Ahsanullah University of Science and Technology

Department of Electrical and Electronic Engineering

LABORATORY MANUAL

FOR

ELECTRICAL AND ELECTRONIC SESSIONAL COURSES

Student Name :

Student ID :

Course no : EEE-2188

Course Title : Electrical Machines

For the students of

Department of Mechanical and Production Engineering

2nd Year, 1st Semester

Experiment no: **1**

Experiment name: **Study of a Single-Phase Transformer.**

Introduction:

A transformer is a static device by means of which electric power in one circuit is transferred into electric power in another circuit of the same frequency. It can raise or lower voltage in the circuit with a corresponding decrease or increase in current. So the volt-ampere rating of two circuits remains same. The simple structure of a 1-ϕ transformer is shown below:

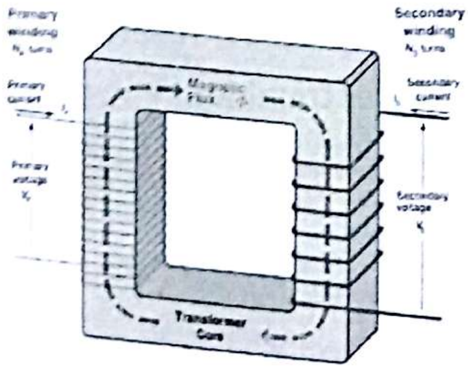


Fig: Simple structure of a 1-ϕ transformer

As the volt-ampere rating of two sides are same so

$$V_1 * I_1 = V_2 * I_2$$

i.e. $V_1/V_2 = I_2/I_1$ ....(1)

Again the induced voltage in the transformer is directly proportional to the no of turns surrounding the transformer windings. So

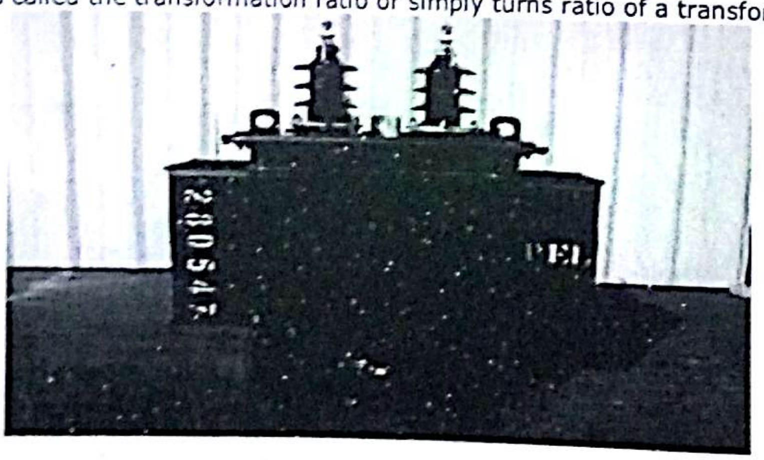
$V_1 \propto N_1$ and $V_2 \propto N_2$

i.e. $V_1/V_2 = N_1/N_2$ -------------------------- (2)

Combining these two equations, (1) and (2) we get

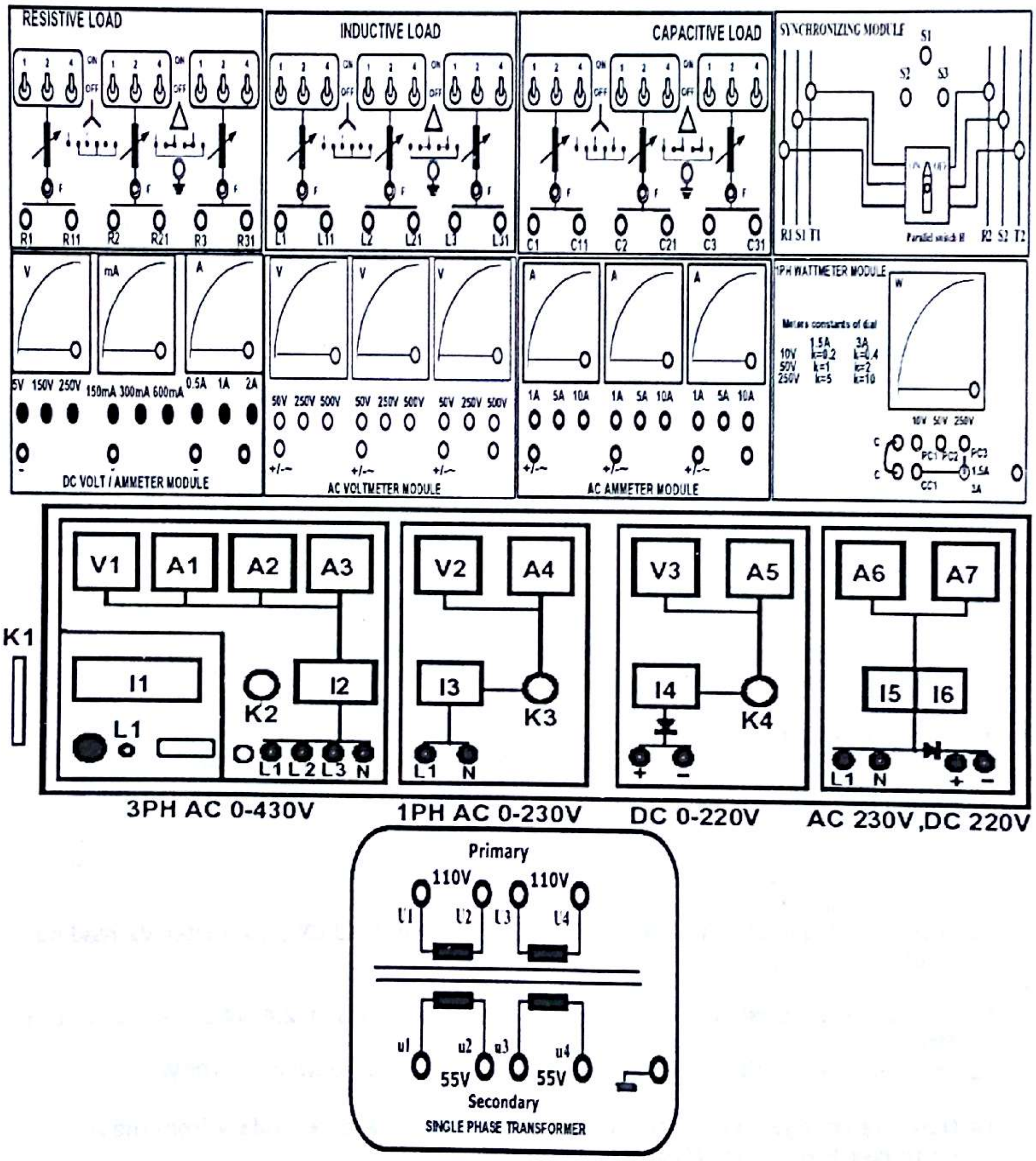
$$V_1/V_2 = I_2/I_1 = N_1/N_2$$

Where N_1/N_2 is called the transformation ratio or simply turns ratio of a transformer



Equipments:

1. Universal Power Supply Module
2. 1PH Transformer
3. AC Ammeter Module 0-1A
4. AC Voltmeter Module 0-250 V
5. Resistive Load
6. 1PH Wattmeter Module

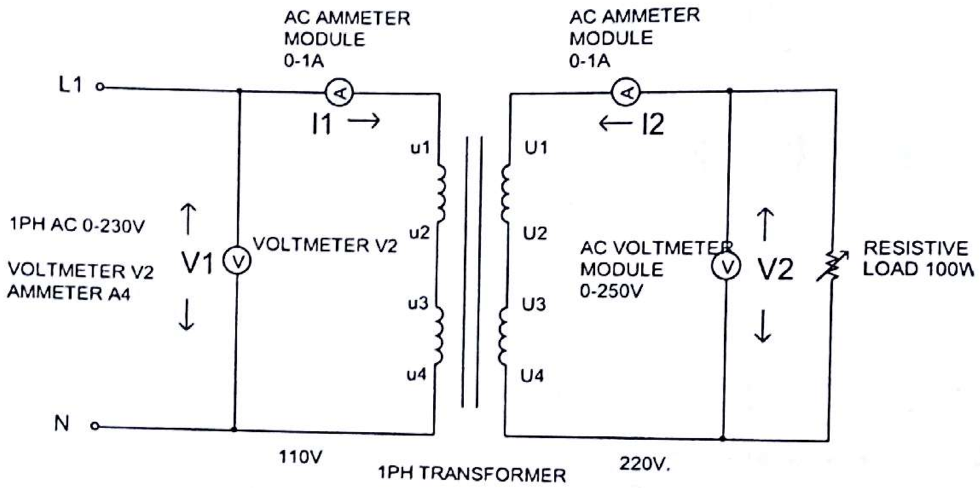


Ratio Test:

