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) = 2KVA
Winding Details:

LV (in Volts): 115V

LV side current: 17.8A

HV (in Volts): 230V

HV side Current: 4.5A

Type (Shell/Core): SHELL

Auto transformer Specifications:

Input Voltage (in Volts): 270V

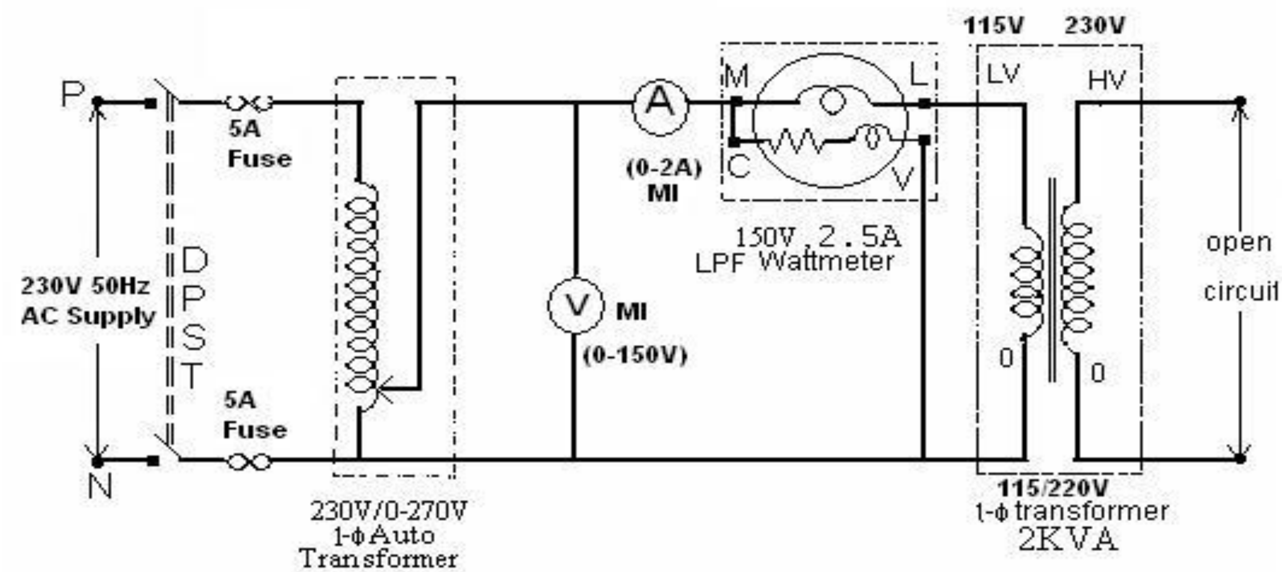
Output Voltage (in Volts): 230V

Frequency (in Hz): 50HZ

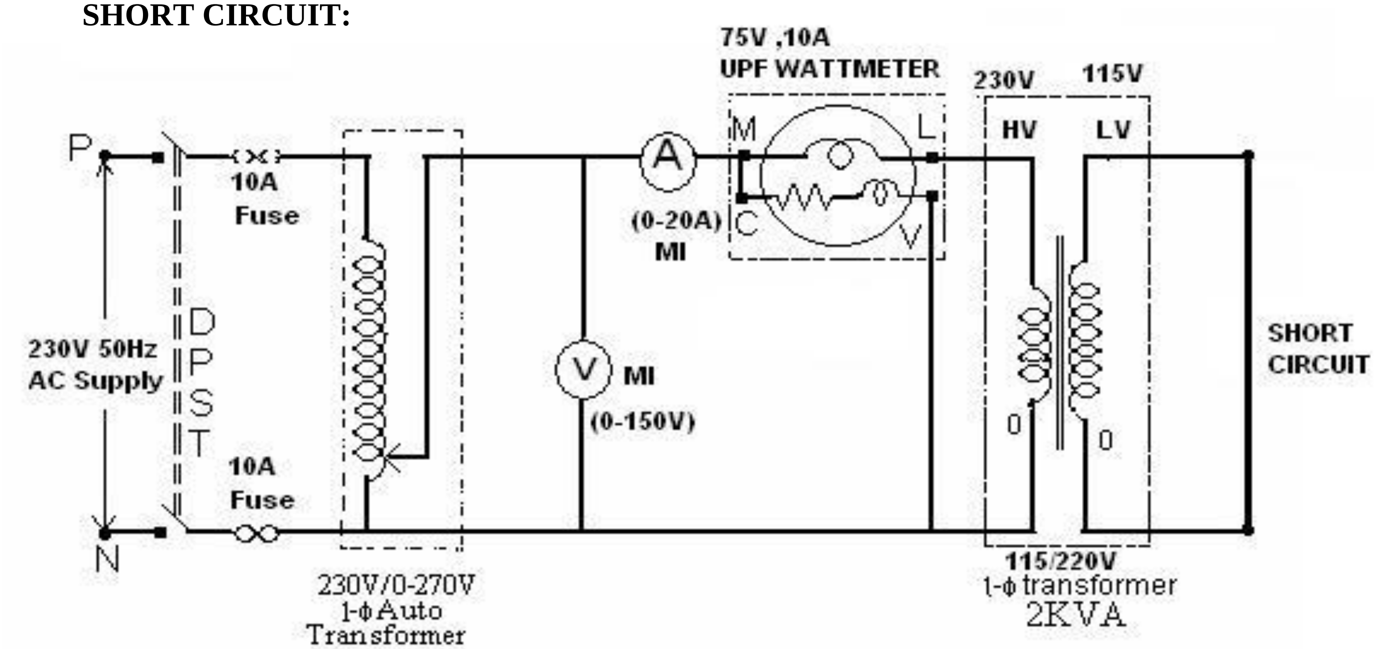
Current rating (in Amp): 10A

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 $\mathbf{R_0}$ and $\mathbf{X_0}$ 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 $\mathbf{R_{01}}$ and $\mathbf{X_{01}}$ from the readings.

OBSERVATIONS:

OPEN CIRCUIT TEST:

S.NO	Voc (Volts)	Ioc (Amps)	Woc(watts)
1			

SHORT CIRCUIT TEST:

S.NO	Vsc (Volts)	Isc (Amps)	Wsc(watts)
1			

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

$X_0 = \frac{V_1}{I_m}$ Where $I_m = I_0 \sin \phi_0$ $R_{01} = \frac{W_{SC}}{I_{SC}^2}$, $Z_{01} = \frac{V_{SC}}{I_{SC}}$

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

Calculations to find efficiency and

regulation For example at ½ full

load

Cupper losses = $W_{sc} \times (1/2)^2$ 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

$$\% \, efficiency = \frac{Output}{Input} \times 100$$

Efficiency at different loads and P.f's

cos ϕ = 0.8

Regulation: From open circuit and Short circuit test

$$\% \, Regulation = \frac{I_2 \, R_{02} \, \cos\phi \pm I_2 \, X_{02} \, \sin\phi}{V_2} \, x \, 100$$

'+' for lagging power factors

- For leading power factor

VOLTAGE REGULATION CHARACTERISTICS:

S.No	Cos Φ	Sin Φ	Lagging P.F full load Regulation	Leading P.F full load Regulation
1				
2				
3				
4				
5				
6				

EFFICIENCY CHARACTERISTICS:

Load ,X	Let Cos Φ=0.8	Let Cos Φ=1
	Efficiency, η	Efficiency, η
x=1/4		
x=1/2		
x=3/4		
x=1		

THEORY:

Transformer is a device which transforms the energy from one circuit to other circuit without change of frequency. The performance of any transformer can be determined by conducting tests. The OC and SC tests are conducted on transformer to find the efficiency and regulation of the transformer at any desired load current.

