DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

ELECTRICAL MACHINES-II LABARATORY

LIST OF EXPERIMENTS

OPEN CIRCUIT & SHORT CIRCUIT TEST ON A SINGLE PHASE TRANSFORMER

AIM:

To perform open circuit and short circuit test on a single phase transformer and to Pre-determine the efficiency, regulation and equivalent circuit of the transformer.

APPARATUS REQUIRED:

Sl. No.	equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V (0-150)V	1 no 1 no
2	Ammeter	MI	(0-2)A (0-20)A	1 no 1 no
3	Wattmeter	Dynamo type	(0-150)V LPF (0-2.5)A	1 no
4	Wattmeter	Dynamo type	(0-150)V UPF (0-10)A	1 no
5	Connecting Wires	*****	*****	Required

Transformer Specifications:

Transformer Rating :(in KVA) _____

Winding Details:

LV (in Volts): _____

LV side current:_____

HV (in Volts): _____

HV side Current:_____

Type (Shell/Core):_____

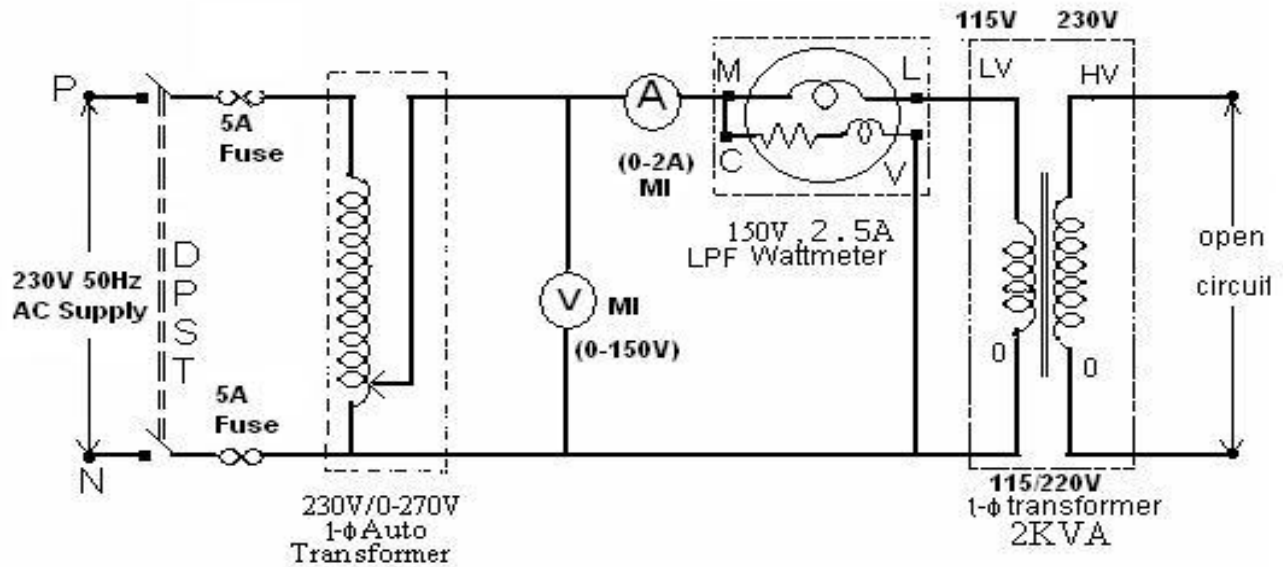**Auto transformer Specifications:**

Input Voltage (in Volts):_____

Output Voltage (in Volts): _____

frequency (in Hz):_____
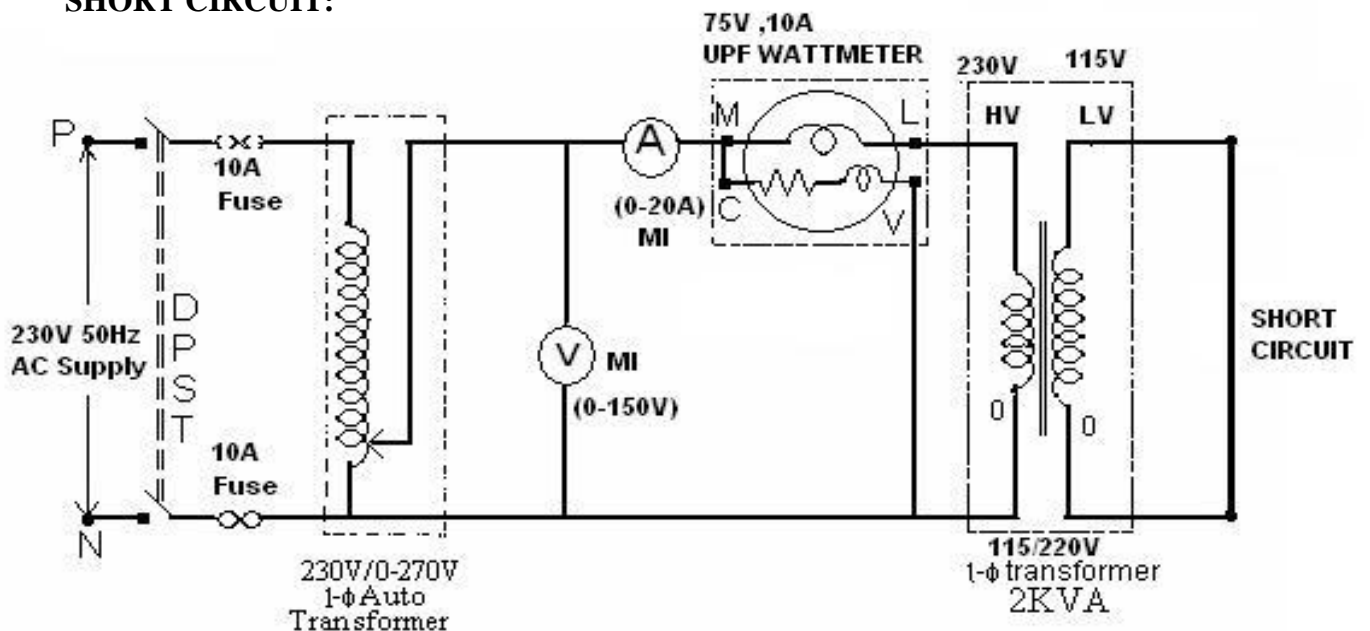
Current rating (in Amp):_____

CIRCUIT DIAGRAM:

OPEN CIRCUIT:

SHORT CIRCUIT:

PROCEDURE:

Open circuit test:

1. Connections are made as per the circuit diagram.

2. Ensure that variac is set to zero output voltage position before starting the experiment.

3. Switch ON the supply. Now apply the rated voltage to the Primary winding by using Variac.

4. The readings of the Voltmeter, ammeter and wattmeter are noted down in Tabular form.

5. Then Variac is set to zero output position and switch OFF the supply.

6. Calculate R_0 and X_0 from the readings.

Short Circuit Test:

1. Connections are made as per the circuit diagram.

2. Ensure that variac is set to zero output voltage position before starting the experiment.

3. Switch ON the supply. Now apply the rated Current to the Primary winding by using Variac.

4. The readings of the Voltmeter, ammeter and wattmeter are noted down in Tabular form.

5. Then Variac is set to zero output position and switch OFF the supply.

6. Calculate R_{01} and X_{01} from the readings.

OBSERVATIONS:

I) For OC test

Sl no.	Voltmeter reading (V_O)	Ammeter reading (I_O)	Wattmeter reading W_o	R_O	X_O	Cos ϕ_O

II) For SC test

Sl no.	Voltmeter reading (V_{SC})	Ammeter reading (I_{SC})	Wattmeter reading W_{SC}	R_{o1}	Z_{o1}	X_{o1}

MODEL CALCULATIONS:

Find the equivalent circuit parameters R_0, X_0, R_{01}, R_{02}, X_{01} and X_{02} from the O. C. and S. C. test results and draw the equivalent circuit referred to L. V. side as well as H. V. side.