For a transformer, we know, the transformation ratio is given by

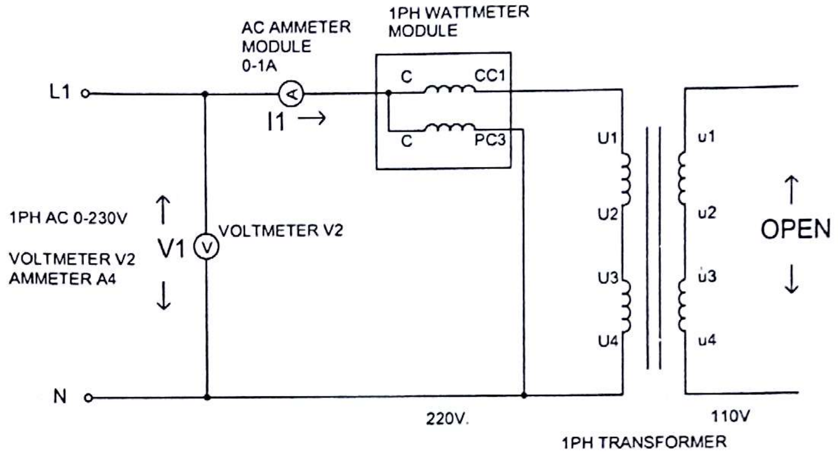
$$\frac{V_1}{V_2} = \frac{I_2}{I_1} = \frac{N_1}{N_2}$$

We shall determine the transformation ratio by measuring the voltages and currents both in the primary and secondary side.



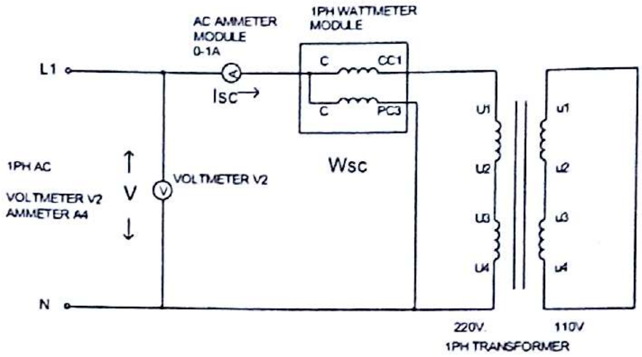
1. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
2. Make sure all the variable knobs (K1, K3, K4) are at the min, counter clock wise (CCW) position.
3. Make sure all the switches (1,2,4) of the Resistive Load Module are OFF (downwards)
4. Make connections according to the above diagram.
5. Verify the connection by your Lab Teacher
6. Turn ON Switch I1 (upwards).
7. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.
8. Make sure the 3PH supply Voltmeter V1 reading 400V.
9. Turn Knob K3 at min (CCW)
10. Turn ON switch I3 (upwards).
11. Slowly Increase 1PH AC Voltage to 110V, Turn Knob K3 CW, Voltmeter V2 reading 110V
12. Increase the Resistive Load by turning ON the switches (1,2,4) of the Resistive Load Module.
13. Increase Load until the current becomes 0.5A, so that power >= 100W
14. Note the voltages and currents both in the primary and secondary from the AC Voltmeter & Ammeter Module

Transformer on No-load/Open Circuit Test:



1. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
2. Make sure all the variable knobs (K1, K3, K4) are at the min, counter clock wise (CCW) position.
3. Make connections according to the above diagram.
4. Verify the connection by your Lab Teacher
5. Turn ON Switch I1 (upwards).
6. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.
7. Make sure the 3PH supply Voltmeter V1 reading 400V.
8. Turn Knob K3 at min (CCW)
9. Turn ON switch I3 (upwards).
10. Slowly Increase 1PH AC Voltage to 220V, Turn Knob K3 CW, Voltmeter V2 reading 220V
11. Note the voltages and currents in the primary from the AC Voltmeter & Ammeter Module

Short Circuit Test: This test determines copper loss in the transformer. Finding this loss the regulation of the transformer can be determined. The circuit arrangement of this test is shown below:



From the wattmeter, voltmeter, ammeter readings, we get

$$W_{CU} = W_{SC} = R_{01} * I_{SC}^2 \quad \text{i.e.} R_{01} = W_{SC}/I_{SC}^2$$

$$X_{01} = \sqrt{((V/I_{SC})^2 - R_{01}^2)}$$

Procedure:

1. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
2. Make sure all the variable knobs (K3, K4) are at the min, counter clock wise (CCW) position.
3. Make connections according to the above diagram.
4. Verify the connection by your Lab Teacher
5. Turn ON Switch I1 (upwards).
6. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.
7. Turn Knob K3 at min (CCW)
8. Turn ON switch I3 (upwards).
9. **Carefully increase the voltage till the rated current (300VA ÷ 220V = 1.4A) flows through the HT, Turn Knob K3 CW**
10. Note the readings on AC Voltmeter, Ammeter and Wattmeter Module

***** For each case write down the data on data sheet.**

Report:

1. What effects are produced in a transformer by change in voltage?
2. Does the transformer draw any current when its secondary is open? If yes, then why?

Group No:
Roll no:

Data Sheet

Ratio test:

V_1 = V_2 = I_1 = I_2 =

Calculate Transformation ratio:

Transformer on No-load:

I_{OC} = V_{OC} = W_{OC} =

Short Circuit Test

I_{SC} = V_{SC} = W_{SC} =

Calculation

Core loss = W_{OC} =

$\Phi_0 =$

$I_W = I_{OC} \cos\Phi_0 =$

$I\mu = I_{OC} \sin\Phi_0 =$

Core resistance (ref. to H.T. side) $= \dfrac{V_{OC}}{I_W} =$

Core reactance (ref. to H.T. side) $= \dfrac{V_{OC}}{I_\mu} =$

Copper loss $= W_{Cu} = W_{SC} =$

Equivalent Resistance (ref. to H.T. side) $= R_{01} = \dfrac{W_{SC}}{I_{SC}^2} =$

Equivalent Reactance (ref. to H.T. side) $= X_{01} = \sqrt{(V_{SC}/I_{SC})^2 - R_{01}^2}$

Signature of the Lab teacher:

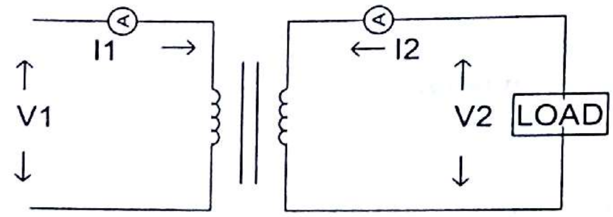
Experiment no: **2**

Experiment name: **To determine the regulation of a transformer under different power factor for both Single and Three phase Transformer.**

Introduction:

Regulation is an indication of voltage changes due to change in load. Any equipment is said to have good regulation if this change of voltage is less. It is defined as

$$\% R = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$$

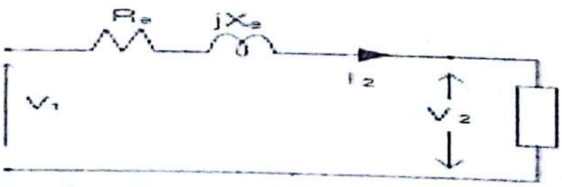


1PH TRANSFORMER

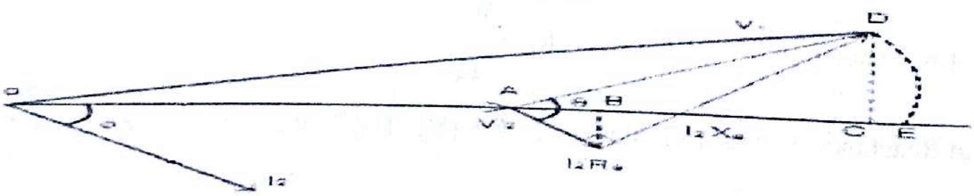
For a transformer, for constant primary voltage as load increases, the voltage at the load decreases, as there is voltage drop due to internal resistance and reactance of the transformer. If we know the resistance and reactance of the transformer, its regulation can be determined under various load conditions.

