ELECTRICAL MACHINES-II

LABORATORY MANUAL

B.TECH
(III YEAR – I SEM)
(2019-20)

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(Autonomous Institution – UGC, Govt. of India)

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Maisammaguda, Dhulapally (Post Via. Kompally), Secunderabad – 500100, Telangana State, India

LIST OF EXPERIMENTS

INTRODUCTION TO TEST PROCEDURE WITH COMPUTER SETUP:

- The machines laboratory is setup with the following new features.
  - The motors are controlled using a static electronic power drive unlike the conventional method of using 3-point starters and DC output power.
  - Further, the motors can be controlled either manually by directly using the electronic drive unit or through PLC/Micro controller unit(Data logger)
- Hence the general procedure for all experiments is given in both methods.
- First, the power is extended to the test bench by switching on the corresponding MCB in the mains panel. Then the test panel is energized by switching on the MCB on the panel(Before switching on the local MCB it is to be confirmed that the drive control pot meter is in minimum position).
- The computer is switched on and ***DIAVIEW*** software is executed from the desktop.
- The computer now displays either the SCADA display (in case of PLC controlled set ups) and Data logger display (in case of data logger/micro controller setup)

MANUAL MODE:

1. METHOD OF STARTING THE MOTOR:

- The field rheostat is kept in minimum resistance position.
- Then the pot meter is rotated in clock wise gradually thus increasing the speed.
- In maximum position of the pot meter, motor is expected to reach slightly lesser than its rated speed.
- Now the field is weakened by increasing the field rheostat and the speed is brought to the rated speed as required for the respective test setup.

2. DATA READ OUT/RECORDING PROCEDURES:

- Depending upon the test setup all the relevant data like voltages, currents, speed and force are read out from the respective panel meters and noted down.
- Even in the manual mode of control the same data whatever is available on the panel meters can also be seen on the computer mimic diagram if the computer and PLC/Micro controller are kept in ON condition.
- This data at the end of the experiment can also be exported to the system memory with the required student information for further analysis and records.

PLC/MICRO CONTROLLER MODE:

1.METHOD OF STARTING THE MOTOR:

- The field rheostat is kept in minimum resistance position.
- Then using the mouse and the curser,
  - PLC/CONTROLLER mode is selected from mimic diagram.
  - Then motor start button is pressed
  - Speed is increased gradually by increasing the drive output voltage till the rated armature voltage is reached as read by the respected panel meter and the computer display.
- Now the field is weakened by increasing the field rheostat and the speed is brought to the rated speed as required for the respective test setup.

2. DATA READ OUT/RECORDIND PROCEDURES:

- Depending upon the test setup all the relevant data like voltages, currents, speed and force are read out are available on the mimic display
- The data at required instant of the experiment is logged by going to the data log in page and clicking on the data logger icon
- After collecting relevant experimental data in the ***<u>DIAVIEW</u>*** screen , the file is exported to system memory with the required student information for further analysis and records.

1 O.C & S.C TEST ON SINGLE PHASE TRANSFORMER

AIM:-

To conduct O.C. & S.C. test on a given transformer and predeterminations of

1) Efficiency,
2) Regulation,
3) Equivalent circuit

NAME PLATE DETAILS:

S.NO	Specifications	Ratings
1	Voltage	220/110v
2	output	3kVA
3	cycle	50Hz
4	phase	1-ϕ

APPARATUS REQUIRED:

S.No.	Equipment	Type	Range	Quantity
1.	Ammeter	DIGITAL	(0-2)A	1
2.	Ammeter	DIGITAL	(0-20)A	1
3.	Voltmeter	DIGITAL	(0-300)V	1
4.	Voltmeter	DIGITAL	(0-150)V	1
5.	Wattmeter	DIGITAL	300V,2A,LPF	1
6.	Wattmeter	DIGITAL	75V,20A,UPF	1
7.	1- Φ auto transformer	-	230/(0-270)V,2KVA	1
8.	Connecting wires	Copper	-	Required

THEORY:

These two tests on a transformer helps to find determine

1. The parameters of equivalent circuit
2. The voltage regulation
3. Efficiency

Complete analysis of the transformer can be carried out once it's equivalent circuit parameters are known. The power required during these two tests is equal to the appropriate power loss Occurring in the transformer

O.C.TEST:

This test is conducted by opening the secondary of a transformer. The core loss of the transformercan be determined from the test. It also gives the no-load current I_0 ,which is used to calculate the parameters R_0 , Xm of the magnetizing circuit. The transformer is connect as indicated in the ckt diagram. One of the windings usually the low voltage winding is connected to the supply voltage source while the high voltage winding is kept open..This ensure magnification of the no-load current I_0 , The rated voltage applied to the transformer using auto-transformer, the ammeter gives the total power loss and the ratio of voltmeter readings V1/V2 gives the ratio of the turns.

No load power factor $(\cos\Phi_0) = W_0/(I_0 * V1)$

Where W_0 = open ckt power in watts

I_0 = open ckt current in Amps

V1 =Open ckt voltage in Volts

No- load working component of current $(I_w) = I_0 \cos \Phi_0$

No-load working magnetizing component of current $(I_\mu) = I_0 \sin \Phi_0$

$R_0 = V_0/ I_w$ in ohms

$X_0 = V_0/ I_\mu$ in ohms

S.C. TEST:

This test gives the full load copper loss. In this test, secondary side low voltage winding is short circuited. A small voltage applied to the primary and increased carefully till the current (I_{sc}) in the primary winding reaches the rated full-load value. Under these conditions, the copper loss in the in the winding is same as that on full load.

Equivalent impedance referred to HV side $Z_{02} = V_{sc}/I_{sc}$ in ohms.

Equivalent resistance referred to HV side $R_{02} = W_{sc}/I^2_{sc}$ in ohms.

Equivalent reactance referred to HV side $X_{02} = \sqrt{(Z^2_{02} - R^2_{02})}$ in ohms.

Equivalent Circuit of 1-Φ transformer referred to LV side:

$(\cos\Phi_0) = W_0/(I_0 * V1)$

$(I_w) = I_0 \cos \Phi_0$

$(I_\mu) = I_0 \sin \Phi_0$

$Z_{02} = V_{sc}/I_{sc}$, $R_{02} = W_{sc}/I^2_{sc}$, $X_{02} = \sqrt{(Z^2_{02} - R^2_{02})}$

Transformation ratio (K) = V2/V1

Equivalent resistance referred to LV side $(R_{01}) = R_{02} / K^2$

Equivalent reactance referred to LV side $(X_{01}) = X_{02}/K^2$

Efficiency & Regulation of 1- Φ transformer:

Output power = (X*KVA*Cos Φ)

Where X = fraction of load. (X=1/4,1/2,3/4,1)

KVA = power rating of transformer, Cos Φ = power factor

Iron losses (Wi) = W_0

Copper losses (W_{cu})= X^2*Wsc

Total losses = Cu losses + Iron losses.

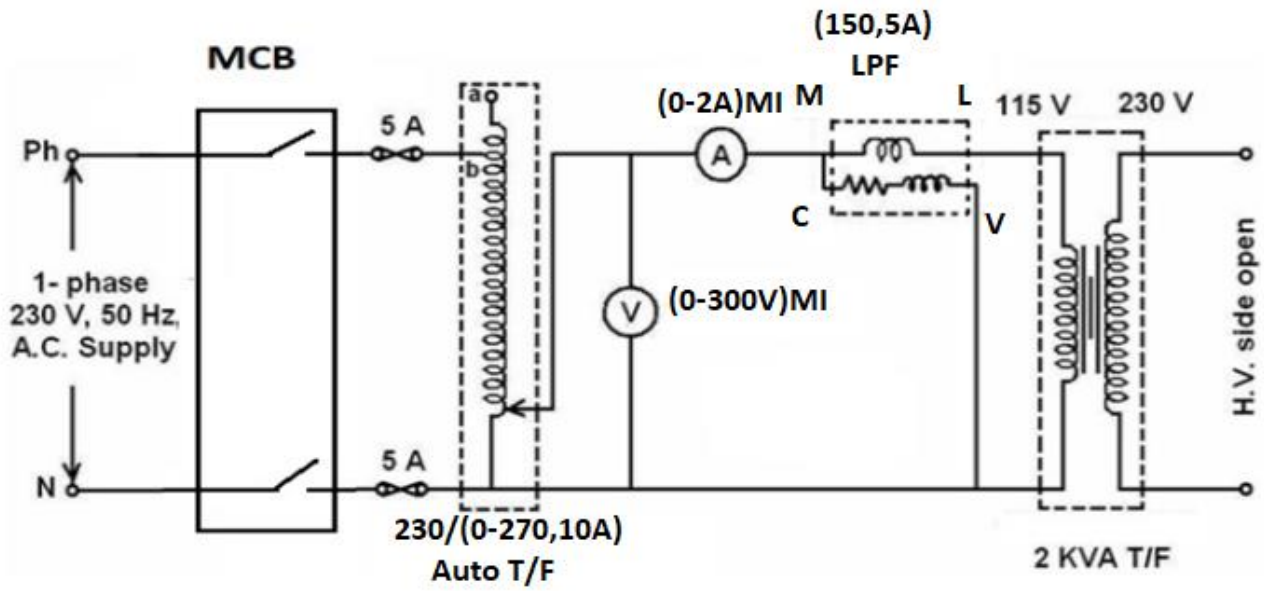
$$\textbf{Efficiency} = \frac{\text{Output power}}{\text{(output power+ losses)}} * 100$$

$$\textbf{Regulation} = \frac{X.I_{sc} [R_{02}\cos\Phi \pm X_{02}\sin\Phi]}{V_2} * 100$$

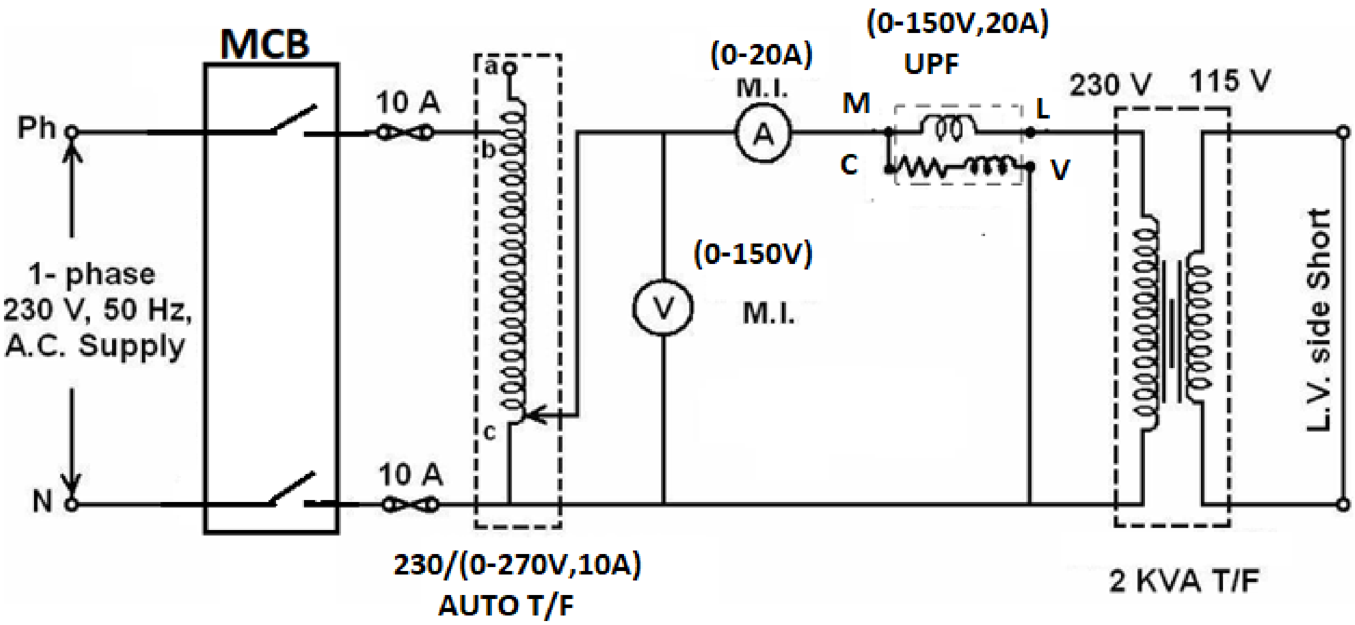
Where " +" for lagging.
"-" for leading.