Let the transformer be the step-down transformer

Primary is H. V. side.

Secondary is L. V. side

$$R_0 = \frac{V_1}{I_w} \text{ where } I_w = I_0 \cos \phi_0$$

$$X_0 = \frac{V_1}{I_m} \text{ Where } I_m = I_0 \sin \phi_0$$

$$R_{01} = \frac{W_{SC}}{I_{sc}^2}, \quad Z_{01} = \frac{V_{SC}}{I_{SC}}$$

$$X_{01} = \sqrt{Z_{01}^2 - R_{01}^2} \; : X_{02} = K^2 X_{01} \text{ Where } K = \frac{V_2}{V_1} = \text{ Transformation ratio.}$$

Calculations to find efficiency and

regulation For example at ½ full load

Cupper losses = W_{sc} x $(1/2)^2$ watts, where W_{SC} = full – load cupper

losses Constant losses = W_0 watts

Output = ½ KVA x cos ϕ [cos ϕ may be assumed]

Input = output + Cu. Loss + constant loss

$$\% \; efficiency = \frac{Output}{Input} \; x \; 100$$

Efficiency at different loads and P.f's

cos ϕ = _____

Regulation: From open circuit and Short circuit test

$$\% \operatorname{Re} gulation = \frac{I_2\ R_{02}\ \cos\phi \pm I_2\ X_{02}\ \sin\phi}{V_2}\ x\ 100$$

'+' for lagging power factors

'-' for leading power factor

S.No	p.f.	% reg	
		Lag	Lead

Cosϕ = 1.0

S.No	Load	Wcu (W)	O/P (W)	I/P (W)	η (%)

Cosϕ = 0.8

S.No	Load	Wcu (W)	O/P (W)	I/P (W)	η (%)

GRAPHS: Plots drawn between

    (i)   % efficiency Vs output
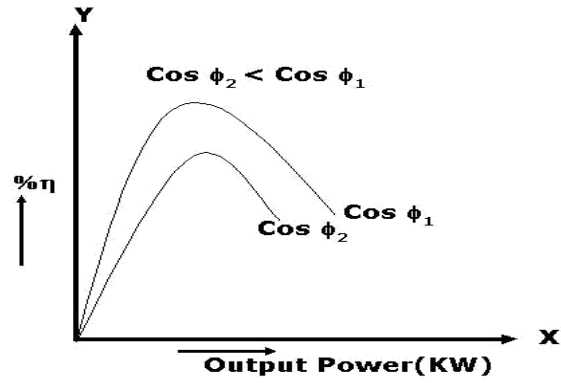
    (ii)   % Regulation Vs Power factor
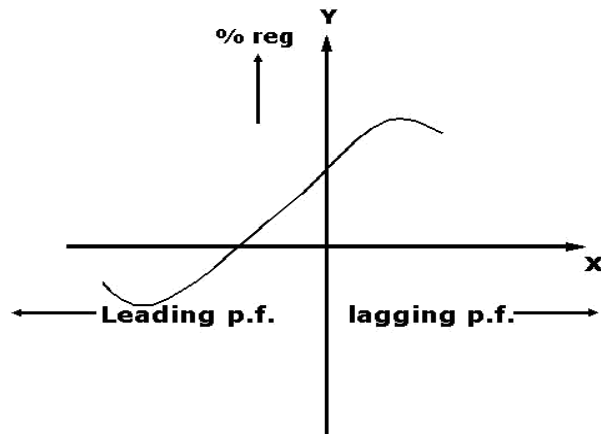
PRECAUTIONS:

    (i)   Connections must be made tight

    (ii)   Before making or breaking the circuit, supply must be switched off

RESULT:

SUMPNER'S TEST

AIM:

To determine the efficiency and losses of a given transformer accurately under full load condition.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V (0-300)V (0-600)V	1 no 1 no 1 no
2	Ammeter	MI	(0-2)A (0-20)A	1 no 1 no
3	Wattmeter	Dynamo type	(0-150)V LPF (0-2.5)A	1 no
4	Wattmeter	Dynamo type	(0-150)V UPF (0-10)A	1 no
5	Connecting Wires	*****	*****	Required

Transformer Specifications:

Two identical 1- ϕ Transformers

Transformer Rating :(in KVA) _____

Winding Details:

LV (in Volts): _____

LV side current:_____

HV (in Volts): _____

HV side Current:_____

Type(Shell/Core):_____

1 - ϕ Auto transformer Specifications:
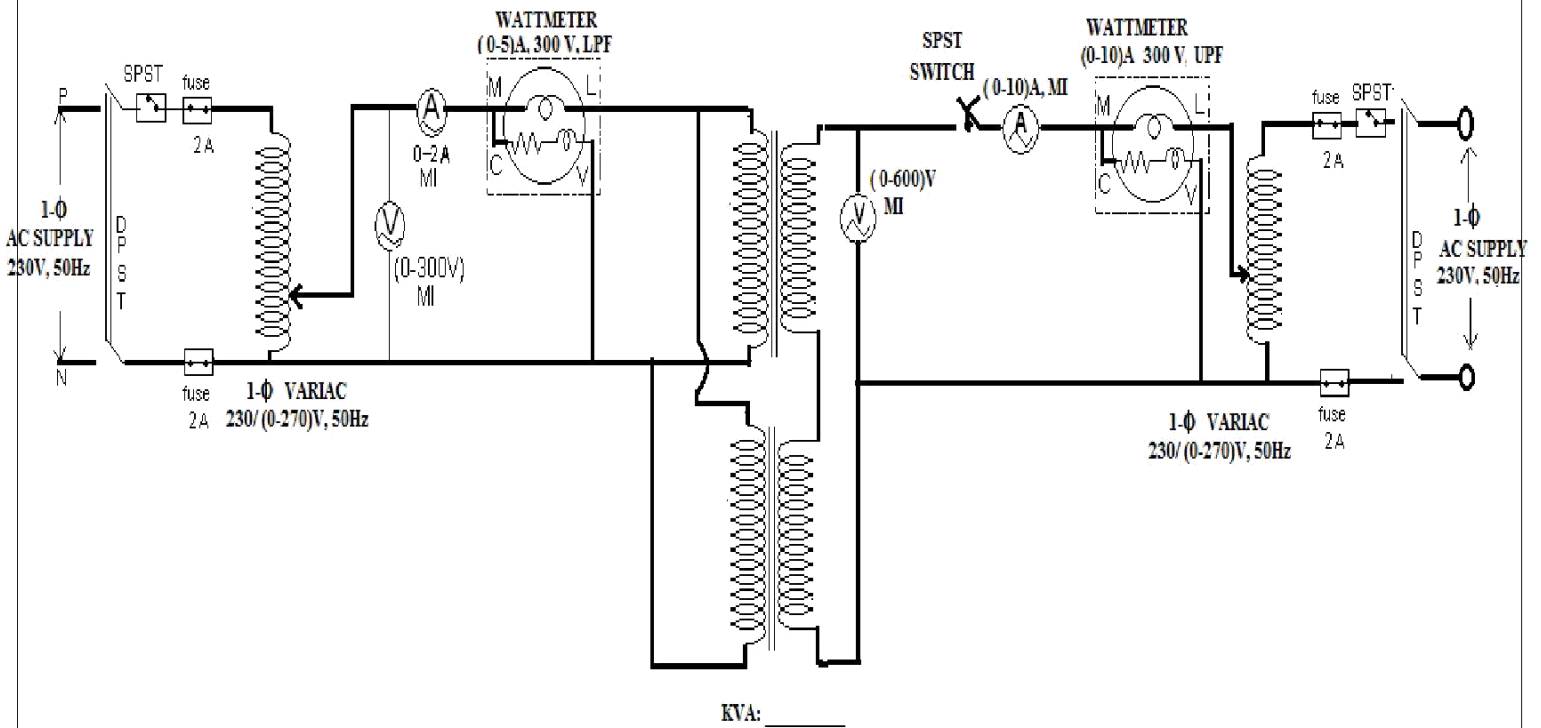
Input Voltage (in Volts):_____