Equipments:

1. Universal Power Supply Module
2. 1PH Transformer
3. AC Ammeter Module 0-1A
4. AC Voltmeter Module 0-250 V
5. 1PH Wattmeter Module
6. Resistive Load Module
7. Inductive Load Module
8. Capacitive Load Module
9. Connecting Cables

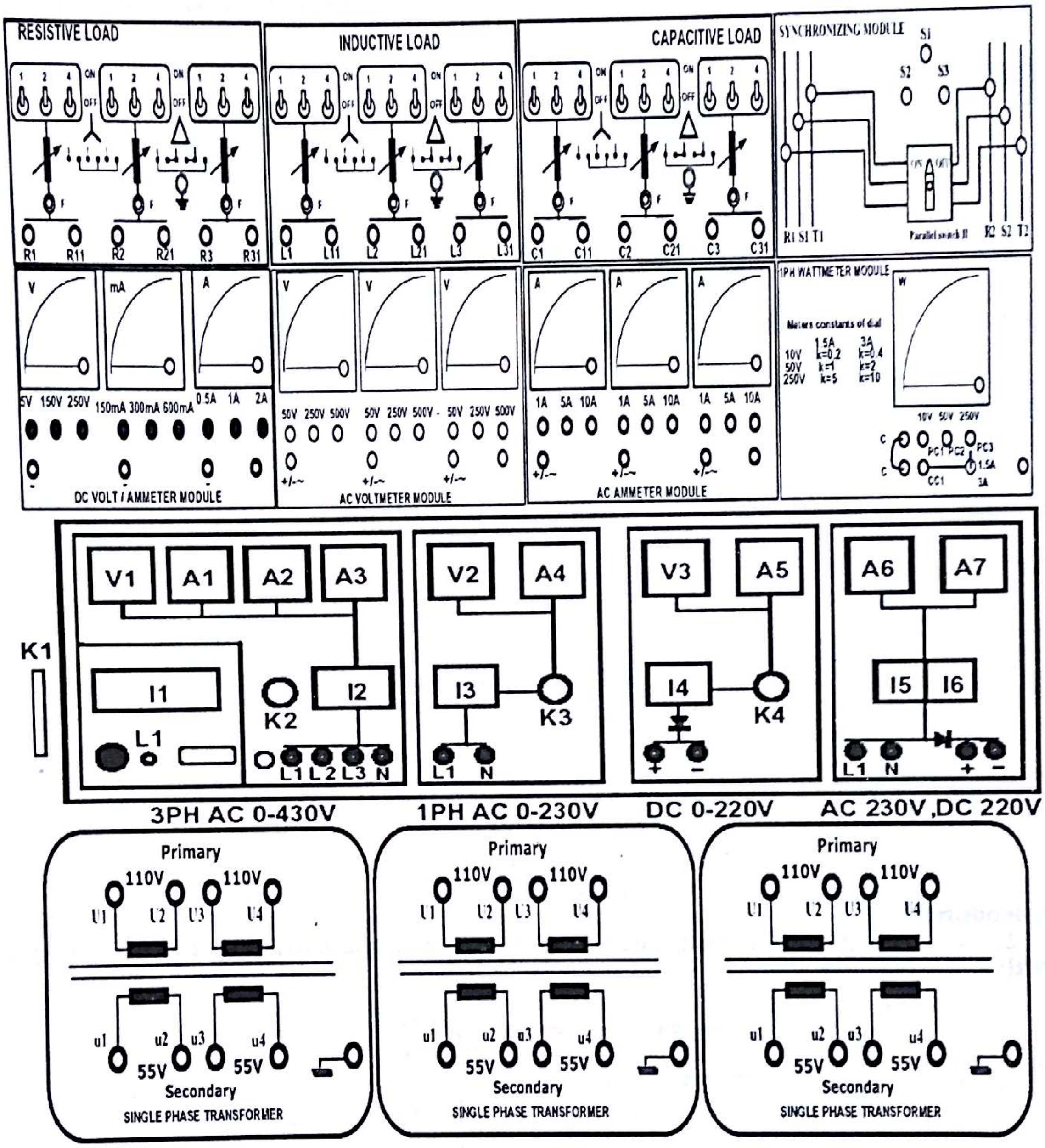


(a) Equivalent Circuit



(b) Phasor Diagram

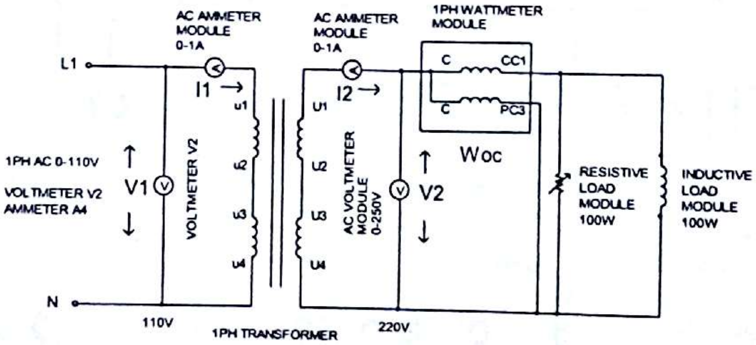
Connection Diagram:



Procedure:

1. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
2. Make sure all the variable knobs (K3, K4) are at the min, counter clock wise (CCW) position.
3. Make connections according to the above diagram.
4. Verify the connection by your Lab Teacher
5. Turn ON Switch I1 (upwards).
6. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.
7. Turn Knob K3 at min (CCW)
8. Turn ON switch I3 (upwards).
9. Keep all the Loads at OFF position
10. Apply voltage **110V** on the LT side.
11. Note the readings on AC Voltmeter, Ammeter and Wattmeter Module
12. Now turn ON all the Loads
13. Note the readings on AC Voltmeter, Ammeter and Wattmeter Module

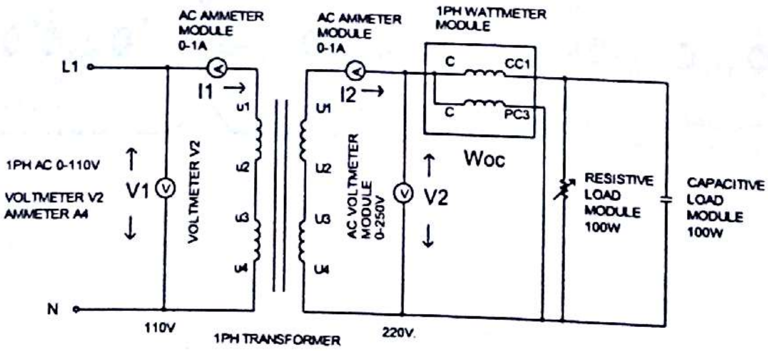
With R-L Load:



Procedure:

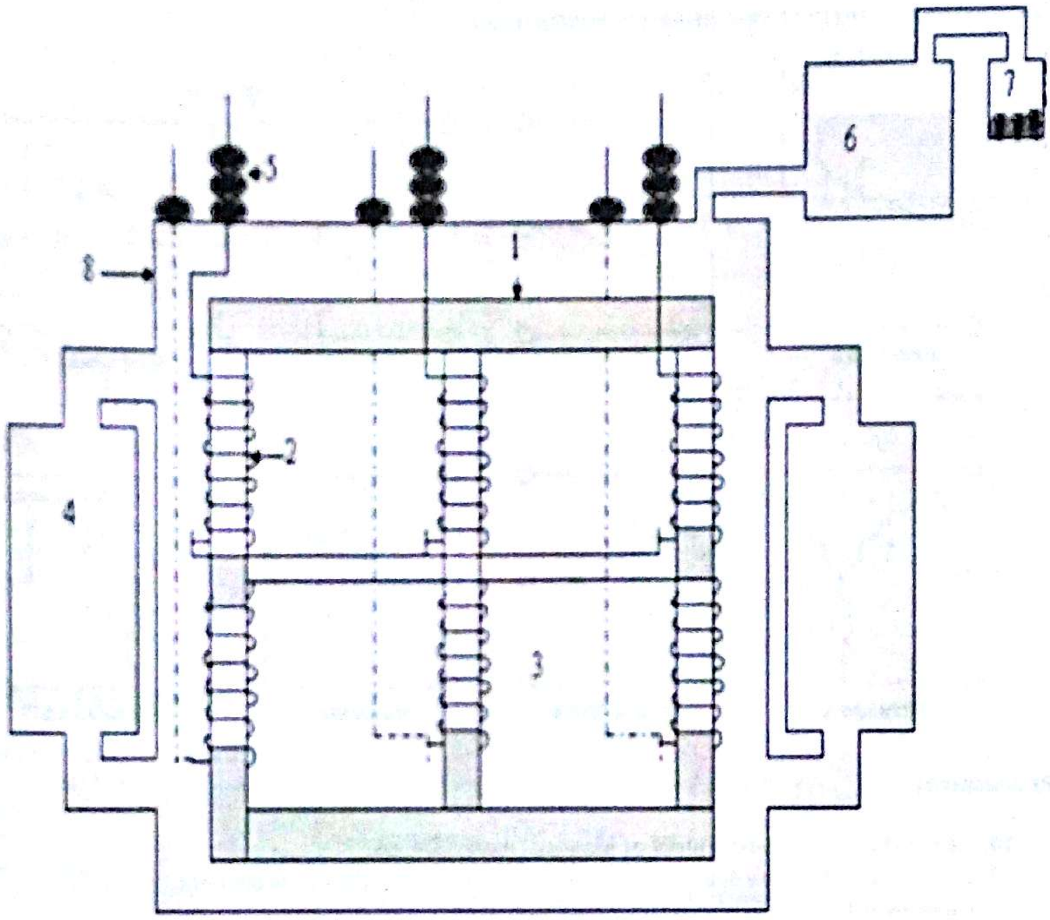
1. Follow the procedure mentioned on Resistive Load for the above Diagram