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 brought back to minimum position and switch OFF the supply.
6. Calculate $\mathbf{R_o}$ and $\mathbf{X_o}$ 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.

7. **OBSERVATIONS:**

O.C. Test:

S.No.	V_1(Volts)	I_0(Amps)	W_0(Watts)

S.C.Test:

S.No.	V_{SC}(Volts)	I_{SC}(Amps)	W_{SC}(Watts)

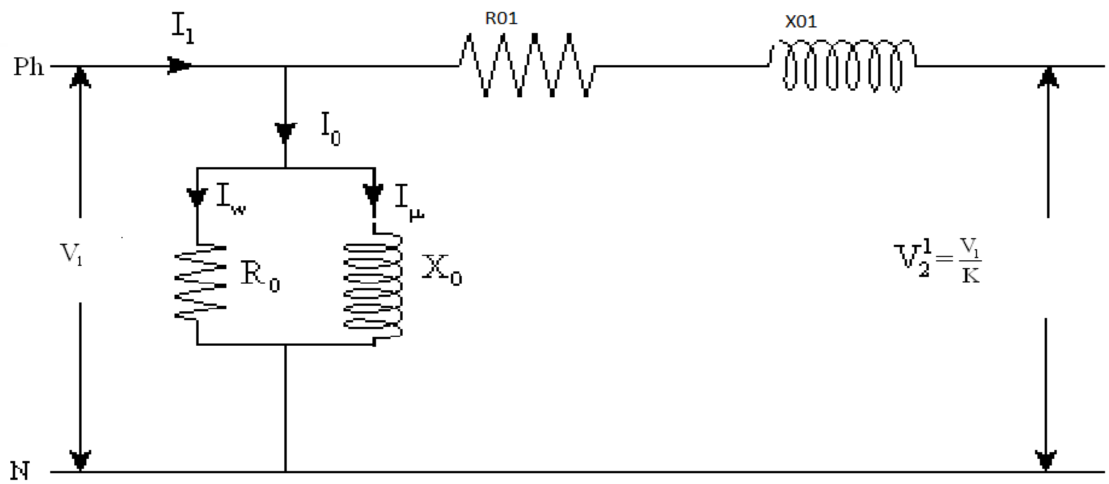
Tabulation to find the efficiency:

Fractinal load (X)	O/P (watts)	Iron losses (Wi)	Cu losses (Wcu)	Total losses	%η
¼					
½					
¾					
1					

Tabulation to find out the regulation:

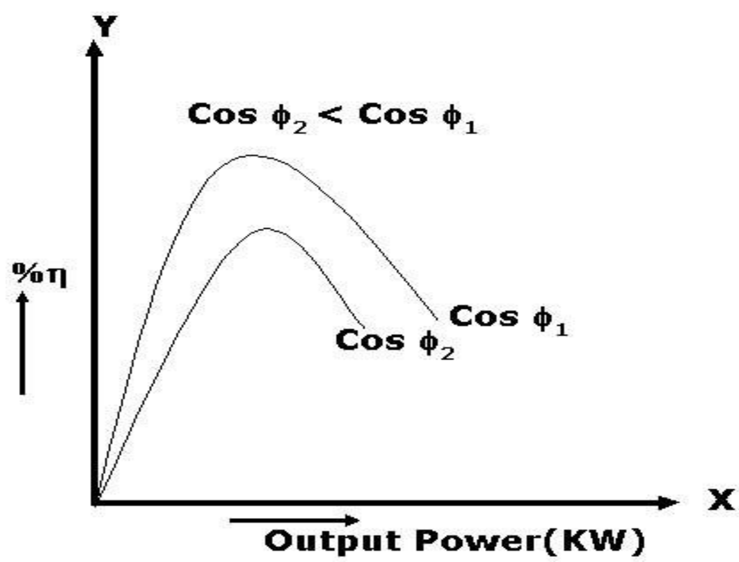
Fraction of load (X)	P.F(CosΦ)	%Reg(lag)	%Reg(lead)
¼			
½			
¾			
1			

EQUIVALENT CIRCUIT DIAGRAM:

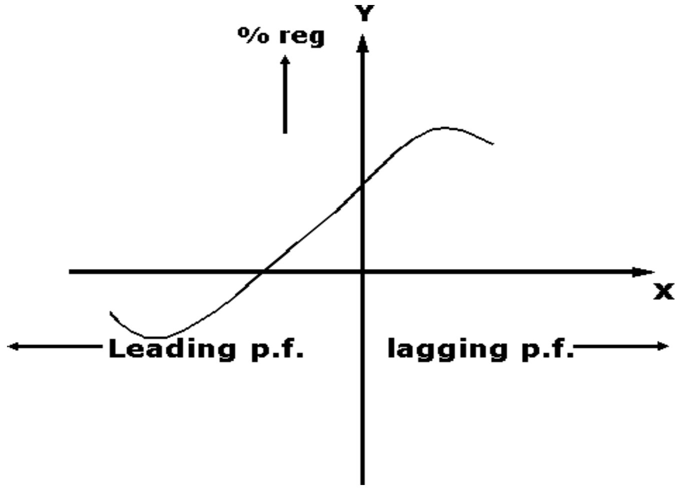


EXPECTED GRAPHS:

GRAPHS: Plots drawn between



(i) % efficiency Vs output



(ii)% Regulation Vs Power factor

RESULT:

VIVA – VOICE QUESTIONS:

1. How would you calculate the multiplying factor of a wattmeter?

2. Why should we select LPF & UPF wattmeter's while conducting OC & SC test?

3. Why Iron losses are considered as negligible while conducting SC test?

4. Why copper losses are considered as negligible while conducting OC test?

5. What are the Advantages and Disadvantages of OC & SC test?

6. What are the requirements to be fulfilled while conducting OC & SC tests?

7. Why the no-load power factor of a transformer is small?

8. Why the transformer rating is in KVA?

9. What is the effect of variation of voltage & frequency on Iron Losses?

10. How the Hysteresis & Eddy current losses are reduced?

2. BRAKE TEST ON 3-PHASE INDUCTION MOTOR

Aim: To perform Brake test on given 3-phase Induction Motor and obtain the characteristics of the motor from the test observations.

Name plate details:

S.NO	Specifications	Ratings
1	Voltage	415V
2	Current	7.39Amps
3	Output	5H.P
4	R.P.M	1430
5	Cycle	50Hz
6	Connection	Δ

Apparatus Required:

S.NO	Name of The Apparatus	Type	Range	Quantity
1.	Ammeter	Digital	(0-10) A	1
2.	Voltmeter	Digital	(0-600)V	1
3.	Wattmeter	Digital	600V,10A,UPF	2
4.	Tachometer	Digital	(0-3000)RPM	1
5.	Connecting wires	Copper	1.5Sqmm	required

THEORITICAL CALCULATIONS:

Torque on the pulley(T)=9.81*S*r N-m

Where $S=S_1-S_2$

S1,S2 are load cell Readings in Kg

Where ‘r’ is the radius of the pulley in meters

Power Output=2πNT/60 Watts

Power Input=(W_1+W_2) Watts

Where W_1 ,W2 are the wattmeter readings.

%Efficiency(%η) =(Output/Input) *100

Synchronous speed(N_s)=120*f/p.

Where f is frequency of supply in Hz

'p' is no. of poles.

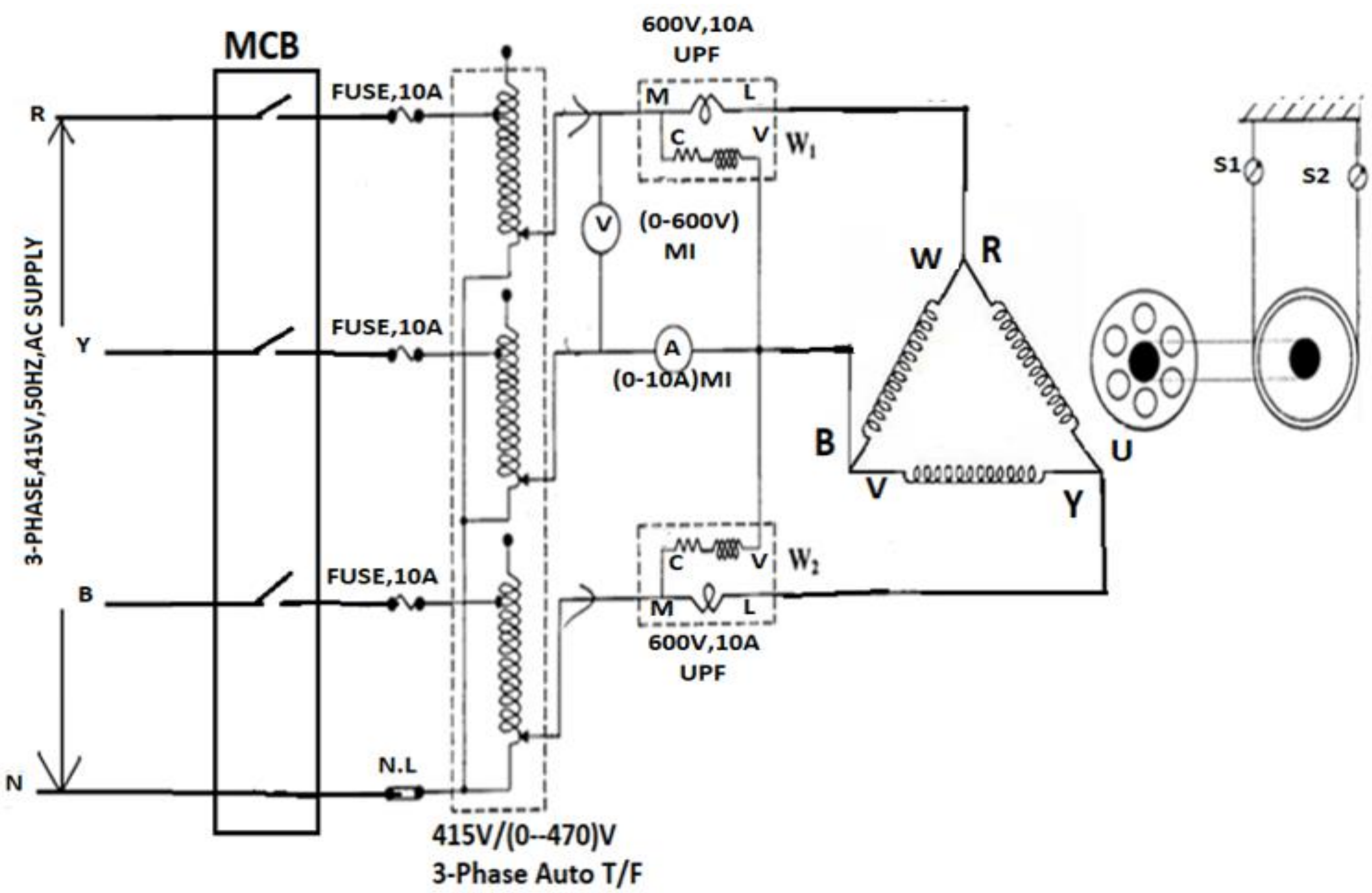
% Slip= $(N_s-N)/N_s$ *100.

Where 'N' is the rotor speed in rpm.

Power factor (cosΦ) =$(W_1+W_2)/\sqrt{3}$ VI

Where V is the Voltage across the motor & 'I' is the current drawn from the motor

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.

PRECAUTIONS:

1) At the time of starting the motor should be in no-load condition.
2) Cool the pulley by using water while the experiment is performed.