Output Voltage (in Volts): _____

Frequency (in Hz):_____

Current rating (in Amp):_____

CIRCUIT DIAGRAM:

KVA: _____

PROCEDURE:

1. Make the connections as per the circuit diagram.

2. The secondary winding terminals of the two transformers are connected in series with polarities in phase opposition which can checked by means of a voltmeter.

3. Before starting the experiment, check the variacs are in minimum output voltage position.

4. Close the first DPST-1 switch and switch ON the supply.

5. Increase the variac slowly, and apply rated voltage to the primary windings of 1-ϕ transformers and check the voltmeter reading connected across the secondary terminals.

6. If the voltmeter reading is Zero, continue with step 8.

7. If the voltmeter reading is not zero, interchange the secondary terminals.

8. Now close the DPST-2 switch and vary the variac-2 slowly till rated current flows in the two series-connected secondaries.

9. Note down the readings of V_1, V_2, I_1, I_2, W_1, and W_2 and enter them in a tabular column.

10. $W_1 = 2P_c$, $W_2 = 2P_{sc}$. Losses of each transformer = $(W_1+W_2)/2$

11. Now the Variacs are brought to zero voltage position and open DPST switches.

OBSERVATIONS:

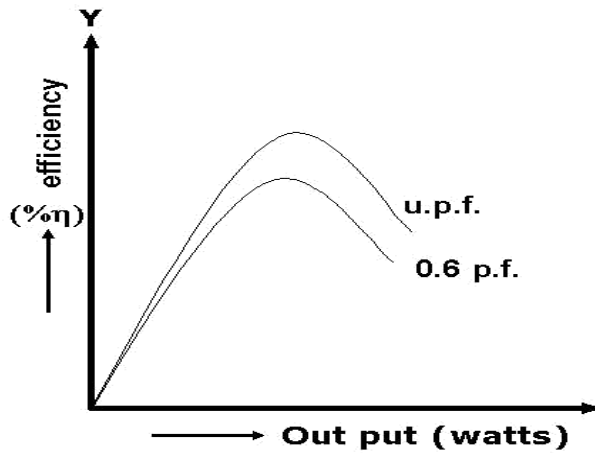| Sl no.	Voltmeter reading V_1	Voltmeter reading V_2	Ammeter reading I_1	Ammeter reading I_1	Wattmeter Reading W_1	Wattmeter Reading W_2	Transformer losses = $(W_1+W_2)/2$	η = op/(op+loss)

MODEL CALCULATIONS:

Losses in each transformer = $\dfrac{w_i + w_c}{2}$ % η combined = $\dfrac{V I_1}{V I_1 + w_i + w_c}$ x 100

Efficiency of each transformer (% η) = $\dfrac{V I_1}{V I_1 + \dfrac{w_i}{2} + \dfrac{w_c}{2}}$ x 100

MODEL GRAPH:

i)   Output power Vs Efficiency

PRECAUTIONS:

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

RESULT:

VIVA QUESTIONS:

1. What for this test is really intended?
2. Why to conduct the test on identical transformers?
3. What happens if the rated values of voltage and frequency of supply vary?
4. What are the advantages and disadvantages of this test?
5. Can you perform this test on $3 - \phi$ star/ delta transformers?
6. What is all-day efficiency?

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	2 no
			(0-600)V	2 no
2	Ammeter	MI	(0-5)A	1 no
3	Connecting Wires	*****	*****	Required

Transformer Specifications:

MAIN Transformer

      Transformer Rating :(in KVA) _____

      Winding Details:

      LV (in Volts): _____

      LV side current:_____

      HV (in Volts): _____

      HV side Current:_____

      Type (Shell/Core):_____

      Tapings: _____

TEASER Transformer

      Transformer Rating :(in KVA) _____

      Winding Details:

      LV (in Volts): _____

      LV side current:_____

HV (in Volts): _____

HV side Current:_____

Type (Shell/Core):_____

Tapings: _____

3 - φ Auto transformer Specifications:

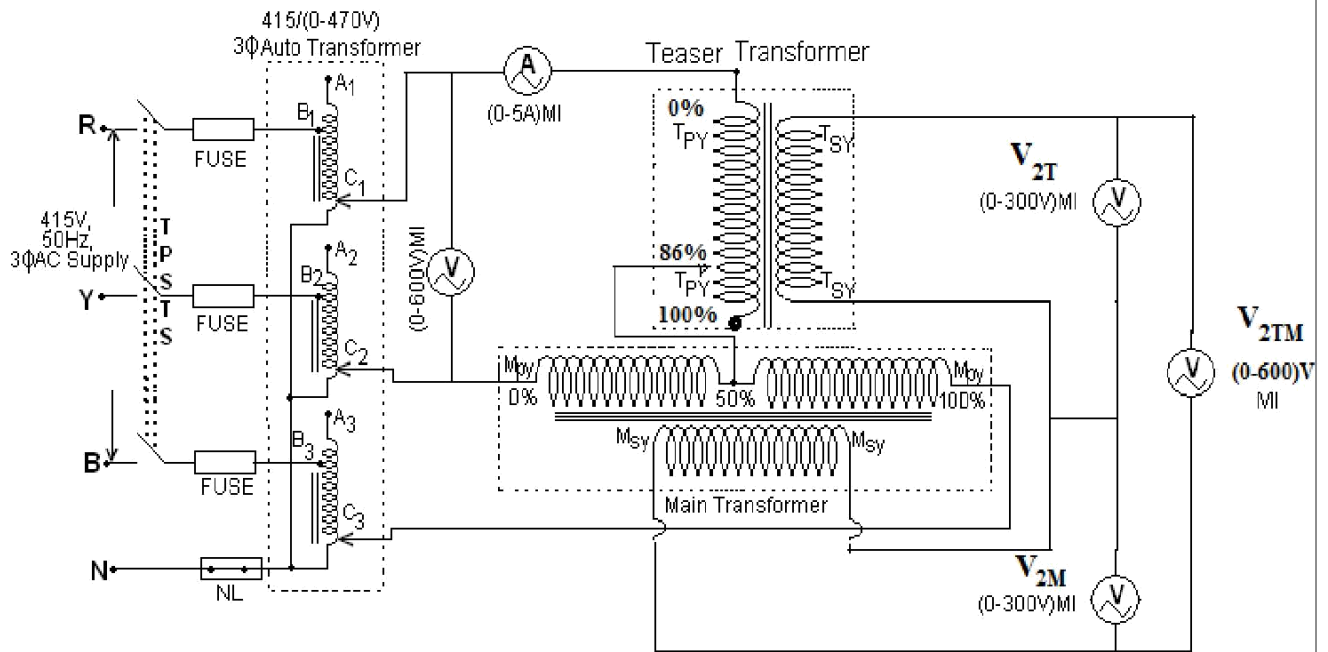Input Voltage (in Volts):_____

Output Voltage (in Volts): _____

Frequency (in Hz):_____

Current rating (in Amp):_____

CIRCUIT DIAGRAM:

PROCEDURE:

1. Connections are made as per the circuit diagram

2. Ensure that output voltage of the variac is set in zero position before starting the experiment.

3. Switch ON the supply.

4. The output voltage of the variac is gradually increased in steps upto rated voltage of single phase MAIN transformer and readings are correspondingly taken in steps.