With R-C Load:



Procedure:

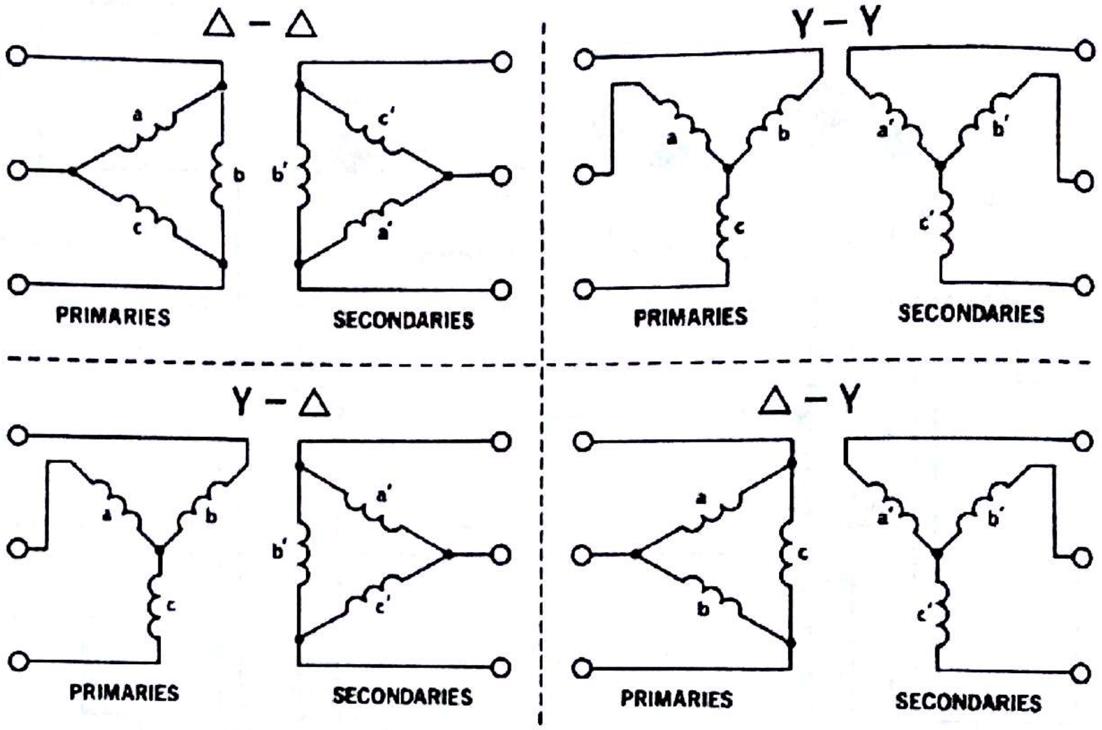
1. Follow the procedure mentioned on Resistive Load for the above Diagram



Important parts of a three-phase transformer

1. **Core**- Core is made by laminated silicon steel
2. **Coil**- Coil(winding) is simply made by insulated copper wire
3. **Transformer oil (mineral oil)** - Transformer oil has two functions one is to provide necessary insulation for the core and coli and other one is to absorb the heat produce by the power loss of transformer.
4. **Fin**- Cooling system for heated transformer oil.
5. **Bushing**- Bushing is used to connect the coils (primary and secondary) to the outer circuit for rigid fitting and avoiding the contact with transformer tank.
6. **Conservator**- Conservator holds the excess oil when the oil gets expanded.
7. **Breather with Silica gel**- Breather is used to pass the air inward and outward of a transformer through conservator and silica gel absorb the moisture of air.
8. **Transformer tank**- Transformer tank houses core, coil and oil.

Connection to form three-phase transformer:



Procedure:

14. Select three 1-ϕ transformers of identical manufacturer.
15. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
16. Make sure all the variable knobs (K3, K4) are at the min, counter clock wise (CCW) position.
17. Make connections according to the above diagram.
18. Verify the connection by your Lab Teacher
19. Now verify the advantages for each type of combination.
20. Keep all the Loads at OFF position
21. Apply voltage **110V** on the LT side.
22. Note the readings on AC Voltmeter, Ammeter and Wattmeter Module.
23. Now turn ON all the Loads.
24. Note the readings on AC Voltmeter, Ammeter and Wattmeter Module.

With constant resistive load determine the efficiency for each combination.

Report:
Draw the vector diagrams under unity, lagging and leading pf and calculate analytically the regulation in each case. Compare the value of regulation found analytically with that of experimental value.

Comment on the regulation under leading pf is it something different? Comment on this value.

Group No:
Roll no:

Data Sheet

With Resistive Load		
Terminal Voltage =	Load current =	Load power =
With R-L Load		
Terminal Voltage =	Load current =	Load power =
With R-C Load		
Terminal Voltage =	Load current =	Load power =

With Δ-Δ connection

With Resistive Load		
Terminal Voltage =	Load current =	Load power =
With R-L Load		
Terminal Voltage =	Load current =	Load power =
With R-C Load		
Terminal Voltage =	Load current =	Load power =

With Y Y connection

With Resistive Load		
Terminal Voltage =	Load current =	Load power =
With R-L Load		
Terminal Voltage =	Load current =	Load power =
With R-C Load		
Terminal Voltage =	Load current =	Load power =

With Y-Δ connection

With Resistive Load		
Terminal Voltage =	Load current =	Load power =
With R-L Load		
Terminal Voltage =	Load current =	Load power =
With R-C Load		
Terminal Voltage =	Load current =	Load power =

With Δ-Y connection

With Resistive Load		
Terminal Voltage =	Load current =	Load power =
With R-L Load		
Terminal Voltage =	Load current =	Load power =
With R-C Load		
Terminal Voltage =	Load current =	Load power =

Signature of the lab Teacher

Experiment no: **3**
Experiment name: **Open Circuit Characteristics (OCC) Of Separately- Excited Shunt Generator**

Introduction:
In this type of generator, the field coil is energized from an independent external DC source. The circuit diagram of a separately excited shunt generator is shown below:

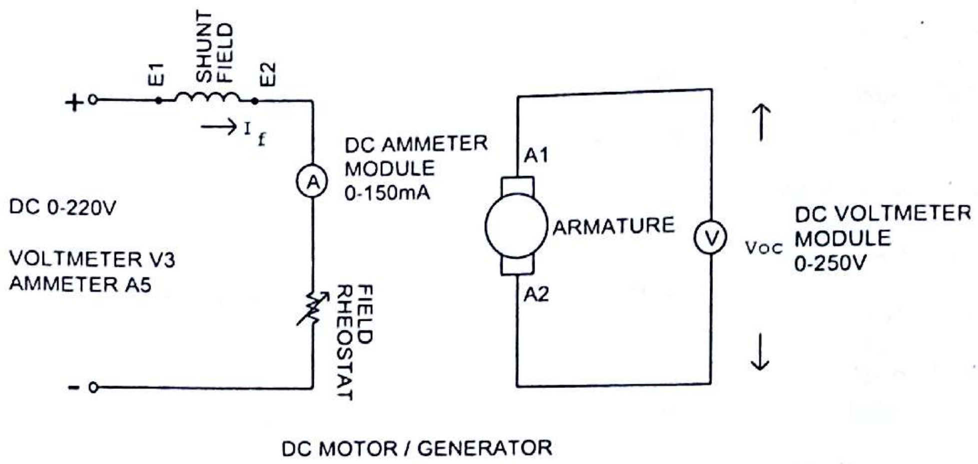


Fig: Separately Excited Shunt Generator

Voltage developed in the DC generator in general form,
$E_G = \phi ZN/60 * (P/A)$ volt
Where, E_G = Generated Emf.
ϕ = Flux/pole in Weber.
Z = Total no of armature conductors.
N = Armature rotation in rpm.
P = No of generator poles.
A = No of parallel paths in armature.