MODEL CALUCALATIONS:

$$\boldsymbol{Z_{SC}} = \frac{\boldsymbol{V_{SC}}}{\boldsymbol{I_{SC}}} =$$

$$\boldsymbol{R_{01}} = \frac{\boldsymbol{W_{SC}}}{\boldsymbol{I_{SC}^2}} =$$

$$\boldsymbol{X_{01}} = \sqrt{\boldsymbol{Z_{sc}^2} - \boldsymbol{R_{01}^2}} =$$

Efficiency at Full load, $\boldsymbol{\eta} = \frac{\boldsymbol{x \times KVA \times Cos\,\emptyset}}{\boldsymbol{x \times KVA \times Cos\,\emptyset + W_{OC} + x^2 W_{SC}}}$

KVA = ,W_{oc} = , W_{sc} = , x=1, UPF

= =

<u>Percentage Regulation for lagging Power Factor:</u>

$\boldsymbol{Cos\,\emptyset = 1}$

% R = $\frac{\boldsymbol{I_{SC}[R_{01} Cos\,\emptyset + X_{01} Sin\,\emptyset]}}{\boldsymbol{V_2}} \times 100$

=

=

<u>Percentage Regulation for leading Power Factor:</u>

$\boldsymbol{Cos\,\emptyset = 0.8}$

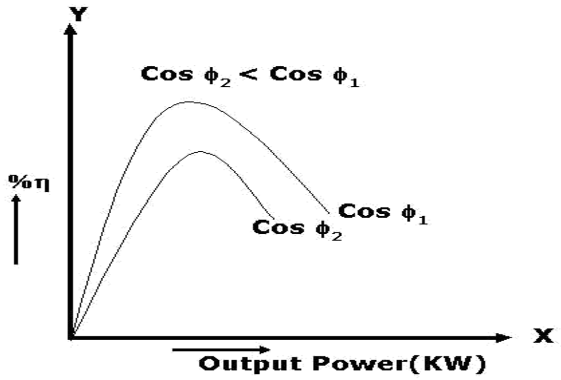
% R = $\frac{\boldsymbol{I_{SC}[R_{01} Cos\,\emptyset - X_{01} Sin\,\emptyset]}}{\boldsymbol{V_2}} \times 100$

=

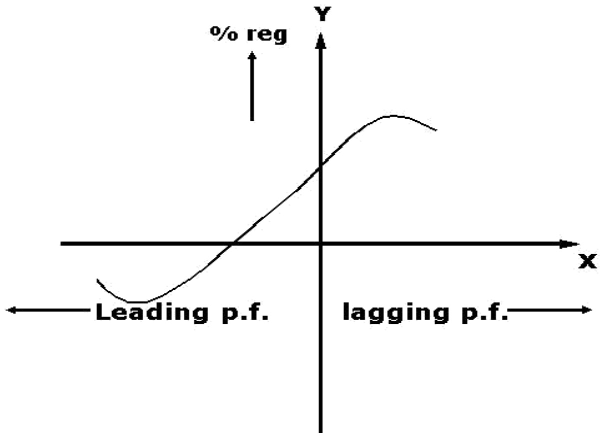
=

GRAPHS: Plots drawn between

(i) % efficiency Vs output



(ii) % Regulation Vs Power factor



PRECAUTIONS:

1. Avoid the loose connections.
2. Avoid connecting of meters directly to the machines.
3. Switch OFF the supply before making the connections.
4. Do not touch the bare conductors.
5. Avoid parallax error while making observations.

RESULT: Hence OC & SC test on a single phase transformer is performed to determine the regulation and efficiency.

OUTCOME: The equivalent circuit parameters are obtained. The efficiency and voltage regulation of a transformer at any load can be predetermined.

Viva questions:

1. What is a transformer?
2. Why transformer rated in KVA?
3. What are the losses present in a transformer?
4. What are the applications of transformer?
5. What is voltage regulation of a transformer?

SUMPNERS 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) -2KVA

Winding Details:

LV (in Volts): 115V

LV side current: 17.4A

HV (in Volts): 230V

HV side Current: 8.7A

1 - ϕ Auto transformer Specifications:

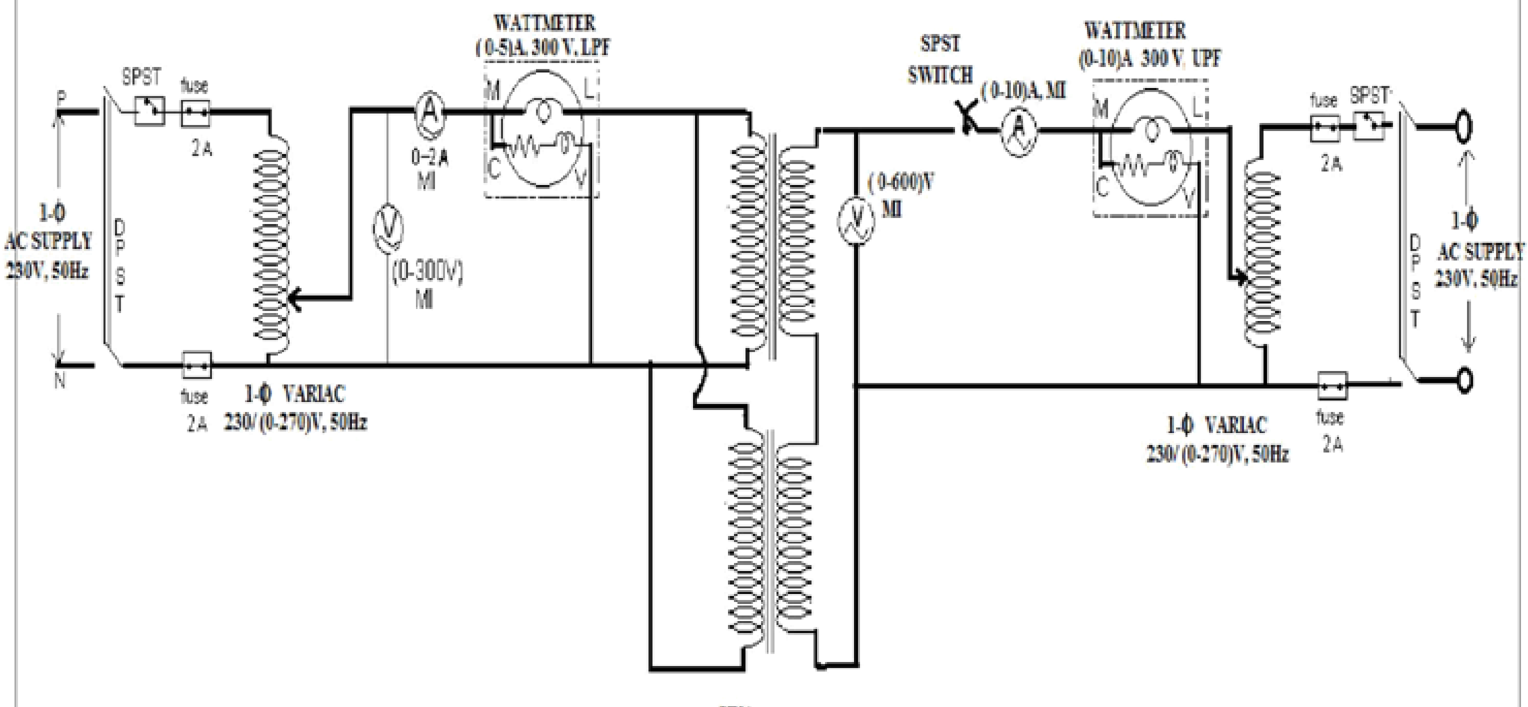
Input Voltage (in Volts): 270V

Output Voltage (in Volts): 230V

Frequency (in Hz): 50HZ

Current rating (in Amp): 10A

CIRCUIT DIAGRAM:



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)**
1								

MODEL CALCULATIONS:

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

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

$\boldsymbol{Z_{SC} = \frac{V_{SC}}{I_{SC}} =}$

$\boldsymbol{R_{01} = \frac{W_{SC}}{I_{SC}^2} =}$

$\boldsymbol{X_{01} = \sqrt{Z_{sc}^2 - R_{01}^2} =}$

Efficiency at Full load, $\boldsymbol{\eta = \frac{x \times KVA \times Cos\,\emptyset}{x \times KVA \times Cos\,\emptyset + W_{OC} + x^2 W_{SC}}}$

KVA = 2,W_{oc} = 36.5, W_{sc} = 112 , x=1, UPF

=

=

<u>Percentage Regulation for lagging Power Factor:</u>

$\boldsymbol{Cos\,\emptyset = 1}$

% R = $\frac{\boldsymbol{I_{SC}[R_{01}Cos\,\emptyset + X_{01}Sin\,\emptyset]}}{\boldsymbol{V_2}} \times 100$

=

=

<u>Percentage Regulation for leading Power Factor:</u>

$\boldsymbol{Cos\,\emptyset = 0.8}$

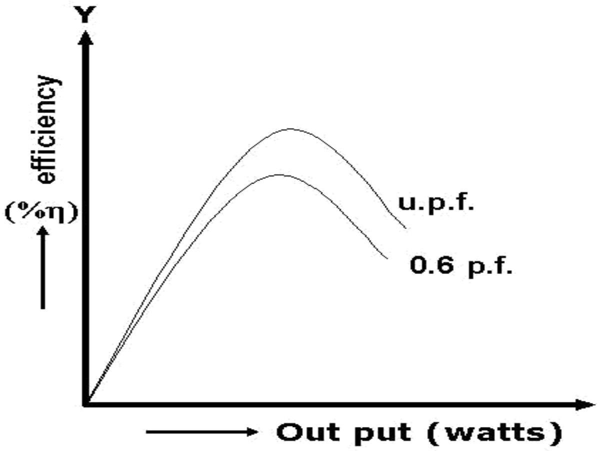
% R = $\frac{\boldsymbol{I_{SC}[R_{01}Cos\,\emptyset - X_{01}Sin\,\emptyset]}}{\boldsymbol{V_2}} \times 100$

=

=

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

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 – ϕ star/ delta transformers?
6. What is all-day efficiency?

RESULT: The voltage regulation and efficiency are determined by conducting sumpners test on single phase transformers

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) -2KVA

Winding Details:

LV (in Volts): _115v

LV side current-17.5A

HV (in Volts): 230V

HV side Current: 4.8A

Type (Shell/Core): SHELL

Tapings: 86.6%

TEASER Transformer

Transformer Rating :(in KVA) - 2

Winding Details:

LV (in Volts): 115V

LV side current: 17.5A

HV (in Volts): 230V

HV side Current: 4.8A

Type (Shell/Core): SHELL

Tapings: 50%

3 - ϕ Auto transformer Specifications:

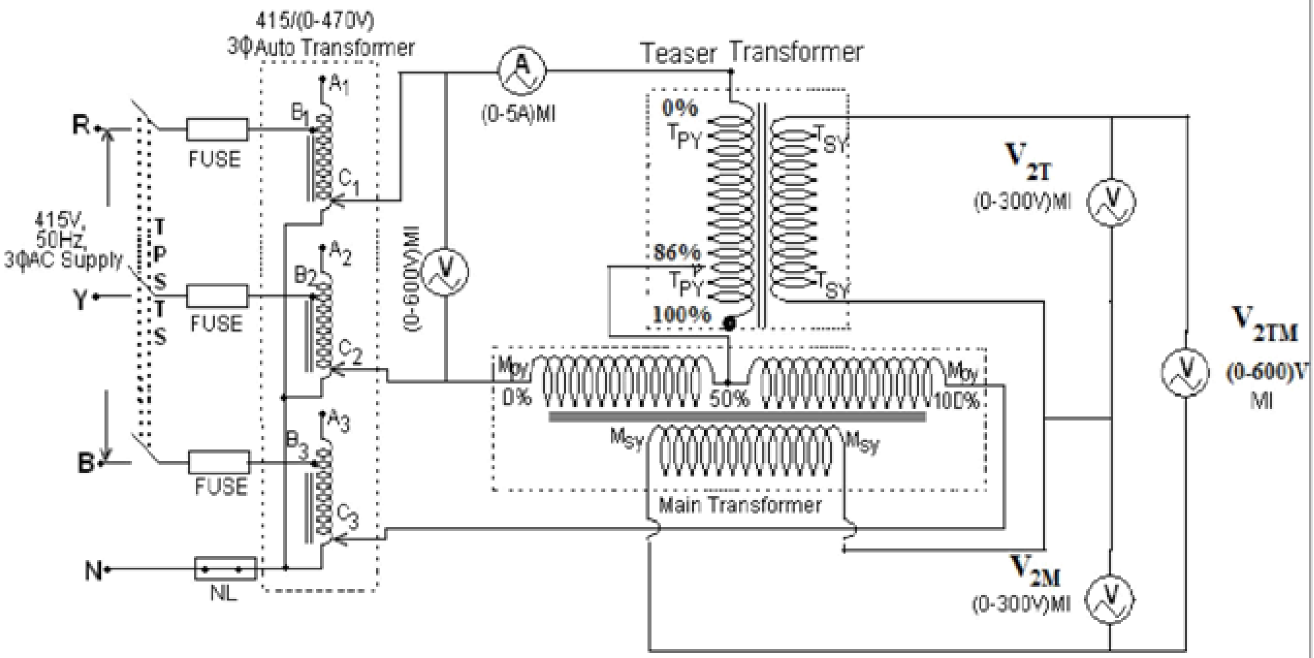
Input Voltage (in Volts): 415V

Output Voltage (in Volts): 115V

Frequency (in Hz): 50HZ

Current rating (in Amp): 10A

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 $V_{2TM} = \sqrt{(V^2_{2T} + V^2_{2M})}$
1						