5. Enter the readings in tabular column.

6. After observations, the variac is brought to zero position and switch OFF the supply.

CALCULATIONS:

Prove

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

TABULAR COLUMN:

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

RESULT:

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	*****	1 no
5	Connecting Wires	*****	*****	Required

NAME PLATE DETAILS:

Power rating	
Voltage	
Current	
Speed(RPM)	

Frequency	
PF	

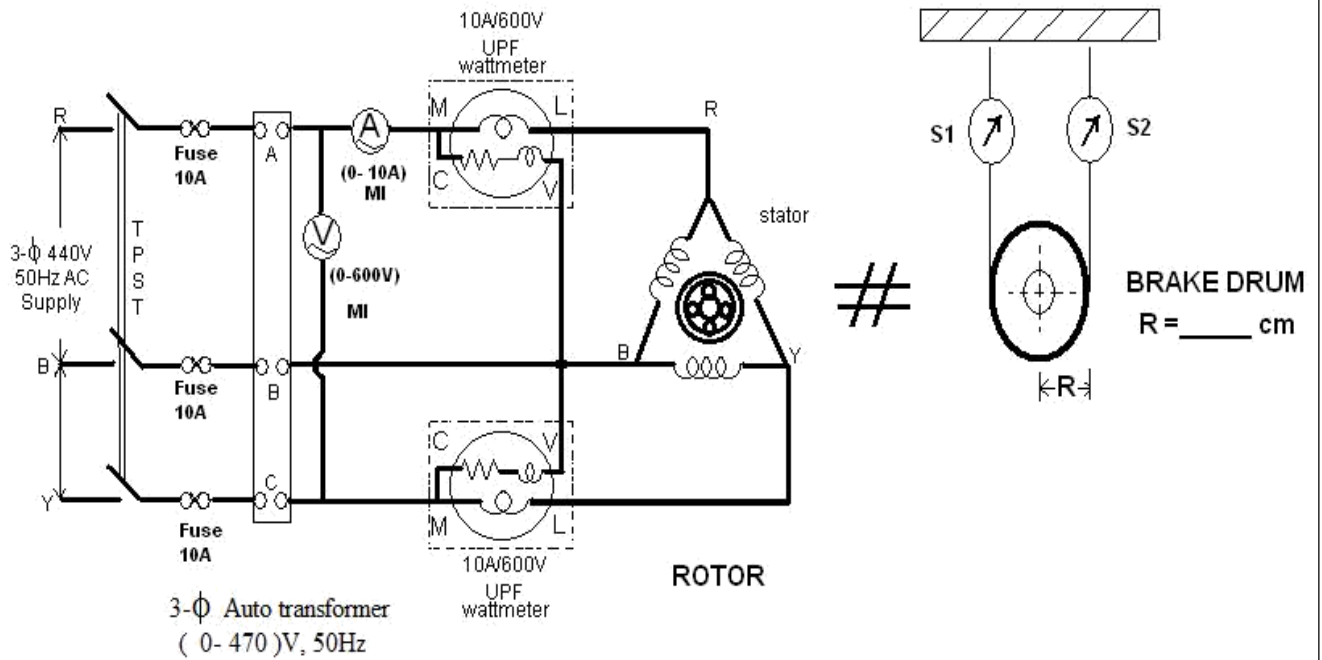## 3- φ Auto transformer Details:

Input Voltage: _____ (Volt)

Output Voltage: _____ (Volt)

Current:_____ (Amp.)

CIRCUIT DIAGRAM:

PROCEDURE:

NO LOAD TEST:

1. Connections are made as per the circuit diagram.

2. Ensure that the 3- ɸ 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- ɸ 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:

Sl no.	Voltmeter reading V_{nl}	Ammeter reading I_{nl}	Wattmeter reading		W_{nl} (P_{nl}) W_1+W_2
			W_1	W_2	

Blocked Rotor Test

Sl no.	Voltmeter reading V_{br}	Ammeter reading I_{br}	Wattmeter reading		W_{br} (P_{br}) W_1+W_2
			W_1	W_2	

Measurement of stator winding resistance (r_1):

CIRCUIT DIAGRAM:
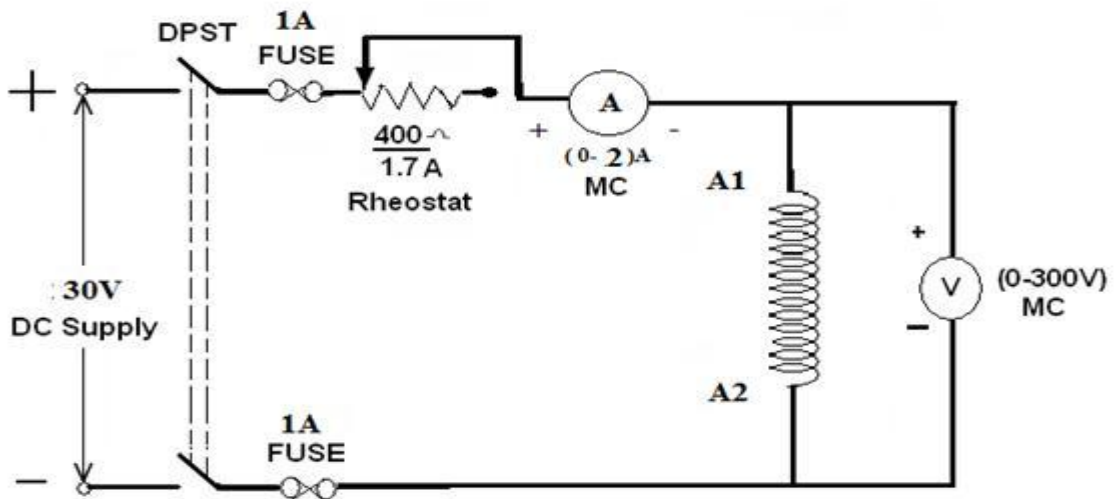
TABULAR COLUMN:

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:

$$G_0 = \frac{W_0}{3V^2} \quad , Y_0 = \frac{I_0}{V} \quad , \quad B_0 = \sqrt{Y_0^2 - G_0^2}$$

$$Z_{01} = \frac{V_{SC}}{I_{SC}} \quad , R_{01} = \frac{W_{SC}}{3 \, x \, I_{SC}^2} \quad , \quad X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$$

For circle diagram

$$\cos\phi_0 = \frac{W_0}{\sqrt{3} \, V_0 \, I_0} \quad , \qquad \phi_0 = \cos^{-1}\left(\frac{W_0}{\sqrt{3} \, V_0 \, I_0}\right)$$

$$\cos\phi_0 = \frac{W_{SC}}{\sqrt{3} \, V_{SC} \, I_{SC}} \quad , \qquad I_{SN} = I_{SC}\left(\frac{V_0}{V_{SC}}\right)$$

PRECAUTIONS:

1.   Connections must be made tight

2.   Before making or breaking the circuit, supply must be switched off

RESULT:

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?