For a given D.C machine Z, P, A are constant. So the voltage equation becomes
$E_G = K_g \phi N$ volt, Where $K_g = ZP/(60*A)$

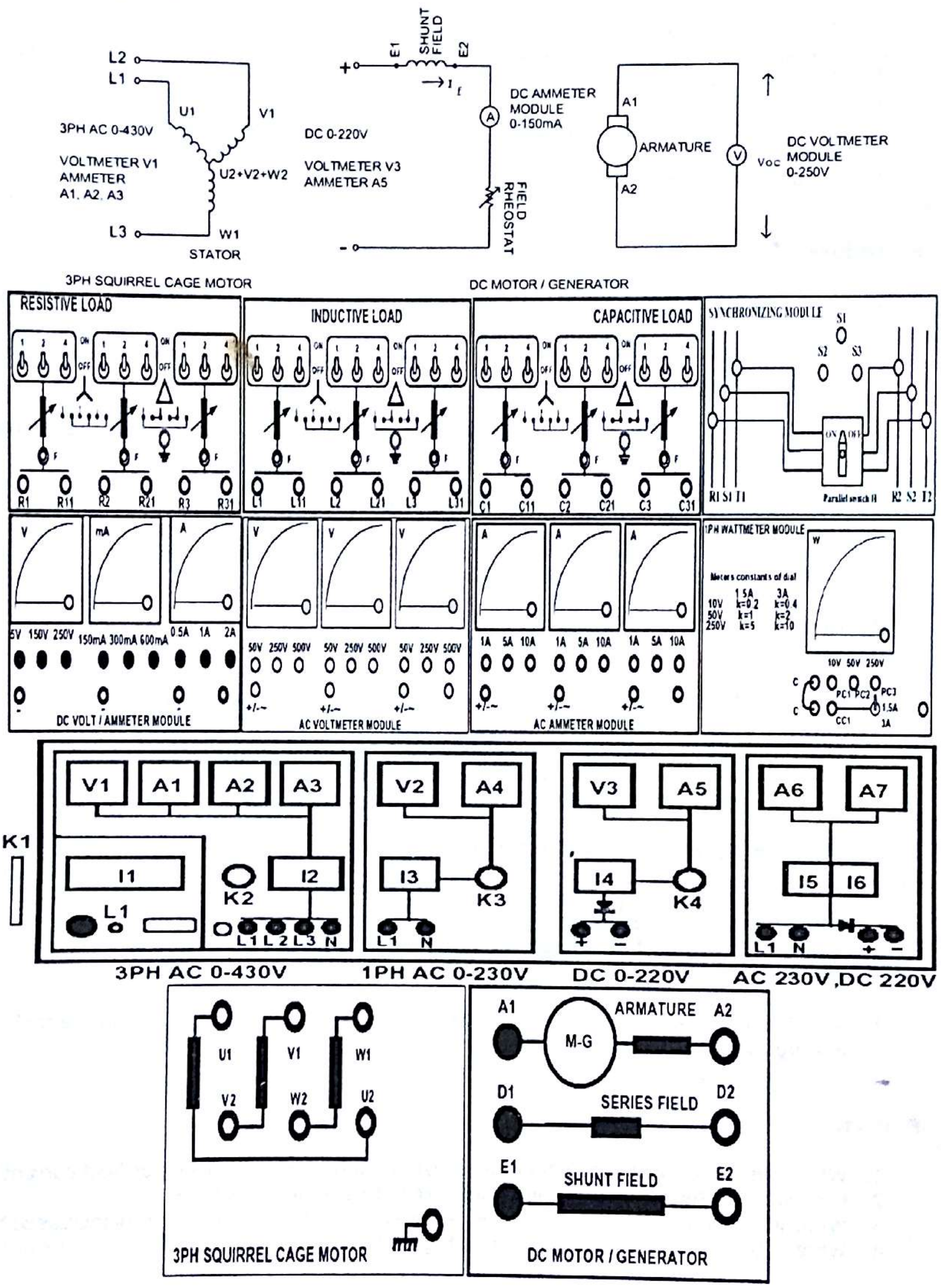
If armature rotation is constant, then **$E_G = K\phi$ volt.**

So the generated voltage is directly proportional to field flux, i.e. field current I_f.
One of the generator characteristics is defined by the **O.C.C** i.e. open circuit characteristics.

The shape of the **O.C.C** is same for all kinds of generator whether separately excited or self excited. It shows the relation between the no-load generated voltage in armature, E_G and the field or exciting current I_f at a given speed.

It is just the magnetization curve for the material of the electromagnet.

Circuit Diagram:



Equipments:

1. Universal Power Supply
2. 3PH Squirrel Cage Induction Motor (Prime Mover)
3. DC Motor / Generator
4. Field Rheostat
5. DC Voltmeter / Ammeter Module
6. Coupling Sleeve
7. Connecting Cables

Procedure:

1. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
2. Make sure all the variable knobs (K1, K3, K4) are at the min, counter clock wise (CCW) position.

3. With a sensitive Multi-meter, measure the shunt field and armature resistance; write the values on the data sheet.

4. Make connections according to the above diagram.
5. Verify the connection by your Lab Teacher
6. Make sure the 3PH Squirrel Cage Induction Motor is mechanically coupled with DC Motor / Generator through the coupling sleeve.

7. Turn ON Switch I1 (upwards).
8. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.

9. Make the 3PH supply at 400V by turning Knob K1, the Voltmeter V1 reading 400V.
10. Turn ON Switch I2 (upwards).
11. 3PH Squirrel Cage Induction Motor should start running at this point.
12. Also DC Motor / Generator starts running since it is mechanically coupled with 3PH Squirrel Cage Induction Motor.

13. Take reading Voc on DC Voltmeter Module (0-250V), If=0.

14. Turn Knob K4 at min (CCW)
15. Turn ON switch I4 (upwards).
16. Increase Shunt Field DC Voltage to 220V, Turn Knob K4 CW, Voltmeter V3 reading 220V

17. Vary Field Rheostat from Min to Max and take readings of Voc & If. Fill up the table-1. Plot Voc vs. If.

Report:

1. Why does the curve tend to become horizontal after a certain value of field current?
2. Can you use the same machine as self-excited generator? Explain.
3. What will happen to the O.C.C curve, if the speed of the prime mover is increased?
4. What is the reason of having some voltage without any excitation?

Group No:
Roll no:

Data Sheet

Armature resistance, $\mathbf{R_a}$ =
Field resistance, $\mathbf{R_{sh}}$ =

Table-1

Field current I_f (mA)	Open circuit voltage V_{oc} (volt)

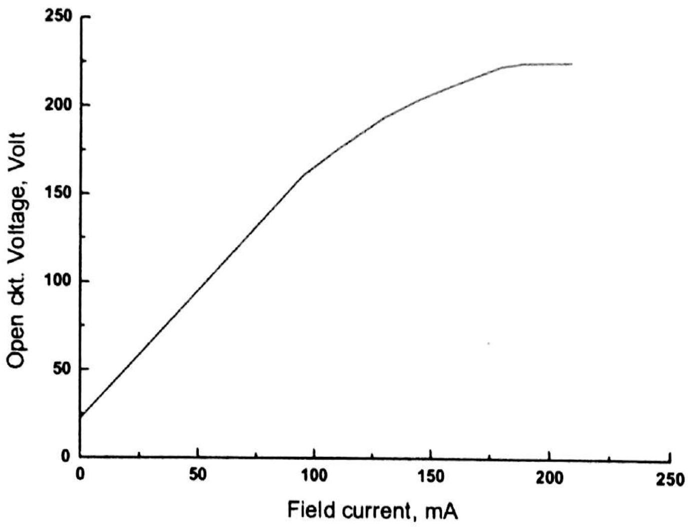
Calculation and Graph
Plot $\mathbf{V_{oc}}$ vs. $\mathbf{I_f}$ on a graph paper and determine the value of critical resistance from this plot.

Signature of the Lab teacher:

Sample Data & Graph

Field current I_f (mA)	Open circuit voltage V_{oc} (volt)
0	22
95	161
110	176
120	185
130	194
145	204
160	212
180	222
190	224
200	224
210	224

<u>Plot of O.C.C:</u>



Experiment no: **4**
Experiment name: **Determination of losses of a DC machine.**

Introduction:
When a DC machine runs either as a motor or generator, losses take place.

These losses are:
Copper losses: Armature copper loss + field copper loss.
Magnetic losses: Eddy current loss + Hysteresis loss
Mechanical losses: Friction loss + bearing loss

Magnetic losses and mechanical losses are collectively known as stray losses. They are also known as rotational losses.