OBSERVATIONS:

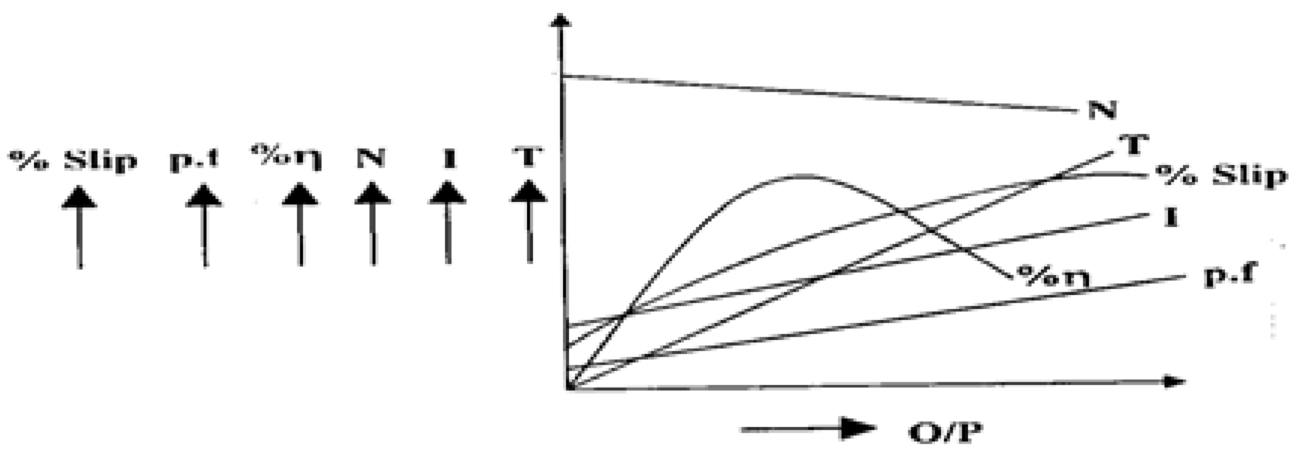
Table 1:

S.NO	Voltage (V)	Current (I)	Speed (N)	Wattmeter Reading			Load Cells Reading	Torque (T) $9.81*(S_1-S_2)$ r N-m	Output (watts) $2\pi NT/60$	%η
				W_1	W_2	W_1+W_2 (I/P)	S			

Table 2:

S.NO	Voltage(V)	Current(I)	Speed(N)	% Slip	I/P Power (W_1+W_2)	P.F(Cos Φ)

EXPECTED GRAPHS:



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?

3. NO LOAD & BLOCKED ROTOR TEST ON 3- ϕ INDUTION MOTOR

AIM: To conduct no load and blocked rotor test on given 3-phase induction motor, to predetermine the efficiency and to draw the equivalent circuit diagram.

NAME PLATE DETAILS:

S.NO	Specifications	Ratings
1	Voltage	415V
2	current	7.5Amps
3	output	5H.P
4	R.P.M	1430
5	cycle	50Hz
6	connection	Δ(Delta)

APPARATUS:

S.No.	Name of the apparatus	Type	Range	Quantity
1	Ammeter	Digital	(0-10)A	1
2	Ammeter	Digital	(0-2)A	1
3	Voltmeter	Digital	(0-600)V	1
4	Voltmeter	Digital	(0-30)V	1
5	Wattmeter	Digital	600V,5A,LPF	2
6	Wattmeter	Digital	150V,10A,UPF	2
7	Tachometer	Digital	(0-300)rpm	1
8	Connecting wires	-		required

THEORITICAL CALCULATIONS:

NO LOAD TEST:

No load power factor $\cos\Phi_o = W_o/(V_o*I_o)$

Where W_o = Power input per phase on no load in Watts.

V_o = Rated applied voltage per phase on no load in Volts.

I_o = No load current per phase in Amps.

No load working component of current $(I_w) = I_o\cos\Phi_o$

No load magnetizing component of current $(I_\mu) = I_o\sin\Phi_o$

No load resistance = $(R_o) = V_o/I_w$

No load reactance = $(X_o) = V_o/I_\mu$

BLOCKED ROTOR TEST:

Motor equivalent impedance per phase referred to stator (Z_{sc}) = V_{sc}/ I_{sc} in ohms.

Motor equivalent resistance per phase referred to stator (R_{sc}) = $W_{sc}/(I_{sc}^2)$. in ohms.

Motor equivalent reactance per phase referred to stator (X_{sc}) = $\sqrt{(Z_{sc}^2 - R_{sc}^2)}$ in ohms.

Where W_{sc} = short circuit power per phase in Watts.

I_{sc} = short circuit current per phase in Amps.

V_{sc} = short circuit voltage per phase in Volts.

Rotor resistance per phase referred to stator $R_2' = R_{sc} - R_1$ ohms

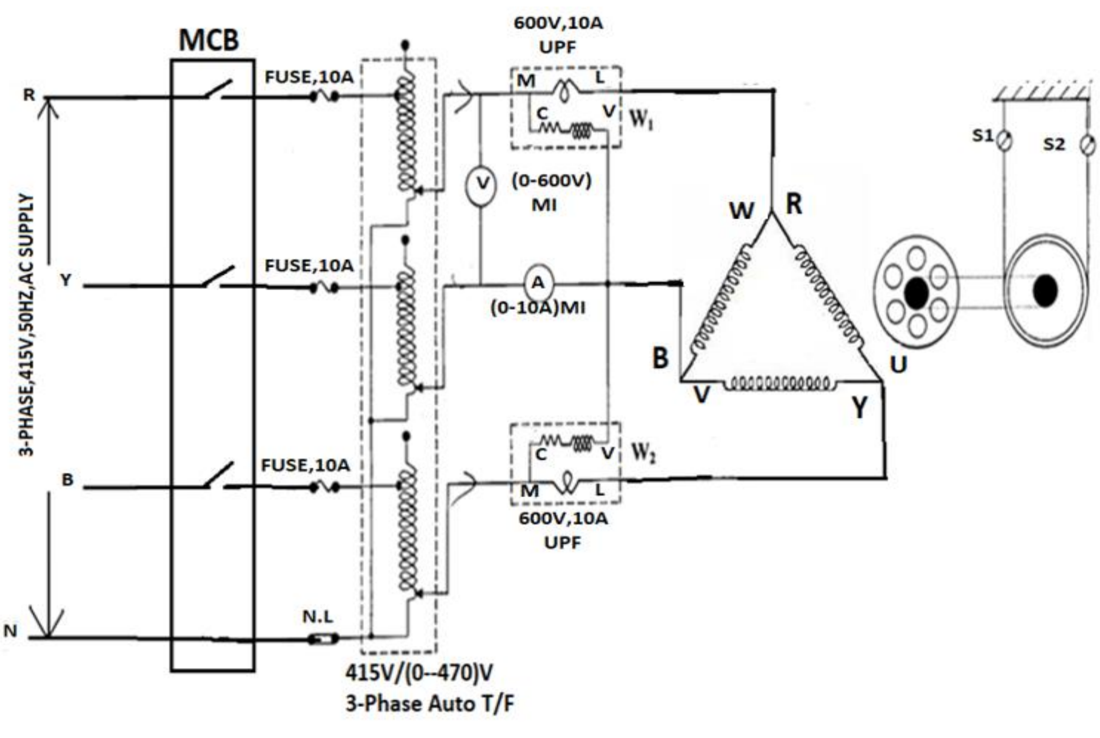
Rotor reactance per phase referred to stator $X_2' = X_{sc}/2 = X_1$ ohms.

Where R_1 = stator resistance per phase in ohms.

X_1= stator reactance per phase in ohms.

Equivalent load resistance (R_L') = R_2' (1/s – 1) in ohms.

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. For no-load test apply the rated voltage by adjusting the auto transformer and note down ammeter, voltmeter & wattmeter readings. In this test rotor is free to rotate.
3. For blocked rotor test apply the rated current by adjusting the auto transformer & note down ammeter, voltmeter & wattmeter readings. In this test rotor is blocked.
4. Find the stator resistance by using ammeter voltmeter method.
5. Switch OFF the supply.

PRECAUTIONS:

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

OBSERVATIONS:

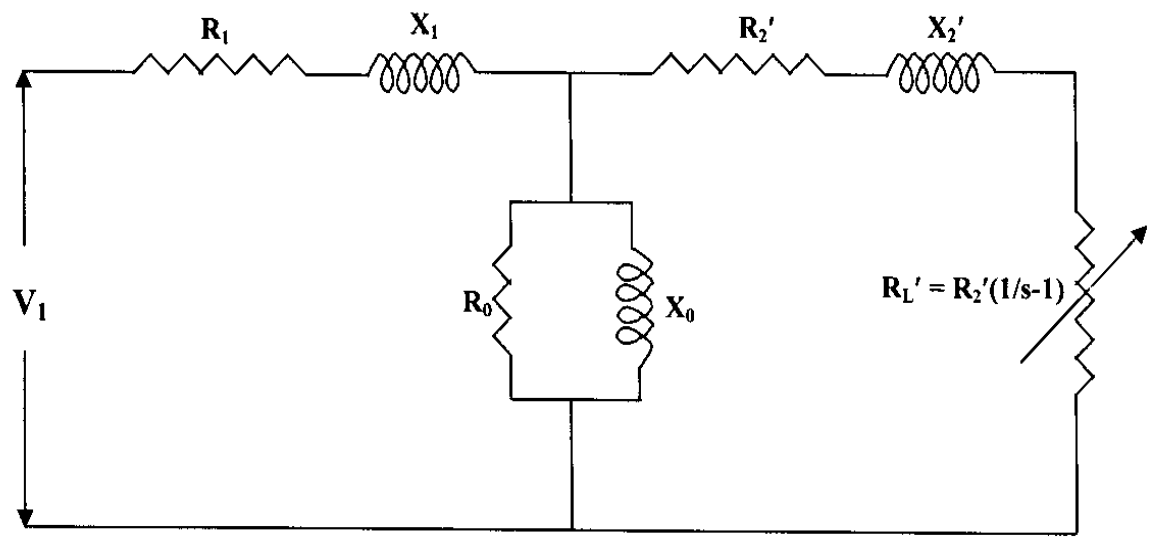
No-Load test:

S.No.	Open Ckt Voltage (Volt)	No load current (amp)	W1	W2	Open Ckt power W0=W1+W2 (Watt)	$\Phi 0=\cos^{-1}(W0/\sqrt{3}\ V0*I0)$

Blocked rotor test:

S.No.	Short Circuit Voltage (Volt)	Short Circuit current (amp)	W_1	W_2	Short circuit power $Wsc= W_1+W_2$ (Watt)	$\Phi sc=Cos^{-1}(Wsc/\sqrt{3}\ Vsc*Isc)$

MODEL EQUIVALENT CIRCUIT:



RESULT:

Viva-Voice Questions

1) The power factor of an induction motor decreases as the applied voltage is increased Explain this with the help of a phasor diagram.

2) Express the no-load stator current corresponding to rated stator voltage as a %of rated full load current.
3) State the frequency of the rotor induced emf when the rotor is (a) rotating at a slip of (**S)** and (b) blocked, the stator supply frequency is 50HZ.
4) Show how you can calculate the efficiency of an induction motor from the results of copper losses in the windings.
5) What is the difference between the LPF and UPF Watt meters?
6) Under blocked rotor condition, the frequency of rotor currents in a 50Hz,3-Φ induction motor?
7) What are the advantages of indirect testing over the direct testing of an induction motor?
8) Why the LPF watt meters are used in no-load test?
9) What is the reading of the wattmeter, when the p.f. is less than 0.5 lag.
10) What is the slip value at no-load?

4. REGULATION OF AN ALTERNATOR BY SYNCHRONOUS IMPEDANCE & MMF METHOD

AIM: To determine the regulation of a 3-phase alternator by using synchronous impedance method & MMF method.