MODELCALUCULATIONS:

V=_____ V

$\mathbf{V=\sqrt{(V_1^2+V_2^2)}}$

%ERROR= $(V_T$-VP$)/V_{PR}$

=

=

RESULT: THE 3ф TO 2ф CONVERSION WAS ACHIVED BY USING SCOTT CONNECTION

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	**3HP**
Voltage	**415V**
Current	**4.7A**
Speed (RPM)	**1400**

Frequency	50HZ
PF	LAG

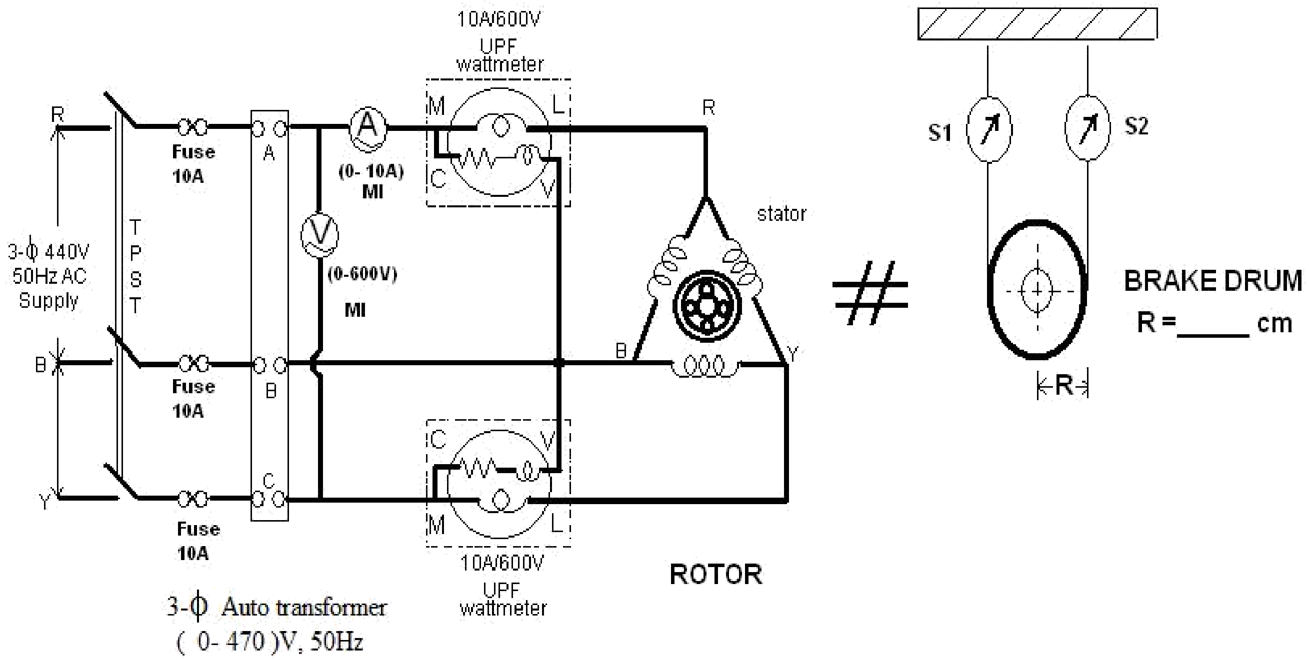
3- ϕ Auto transformer Details:

Input Voltage: 415 (Volt)

Output Voltage: 415 (Volt)

Current: 15 (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 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:

Sl no.	Voltmeter Reading V_{nl}	Ammeter reading I_{nl}	Wattmeter reading		W_{nl} (P_{nl})
			W_1	W_2	W_1+W_2
1					

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
1					

MODEL CALCULATIONS:

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

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

For circle diagram

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

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

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 - ϕ alternator by using synchronous impedance method.

APPARATUS REQUIRED:

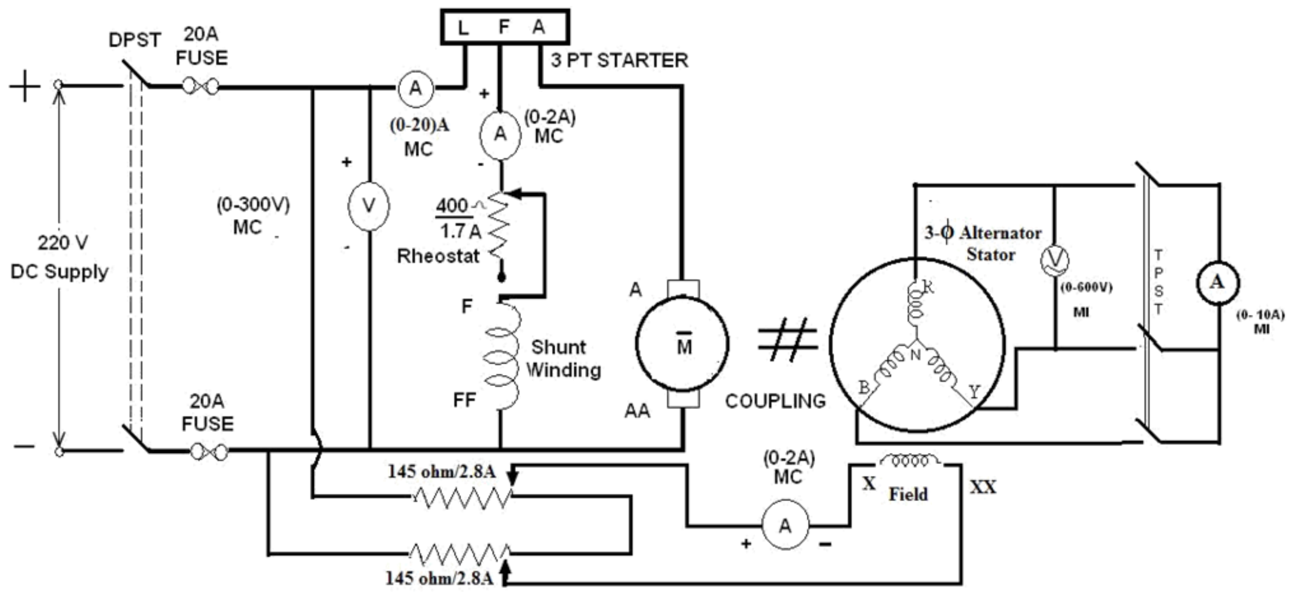
Sl. No.	**Equipment**	**Type**	**Range**	**Quantity**
1	Voltmeter	MI	(0-300/600)V	1 no
2	Ammeter	MI	(0-5/10)A	1 no
3	Ammeter	MI	(0-2.5/5)A	1 no
3	Rheostat	Wire-wound	400 Ω /1.7A 145Ω /2A	1 no 2 no
4	Tachometer	Digital	*****	1 no
5	Connecting Wires	*****	*****	Required

NAME PLATE DETAILS:

DC Motor(prime mover)	**3- ϕ Alternator**
KW : 3	Power Rating: 3
Voltage : 220V	PF :LAG
Current : 15A	Line voltage: 440V
Speed : 1500RPM	Speed 1500RP
Exctn : Shunt	Exctn Voltage:230V
Voltage :220V	Rated Current :15A