Equipments:

1. Universal Power Supply
2. DC Motor / Generator
3. Field Rheostat
4. DC Voltmeter / Ammeter Module
5. Tachometer
6. Multimeter
7. Coupling Sleeve
8. Connecting Cables

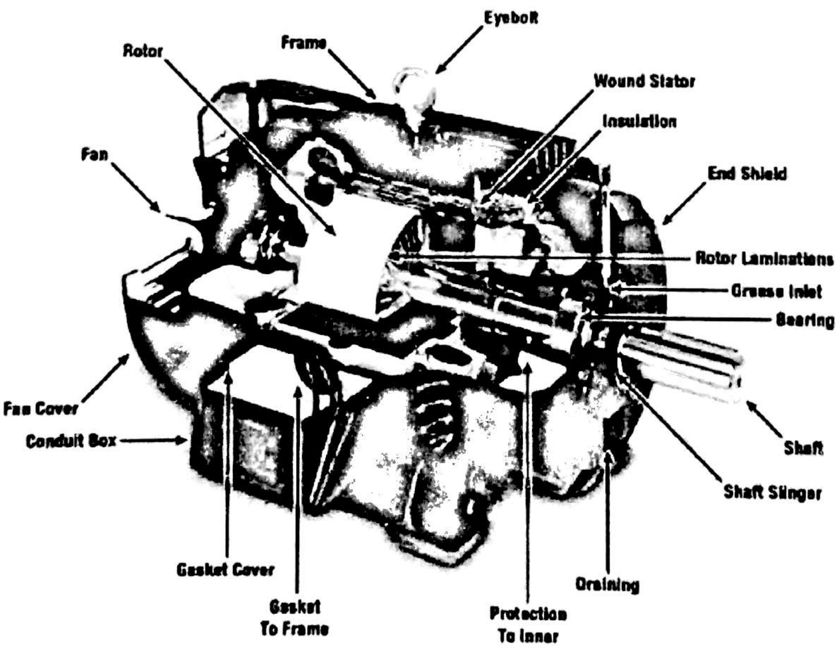
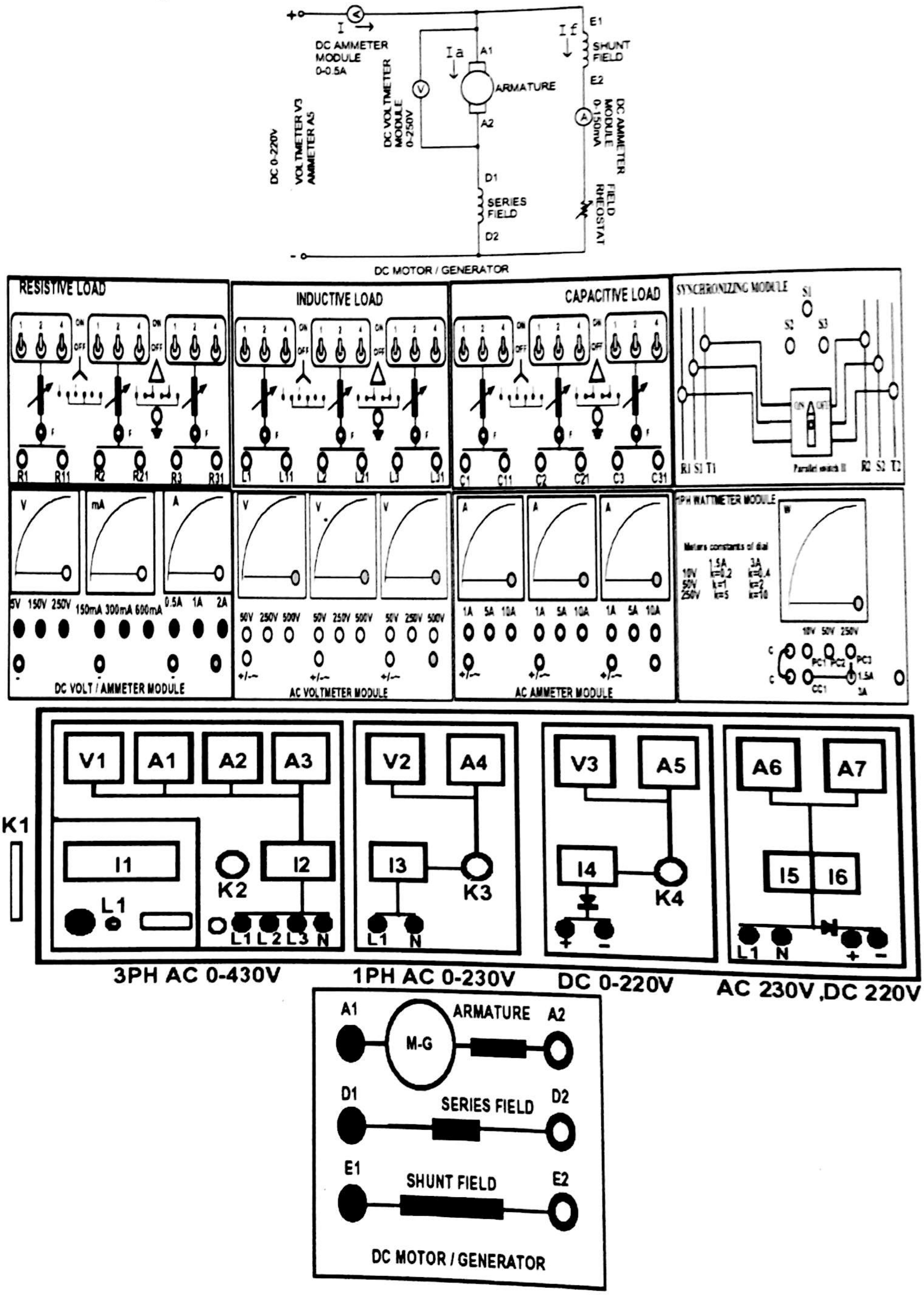


Figure 8 - Motor Construction

Connection Diagram:



Procedure:

1. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
2. Make sure all the variable knobs (K3, K4) are at the min, counter clock wise (CCW) position.
3. With a sensitive Multi-meter, measure the shunt field and armature resistance; write the values on the data sheet.
4. Make connections according to the above diagram.
5. Verify the connection by your Lab Teacher
6. Turn ON Switch I1 (upwards).
7. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.
8. Make sure the 3PH supply Voltmeter V1 reading 400V.
9. Turn Knob K4 at min (CCW)
10. Turn ON switch I4 (upwards).
11. **SLOWLY** Increase Armature DC Voltage to 120V, Turn Knob K4 CW, Voltmeter V3 Adjust field rheostat to obtain the rated speed 3000RPM
12. Now increase the armature voltage by 20 V in each step and adjust the speed to rated speed 3000 RPM by varying field rheostat.
13. Take readings up to rated armature voltage 220V. Fill-up the table-1.
14. Now repeat step 11-13, adjust field rheostat to obtain 75% of rated speed 3000 RPM fill-up table-2.

Calculation + Graph:

1. Calculate copper losses, total power input and armature power output, Po
2. Po vs. armature voltage, Va using the data of table-1 and draw a tangent and extend the tangent to Y-axis. This interception at the Y-axis is the mechanical loss of a machine at rated speed.
3. Repeat step-2 using the data of table-2.
4. At first from plot-1 find Po for a voltage say 180 V. Then subtract mechanical loss (from step-2) from that Po. This will represent the Eddy current and Hysteresis loss. Term this loss as W_1.
5. Repeat step-4 using plot-2 and term this loss as W_2.
6. Now use this equation to isolate Eddy current and Hysteresis loss.
7. $W_1 = AN_1 + BN_1^2$, where N_1 is rated speed
8. $W_2 = AN_2 + BN_2^2$, where N_2 is 75% of rated speed.
9. A and B are Eddy current and Hysteresis loss respectively. Solve two equations to find A and B.

Report:

1. Discuss about the nature of Po vs. armature voltage curve at two different speeds.
2. Comment on the results.

Data Sheet

Armature resistance, R_a =
Field resistance, R_{sh} =
Rated Speed, N =
Rated Voltage =

Group No:
Roll no:

At rated Speed, N =

(A) V_a (Volt)	(B) I_a (D)-(C) (Amp)	(C) I_f (Amp)	(D) Total Current, I (Amp)	(E) Copper loss (Watt) $V_a I_f + I_a^2R_a$	(F) Power Input (watt) Va x I (A)×(D)	(G) Armature Power Output (watt) Po=(F)-(E)

Table-1

At 75% of rated Speed, N =

(A) V_a (Volt)	(B) I_a (Amp)	(C) I_f (Amp)	(D) Total Current, I (B)+(C)	(E) Copper loss (Watt) $V_a I_f + I_a^2R_a$	(F) Power Input (watt) (A)×(D)	(G) Armature Power Output (watt) Po=(F)-(E)

Table-2

Signature of the Lab Teacher

Experiment no: **5**
Experiment name: **Speed Control of a DC Shunt Motor**

Introduction:

Voltage developed in the D.C generator in general form ---

$$\mathbf{E_g = \phi ZN/60 * (P/A) \text{ volt}}$$

The same equation can be written for motor replacing $\mathbf{E_g}$ by $\mathbf{E_b}$ ---

$$\mathbf{E_b = \phi ZN/60 * (P/A) \text{ volt}} \quad \text{-------------------- } \mathbf{(1)}$$

Where, $\mathbf{E_b}$ is called the Back EMF.

The simple diagram of a DC motor is shown below:

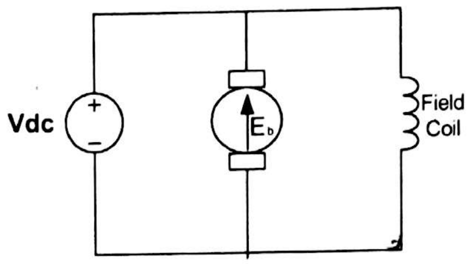


Figure 1: DC Motor

From the diagram, $E_b = V - I_a*R_a$ Where, V = Supply voltage in volt.
I_a = Armature Current in Ampere.
R_a = Armature Resistance in Ohm.