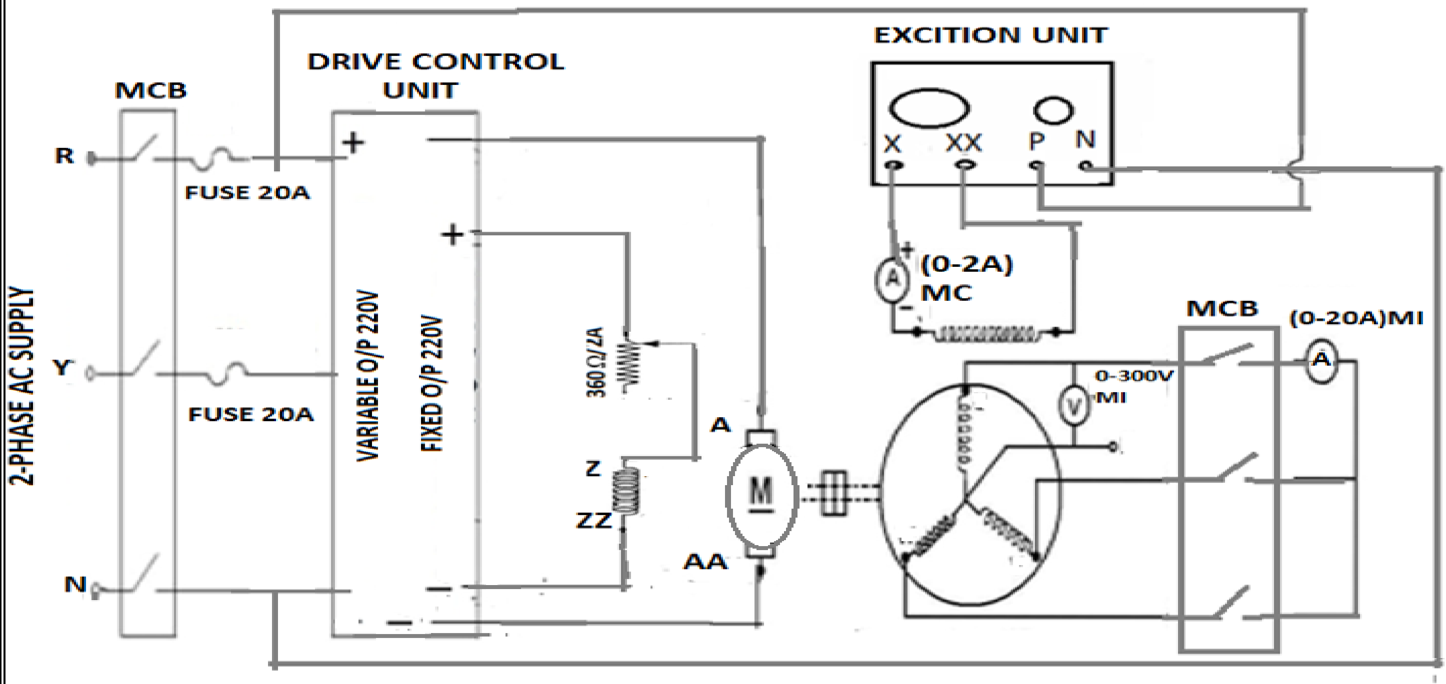
NAME PLATE DETAILS:

Specifications	Motor	Alternator
Rated voltage	220V	415V
Rated Current	19A	4.2A
Rated Power	5H.P.	3KVA
Rated Speed	1500rpm	1500rpm
Type of connection	Shunt	Star

APPARATUS REQUIRED:

S.No.	Name of the apparatus	Range	Type	Quantity
1	Voltmeter	(0-300)V	Digital	1
2	Ammeter	(0-5)A	Digital	1
3	Ammeter	(0-2)A	Digital	1
4	Rheostat	300 Ω/2A	Digital	1
5	Tachometer	(0-3000)rpm	Digital	1
6	Connecting wires	--	--	Required

CIRCUIT DIAGRAM:



PROCEDURE (EMF):

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.

PROCEDURE(MMF):

1) Make the connections as per the circuit diagram.
2) Give the supply to the dc-motor by closing the MCB.
3) Start the dc-motor with the help of Drive control unit.
4) By adjusting the field rheostat, bring the motor at rated speed of alternator.

O.C.Test

1) by opening the o/p of the alternator and adjusting the excitation gradually note down voltmeter & ammeter readings.
2) Repeat the above procedure till the 125% of the rated voltage.

S.C.Test:

1) Short ckt the open terminals of the alternator by thick wire .
2) Gradually increase the excitation current and take both ammeter's readings.
3) Repeat the above procedure till the 125% of the rated current.

OBSERVATIONS:

O.C. Test

S.NO	Field Current(I_f) (Amps)	No-Load Voltage (Vo) (Volts)

S.C.Test

S.NO	Field Current(If) (Amps)	Short Circuit current(Isc) (amps)

MODEL CALCULATIONS:

EMF METHOD :

$$Z_S = \frac{V_{OC}}{I_{SC}} \text{ for the same } I_f \text{ and speed: } X_S = \sqrt{Z_S^2 - R_a^2} \quad [R_{ac}=1.6R_{dC}]$$

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

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

Where

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

V – full load, rated terminal voltage per phase.

MMF METHOD:

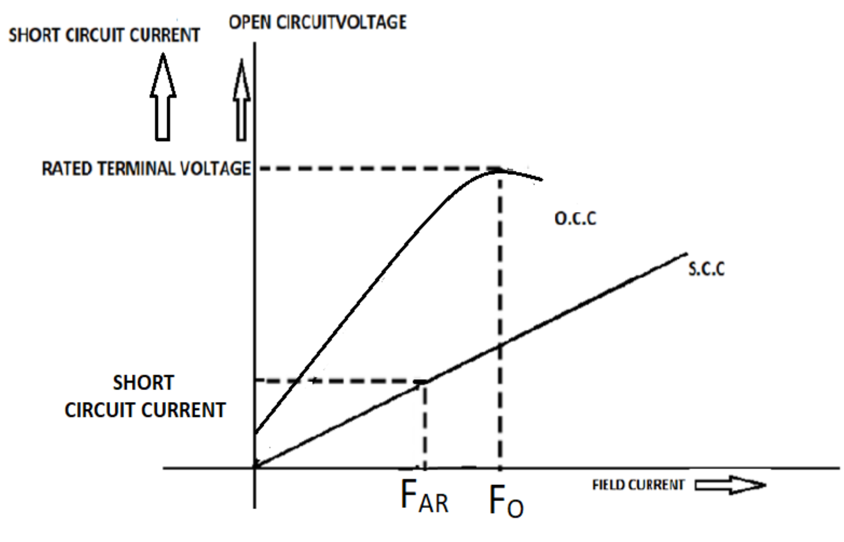
I_{f1} Corresponds to drop of $\left(V_{ph} + I_{aph} R_a \cos \emptyset\right)$

I_{f2} *corresponds to full load short circuit current*

$$I_f = \sqrt{{I_{f1}}^2 + {I_{f2}}^2 + 2 I_{f1} I_{f2} \cos[180° - (90 \pm \emptyset)]}$$

$$\text{Regulation} = \frac{E_{ph} - V_{ph}}{V_{ph}} \times 100$$

Expected Graph:



Result:

Viva-Voce Questions:

1) Define Voltage Regulation of an Alternator?
2) Define Synchronous Impedance?
3) On which factors Voltage regulation depends on?
4) Why synchronous impedance method is called pessimistic method?
5) Mention the advantages and disadvantages of finding regulation of an alternator by synchronous impedance method(indirect method)and by direct loading method.
6) Explain about the salient pole and non salient pole rotors of an alternator?
7) What is the another name of Synchronous Impedance method?
8) Explain the different methods used for finding the regulation of an alternator?
9) Why regulation up is considered for Alternator?
10) Why the Alternator is called Synchronous Generator

5. DETERMINATION OF X_d & X_q OF A SALIENT POLE SYNCHRONOUS MACHINE

Aim: To find Xd & Xq of given salient pole synchronous machine by conducting slip test.

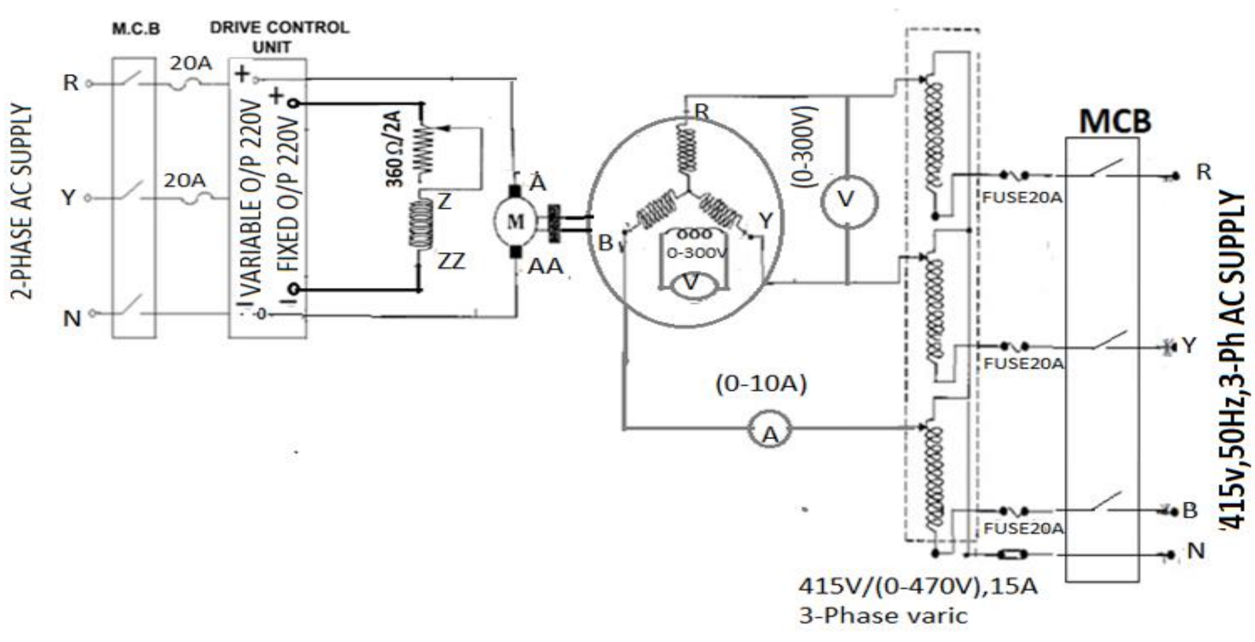
Name Plate Details :

Specifications	Alternator	DC Motor
Voltage	415V	220V
Current	4.2A	19.5A
Power	3KVA	5H.P.
Speed	1500rpm	1500
Connection	Star	Shunt

Apparatus required:

S.No.	Name of the apparatus	Range	Type	Quantity
1.	Ammeter	(0-10)A	Digital	1
2.	Voltmeter	(0-600)V	Digital	1
3.	3-Φ variac	415-470V,10A	-	1
4.	Tacho meter	(0-3000)rpm	Digital	1
5.	Voltmeter	(0-300)V	Digital	1
6.	Ammeter	(0-2)A	Digital	1
7.	Connecting wires	-	-	required

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

PRECAUTIONS:

1) Motor field rheostat should kept in minimum position
2) Direction of rotation due to prime mover & due to alternator run as motor should be same.
3) Initially all switches are kept open.

OBSERVATIONS:

S.No.	I_{min}	I_{max}	V_{min}	V_{max}	$X_d = V_{max}/I_{min}$	$X_q = V_{min}/I_{max}$
1.						

RESULT:

6.SUMPNER'S TEST ON TWO IDENTICAL 1-PHASE TRANSFORMERS

Aim: To conduct Sumpner's test on a given two identical 1-Phase transformers and predetermination of 1) Efficiency 2) Regulation 3) Equivalent circuit parameters.