REGULATION OF ALTERNATOR USING SYNCHRONOUS IMPEDANCE METHOD

AIM:

To find the regulation of a 3 - ɸ 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	*****	1 no
5	Connecting Wires	*****	*****	Required

NAME PLATE DETAILS:

DC Motor(prime mover)	3- ɸ Alternator
KW :	Power Rating:
Voltage :	PF :
Current :	Line voltage:
Speed :	Speed
Exctn : Shunt	Exctn Voltage:
Voltage :	Rated Current :

Field current::	

CIRCUIT DIAGRAM:
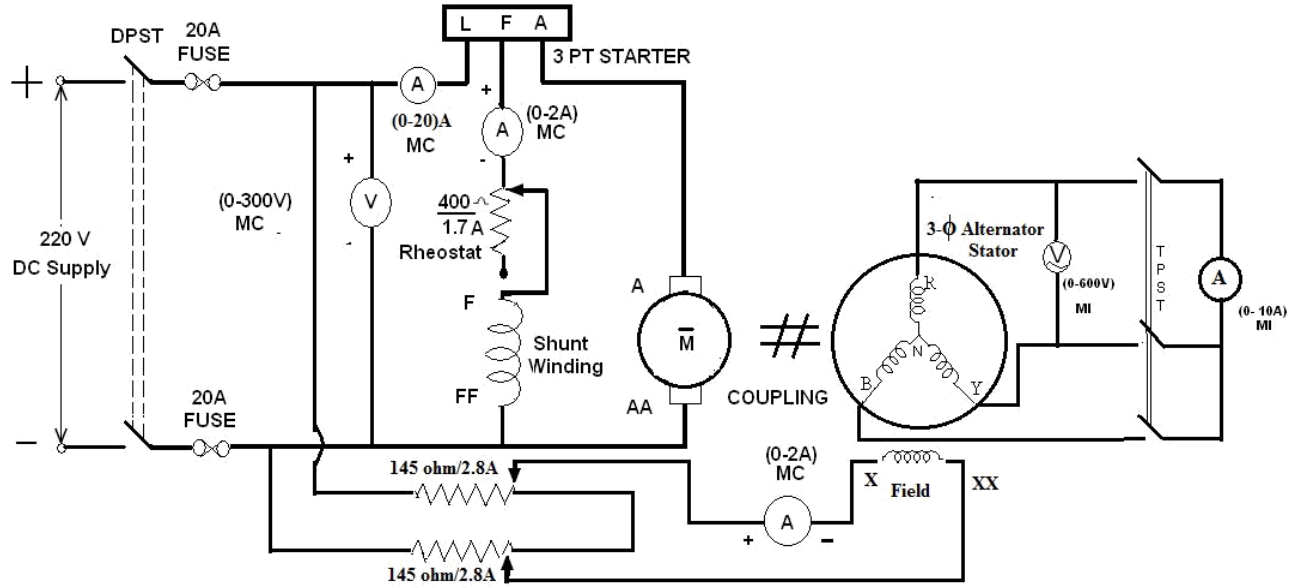
PROCEDURE:

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 (V_o)		Field current I_f(Amp.)	SC current I_{sc} Amp.

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
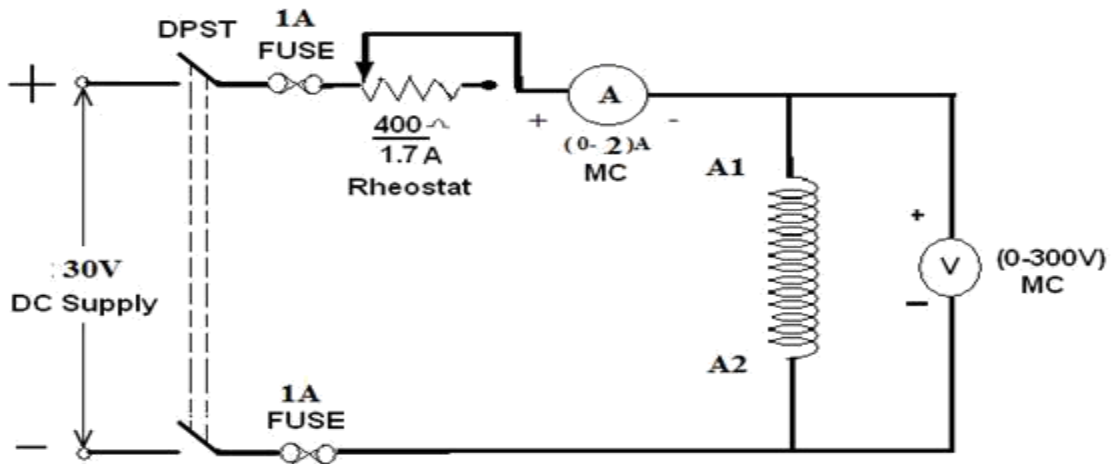
OBSERVATIONS:

Sl 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:

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

Generated emf of alternator on no load is

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

+ for lagging p.f.

- for leading p.f.

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

$$\% \text{ Re}g = \frac{E_0 - V}{V} \ x\ 100$$
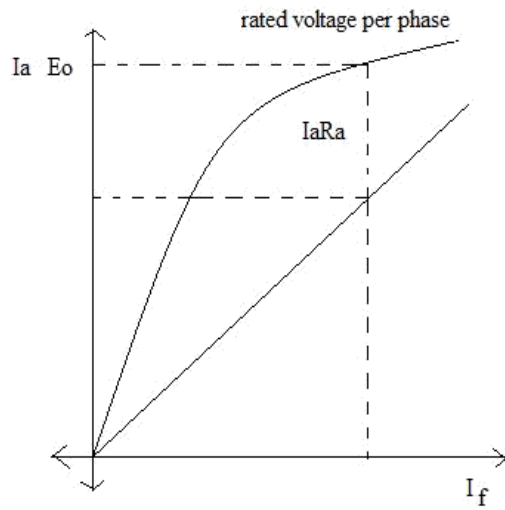
Where

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:

    (iii)   Connections must be made tight

    (iv)   Before making or breaking the circuit, supply must be switched off

RESULT:

'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	(0-2.5)A	1 no
		MI	(0-10)A	1 no
3	Rheostat	Wire-wound	400 Ω /1.7A	1 no
4	Tachometer	Digital	*****	1 no
5	Wattmeter	Electrodynamometer	10A, 600V UPF	1 no
			10A , 600V LPF	1 no
6	Connecting Wires	*****	*****	Required

NAME PLATE DETAILS

3- ϕ Synchronous motor	
Power Rating:	
PF	
Line voltage:	
Speed	

Freq.	
Rated Current :	
Field current (I_f)	
Field Voltage (V_f)	