Field current	2A

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 up to 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:

OPEN CIRCUIT CHARACTERITICS:

S.NO	I_f (amps)	V_{oc} (volts)
1		
2		
3		
4		
5		
6		

SHORT CIRCUIT CHARACTERITICS:

S.NO	I_f (amps)	I_{sc} (amps)
1		

VOLTAGE REGULATION CHARACTERISTICS:

S.No	Cos Φ	Sin Φ	Lagging P.F full load Eo	Leading P.F full load Eo
1	0.2	0.97	436.4	72.03
2	0.4	0.91	430.08	113.57
3	0.6	0.8	420.36	189.98
4	0.8	0.6	401.07	215.09
5	1	0	324.18	324.18

MODEL CALUCALATIONS:

$$V_{Ph} = \frac{V_L}{\sqrt{3}} =$$

$$Z = \frac{V_{OC}}{I_{SC}} = 198/4.2 =$$

$$R_{AC} = 1.5 \times R_{DC} =$$

$$X_S = \sqrt{Z^2 - R_{AC}^2} =$$

For lagging P.F:

Let : 0.8 PF ,sinφ = 0.6.

By substituting all the values in E_o, We will get

$$E_0 = \sqrt{((V_{Ph} Cos\,\emptyset + I_{Sc}R_a)^2) + ((V_{Ph} Sin\,\emptyset + I_{Sc}x)^2)}$$

$$=$$

For leading P.F:

Let: 0.8 PF, sinφ = 0.6.

By substituting all the values in E_o, We will get

$$E_0 = \sqrt{((V_{Ph}Cos\,\emptyset + I_{Sc}R_a)^2) + ((V_{Ph}Sin\,\emptyset - I_{Sc}x)^2)}$$

=

Percentage Regulation: At 08 PF lag

$$\%\ R = \frac{E_0 - V_{Ph}}{V_{Ph}} \times 100$$

=

=

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:

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

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

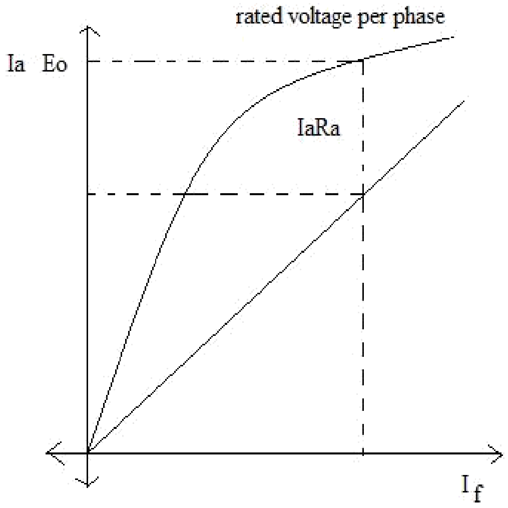
Where

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:

1. Avoid loose connections.
2. Switch OFF the Supply before making connections.
3. Do not touch the bare conductors.
4. Avoid parallax error while making observations.

RESULT: The regulation of a three phase alternator using synchronous impedance method is obtained.

OUTCOME: The performance of the three phase alternator can be obtained.

Viva questions:

1. What is an Alternator?
2. What is the principle of alternator?
3. Define regulation of an Alternator?
4. What are the different methods for finding regulation of an alternator?
5. What are the applications of an alternator?

‘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	*****	1 no
5	Wattmeter	Electrodynamometer	10A, 600V UPF 10A , 600V LPF	1 no 1 no
6	Connecting Wires	*****	*****	Required

NAME PLATE DETAILS

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

Frequency.	50HZ
Rated Current:	3.5A
Field current (I_f)	1.4A
Field Voltage (V_f)	220v DC

3- ϕ Auto transformer details

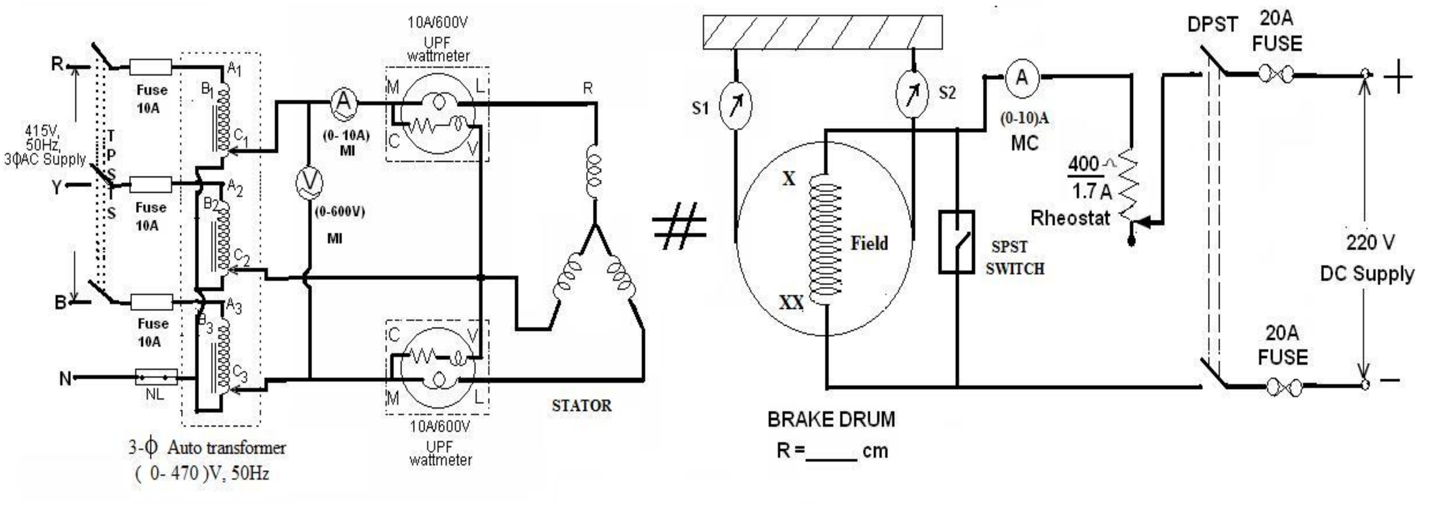
Input voltage: 440(Volt)

Output Voltage: 415 (Volt)

Frequency. : 50(Hz)

Current: 15(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.	Supply Voltage	Wattmeter W1	Wattmeter W2	Field current If(Amp)	Armature current I_a(Amp)	Cos ϕ
1 2 3						

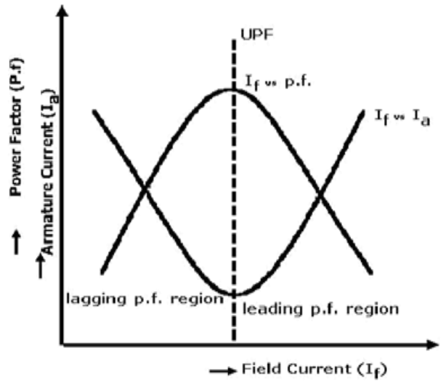
CALCULATIONS:

Power factor = Cos [tan^{-1}(——)]

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

COSϕ=

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?