NAME PLATE DETAILS:

S.No	Specification	Rating
1	Voltage	220/110 V
2	Current	8.7A
3	Cycles	50Hz
4	Output	2KVA
5	Phase	1-Phase

APPARATUS REQUIRED:

S.No	Name Of The Apparatus	Type	Range	Quantity
1)	Ammeter	MI	(0-20)A	1
2)	Ammeter	MI	(0-2.5)A	1
3)	Voltmeter	MI	(0-300)V	1
4)	Voltmeter	MI	(0-30)V	1
5)	Wattmeter	Dynamo	300V,5A,LPF	1
6)	Wattmeter	Dynamo	75V,10A,UPF	1
7)	Voltmeter	MI	(0-600)V	1
8)	1-Phase Auto Transformer	-	230V/(0-270)V	2
9)	Connecting Wires	-	(0-20)A	Required

THEORY:

This test is also called Heat Run Test. Two identical transformers are required to conduct this test. This is an indirect test similar to the OC & SC tests in transformers. Sumpner's test is a combination of both OC& SC tests from the result of this test parameters of equivalent circuit, the efficiency & Regulation of each transformer can be determined. In addition to the above parameters, temperature rise in the transformers can also be determined since the transformers are subjected to full load copper loss & core loss.

OC-Test:

No-Load power factor ($\cos\Phi_0$) = (W_0/2) (V0/(I_0/2))

Where W_0 = Open circuit power in Watts

V_0= Open circuit Voltage in Volts

I_0 = Open circuit Current in Amps

No-Load working component of current (I_w) = $(I_0/2)*\cos\Phi_0$

No-Load magnetizing component of current (I_u) = $(I_0/2)*\sin\Phi_0$

SC-Test:

Equivalent impedance referred to HV side (Z_{02}) = $((V_{sc}/2)/I_{sc})$ ohm

Equivalent Resistance referred to HV side (R_{02}) = $(W_{sc}/2)/(I_{sc}^2)$ ohm

Equivalent Reactance referred to HV side (X_{02}) = $\sqrt{Z_{02}^2 - R_{02}^2}$ ohm

Where W_{sc} = Short Circuit Power in watts

V_{sc} = Short Circuit Voltage in volts

I_{sc} = Short Circuit Current in Amps.

Equivalent Circuit of 1-phase transformer referred to LV side:

$\cos\Phi_0 = (W_0/2)/(V_0*I_0/2)$

$I_w = I_0/2 * \cos\Phi_0$

$I_u = I_0/2 * \sin\Phi_0$

$R_0 = V_0 / I_w$

$X_0 = V_0 / I_u$

$Z_{02} = (V_{sc}/2)/I_{sc}$

$R_{02} = (W_{sc}/2)/ I_{sc}^2$

$X_{02} = \sqrt{Z_{02}^2 - R_{02}^2}$

Transformer ratio (k) = V_2/V_1

Equivalent Resistance referred to LV side (R_{01}) = R_{02}/k^2

Equivalent Reactance referred to HV side (X_{01}) = X_{02}/k^2

Efficiency & Regulation Of 1-phase transformer

Output power= $(X*KVA*\cos\Phi_0)$

Where X = Fraction of load

KVA = power rating of transformer

$\cos\Phi_0$ = power factor

Iron losses(W_i)= $W_0/2$

Copper losses of each transformer (W_{cu}) = $X^2 * W_{sc}/2$

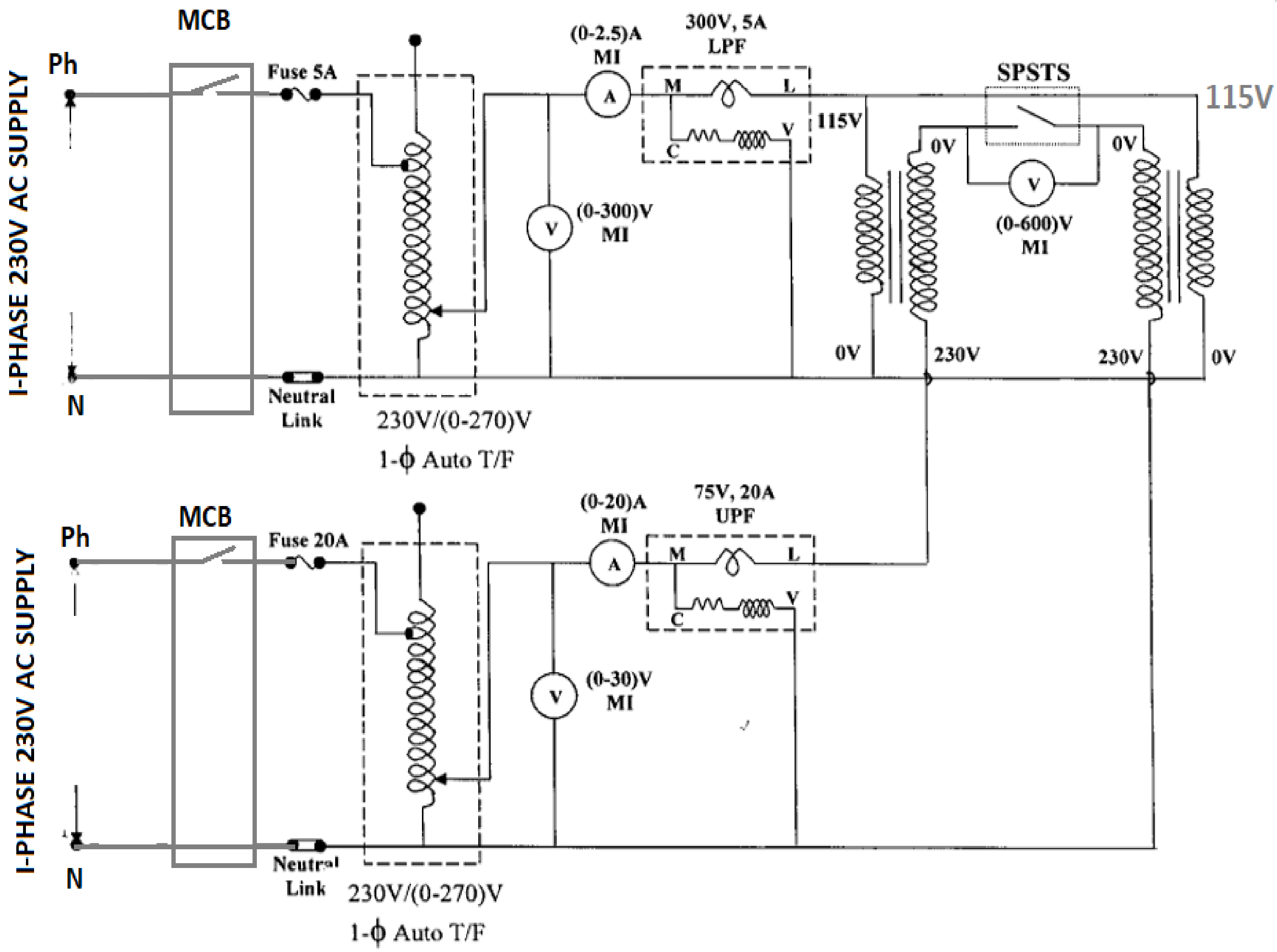
$$\text{Efficiency of each transformer} = \frac{\text{Output power}}{(\text{Output power} + \text{losses})} * 100$$

$$\text{Regulation Of each transformer} = \frac{X.\mathbf{I}sc[R_{02}\cos\Phi \pm X_{02}\sin\Phi]}{V_2} * 100$$

Where "+" for lagging.

"-" for leading.

<u>Circuit Diagram:</u>



PROCEDURE:

1) Make connections as per the circuit diagram
2) Initially kept SPSTs switch to be open & give supply to primarily by closing MCB.
3) By adjusting auto T/F apply rated voltage across primaries.
4) If the voltmeter connected across SPST s voltage reads zero then close the switch.If not interchange the connections of any one of the transformer winding is ensure that voltmeter reading should be zero.
5) By adjusting Booster T/F pass rated current through high voltage side.
6) Note down the readings of voltmeter, Ammeter & wattmeter.
7) Slowly bring the auto T/F to the initial position and switch off the supply.

Precautions:

1.MCB & SPST switch should be kept in open while making connections

2. Make connections tightly.
3. The SPSTs Should kept open till the voltage across the SPSTs is brought to zero.
4. High voltage & low voltage sides of the T/F should be properly used as primary or secondary respective to the experiments.

Observations:

	OC Test			SC Test		
S.No	V0(Volts)	I0/2(amps)	W0/2(Watts)	Vsc/2(volts)	Isc(amps)	Wsc/2(watts)

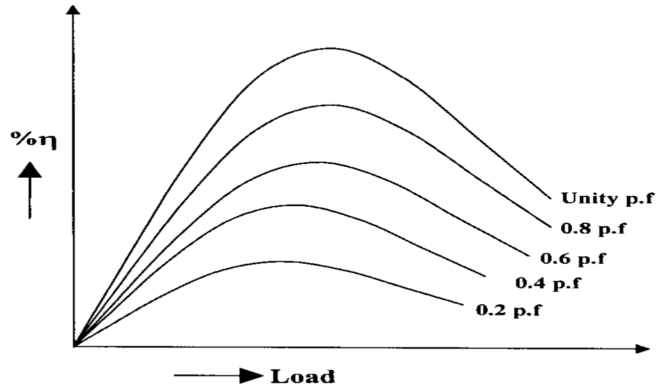
Tabulation to find the efficiency.

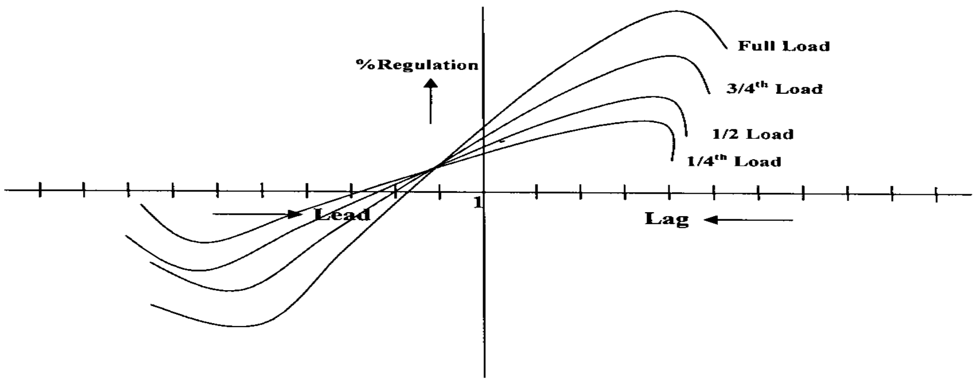
CosΦ	Fractinal load (X)	O/P (watts	Iron losses (Wi)	Cu losses (Wcu)	Total losses	%η
0.2						
0.4						
0.6						
0.8						
1						

Tabulation to find out the regulation.

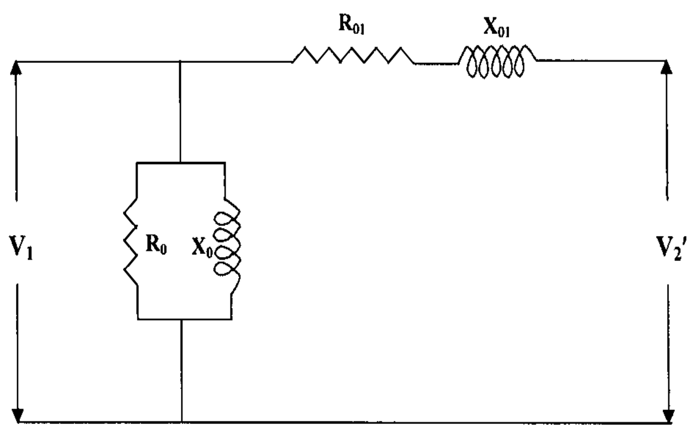
Fraction of load (X)	P.F(CosΦ)	%Reg(lag)	%Reg(lead)
¼			
½			
¾			
1			

Expected Graghs





Equivalent Circuit:



Result:

7. SCOTT CONNECTION OF SINGLE PHASE TRANSFORMER

AIM: To perform the scott connection of 1-phase transformer and converting 3-phase supply into 2-phase supply voltage.