3- φ Auto transformer details
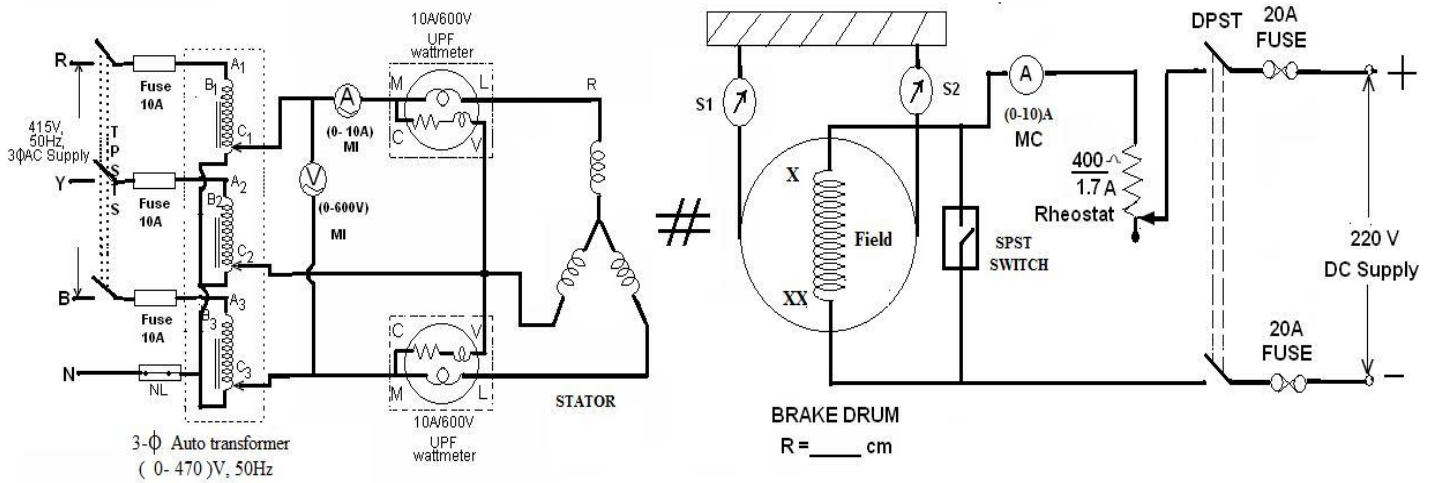
Input voltage: _____(Volt)

Output Voltage : _____(Volt)

Frequency. :_____(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 3/4th 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.	Supply voltage	Wattmeter W1	Wattmeter W2	Field current If(Amp)	Armature current I_a(Amp)	Cos ϕ

Load 1 : 18.1% FL N = 1500 rpm V_L = 415V S_1 = 2.2 kg S_2 = 5.2 lg

I_f (A)	I_a (A)	W_1 (W)	W_2 (W)	$Tan\phi = \dfrac{\sqrt{3}\,(W_1 - W_2)}{(W_1 + W_2)}$	ϕ	$Cos\phi$

Load 2 : 39.2% FL N = 1500 rpm V_L = 415V S_1 = 3.5 kg S_2 = 9 kg

I_f (A)	I_a (A)	W_1 (W)	W_2 (W)	$Tan\phi = \dfrac{\sqrt{3}\,(W_1 - W_2)}{(W_1 + W_2)}$	ϕ	$Cos\phi$

CALCULATIONS:

Power factor = Cos [tan^{-1}($\dfrac{\overline{\qquad}}{\qquad}$)]

$$\phi = Tan^{-1} \left[\frac{\sqrt{3}\,(W_1 - W_2)}{(W_1 + W_2)} \right]$$

MODEL GRAPHS:
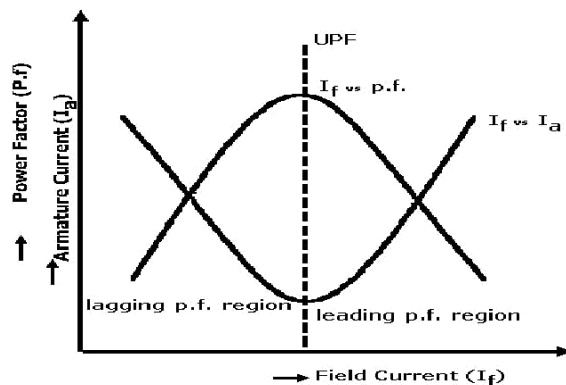
RESULT:

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?

RESULT:

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	*****	*****	Required

1 - ф Induction motor specifications:

Name plate details

Sl. no.	Quantity	
1	rated power	
2	Rated voltage	

3	Current	
4	Speed(RPM)	
5	Cos φ (pf)	
6	Frequency	
7	rotor	Squirrel cage

CIRCUIT DIAGRAM:
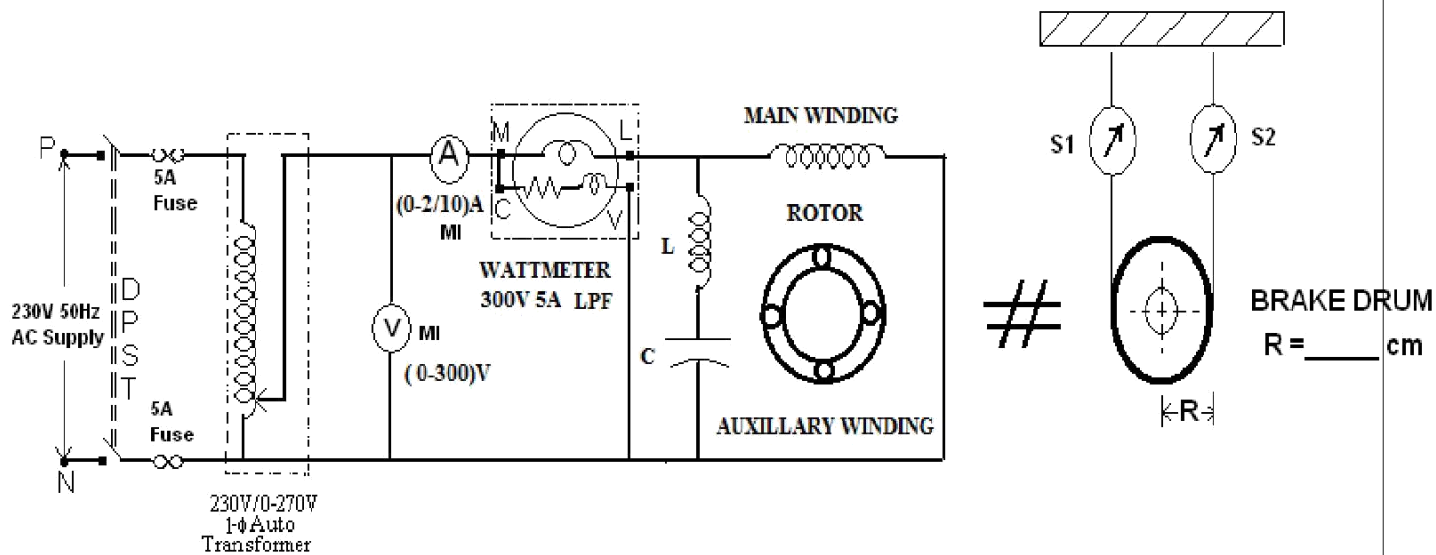
PROCEDURE:

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_0	Ammeter reading I_0	Wattmeter reading W_0

For Blocked Rotor Test:

Sl no.	Voltmeter reading V_{sc}	Ammeter reading I_{sc}	Wattmeter reading W_{sc}

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 taken.