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

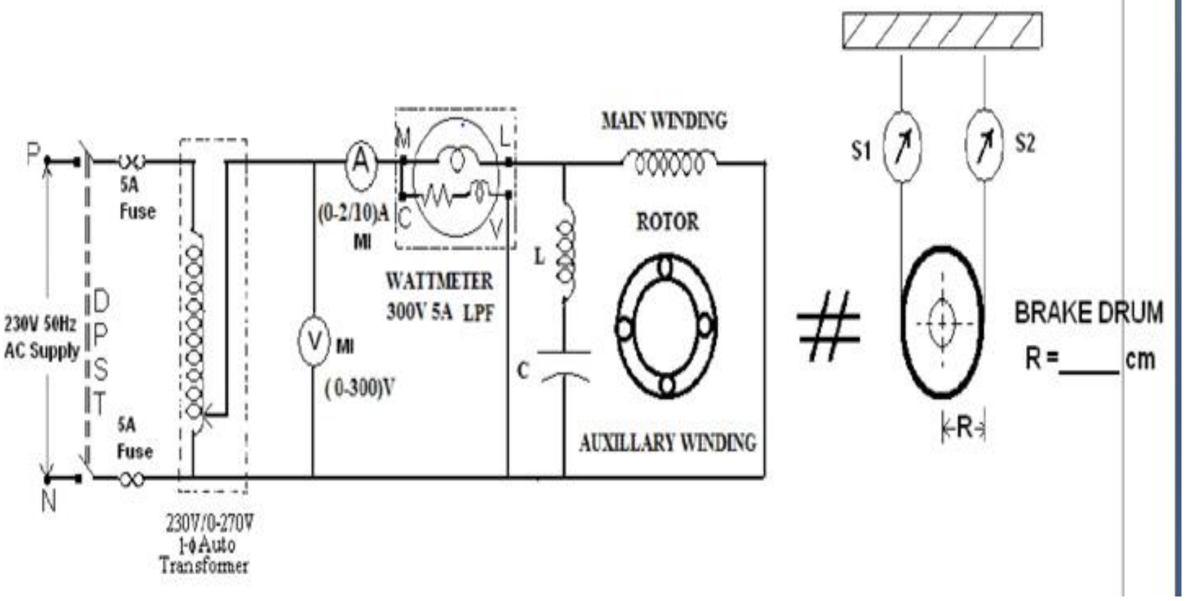
1 - ϕ Induction motor specifications:

Name plate details

Sl. no.	Quantity	
1	rated power	1 HP
2	Rated voltage	230 V

3	Current	5.8 AMP
4	Speed(RPM)	1440 RPM
5	Cos ϕ (pf)	
6	Frequency	50 HZ
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:

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

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

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

$$X_o = Z_o \sin\phi_o \qquad =$$

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

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

Calculation For Blocked Rotor Test:

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

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

r_1 is the DC resistance of stator of motor

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

$$x_1 + x_2 = X_{sc} \qquad = \quad \Omega$$

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
1			

For Blocked Rotor Test:

Sl no.	Voltmeter reading V_{sc}	Ammeter reading I_{sc}	Wattmeter reading W_{sc}
1			

PROCEDURE:

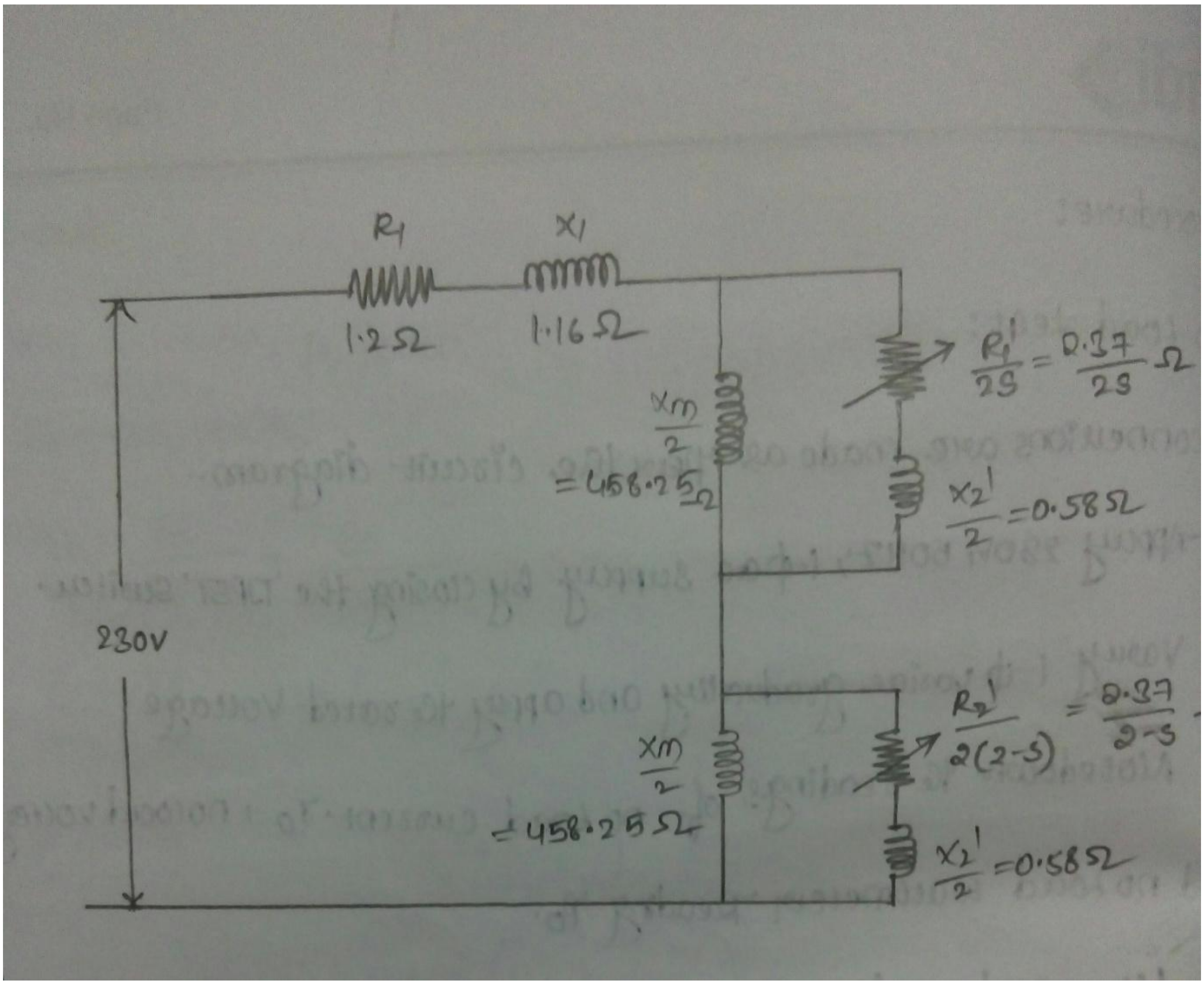
1. Connections are made as per the circuit diagram.

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 taken

EQUIVALENT CIRCUIT



PRECAUTIONS:

- Connections must be made tight
- Before making or breaking the circuit, supply must be switched off

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?

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:

S.No	Specifications	Rating
1	Power	3 HP
2	Voltage	415V
3	Current	6A
4	Speed	1440rpm
5	Frequency	50Hz
6	PF	0.8

3- ϕ Auto transformer Details:

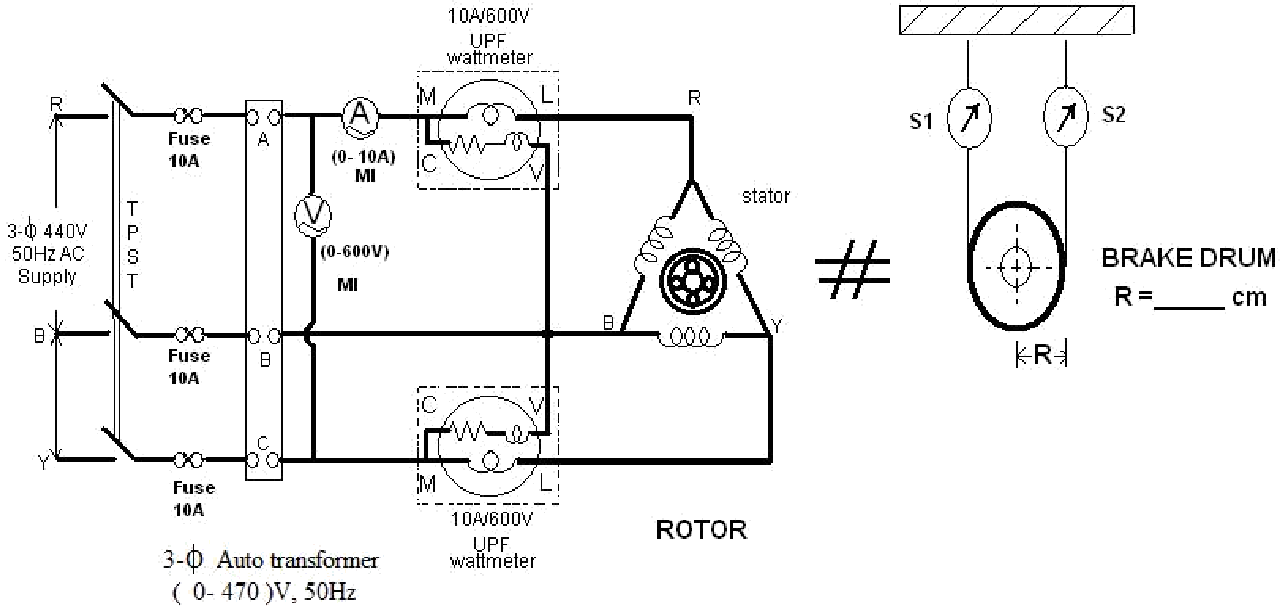
Input Voltage: 440(Volt)

Output Voltage:415(Volt)

Current: 15(Amp.)

Freq.:50(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   R → Radius of drum in mts.

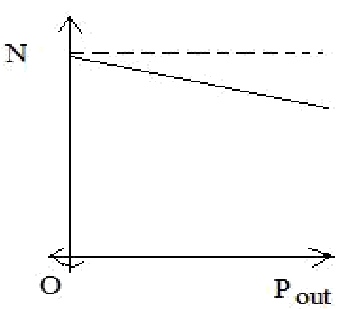
Output power in watts = $\dfrac{2\pi N\, T_{sh}}{60}$ *watts*

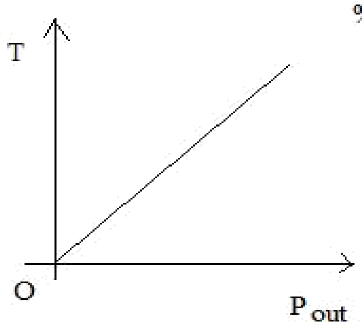
$$\%\ efficiency = \frac{output\ power\ in\ watts}{Input\ power\ in\ watts} \times 100$$

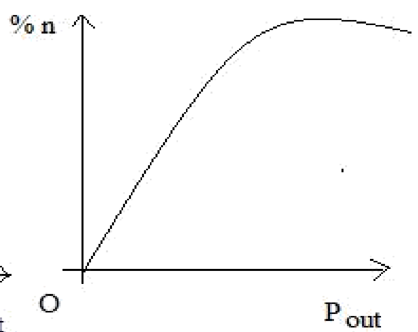
power factor of the induction motor $\cos\phi = \dfrac{W}{\sqrt{3}\, V_L\, I_L}$

MODEL GRAPHS:

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







TABULER FORM:-

S.No	Input Voltage (V)	Input Current (A)	Speed, N (rpm)	W1	W2	Spring Balance		Torque N-m	P_{in}= W1+W2 (W)	$P_{out,}$ (W)	$\eta = P_{out}/P_{in}$ X 100 (%)
						S1	S2				
1											
2											
3											
4											
5											
6											
7											
8											

CALCULATIONS:

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

=

=

Output Power = $2\pi NT/60$

=

=

Input Power = W1+W2

=

% Efficiency = (Output/ Input) x100

=

=

PRECAUTIONS:

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

RESULT:

OUTCOME: From the performance characteristics, as the load increases the speed is decreases, the torque, efficiency and load current increases.

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?

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::	

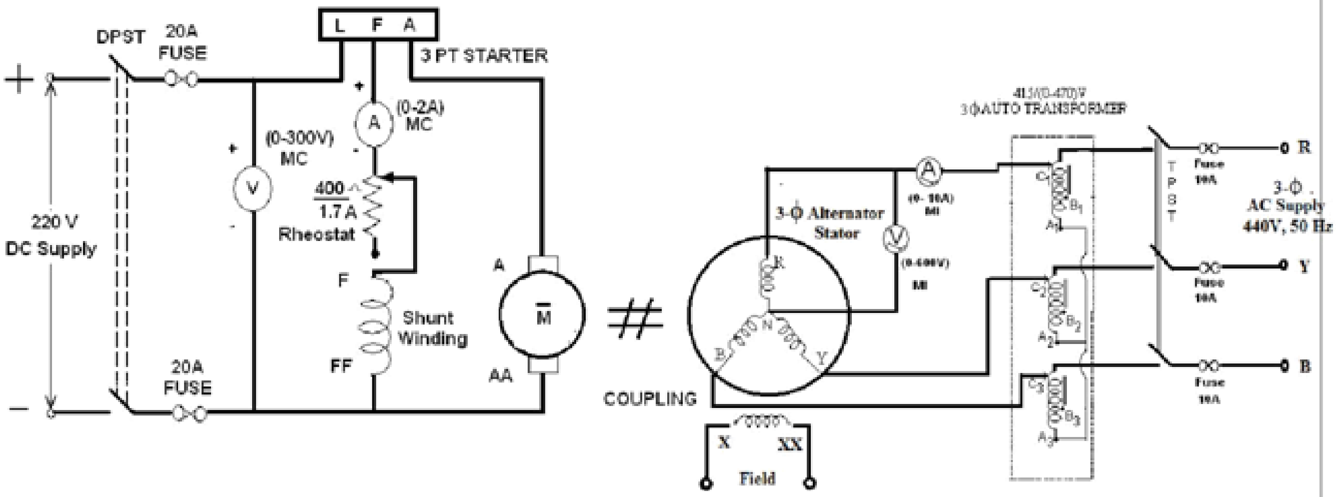
3- ϕ Auto transformer Details:

Input Voltage: 440(Volt)

Output Voltage: 110(Volt)

Current: 15(Amp.)

Frequency: 50(Hz)



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

TABULAR COLUMN:

Sl no.	Speed	Vmax (V_L)	Vmin (V_L)	Imax (I_L)	Imin (I_L)	X_d	X_q
1							

CALCULATIONS:

MINIMUM CURRENT =

MAXIMUM CURRENT =

MINIMUM VOLTAGE =

MAXIMUM VOLTAGE =

$$Xd = \frac{V\max}{\mathrm{Im}in} =$$

$$Xq = \frac{V\min}{\mathrm{Im}ax} =$$

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.

RESULT:

PARLLEL OPERATION OF TWO SINGLE PHASE TRANSFORMERS

AIM: To conduct parallel operation of two single phase transformers and to determine

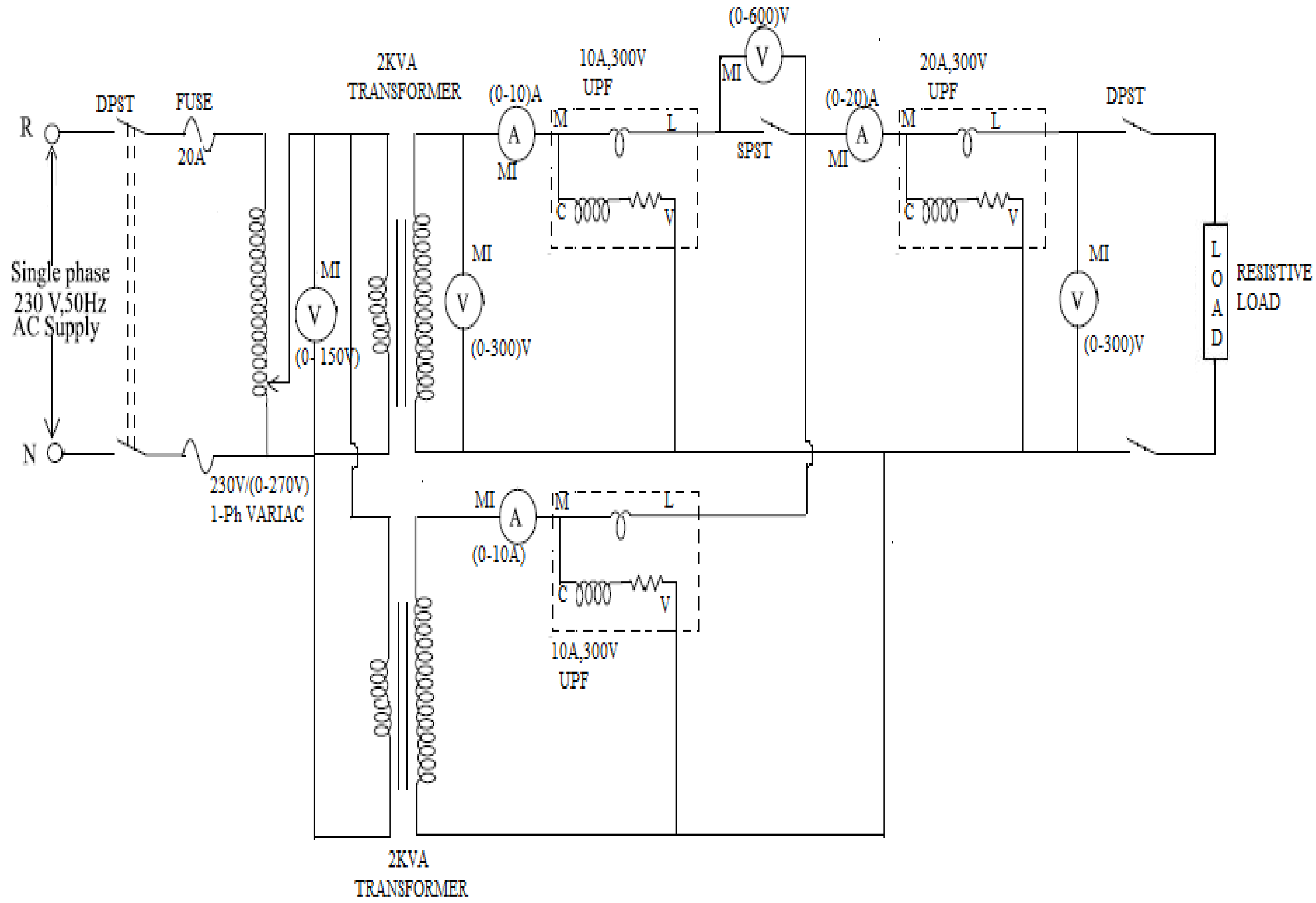
The load shared by each transformer

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:

S.No	**Specifications**	**Rating**
1	Transformer Rating :(in KVA)	2 KVA
2	LV (in Volts)	115V
3	LV side current	17.4A
4	HV (in Volts)	230V
5	HV side Current	8.7A
6	Type (Shell/Core)	Core
7	Frequency(Hz)	50Hz


R
N
Single phase
230 V,50Hz
AC Supply
DPST
FUSE
20A
230V/(0-270V)
1-Ph VARIAC
MI
(0- 150V)
2KVA
TRANSFORMER
MI
(0-300)V
(0-10)A
MI
10A,300V
UPF
M
L
C
V
(0-600)V
MI
SPST
(0-20)A
MI
20A,300V
UPF
M
L
C
V
DPST
MI
(0-300)V
L
O
A
D
RESISTIVE
LOAD
MI
(0-10A)
M
L
C
V
10A,300V
UPF
2KVA
TRANSFORMER

PROCEDURE:

1. Connections are made as per the circuit diagram
2. Apply 230v 50hz 1-phase ac supply
3. By varying the 1-phase variac apply rated voltage on Lv side
4. If the voltmeter across the spst shows 0v then close the Switch
5. Gradually add the loads and the readings of voltmeter, ammeter And wattmeter's
6. Gradually decrease the loads and open spst switch
7. Switch off the supply by opening the dpst

OBSERVATION TABLE:-

S.N	V_1	V_2	V_3	A_1	A_2	A_3	W_1	W_2	W_3
1									
2									
3									
4									
5									

PRECAUTIONS:

1. Avoid the loose connections.
2. Avoid connecting of meters directly to the machines.
3. Switch OFF the supply before making the connections.
4. Do not touch the bare conductors.
5. Avoid parallax error while making observations.

MODEL CALUCULATION:-

CURRENT OF FIRST T/F I_1 =

CURRENT OF SECOND T/F I_2 =

CURRENT FLOWING THROUGH LOAD T/F I_3 =

$I_1 + I_2$ =

PRACTICAL CURRENT =

%ERROR = $\frac{(I1 + I2) - I3}{I1 + I2}$

=