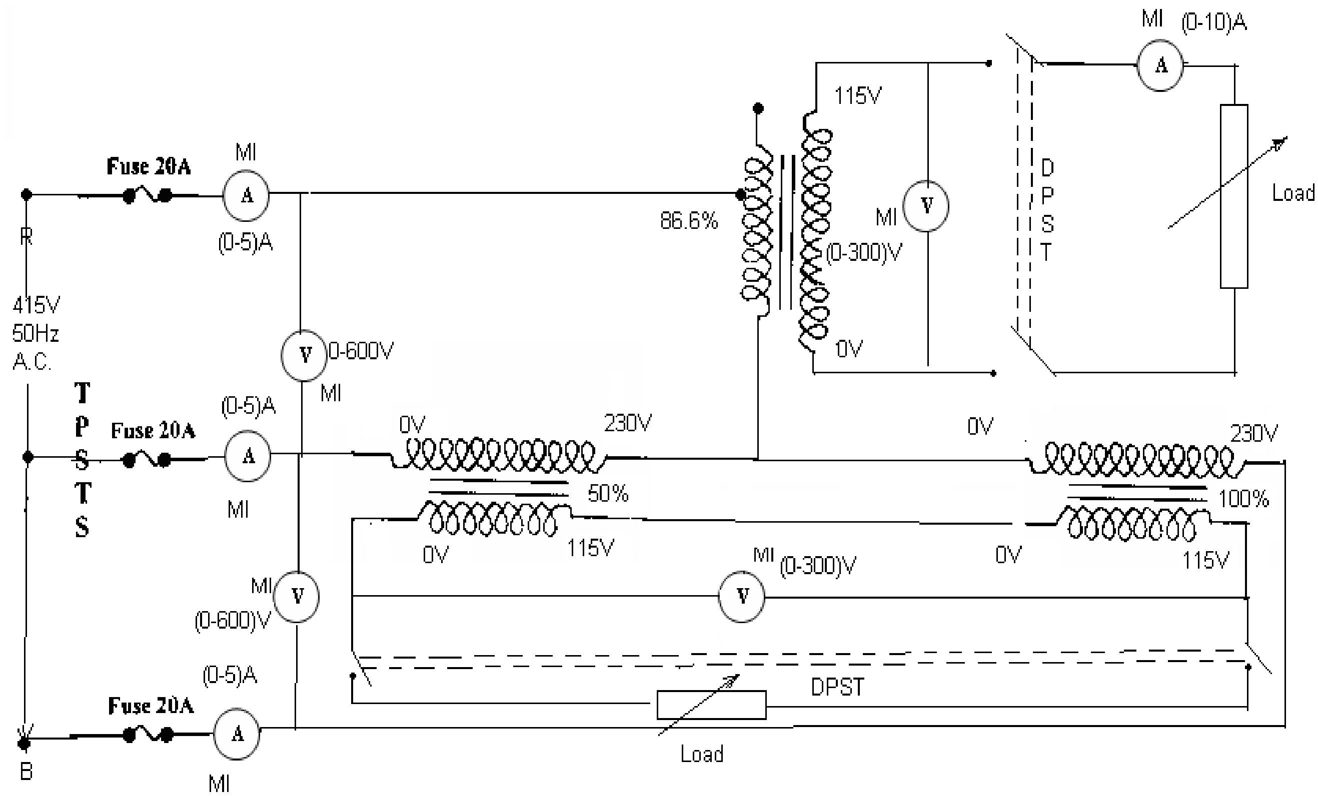
NAME PLATE DETAILS:

S.No	Specification	Range
1	Voltage	230/115V
2	Current	13A
3	Cycles	50Hz.
4	Output	3KVA
5	Phase	1-phase

APPARATUS REQUIRED:

S.No.	**Name of the apparatus**	**Range**	**Type**	**Quantity**
1.	Transformer	2KVA		2
2.	Teaser transformer	2KVA	100%,86.6%,50% 0% Tappings	1
3.	Voltmeter	(0-600)V	Digital	2
4.	Voltmeter	(0-300)V	Digital	2
5.	Ammeter	(0-10)A	Digital	2
6.	Ammeter	(0-5)A	Digital	3
7.	Connecting wires	-	-	required

Circuit Diagram:



Procedure:

1. Connect the circuit as per the circuit diagram.
2. Apply rated 3-phase supply at 86.6% of teaser T/F,0% & 100% of the main transformer by adjusting the auto transformer.
3. Load the two different 1-phase outputs of the transformer with separate loads and note down all meter readings. (The balance load connection can be maintained)
4. Repeat the above procedure for different i/p voltages by adjusting the auto transformer.

Observations:

	Input Voltage		Output Voltage		Output current		Input Current		
S.No	Main	Teaser	Main	Teaser	Main	Teaser	I_R	I_Y	I_B

Result:

8.V & INVERTED V CURVES OF SYNCHRONOUS MOTOR

Aim: To obtain V and inverted V curves of a synchronous motor.

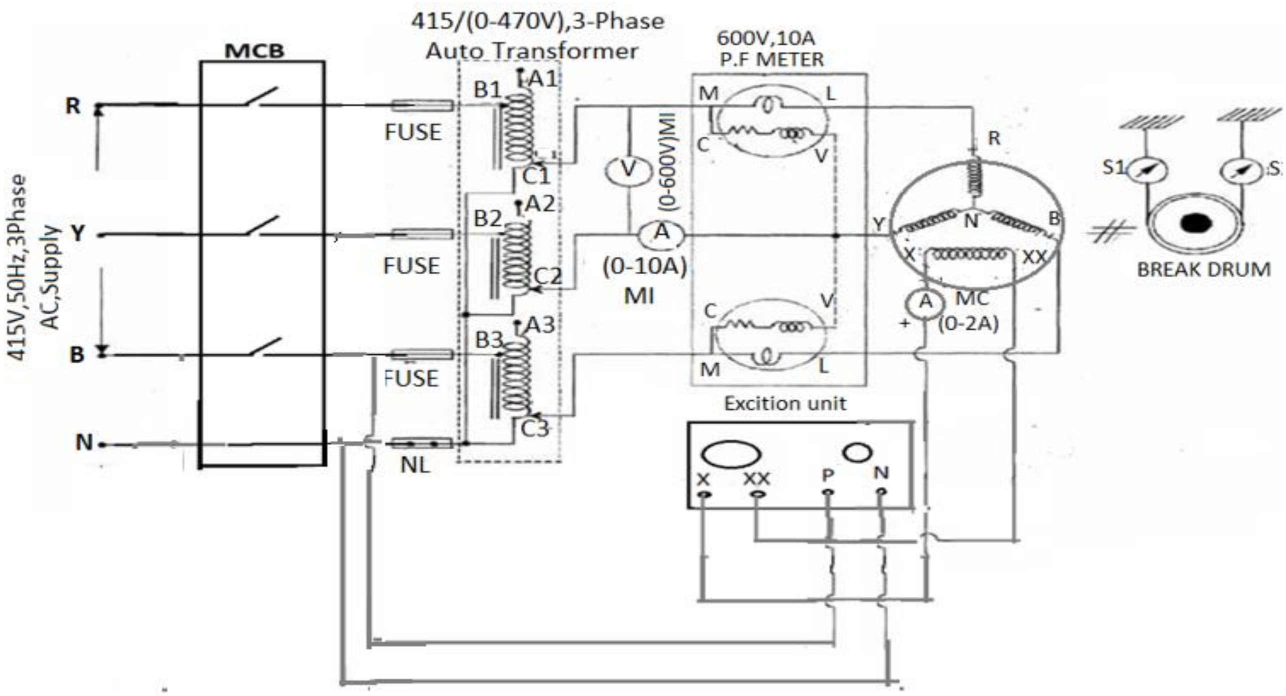
Name plate details:

S.NO	Specifications	Ratings
1	Voltage	415V
2	Power	3kVA
3	current	4.2A
4	Speed	1500rpm

Apparatus required:

S.No.	Name of the apparatus	Range	Type	Quatity
1.	Ammeter	(0-2)A	Digital	1
2.	Ammeter	(0-10)A	Digital	1
3.	Voltmeter	(0-600)V	Digital	1
4.	Wattmeter	600V,10A	Digital	1
5.	Tachometer	(0-3000)rpm	Digital	1
6.	Rheostat	220Ω/2A	Wire wound	2
7.	Connecting wires		-	required

Circuit diagram:



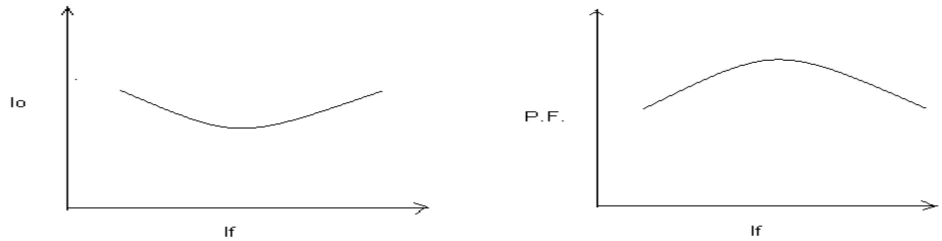
Procedure:

1) Connect the circuit as per the diagram.
2) Start synchronous motor by using rotor resistance starter.
3) Close DPST switch of excitation circuit by gradually increasing the excitation, note down the values of ammeter and wattmeter readings.
4) Repeat experiment until armature current reaches 125% of rated current.
5) Gradually decrease excitation and switch off supply
6) Tabulate the readings.

Observations:

S.No.	Field Current(If) (Amps)	Armature current(Ia) (Amps)	Wattmeter (P) (Watts)	CosΦ= P/(√3*V*I)

Expected Graphs:



Result:

9) EQUIVALENT CIURCUIT AND PRE-DETERMINATION OF PERFORMANCE CHARACTERISTICS OF 1-Φ INDUCTION MOTOR

AIM: to conduct no load and blocked rotor tests and to find equivalent circuit parameters and performance characteristics

NAME PLATE DETAILS:

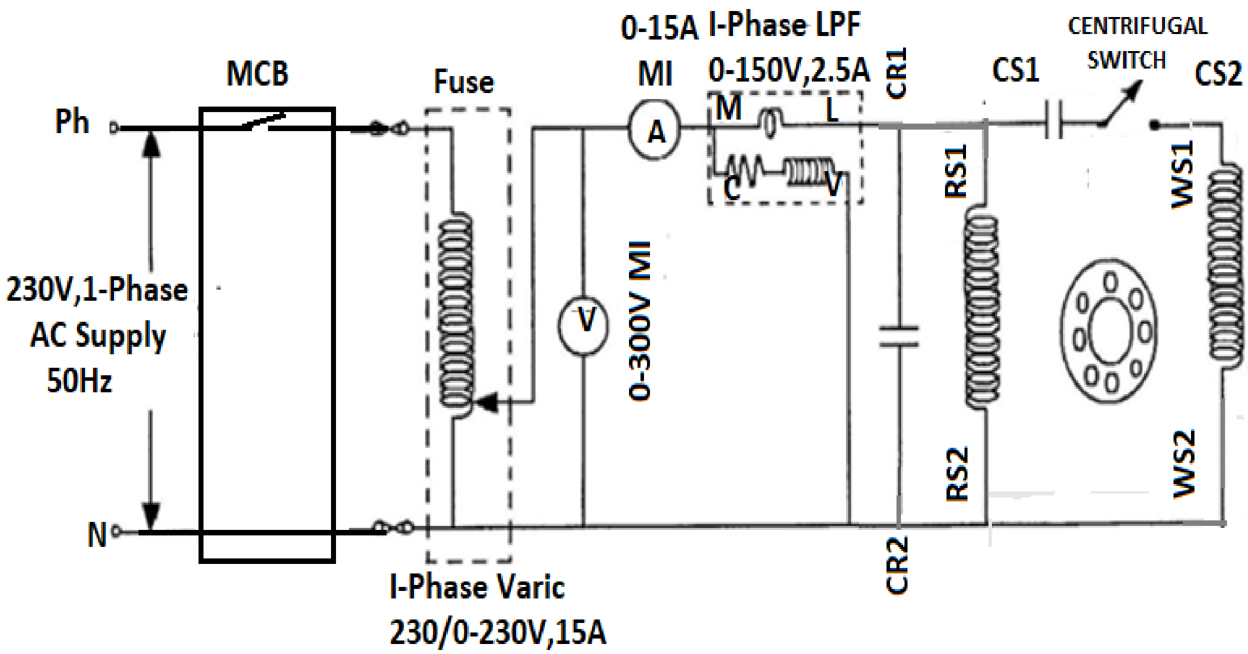
Parameter	1Φ-InductionMotor
Rated Power	1HP
Rated Voltage	230V
Rated Current	6A
Rated Speed	1430

APPARATUS REQUIRED:

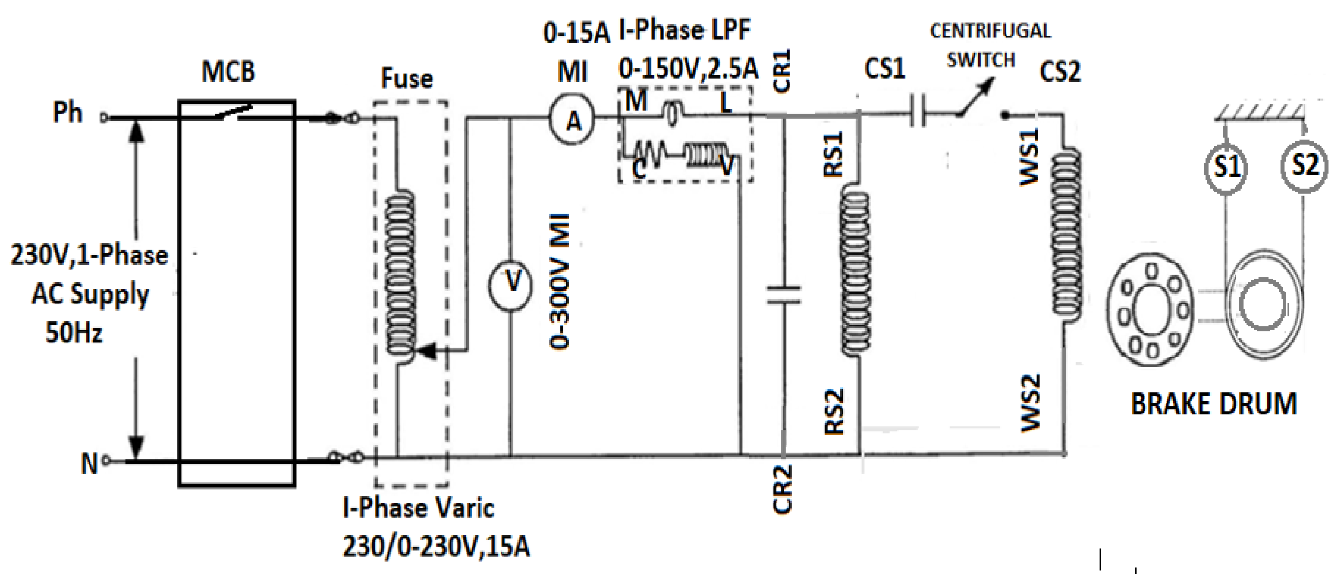
S. No	Name of Apparatus	Range	Type	Qty.
1	Voltmeter	0-300	Digital	
2	Ammeter	5A	Digital	
3	Wattmeter	300V,2A,LPF	Digital	
4	Wattmeter	75V,5A,UPF	Digital	
5	Connecting wires			

CIRCUIT DIAGRAM:

NOLOAD TEST ON SNGLE PHASE INDUCTION MOTOR:



BLOCKED ROTOR TEST ON SNGLE PHASE INDUCTION MOTOR:



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.

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.

PRECAUTIONS:

NO LOAD TEST:

1. Initially MCB is kept open.
2. Autotransformer is kept at minimum potential position.
3. The machines must be started on no load.

BLOCKEDROTOR TEST:

1. Initially the MCB is kept open.
2. Autotransformer is kept at minimum potential position.
3. The machine must be started at full load (blocked rotor). Reff=1.5*Rdc

FORMULAE:

NO LOAD TEST:

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

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

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

$$X_o = Z_o \sin\phi_o$$

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

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

BLOCKEDROTOR 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 $x_1 = x_2$

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

TABULAR COLUMNS

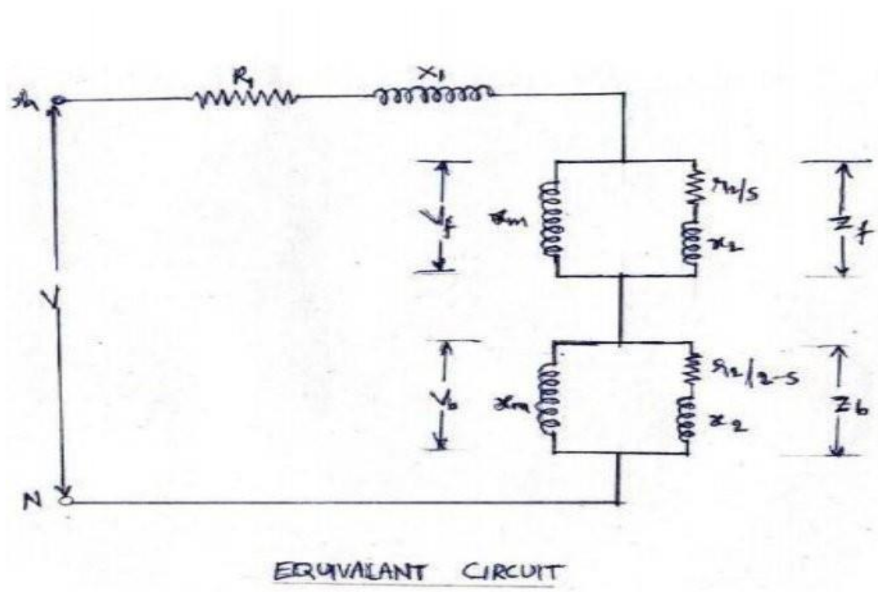
NO LOAD TEST:

S.No.	Vo(volts)	Io(amps)	Wo (watts)
1			

BLOCKEDROTOR TEST:

S.No.	Vsc (volts)	Isc (amps)	Wsc(watts)
1			

EQIVALENT CIRCUIT:



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?

10 REGULATION OF THREE PHASE ALTERNATOR BY ZPF METHOD

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

NAME PLATE DETAILS:

Specifications	**Alternator**	**Motor**
Voltage	415V	220V
Current	4.2A	19.5A
Power	3KVA	5H.P.
Speed	1500	1500
Connection	Star	DC

APPARATUS REQUIRED:

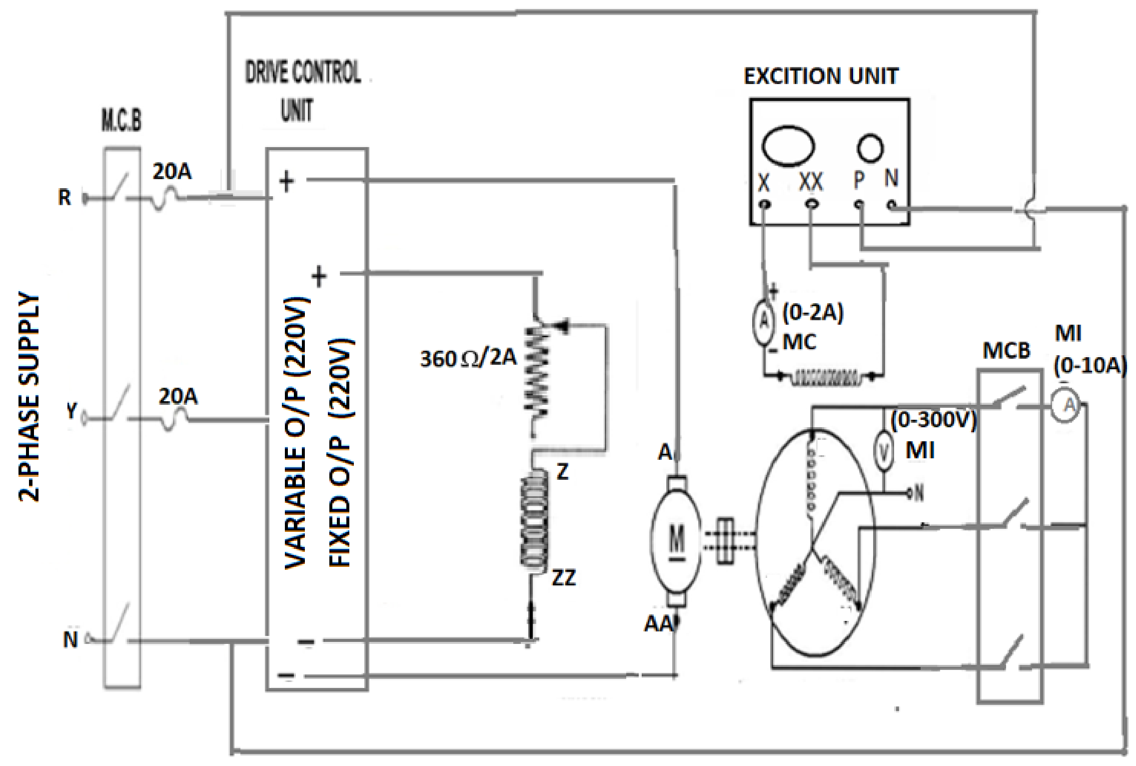
S. No	**Name of Apparatus**	**Range**	**Type**	**Qty.**
1	Voltmeter	(0—600v)	Digital	1
2	Voltmeter	(0—150v)	Digital	1
3	Ammeter	(0—10A)	Digital	1
4	Ammeter	(0—10A)		1
5	Ammeter	(0—2A)		1
6	Rheostat	Wire wound		1
7	Rheostat	Wire wound		1
8	Connecting wires	-		Required

FUSE RATING CALCULATION:

125% of rated current.

No-load test - 10% of rated current.

CIRCUIT DIAGRAM:



FORMULAE USED:

1. From Poitier triangle BCD, the armature leakage reactance drop is l (DE)
   Iph * XL ph = l (DE) x scale

2.Iph = KVA/(√3* VL) Ampere

3. (E1 ph)2 = (Vph Cos φ + Iph Ra ph)2 + (Vph Sin φ ± Iph XL ph)2
   + for lag; - for lead.

4.Field excitation If 1 required to induce E1 ph is obtained from open circuit characteristics.

5. The field current If 2 required to balance armature reaction is obtained from Potier triangle. If 2 = l (BE) x scale

6. Resultant field current, If2 = I2f 1 + I2f 2 – 2 If 1 If 2 Cos (90 ± φ)
+ for lag; - for lead.

7. Obtain Eph corresponding to resultant field current, If from open circuit characteristics. 8. % regulation =( )x 100

TABULATION:

OPEN CIRCUIT TEST:

S.NO	Field Current (If) (Amp)	Open Circuit Line Voltage (Voc)L (Volts)	Open Circuit Phase Voltage (Voc) ph = (Voc)L / √3 (Volts)

SHORT CIRCUIT AND ZPF TEST:

	Short Circuit Test		Zero Power Factor Test		
S.NO	Field Current (If)(Amp)	Short Circuit Current (Isc)(Amp)	Field Current (If) (Amp)	Rated Armature current (Ia)(Amp)	Rated Armature Voltage (Volt)

PRECAUTION:

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

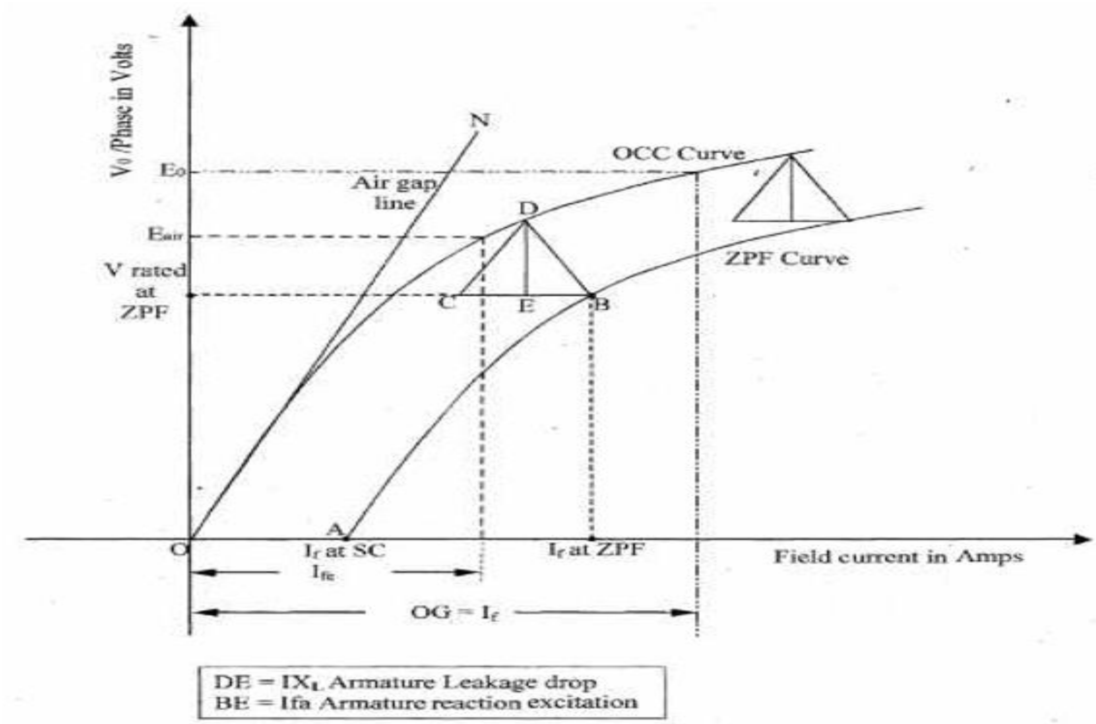
PROCEDURE:

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

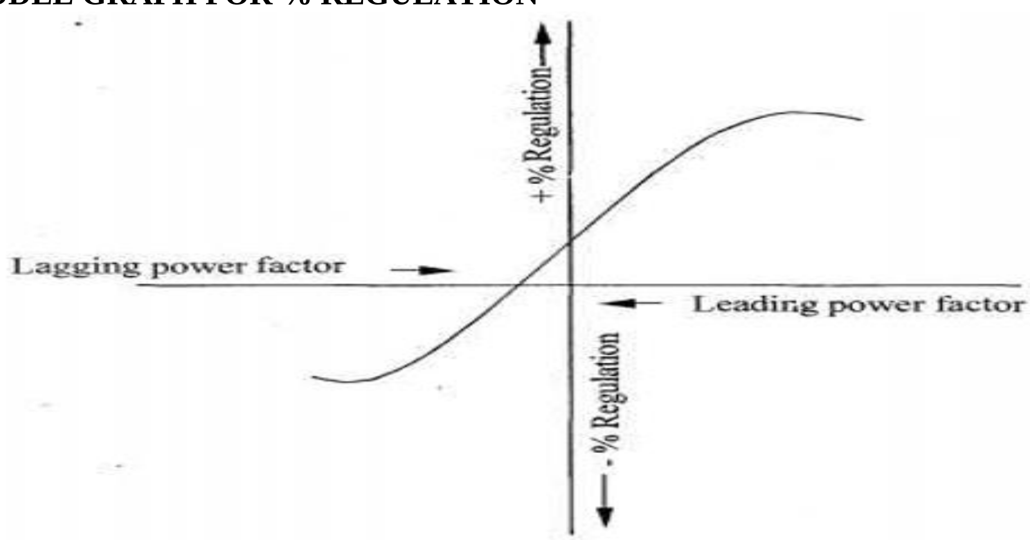
PROCEDURE TO DRAW THE POTIER TRIANGLE:

1. Draw the open circuit characteristics curve (generated voltage per phase Vs field current)
2. Mark the point A at X-axis, which is obtained from short circuit test with full load armature current.
3. From the ZPF test, mark the point B for the field current to the corresponding rated armature current and the rated voltage.
4. Draw the ZPF curve which passing through the point A and B in such a way parallel to the open circuit characteristics curve.
5. Draw the tangent for the OCC from the origin (i.e.,) air gap line.
6. Draw the line BC from B towards Y axis, which is parallel and equal to OA.
7. Draw the parallel line for the tangent from C to the OCC curve.
8. Join the point B and D. Also drop a perpendicular line DE to BC. Line DE represent armature leakage reactance drop (IXL) and BE represent armature reaction excitation.

MODEL GRAPH



MODEL GRAPH FOR % REGULATION



TABULATION FOR % REGULATION:

S.NO	Power factor	E1 ph Volts		If 1 (A)		If 2 (A)	If (A)		Eph (V)		% Regulation	
		Lag	Lead	Lag	Lead		Lag	Lead	Lag	Lead	Lag	Lead
1	0.1											
2	0.2											
3	0.3											
4	0.4											
5	0.5											
6	0.6											
7	0.7											
8	0.8											
9	0.9											
10	1											

RESULT:

11)MEASUREMENT OF NEGATIVE SEQUENCE AND ZERO SEQUENCE IMPEDANCE OF AN ALTERNATOR

AIM: To determine the negative sequence and zero sequence impedance of an alternator

NAME PLATE DETAILS:

	Alternator	**Motor**
Voltage	415V	220V
Current	4.2A	19.5A
Power	3KVA	5H.P.
Speed	1500	1500
Connection	Star	DC

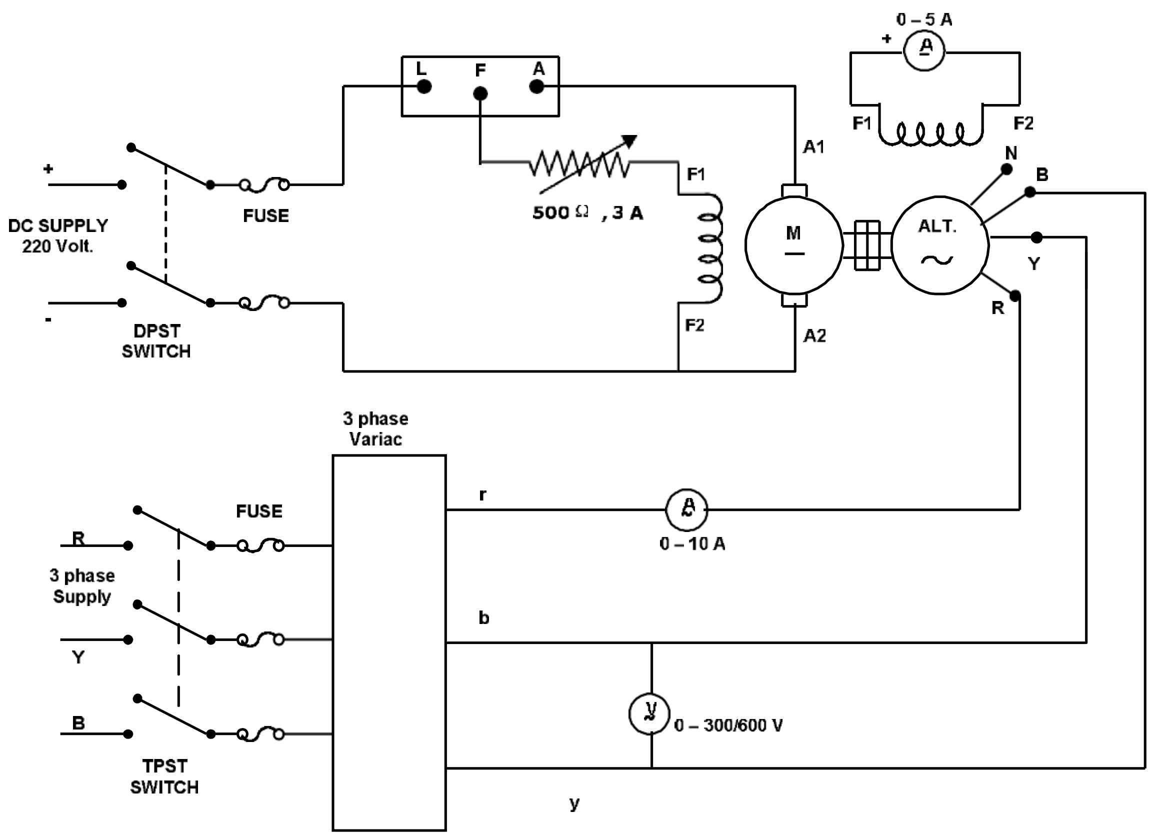
APPARATUS REQUIRED:

Sl.No	**Instrument/Equipment**	**Type**	**Specification**	**Quantity**
1	Ammeter	Digital	0 – 5/10 A	1 No
2	Ammeter	Digital	0 – 5 A	1 No
3	Voltmeter	Digital	0 – 75/150 V	1 No
4	Voltmeter	Digital	0 – 300/600 V	1 No
5	Rheostat	Tubular	360Ohm/2A	1 No
6	1-ϕVariac	Iron core	230 V, 10 A	1 No
7	3-ϕVariac	Iron core	415 V, 10 A	1 No
8	Tachometer	Digital	--	1 No
9	Connecting Wires	Cu	1.5 sq. mm	As required

Machine specification:

Sl.No	Machine	Specification	Quantity
1.	D.C. Motor coupled with 3-Φ Alternator	D.C. Shunt Motor :-6 HP , 1500 RPM 220 V , 24 A , Excitation- 220 V/ 2 A 3-Φ Alternator :-5 kVA , 415 V,50 Hz 7 A ,1500 RPM ,0.8 pf Excitation- 220 V/4 A	1 Set

CIRCUIT DIAGRAM:



Circuit Diagram for negative sequence reactance (X_2).

PRECAUTION:

- While applying voltage the armature current should not exceed 7 A.
- The short circuit current should be kept low in order to avoid undue heating of the field winding.

PROCEDURE:

1. For negative sequence synchronous reactance(X_2)

1. Connect the circuit as shown in Fig-1.
2. Rotate the rotor at synchronous speed with field winding unexcited & short circuited.
3. Apply the balanced 3-ϕ voltage.
4. Note down the instrument readings in observation table-1.
5. Switch off the 3-ϕ supply & stop the machine.

2. For zero sequence synchronous reactance(X_0)

1. Connect the circuit as shown in Fig-2.
2. Rotate the rotor at synchronous speed with field winding unexcited & short circuited.
3. Apply the 1-ϕ voltage.
4. Note down the instrument readings in observation table-2.
5. Switch off the1-ϕ supply & stop the machine.

OBSERVATION:

Table-1 for X_2

Sl. No	V	I	I_f	P	X_2

Table-2 for X_0

Sl. No	V	I	I_f	X_0

CALCULATIONS:

$$X2 = \frac{V}{\sqrt{3}I}$$

$$X0 = \frac{3V}{I}$$

RESULT:

VIVA-VOICE:

1. Define positive, negative and zero sequence components for unbalanced power system.
2. Can zero sequence currents produce rotating field? Justify your answer.
3. Explain how double frequency current are produced in the rotor field when negative sequence currents are impressed on armature.
4. Explain why X_1& X_2 are different in synchronous machine whereas they are equal in Transformer.
5. Explain how X_2 is arithmetic sum of "X_d" and "X_q".