Circuit diagram for measurement of R$_1$:
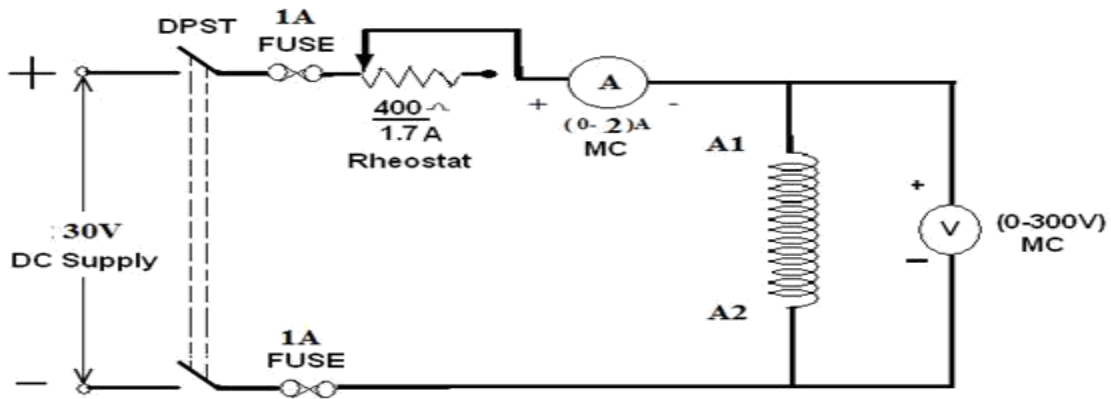
To find stator Resistance:

S.No	I (A)	V (volts)	$R = \dfrac{V}{I}$ (Ω)

Average Value: R$_{dc}$ R$_{ac}$ R$_{dc}$ =

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:

➢ Connections must be made tight

➢ Before making or breaking the circuit, supply must be switched off

BRAKE TEST ON 3- ф SQUIRREL CAGE INDUCTION MOTOR

AIM:

To determine the efficiency of 3- ф 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	
Voltage	
Current	
Speed (RPM)	

Frequency	
PF	

3- ϕ Auto transformer Details:
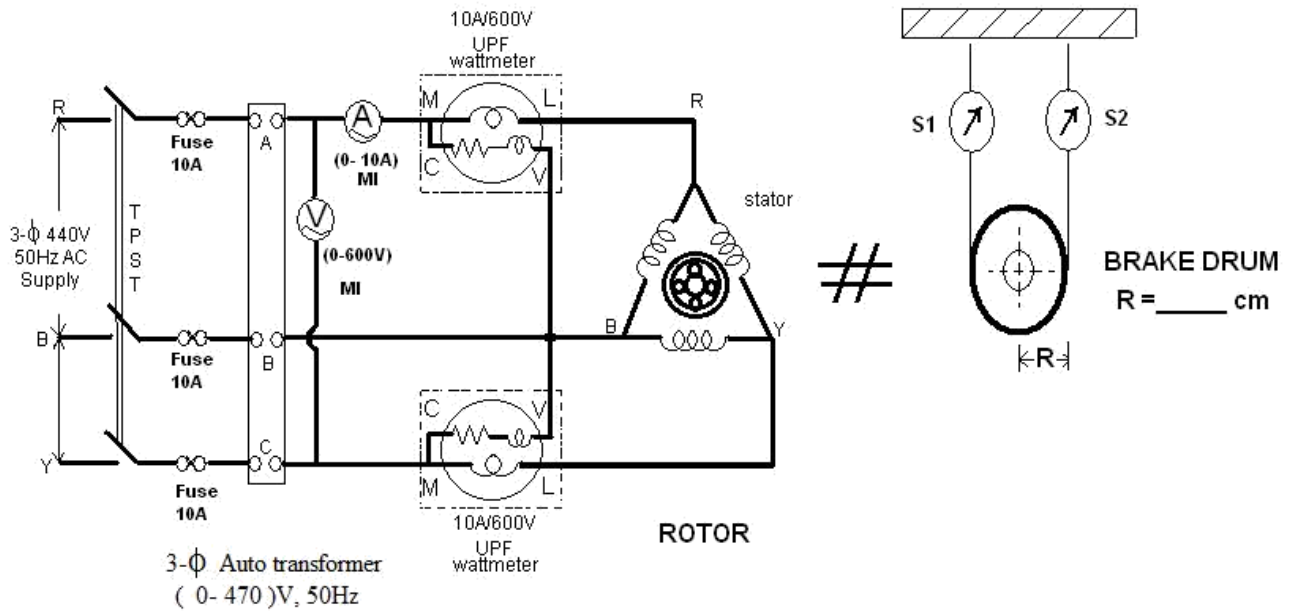
Input Voltage: _____ (Volt)

Output Voltage: _____ _(Volt)

Current :_____(Amp.)

Freq.:_____(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 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.

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 $\qquad$ R $\rightarrow$ Radius of drum in mts.

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

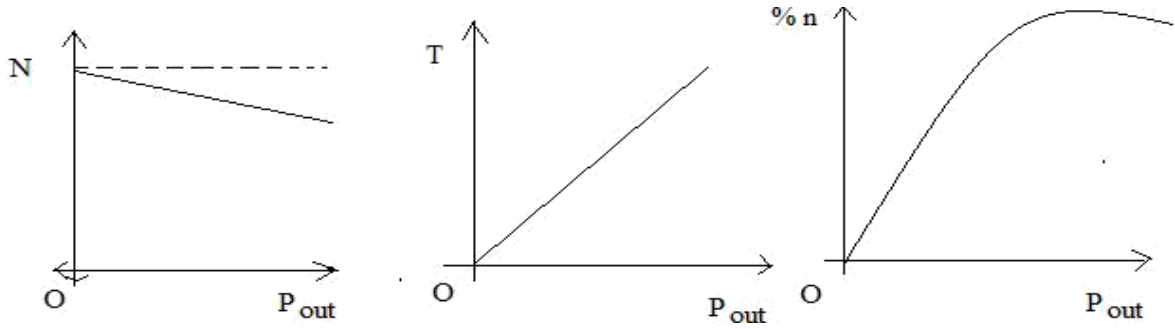$\% \text{ efficiency } = \dfrac{output\ power\ in\ watts}{Input\ power\ in\ watts} \times 100$

$\% \text{ slip} = \dfrac{N_s - N}{N_s} \times 100 \qquad \left[where\ N_s = \dfrac{120 \times f}{p} \right]$

power factor of the induction motor $\cos \phi = \dfrac{W}{\sqrt{3}\ V_L\ I_L}$

41

MODEL GRAPHS:

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

OBSERVATIONS:

S. No.	V (Volts)	I (Amps)	Power, W (Watts)		Speed (RPM)	Torque (N-m)	Spring balance (Kg)		% Slip	Cos Ø	Output Power (W)	%η
			W_1	W_2			S_1	S_2				

PRECAUTIONS:

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

RESULT:

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?

SEPARATION OF NO LOAD LOSSES IN 1-Φ TRANSFORMER

AIM:

To separation the Eddy current loss and Hysteresis loss from the iron loss of 1-Φ Transformer.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V	1 no
2	Ammeter	MC	(0-2.5)A	1 no
3	Rheostat	Wire-wound	370 Ω /1.7A 150Ω /2A	1 no 2 no
4	Tachometer	Digital	*****	1 no
5	Wattmeter	Electro dynamo meter type	10A/600V LPF	1 no
6	Connecting Wires	*****	*****	Required

NAME PLATE DETAILS:

DC Motor(prime mover)	3- φ Alternator
KW :	Power Rating:
Voltage :	PF :
Current :	Line voltage:
Speed :	Speed
Exctn : Shunt	Exctn Voltage:

Voltage :	Rated Current :
Field current::	

Transformer Specifications:

Transformer Rating :(in KVA) _____

Winding Details:

LV (in Volts): _____
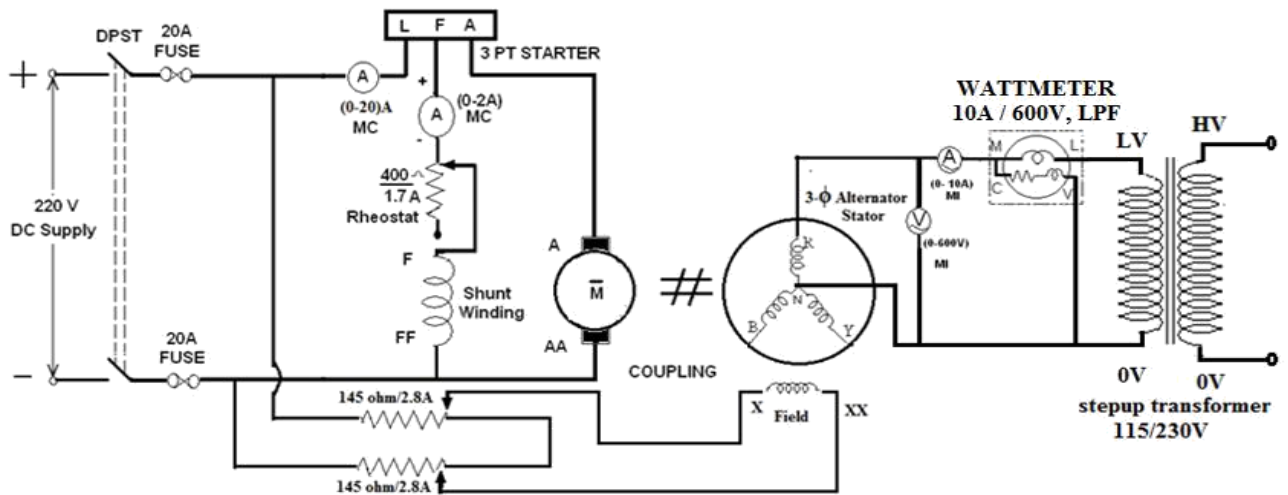
LV side current:_____

HV (in Volts): _____

HV side Current:_____

Type (Shell/Core):_____

CIRCUIT DIAGRAM:

PROCEDURE:

1. Make the circuit connections as per the circuit diagram.

2. The prime mover is started with the help of 3-point starter and it is made to run at rated speed.

3. By varying alternators field rheostat gradually, the rated primary voltage is applied to transformer.

4. By adjusting the speed of prime mover the required frequency, is obtained and corresponding reading are noted.

5. The experiment is repeated for different frequency and corresponding readings are tabulated.

6. The prime mover is switched off using the DPIC switch after bringing all the rheostats to initial position

7. From the tabulated readings the iron loss is separated from eddy current loss and hysteresis loss by using respective formulae.

OBSERVATIONS:

Separation of No load losses in single phase Transformer:

Multiplication factor=

S.No	Speed of the prime mover N(rpm)	Supply frequency (f)Hz	Primary voltage (V)volts	Wattmeter readings(w)		Iron or core loss (Wi)watts	Wi/f
				Observed (watts)	Actual (watts)		

CALCULATIONS:

1. Frequency$(f)=PN_s/120$

   Where P-number of poles; N_s-Synchronous speed in rpm

2. Hysteresis loss$(W_h)=Af$

3. Eddy current loss$(W_e)=Bf^2$

4. Iron loss or core loss$(W_i)= W_e +W_h$

MODEL GRAPH:

The graph drawn as frequency Vs(W_i/f)

$$B = \frac{\Delta W_i/f}{\Delta f}$$
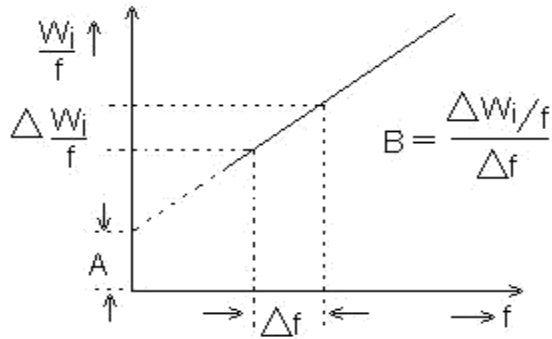
PRECAUTIONS:

1. The motor field rheostat should be kept at minimum resistance position.

2. The alternator field rheostat should be kept maximum resistance position.

3. The motor should be run in anticlockwise direction.

4. Avoid loose connections.

5. Take the readings with any parallax error.

VIVA Questions:

1. What are core losses in a transformer? Why they occur? On what factors do they depend? What are the usual methods that are being employed in reducing them?

2. How does change in frequency affect the operation of a given transformer?

3. A transformer is designed for 50C/S operation. It is worked at double and half the designed frequency what changes do you except in the performance? Discuss?

4. Whether you can excite a transformer from a DC supply of rated voltage Justify your answer

PRECAUTIONS:

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

RESULT:

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:

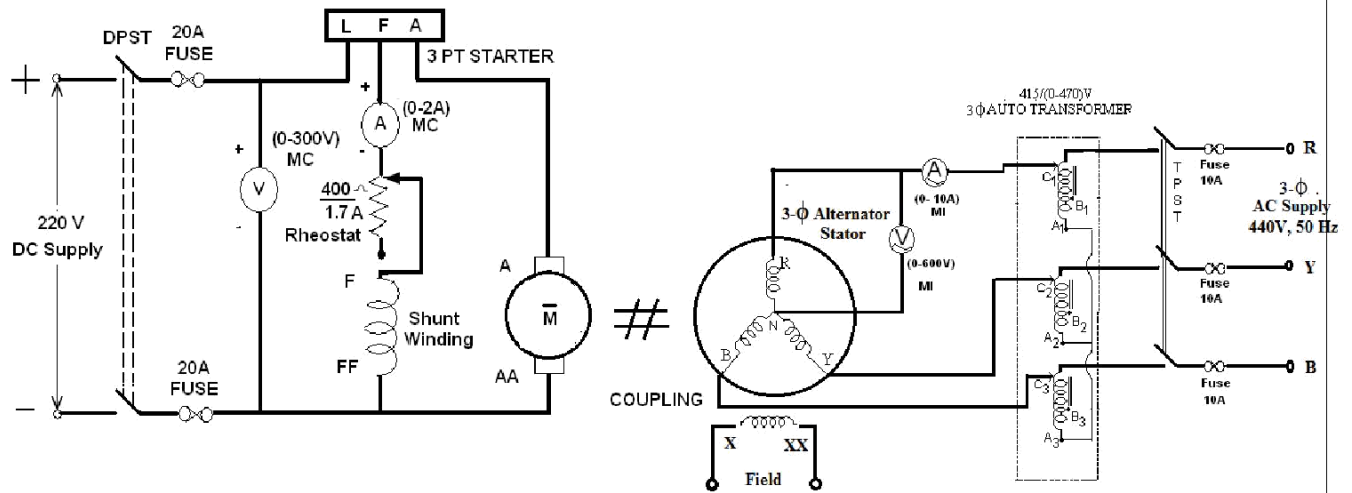| DC Motor (prime mover)	3- ϕ Alternator
KW :	Power Rating:
Voltage :	PF :
Current :	Line voltage:
Speed :	Speed
Exctn : Shunt	Exctn Voltage:
Voltage :	Rated Current :
Field current::	

3- ф Auto transformer Details:

Input Voltage: _____(Volt)

Output Voltage: _____(Volt)

Current:_____(Amp.)

Frequency: _____(Hz)

CIRCUIT DIAGRAM:

PROCEDURE:

1. Connections are made as per the circuit diagram.

2. Initially set field regulator, 3-ф 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$_q$

RESULT: