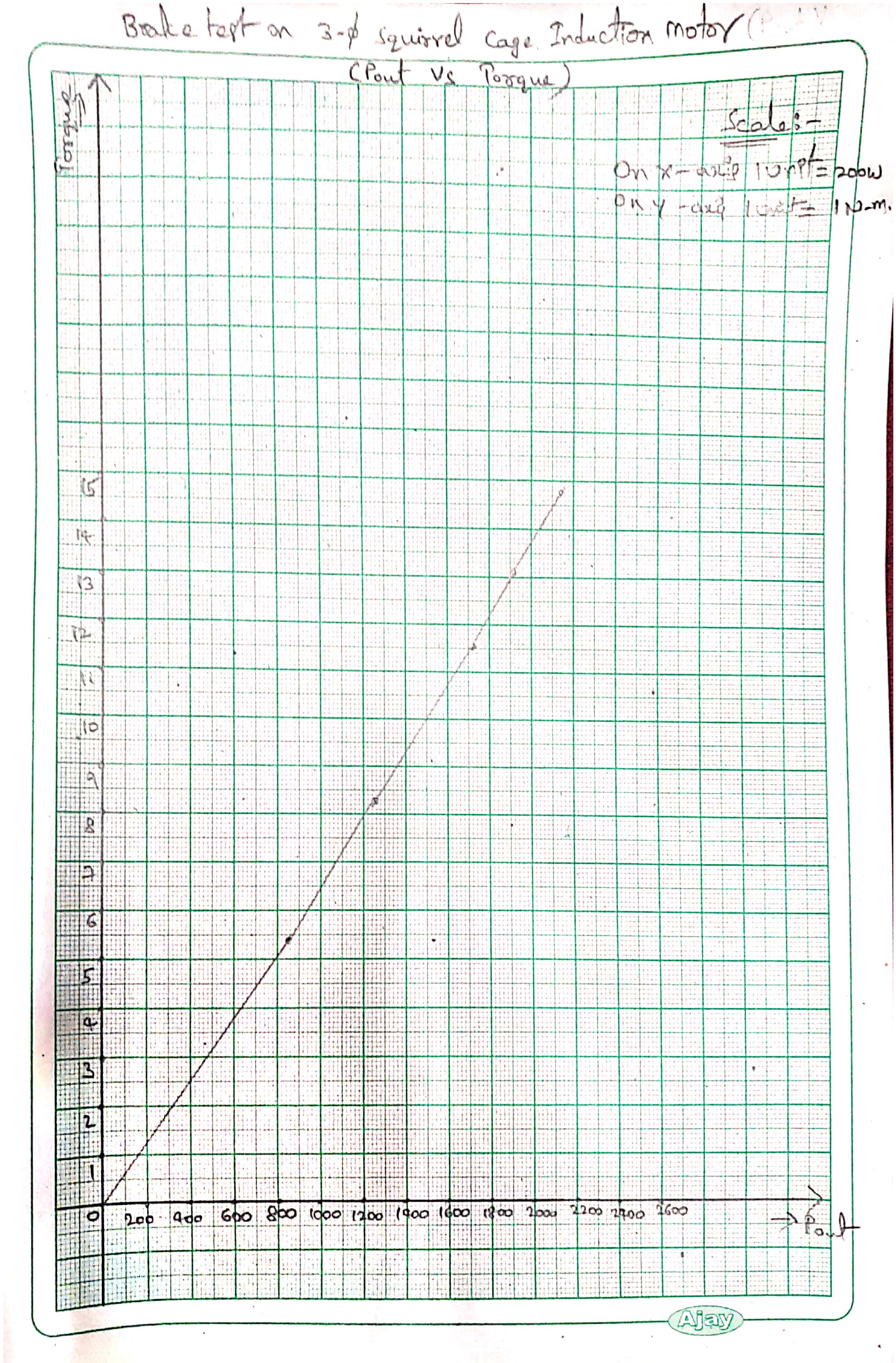
Power factor of the induction motor $\cos\Theta = W/\sqrt{3}\ V_L I_L$

MODEL GRAPHS:

1. Speed or slip Vs output power
2. Torque Vs output power
3. % efficiency Vs output power

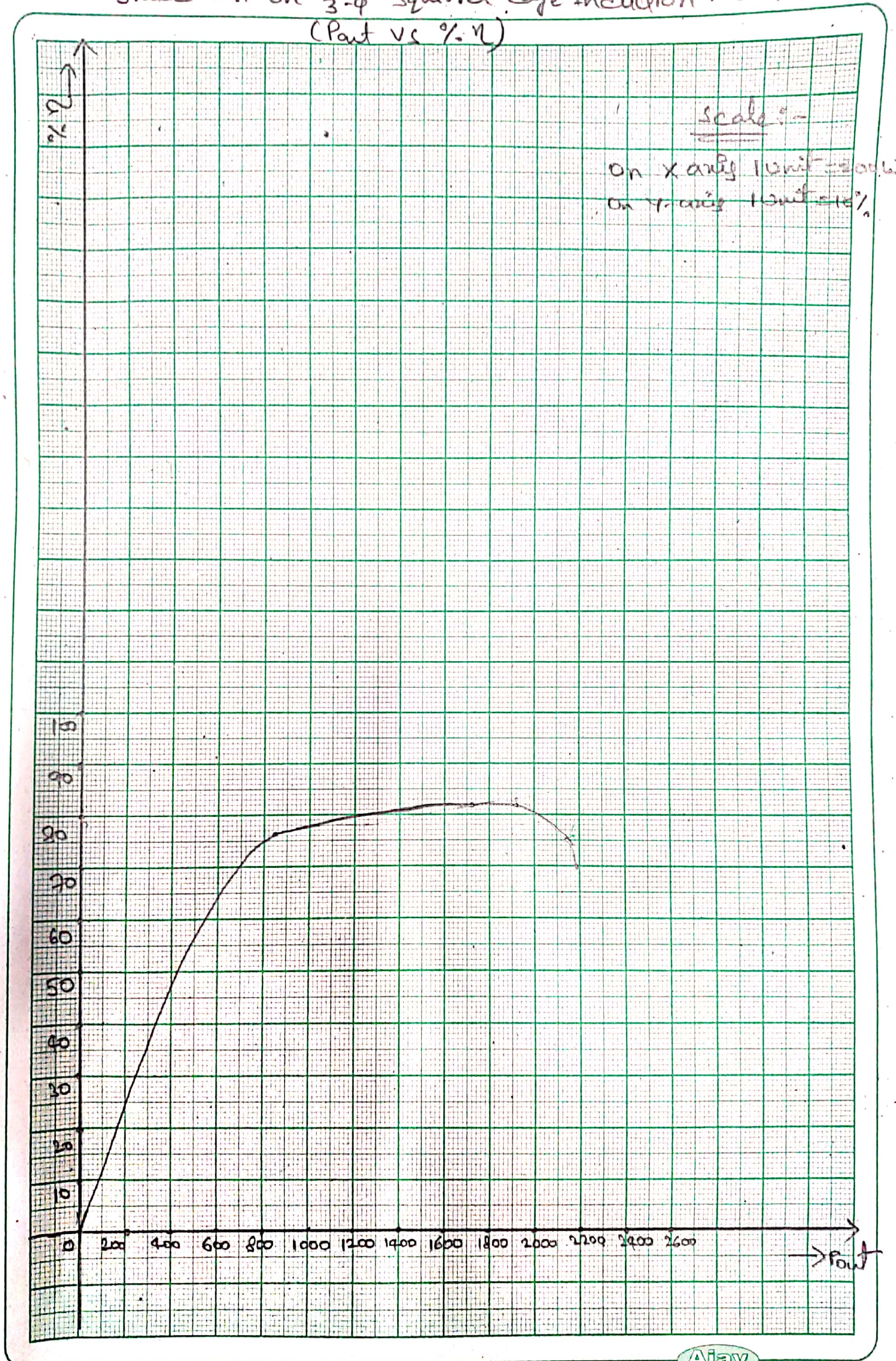



Brake test on 3-φ Squirrel cage Induction motor (Pout Vs N)
Scales:-
On X-axis 1 Unit = 200W
On Y axis 1 Unit = 20 rpm.
Speed
1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
Pout
Ajay


Brake test on 3-ϕ squirrel cage Induction motor
(Pout Vs Torque)
Scale:-
On x-axis 1unit = 200W
On y-axis 1unit = 1N-m.
Torque
Pout
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600

Brake test on 3-ϕ squirrel cage Induction Motor

(Pout vs %η)



PRECAUTIONS:

1. Connections must be made tight
2. Before making or breaking the circuit, supply must be switched off

RESULT:

The load test on 3-Φ squirrel cage induction motor conducted and the characteristics of torque, speed, efficiency versus output power were drawn.

VIVA Questions:

1. Why starter is used? What are different types of starters?
2. Compare a slip ring induction motor with cage induction motor?
3. Why the starting torque is zero for a Single Phase induction motor and non-zero of 3phase induction motor?
4. What are the disadvantages of this method?
5. Can we use rotor resistance method for starting?

3. LOAD TEST ON 3-PHASE AC SLIPRING INDUCTION MOTOR

AIM :

To Perform Load Test on 3 Phase AC Slipring Induction Motor.

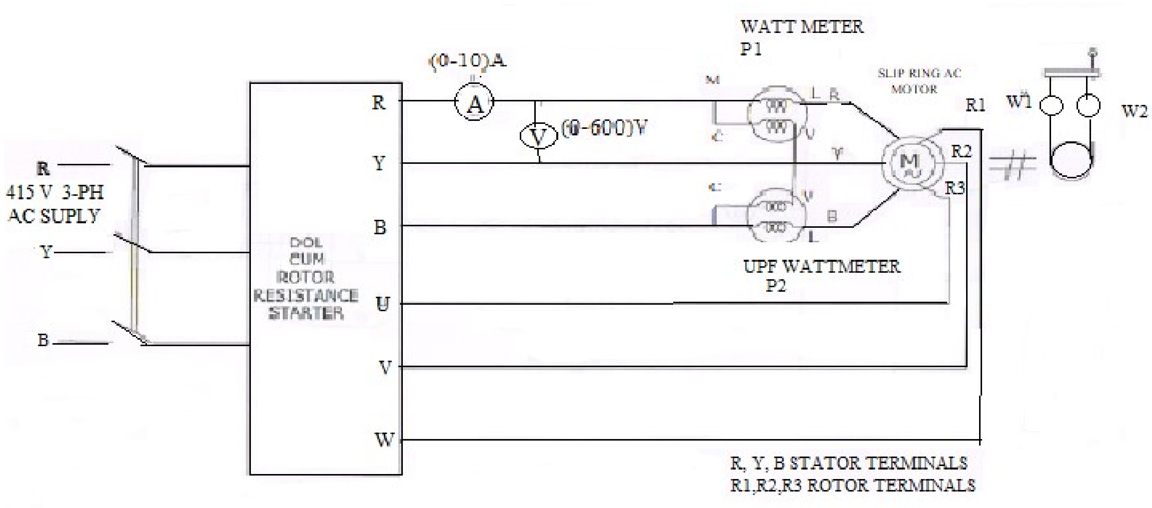
APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Ammeter	MI	(0-10) A	1 no
2	Voltmeter	MI	(0-500) V 10A/600V UPF	1 no 1 no
3	Wattmeter	Electro dynamo meter type	10A/600V UPF	1 no
4	Tachometer	Digital	(0-10000)RPM	1 no
5	Connecting Wires	*****	(0-20)A	Required

NAME PLATE DETAILS:

Power rating	5Hp
Voltage	400V
Current	6.8A
Speed (RPM)	1500
Frequency	50Hz
PF	Lagging
Stator	Delta connection
Rotor	Star connection

CIRCUIT DIAGRAM:



PROCEDURE:

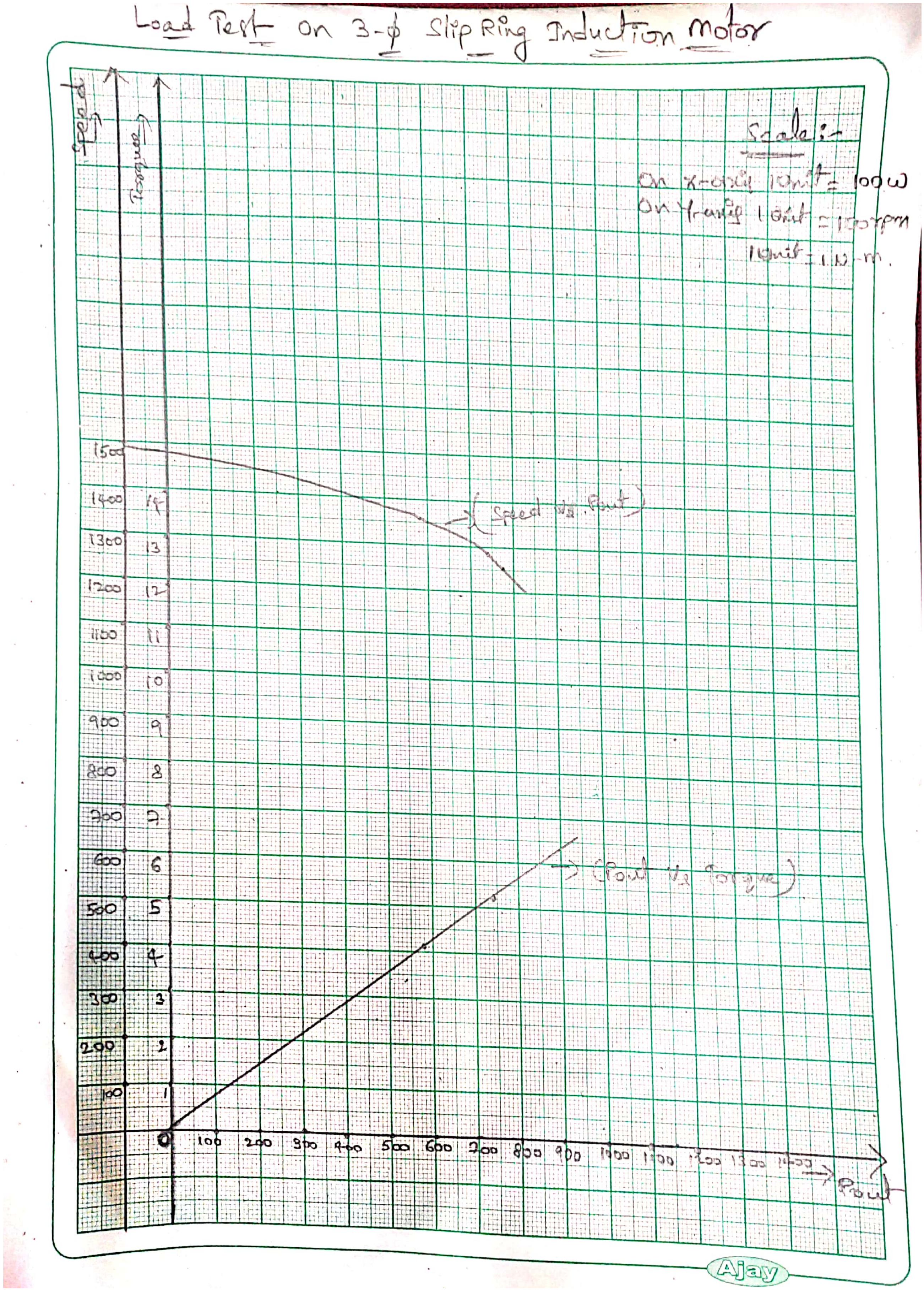
1. Connect circuit. as shown in diagram.
2. Adjust 'Zero set' for Balances.
3. Switch on Mains supply s/w.
4. To Start AC Motor, press START Push Button & Shift position of Rotor resistance s/w from 1 to 2 to 3 to 4. Resistance is cut out and rotor is short circuited at position – 4.
5. Note down readings of voltmeter, Ammeter, Wattmeter's & load on balances W1 & W2 Kg.
6. Using hand wheel of Brake drum arrangement load the motor in steps from no load to rated torque.
7. Rated torque T = (W1-W2) *A

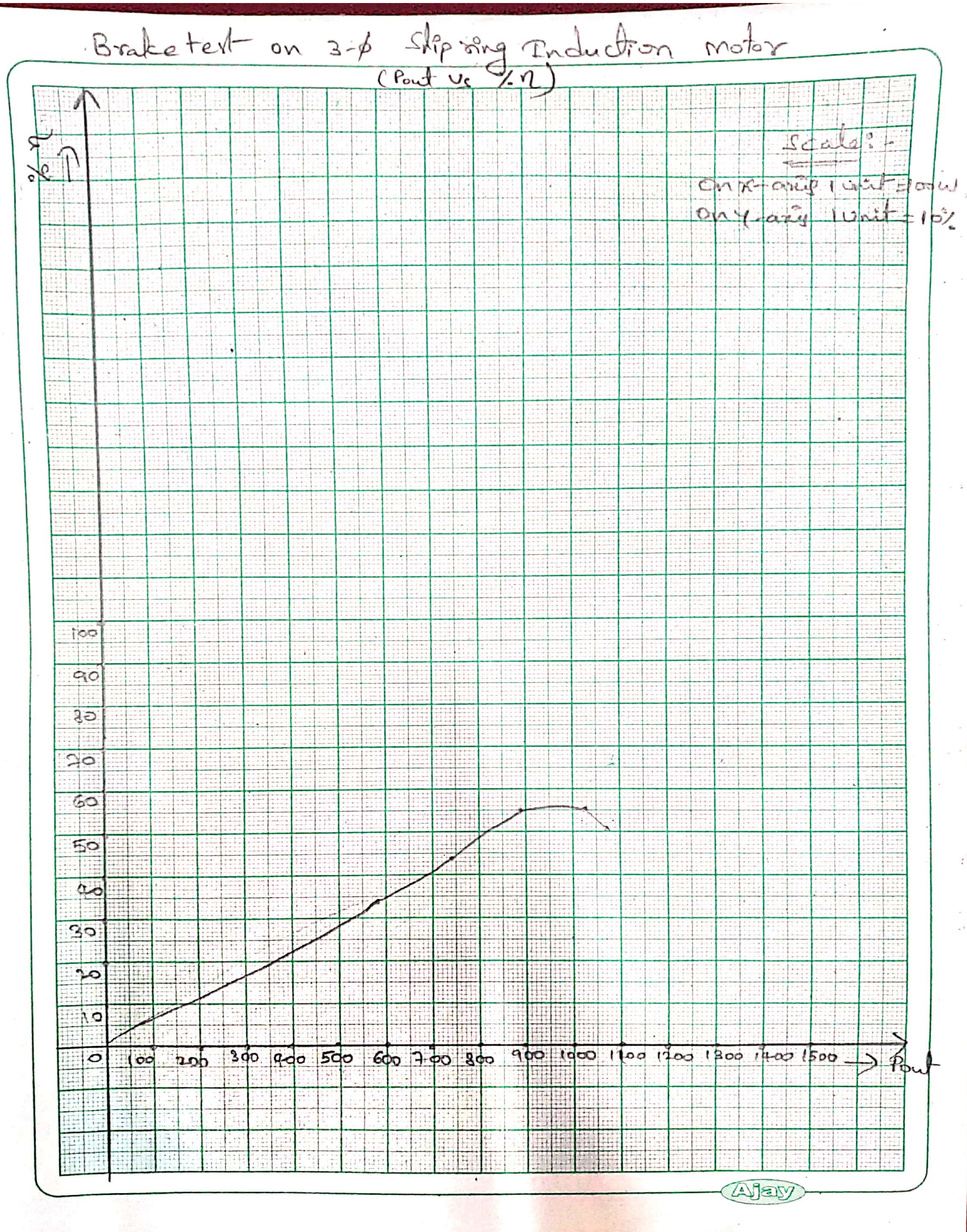
   A = Break drum Constant = Radius of Pulley (Meter) * 9.81

8. At each step repeat Step 5.
9. Calculate power output P = 2ЛNT/60.
10. Calculate efficiency = output / input.

Observation Table:

S NO.	Line Volts V_L	Line Amps. I_L	Wattmeter's watts		I/P Power P1 + P2	Load W1 Kg.	Load W2 Kg.	W1-W2	Speed RPM	Torque N-m	Output power	%η
			P1	P2								
1.	420	3.8	0.24	0.29	0.53	0	0	0	1472	0	0	0
2.	420	4	0.32	0.19	0.51	4	0.5	3.5	1420	4.12	612.6	30.02
3.	420	4.2	0.34	0.09	0.43	4.5	1	3.5	1360	4.12	586.7	34.11
4.	420	4.4	0.38	0.04	0.42	6	1.5	4.5	1348	5.29	746.7	44.9


Load Test on 3-ϕ Slip Ring Induction Motor
Scale:-
On x-axis 1Unit = 100W
On Y-axis 1Unit = 100rpm
1Unit = 1N-m.
Speed
Torque
(Speed Vs. Pout)
(Pout Vs Torque)
Pout



RESULT:

Load test is performed on 3-Θ A.C. Slip ring Induction motor, and characteristics performances are observed.

4.LOAD TEST ON SINGLE PHASE INDUCTION MOTOR

AIM:

To conduct the direct load test on the given single phase induction motor and to determine and plot its performance characteristics.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V	1 no
2	Ammeter	MI	(0-10)A	1 no
3	Tachometer	Digital	0-9999 RPM	1 no
4	Wattmeter	Dynamo-type	(0-150)V UPF (0-10)A	1 no
5	Connecting Wires	*****	(0-20)A	Required

NAME PLATE DETAILS:

1Φ Induction motor

Rated Voltage : ________220V____________

Rated Current : ______8A_______________

Rated Speed : _______1500rpm_____________

Rated Power : ________2HP_____________

Rated Frequency: ______50Hz_____________

FORMULA USED:

Torque = 9.81 × (S_1-S_2) × R Nm, where R is the radius of the brake drum in meter.

Output power, P_o= 2πNT/60 Watts

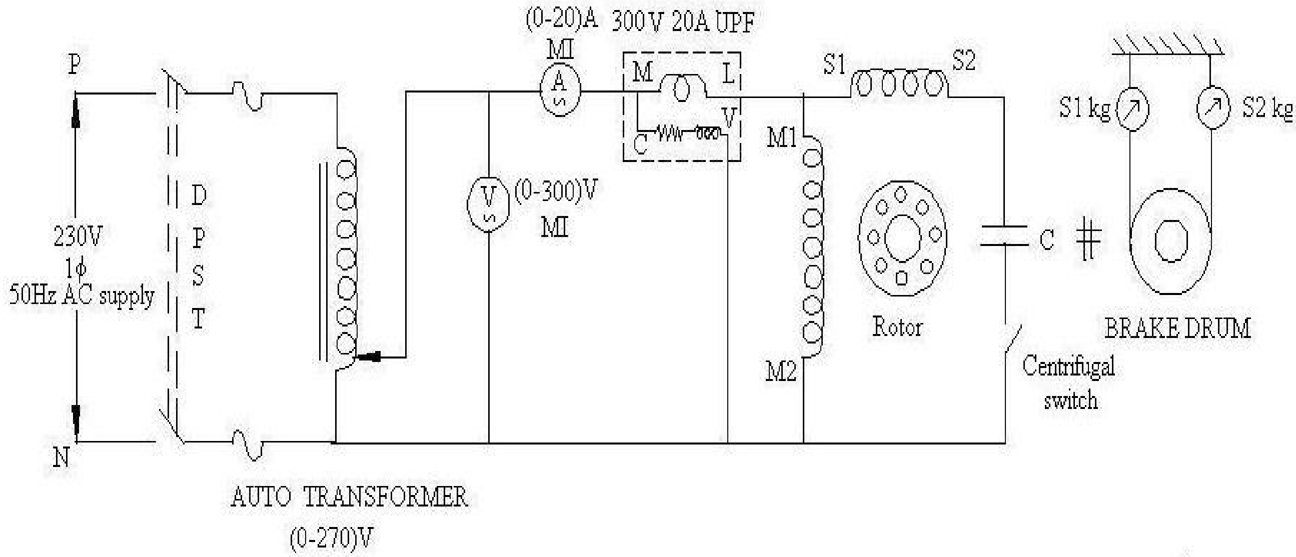
Input power, P_i = W_1+W_2 Watts

%Efficiency, %η = (output power/input power) ×100

% Slip = (N_s-N)/N ×100

Power factor = Cos φ=W/VI

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connections are given as per the circuit diagram.

2. Switch on the supply at no load condition.

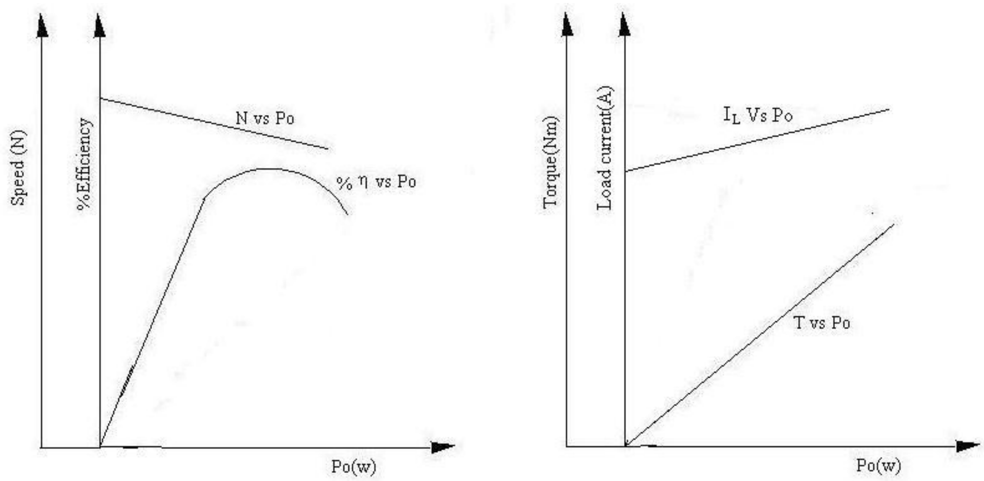
3. Apply the rotor voltage to the motor using the variac and note down the readings at ammeter And wattmeter.

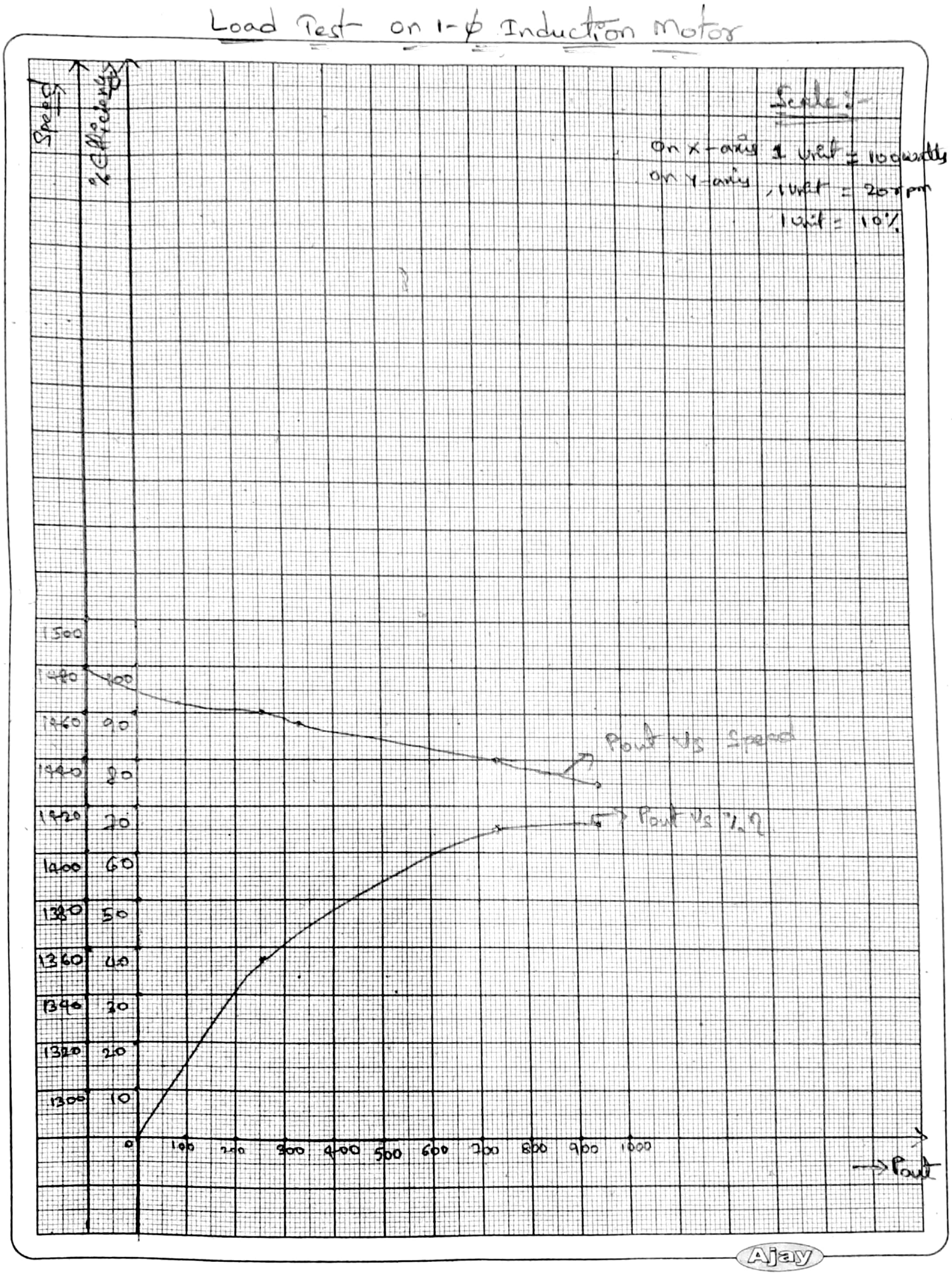
4. Vary the load in suitable steps and note down all the meter readings till fill load condition.

TABULAR COLUMN:

S. No	V_L Volts	I_L Amps	S_1 kg	S_2 kg	S kg	W watts	Speed rpm	Torque Nm	Po watts	%η
1	220	2	0	0	0	480	1480	0	0	0
2	220	4	2	0.5	1.5	680	1460	1.65	252.142	37.09
3	220	5	4.5	1.5	2	960	1448	2.197	332.97	34.68
4	220	6	6.5	2	4.5	1120	1440	4.94	745.15	65.53
5	220	7	8.3	2.5	5.8	1440	1430	6.372	953.71	66.23

MODEL GRAPH:


Speed (N)
%Efficiency
N vs Po
% η vs Po
Po(w)
Torque(Nm)
Load current(A)
I_L Vs Po
T vs Po
Po(w)



Load Test on 1-φ Induction Motor
Scale:-
On X-axis 1 unit = 100 watts
On Y-axis, 1 unit = 20 rpm
1 unit = 10%
Speed
% Efficiency
Pout Vs Speed
Pout Vs % η
Pout
1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
100
90
80
70
60
50
40
30
20
10
0
100
200
300
400
500
600
700
800
900
1000

RESULT:

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

VIVAQUESTIONS

1. What is the purpose of this experiment?

2. Whether single phase induction motor self starting motor?

3.What are the starting methods of single phase induction motor?

5. EQUIVALENT CIRCUIT OF A SIGLE PHASE INDUCTION MOTOR

AIM:

To determine the equivalent circuit parameters of a single phase induction motor by performing the no- load and blocked rotor tests.

APPARATUS REQUIRED:

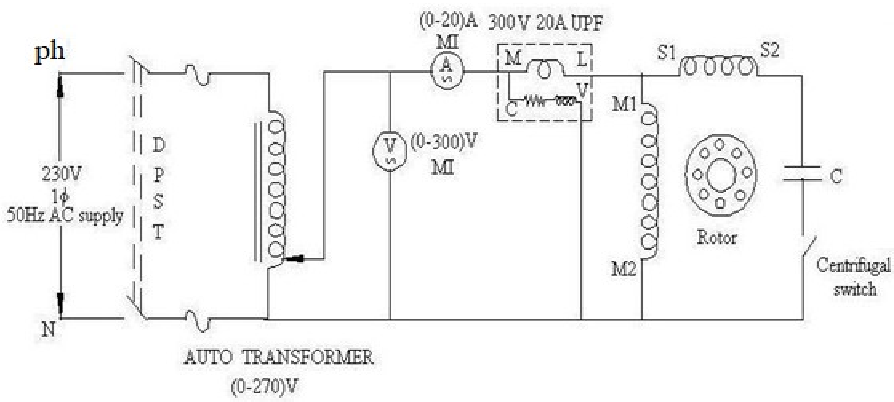
Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V	1 no
2	Ammeter	MI	(0-10)A	1 no
3	Wattmeter	Dynamo-type	(0-300)V LPF (0-10)A	1 no
4	Wattmeter	Dynamo-type	(0-150)V UPF (0-10)A	1 no
5	Connecting Wires	*****	(0-20)A	Required

1 - ϕ Induction motor specifications:

Name plate details:

Rated power	2HP
Rated voltage	220V
Current	8A
Speed(RPM)	1500rpm
Cos ϕ (pf)	Lagging
Frequency	50Hz
Rotor	Squirrel Cage

CIRCUIT DIAGRAM:



PROCEDURE:

No load Test:

1. The circuit connections are made as per the circuit diagram.
2. Be sure that variac (auto transformer) is set to zero output voltage position before starting the experiment.
3. Now switch ON the supply and close the DPST switch.
4. The variac is varied slowly, until rated voltage is applied to motor and rated speed is obtained.
5. Take the readings of Ammeter, Voltmeter and wattmeter in a tabular column.
6. The variac is brought to zero output voltage position after the experiment is done, and switch OFF the supply.

Blocked Rotor Test:

1. To conduct blocked rotor test, necessary meters are connected to suit the full load conditions of the motor.
2. Connections are made as per the circuit diagram.
3. Before starting the experiment variac (auto transformer) is set to zero output voltage position.
4. The rotor (shaft) of the motor is held tight with the rope around the brake drum.

5. Switch ON the supply, and variac is gradually varied till the rated current flows in the induction motor.
6. Readings of Voltmeter, Ammeter, and wattmeter are noted in a tabular column.
7. The variac is brought to zero output voltage position after the experiment is done, and switch OFF the supply.
8. Loosen the rope after the experiment is done.

Calculation for No-Load Test:

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

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

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

$$X_o = Z_o \sin\phi_o$$

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

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

Calculation For Blocked Rotor Test:

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

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

r_1 is the DC resistance of stator of motor

$$r_2 = R_{sc} - r_1$$

$$x_1 + x_2 = X_{sc}$$

since leakage reactance can't be seperated out , it is common practice to to assume $x_1 = x_2$

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

OBSERVATIONS:

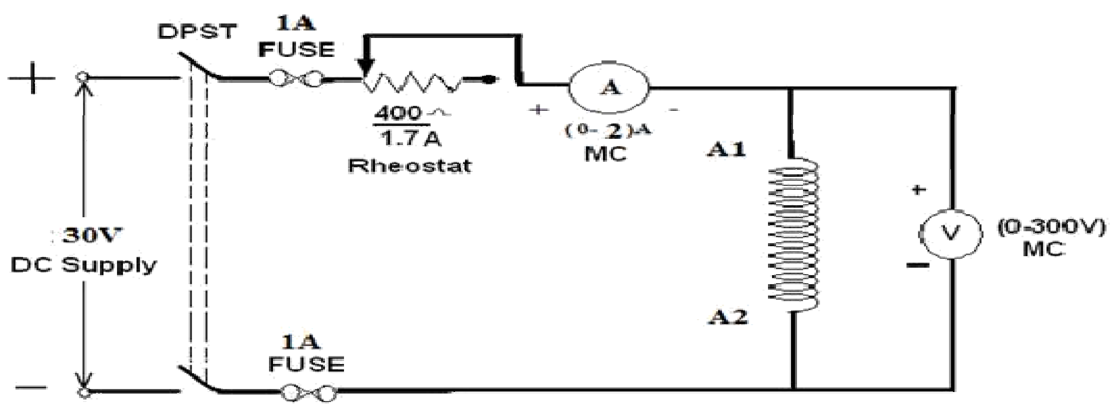
For No-Load Test:

Sl no.	Voltmeter reading V_o	Ammeter reading I_o	Wattmeter reading W_o	$\cos\Phi_0=W_0/V0I0$
1	220	2	80*2=160	0.3636

For Blocked Rotor Test:

Sl no.	Voltmeter reading Vsc	Ammeter reading Isc	Wattmeter reading Wsc	$\cos\Phi_{sc}$
1	38	8	130*2=260	0.855

Circuit diagram for measurement of R_1 :



PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Initially rheostat is set at maximum resistance position.
3. Switch ON the supply, and vary the rheostat gradually and note down the readings of ammeter and voltmeter
4. For the corresponding values, average of r1 is take

To find stator Resistance:

S.NO.	V(volts)	I(Amps)	R=V/I Ω
1	5	4.76	1.05
2	10	9.09	1.1
3	15	13.39	1.12
4	18	15.65	1.15
5	20	18.18	1.1

Average Value: R_{dc} R_{ac} R_{dc} =1.1

Comments:

1. Since IM is not self starting Machine, it is started by placing an auxiliary winding in the circuit.
2. Here no-load test is similar to open circuiting the load terminals and blocking the rotor is similar to conducting short circuit on the IM.

VIVA Questions:

1. Why there is no starting torque in a single phase induction motor?
2. What are different starting methods employed in single phase induction motors?
3. Compare the performance of capacitor - start, capacitor – run, shaded pole single phase induction motors?
4. Mention a few applications of single phase induction motors?

PRECAUTIONS:

1. Connections must be made tight.
2. Before making or breaking the circuit, supply must be switched off

RESULT:

Equivalent circuit parameters of 1-Φ Induction motor are determined by using No-load and blocked rotor tests.

6. REGULATION OF ALTERNATOR USING SYNCHRONOUS IMPEDANCE METHOD

AIM:

To find the regulation of a 3 - ϕ alternator by using synchronous impedance method.

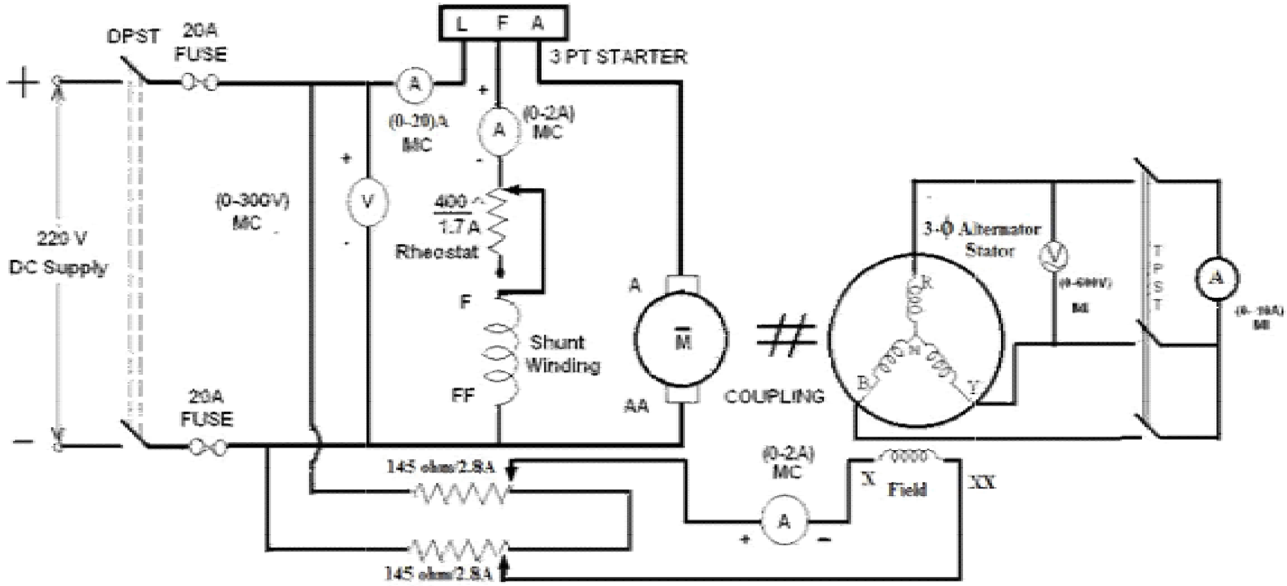
APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300/600)V	1 no
2	Ammeter	MI	(0-5/10)A	1 no
3	Ammeter	MI	(0-2.5/5)A	1 no
3	Rheostat	Wire-wound	400 Ω /1.7A 145Ω /2A	1 no 2 no
4	Tachometer	Digital	(0-100000)RPM	1 no
5	Connecting Wires	*****	(0-20)A	Required

NAME PLATE DETAILS:

DC Motor(prime mover)	3- ϕ Alternator
Power rating : 5HP	Power Rating : 3KVA
Armature Voltage : 220V	Voltage : 415 V
Current : 19A	Rated Current : 3.8A
Speed : 1500rpm	Speed : 1500rpm
Excitation : Shunt	Excitation : DC Generator

CIRCUIT DIAGRAM:



PROCEDURE:

Open Circuit Test:

1. Make the connections as per the circuit diagram.
2. Before starting the experiment, the potential divider network in the alternator field circuit and field regulator rheostat of motor circuit is set minimum resistance position.
3. Switch ON the supply and close the DPST switch. The DC motor is started by moving starter handle.
4. Adjust the field rheostat of DC motor to attain rated speed (equal to synchronous speed of alternator)
5. By decreasing the field resistance of Alternator, the excitation current of alternator is increased gradually in steps.
6. Note the readings of field current, and its corresponding armature voltage in a tabular column.
7. The voltage readings are taken upto and 10% beyond the rated voltage of the machine.

Short Circuit Test:

1. For Short circuit test, before starting the experiment the potential divider is brought back to zero output position, i.e., resistance should be zero in value.
2. Now close the TPST switch.
3. The excitation of alternator is gradually increased in steps until rated current flows in the machine and note down the readings of excitation current and load current (short circuit current).
4. Switch OFF the supply.

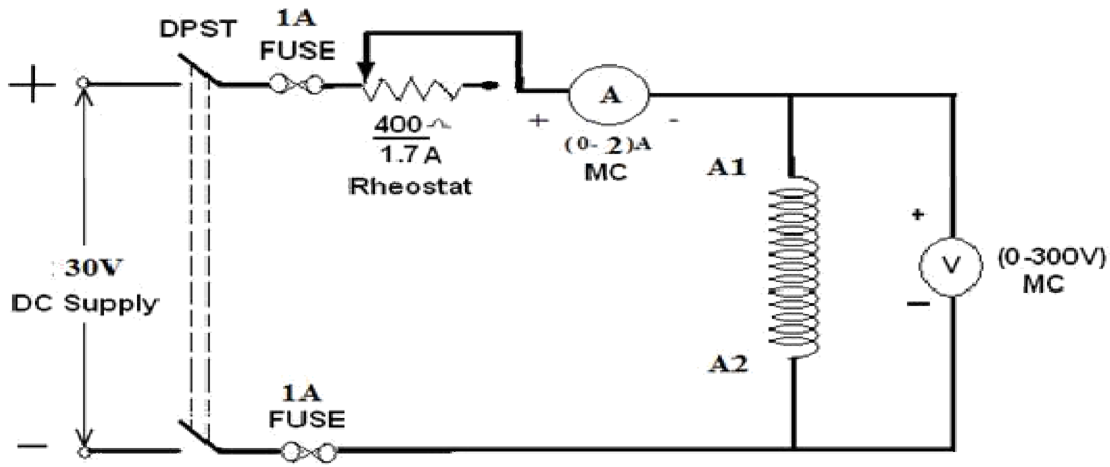
OBSERVATIONS:

SL. No.	OC test		SL. No.	S.C. test	
	Field current in Amp.(I f)	OC voltage per phase (Vo)		Field current I_f(Amp.)	SC current I_{sc} Amp.
1	0.25	140	1	0.24	0.5
2	0.3	160	2	0.3	1
3	0.35	175	3	0.35	1.2
4	0.4	205	4	0.4	1.6
5	0.45	228	5	0.45	1.9
6	0.5	250	6	0.5	2.15
7	0.55	270	7	0.55	2.4
8	0.6	265	8	0.6	2.8
9	0.7	320	9	0.65	3.1
10	0.75	335	10	0.7	3.4

Procedure to find Armature resistance of Alternator:

1. Connections are made as per the circuit diagram.
2. Switch ON the supply. By varying the rheostat, take different readings of ammeter and voltmeter in a tabular column.
3. From the above readings, average resistance Ra of a armature is found out.

Connection diagram to find Ra:



OBSERVATIONS:

S No.	Armature current I(amp)	Armature voltage Va (volts)	R_{dc}=V / I

Procedure to find synchronous impedance from OC and SC tests:

1. Plot open circuit voltage, short circuit current verses field current on a graph sheet.
2. From the graph, the synchronous impedance for the rated value of excitation is calculated.
3. The excitation emf is calculated at full load current which is equal to the terminal voltage at No load.
4. The voltage regulation is calculated at rated terminal voltage.

MODEL CALCULATIONS:

$Zs = Voc/Isc$ for the same If and speed : $Xs = \sqrt{Zs^2 - Ra^2}$ ($Ra = Rdc$)

Generated e.m.f. of alternator on no load is

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

+ for lagging p.f.

- for leading p.f.

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

1. $\mathrm{Re}\,g = \dfrac{E_0 - V}{V} x\, 100$

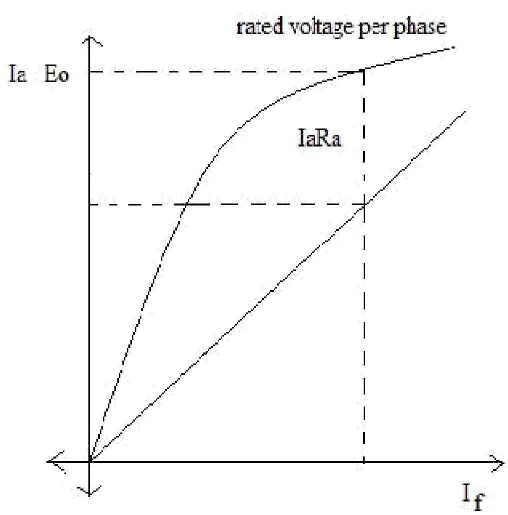
Where

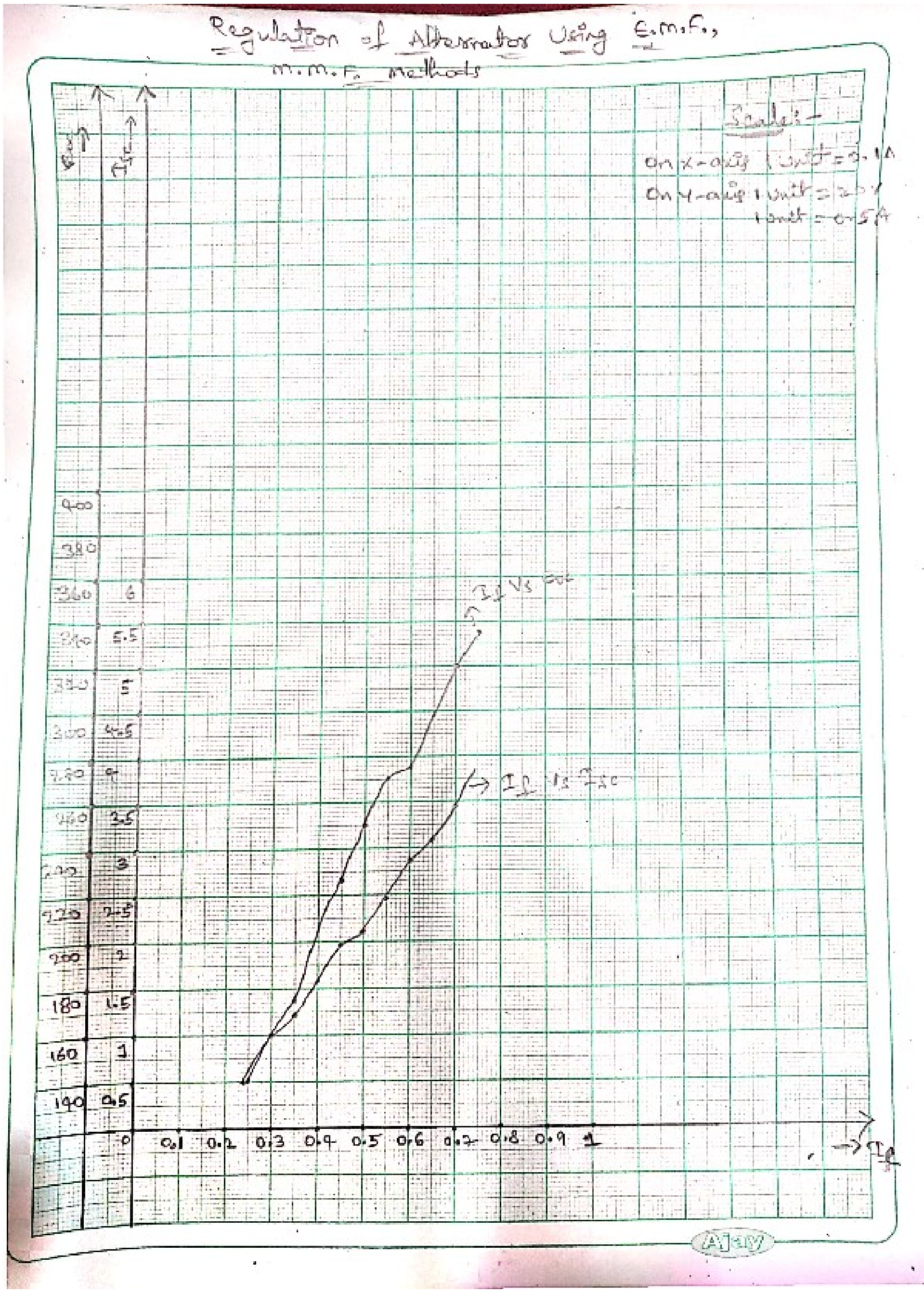
E_0 – generated emf of alternator (or excitation voltage per phase)

V – full load, rated terminal voltage per phase.

MODEL GRAPHS:

Draw the graph between I_f V_S E_0 per phase and I_f V_S I_{SC}





PRECAUTIONS:

1. Connections must be made tight.
2. Before making or breaking the circuit, supply must be switched off.

RESULT:

The O.C. and S.C. tests were conducted on the given 3-Φ Alternator and the regulation of Alternator was predetermined by e.m.f. and m.m.f. method.

7. 'V' AND 'INVERTED V' CURVES OF SYNCHRONOUS MOTOR

AIM:

To plot the 'v' and 'inverted v' curves of Synchronous motor.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-600)V	1 no
2	Ammeter	MC MI	(0-2.5)A (0-10)A	1 no 1 no
3	Rheostat	Wire-wound	400 Ω /1.7A	1 no
4	Tachometer	Digital	(0-10000)RPM	1 no
5	Wattmeter	Electrodynamometer	10A, 600V UPF 10A , 600V LPF	1 no 1 no
6	Connecting Wires	*****	(0-20)A	Required

NAME PLATE DETAILS:

3- ϕ Synchronous motor	
Power Rating:	5HP
PF	
Line voltage:	415V
Speed	1500 rpm

Frequency	50Hz
Rated Current :	6.5A
Field current (I_f)	1.5A
Field Voltage (V_f)	220V

3- ϕ Auto transformer details:

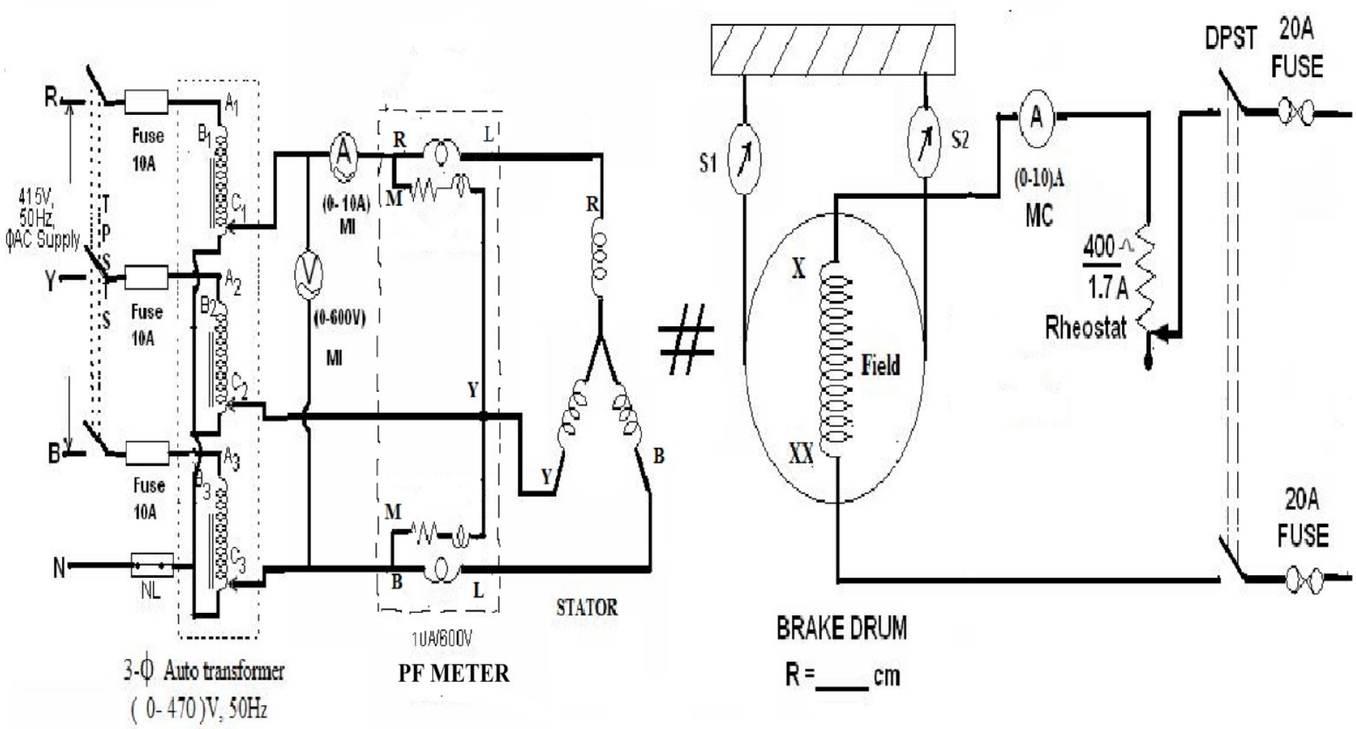
Input voltage: ___415________________(Volt)

Output Voltage : ____(0-470)______________(Volt)

Frequency. :________50________________(Hz)

Current: _________________________(Amp)

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Opening the SPST switch connected across the field DC supply is given to the field and field current is adjusted to 0.3A (20% of rated field current)
3. The DC supply to the field is removed and SPST switch is connected across the field by closing the switch
4. As 3- ϕ , 440V, 50Hz AC supply is applied to 3- ϕ dimmer stator keeping it in minimum output position, keeping it prior to that motor is kept in no load state.
5. Gradually supply voltage to synchronous motor is increased and then motor starts running as squirrel cage induction motor. The direction of rotation is observed. if it is not proper then supply phase sequence is altered.
6. Observing I_a, the voltage is gradually increased. It will reach a high value and suddenly falls to a low value.
7. At that instant, open SPST switch connected across the field. The DC supply is then given to the field. Then the motor is pulled into synchronism and motor now works as a synchronous motor.
8. Gradually the supply voltage to stator is increased by observing the armature current. If I_a, increases above the rated value then increase If such that I_a will be within limits and thus full rated supply voltage is gradually given to the motor. Now motor will work as synchronous motor with full rated voltage.
9. By varying If in steps, armature currents are recorded at no-load.
10. By applying half of full load on motor, If and I_a are recorded again. The same experiment is repeated at $3/4^{th}$ load, full load and corresponding readings are recorded.
11. Completely removing the load on motor, the 3- ϕ supply to stator and then the DC supply to the field are switched OFF.

OBSERVATION TABLE:

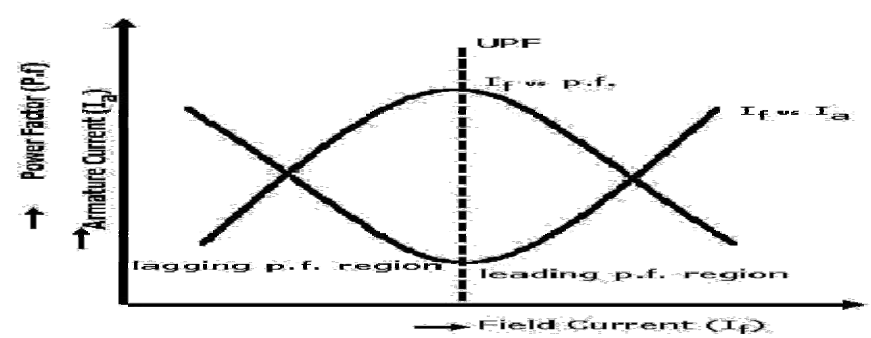
Sl no.	Field current If(Amp)	Armature current I_a(Amp)	Cos ϕ
1	0.05	1	
2	1	0.5	
3	0.15	0.6	
4	02	0.4	
5	0.25	0.2	
6	0.35	0	
7	0.45	0	0.5lag
8	0.5	0.2	0.8lag
9	0.55	0.4	0.98lag
10	0.6	0.5	0.8lead
11	0.65	0.6	0.75
12	0.7	0.7	0.7lead
13	0.8	0.8	0.6lead
14	0.85	1	0.55lead
15	0.9	1.5	0.5lead

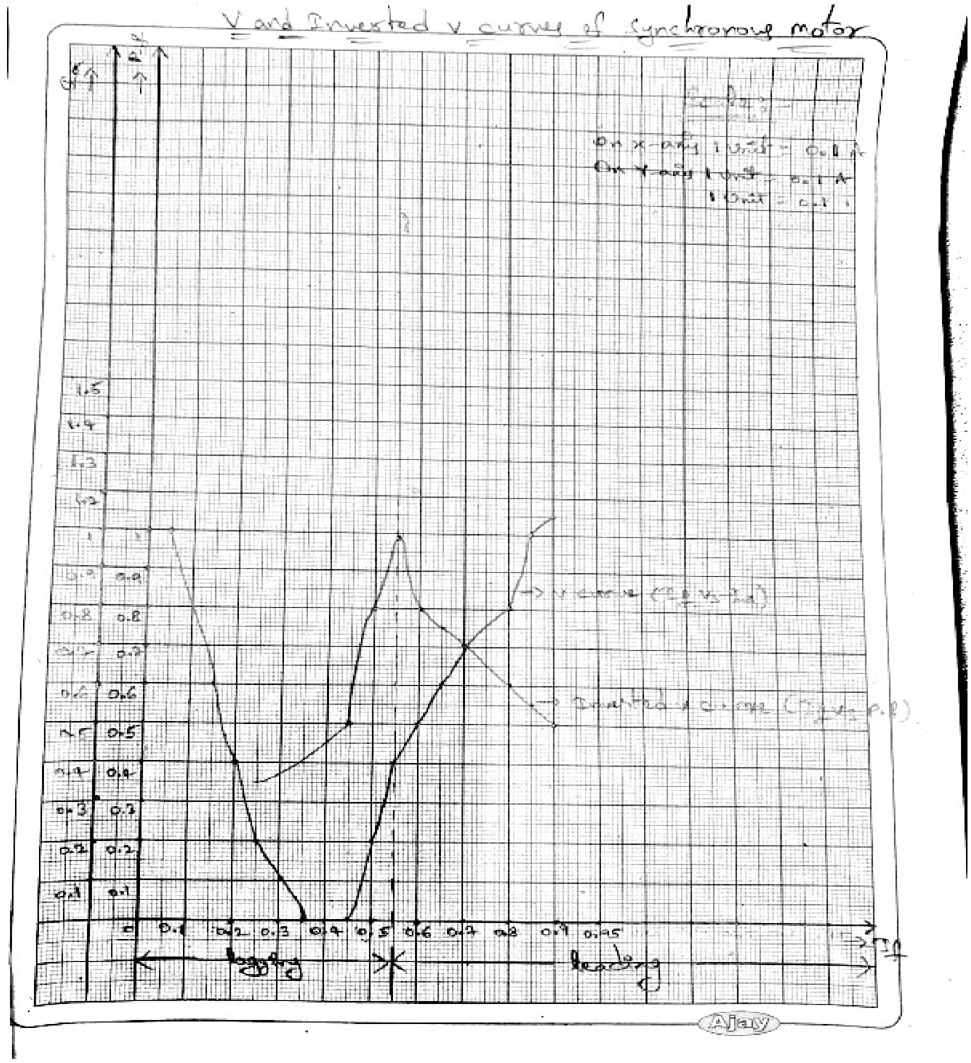
CALCULATIONS:

Power factor = $\cos [Tan^{-1}[\sqrt{3}(W_1-W_2)/(W_1-W_2)]]$

$\Phi = Tan^{-1}[\sqrt{3}(W_1-W_2)/(W_1-W_2)]$

MODEL GRAPHS:





RESULT:

V and inverted V curves of synchronous motor are drawn.

VIVA Questions:

1. What are the difficulties in starting a synchronous motor?
2. What are the commonly employed methods of starting a synchronous motor?
3. What are the applications of synchronous motor?
4. What is synchronous condenser?
5. What do you understand by hunting?

8. DETERMINATION OF X_d AND X_q OF SALIENT POLE SYNCHRONOUS MOTOR

AIM:

To determine the direct axis reactance X_d and quadrature axis reactance X_q by conducting a slip test on a salient pole synchronous machine.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V	1 no
2	Ammeter	MI	(0-5)A	1 no
3	Rheostat	Wire-wound	400 Ω /1.7A	1 no
4	Tachometer	Digital	*****	1 no
5	Connecting Wires	*****	*****	Required

NAME PLATE DETAILS:

DC Motor (prime mover)		**3- ϕ Alternator**	
Power rating	5HP	Power Rating	3 kVA
Voltage	220V	Voltage	415
Curren t	19A	Current	3.8
Speed	1500rpm	Speed	1500rpm
Excitation	Shunt	Excitation	Shunt
Field current	1.2A	Field current	1.5

3- ϕ Auto transformer Details:

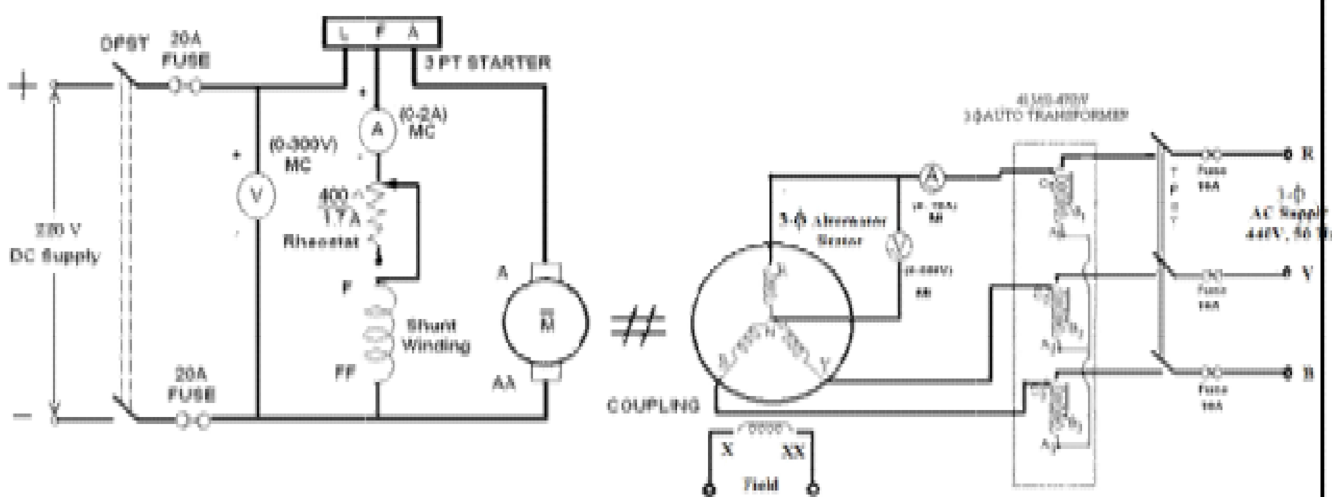
Input Voltage: ________415__________(Volt)

Output Voltage: ______(0-470)_________(Volt)

Current:____________6__________(Amp.)

Frequency: _________50___________(Hz)

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Initially set field regulator, 3-ϕ variac at minimum position and TPST switch open.
3. The DC motor is started slowly by sliding starter handle and it is run at a speed slightly less than the synchronous speed of the alternator.
4. Close the TPST switch.
5. With field winding left open, a positive sequence balanced voltages of reduced Magnitude (around 25% of rated Value) and of rated frequency are impressed across the armature terminals.
6. The prime mover (DC motor) speed is adjusted till ammeter and voltmeters pointers swing slowly between maximum and minimum positions.
7. Under this condition , readings of maximum and minimum values of both ammeter and voltmeter are recorded

CALCULATIONS:

X_d= ____________________________________

Xq = ____________________________________

Note:

1. When performing this test, the slip should be made as small as possible.
2. During Slip test, it is observed that swing of the ammeter pointer is very wide, whereas the voltmeter has only small swing.

TABULAR COLUMN:

Sl no.	Speed	Vmax (V_L)	Vmin (V_L)	Imax (I_L)	Imin (I_L)	X_d	X_q
1	1500	87.7	85.4	3.4	2.7	32.48	25.14

RESULT:
Xd and Xq of a salient pole synchronous motor are determined by conducting slip test.

9. SCOTT CONNECTION OF TRANSFORMERS

AIM:

To perform the Scott connection of transformer from three phases to two phase connection.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V (0-600)V	2 no 2 no
2	Ammeter	MI	(0-5)A	1 no
3	Connecting Wires	*****	*****	Required

Transformer Specifications:

MAIN Transformer

Transformer Rating :(in KVA) __3kVA__________

Winding Details:

LV (in Volts): ___150V______________________

LV side current:_______20A________________

HV (in Volts): ________230V________________

HV side Current:______13A_________________

Type(Shell/Core):______________________

Tapping's: ___________0% , 50% , 100%_________________

TEASER Transformer

Transformer Rating :(in KVA) ______3kVA_____

Winding Details:

LV (in Volts): _____________150V__________

LV side current:____________20A__________

HV (in Volts): 230V

HV side Current: 13A

Type(Shell/Core):

Tappings: 0 % , 86.6 %

3 - ϕ Auto transformer Specifications:

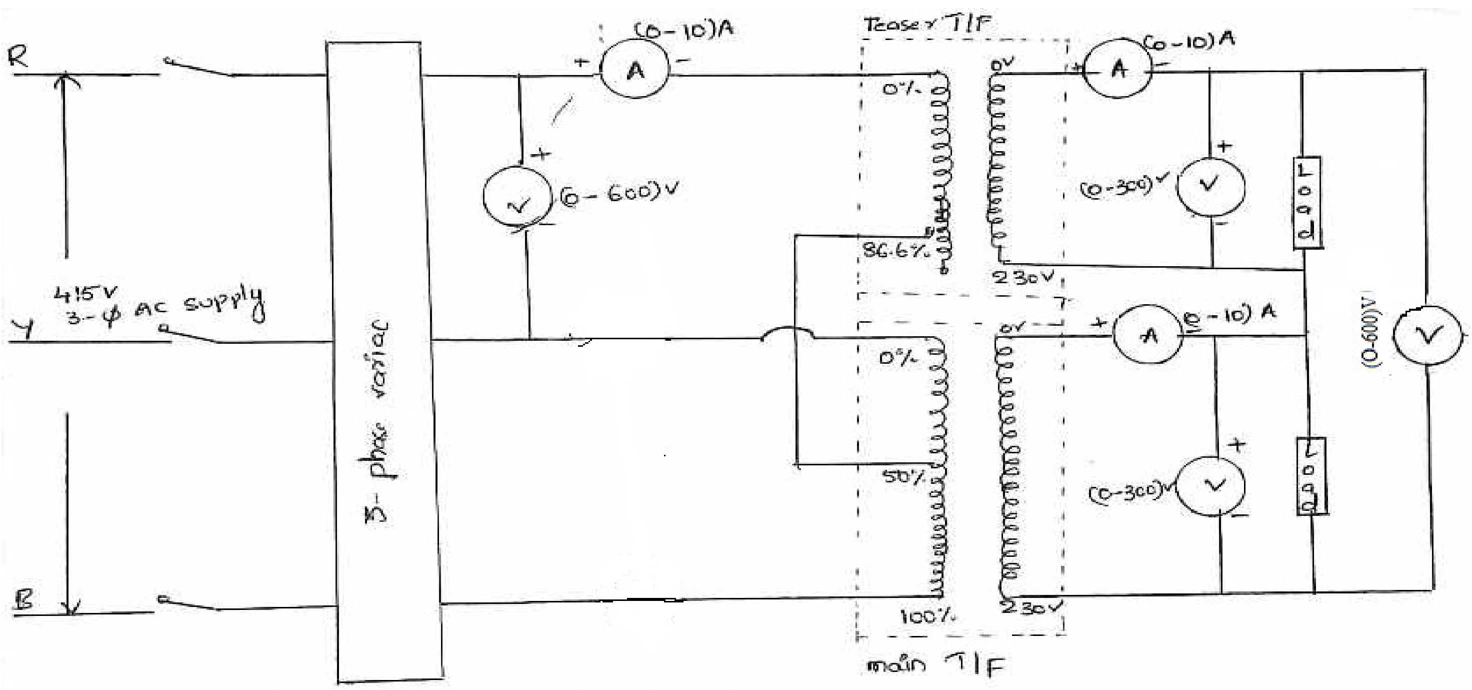
Input Voltage (in Volts): 415V

Output Voltage (in Volts): (0-470)V

Frequency (in Hz): 50Hz

Current rating (in Amp): 8A per line

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Ensure that output voltage of the variac is set in zero position before starting the experiment.
3. Switch ON the supply.
4. The output voltage of the variac is gradually increased in steps upto rated voltage of single phase MAIN transformer and readings are correspondingly taken in steps.

5. Enter the readings in tabular column.
6. After observations, the variac is brought to zero position and switch OFF the supply.

CALCULATIONS:

Prove

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

TABULAR COLUMN:

S. NO	Set1(L1, L2,L3,L4)	Set2(L1,L2,L3,L4)	Input voltage(V_1) (V)	Input current I_1 (A)	Output current(A)		Output voltage (V)		Theoretical calculations $V_{2TM}=\sqrt{(V_{2T})^2+(V_{2M})^2}$
					Teaser (I_{T1}) (A)	Main (I_{M1}) (A)	Teaser (V_{2T}) (V)	Main (V_{2M})	
1	0	0	415	0	0	0	230	230	320
2	L1	0	415	0.3	0.8	0	230	230	320
3	L1	L1	415	0.35	0.8	0.8	230	230	320
4	L1,L2	L1	415	1	1.5	0.8	230	230	320
5	L1,L2	L1,L2	415	1	1.5	1.5	230	230	320
6	L1,L2,L3	L1,L2	415	1.4	2.4	1.5	230	230	320
7	L1,L2,L3	L1,L2,L3	415	1.4	2.4	2.4	230	230	320
8	L1,L2,L3,L4	L1,L2,L3	415	1.8	3	2.4	230	230	320
9	L1,L2,L3,L4	L1,L2,L3,L4	415	1.8	3	3	230	230	320

Result:

Scott connection is performed on transformers and 3- Φ supply to 2- Φ conversion is observed.