From the equation (1) we get ---- $E_b = \phi*N\ (Z*P/60*A)$
$= \phi*N*K$, where K is constant

i.e. $N = (1/K)* E_b/\phi$
$= K_m * (V - I_a*R_a)/\phi$ r.p.m

So the speed of the DC motor is directly proportional to the supplied voltage applied across the armature and Proportionally decreasing with armature current. The speed is also inversely proportional to the field flux i.e. field current.

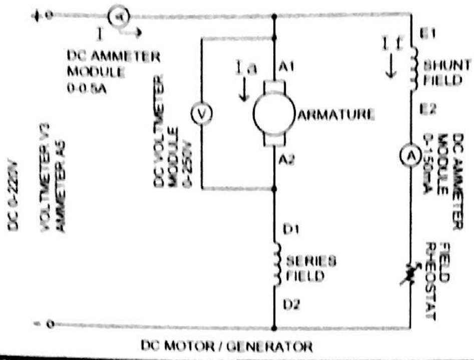
So the speed of the DC motor can be controlled by three methods. They are-

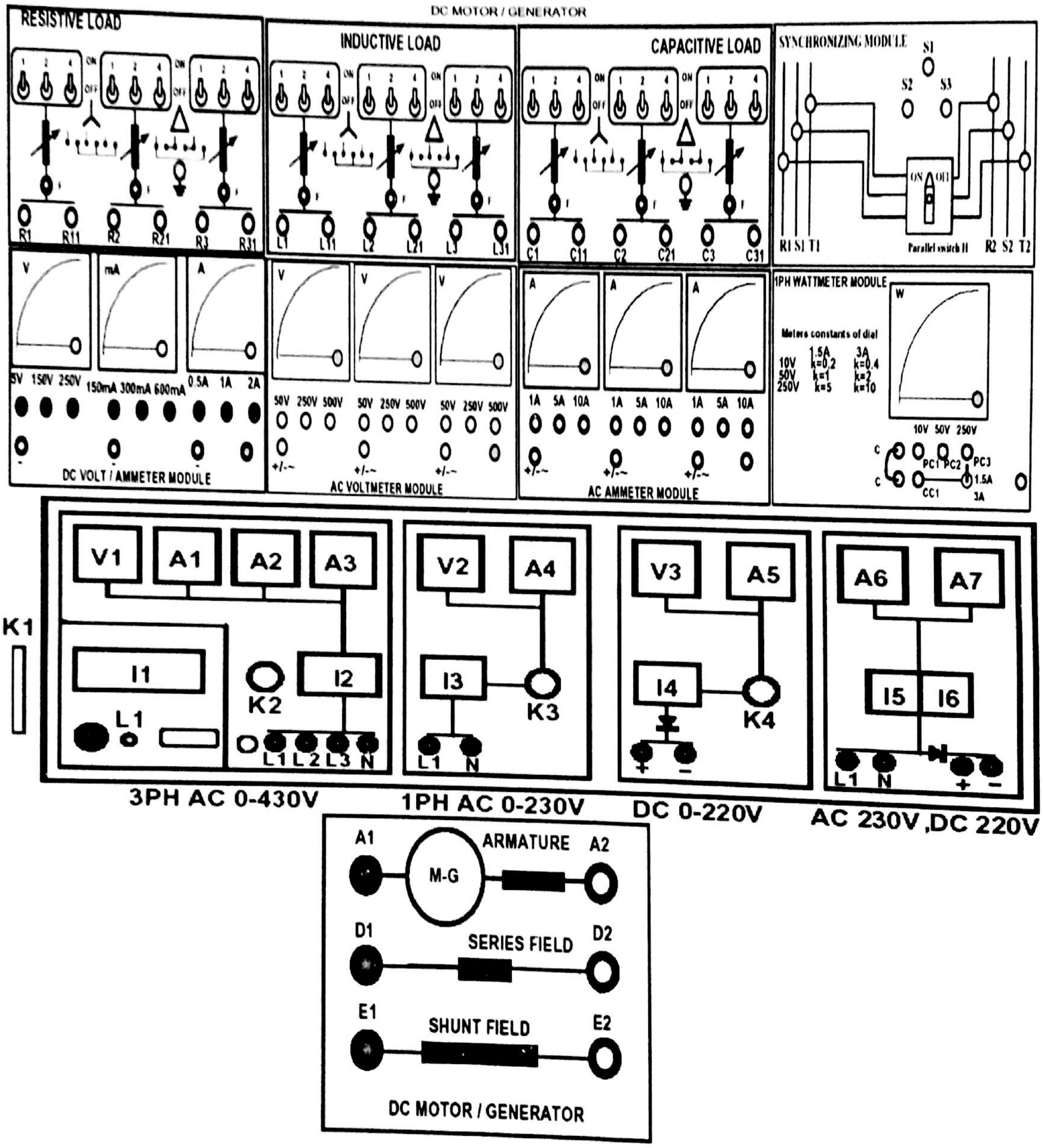
1. Flux Control
2. Armature Resistance Control
3. Voltage Control

Equipments:

1. Universal Power Supply
2. DC Motor / Generator
3. Field Rheostat
4. DC Voltmeter / Ammeter Module
5. Coupling Sleeve
6. Connecting Cables
7. Multimeter

Flux Control Method:

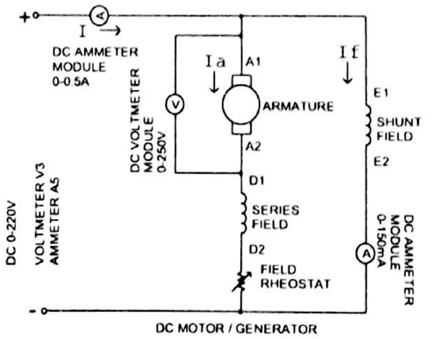




Procedure:

1. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
2. Make sure all the variable knobs (K3, K4) are at the min, counter clock wise (CCW) position.
3. With a sensitive Multi-meter, measure the Series, Shunt field and Armature resistance; write the values on the data sheet.
4. Make connections according to the above diagram.
5. Verify the connection by your Lab Teacher
6. Turn ON Switch I1 (upwards).
7. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.
8. Turn Knob K4 at min (CCW)
9. Turn ON switch I4 (upwards).
10. Keep the Field Rheostat to the Min
11. Make the Motor running by increasing the voltage to 200VDC
12. Make the supply voltage at **200VDC** and keep Field Rheostat at minimum position.
13. Now vary the Field Rheostat and measure the field current $\mathbf{I_f}$ and the motor speed **N** and fill up the Table-1.

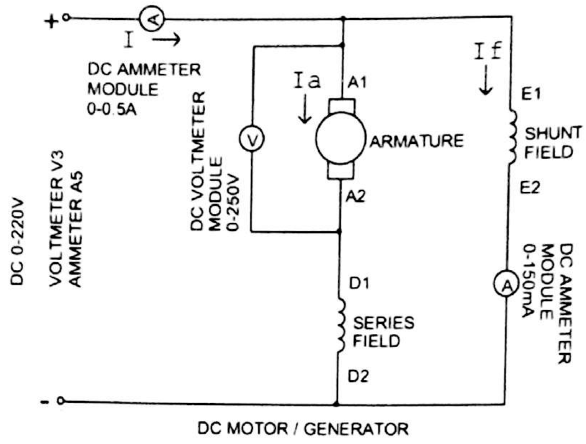
b**) Armature Resistance Control**:



Procedure:

1. Follow the steps from 1-11 of Flux Control Method
2. Make the Motor running by increasing the voltage to **200VDC**
3. Make the supply voltage at **200VDC** and keep Field Rheostat at minimum position.
4. Now vary the Field Rheostat and measure the Armature current Ia and the motor speed N and fill up the Table-2.

c) Voltage Control:



Procedure:

1. Follow the steps from 1-11 of Flux Control Method
2. Make the Motor running by increasing the voltage to **200VDC**
3. Make the supply voltage at **120VDC**
4. Increase the supply voltage and fill up the Table-3.

Report:

1. Explain the curves plotted on the graph paper.
2. Variation of which parameter affects the speed most? Why?
3. Explain the relative merits and demerits of each method.
4. What the significance of Back EMF? Briefly explain.

Group No:
Roll no:

Data Sheet

Table-1		Table-2		Table-3	
I_f (mA)	N (rpm)	I_a (mA)	N (rpm)	V_a (volt)	N (rpm)

Graph

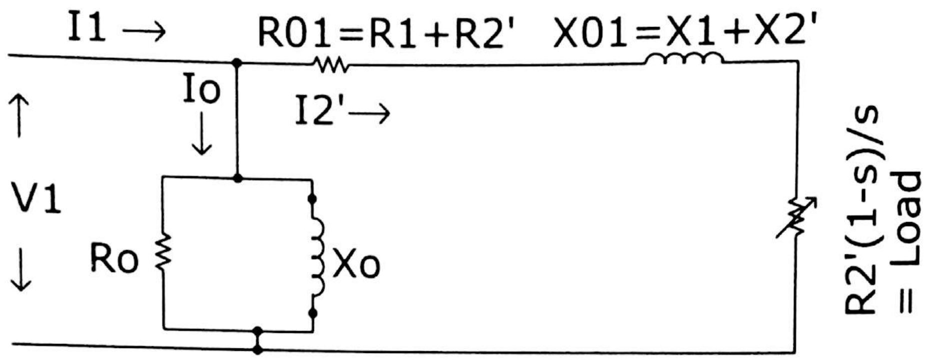
Plot **I_f vs. N**, **I_a vs. N** and **V_a vs. N** on the same graph paper.

Signature of the Lab Teacher

Experiment no: 6
Experiment name: **Determination of Circuit Parameters of a 3 Phase Induction Motor.**

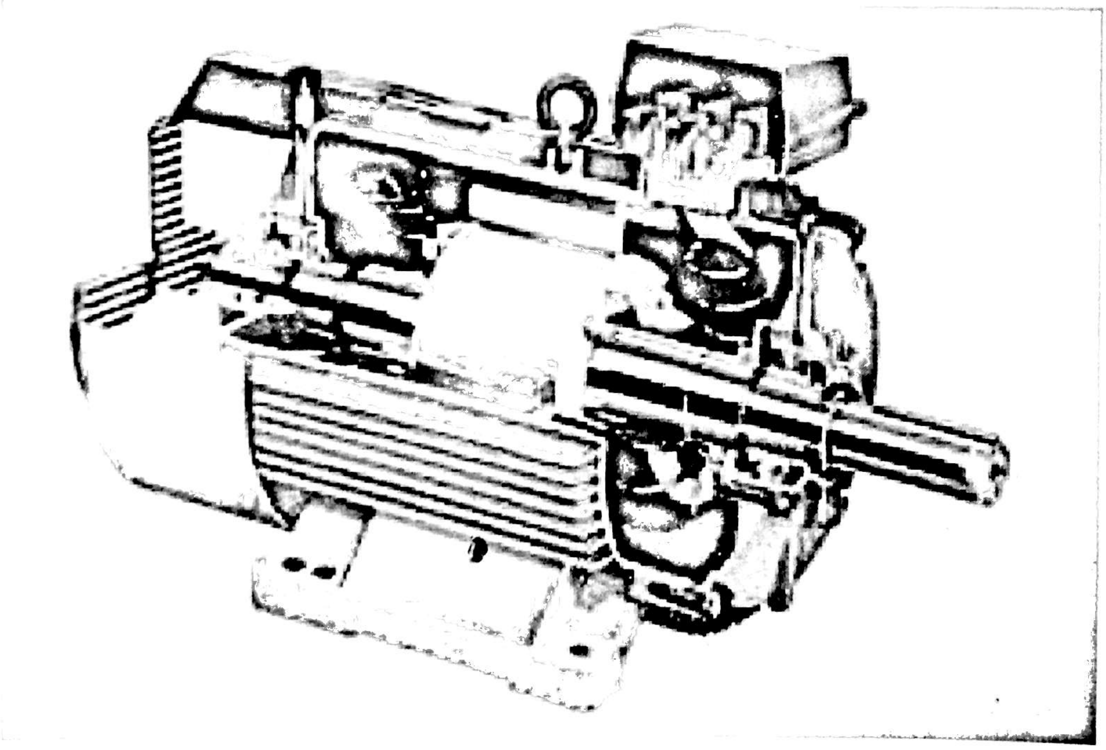
Introduction:

For an induction motor the equivalent circuit referred to secondary (rotor) is basically an R-X circuit with variable s (slip). As load varies, s varies so the magnitude of R varies.



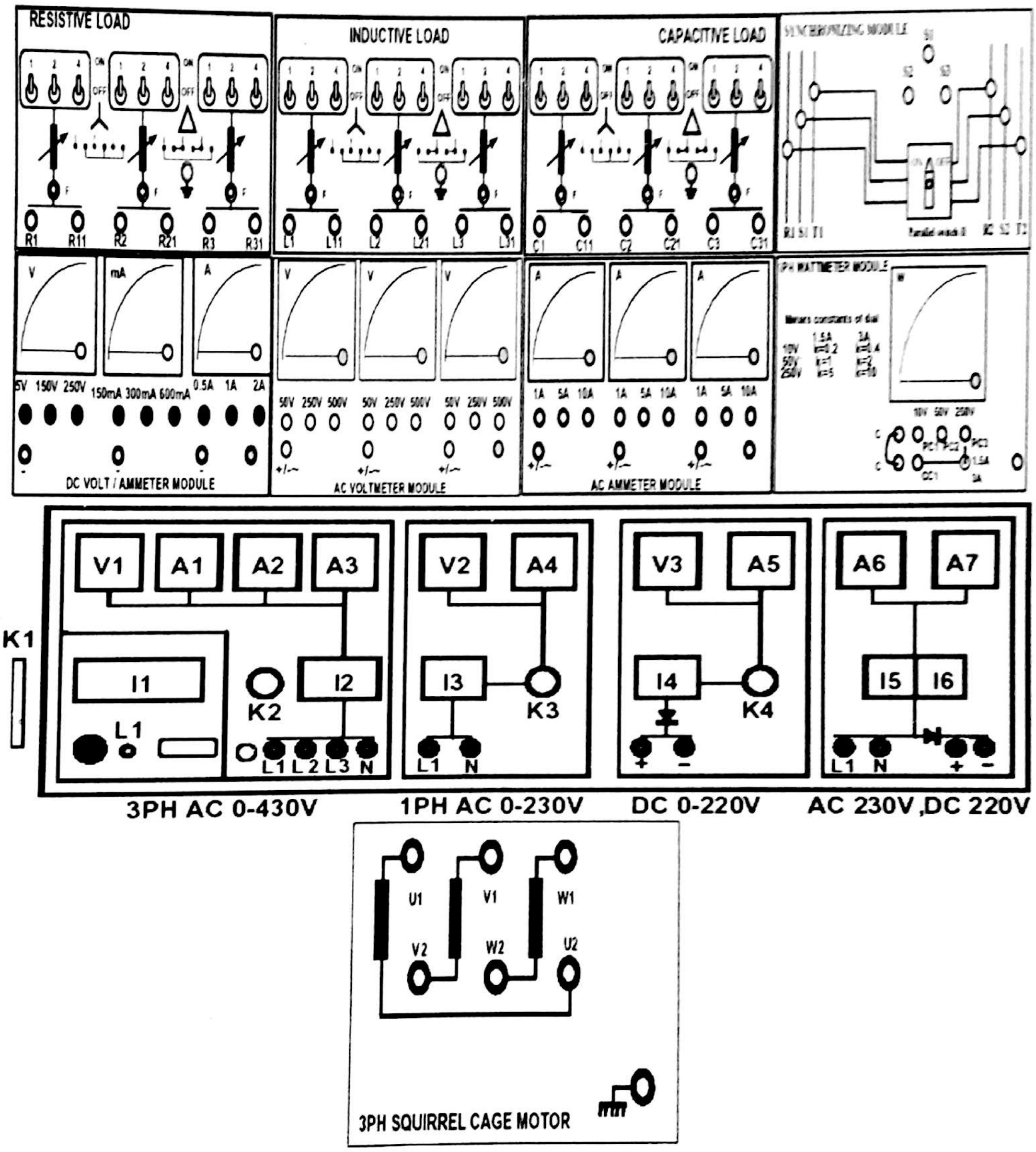
The following tests are required to determine the circuit constants.

1. No- load test
2. Blocked rotor test

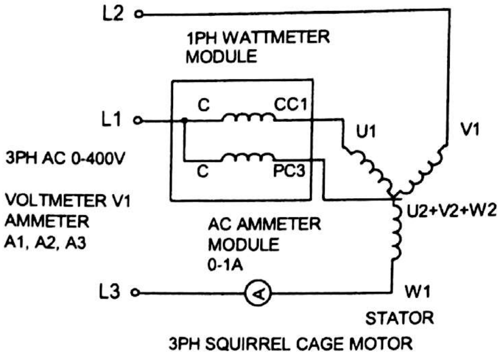


Equipments:

1. Universal Power Supply Module
2. 3 Phase Squirrel Cage Induction Motor
3. AC Ammeter Module 0-1A
4. AC Voltmeter Module 0-250 V
5. 1PH Wattmeter Module
6. Connecting Cables



A. No-Load Test:



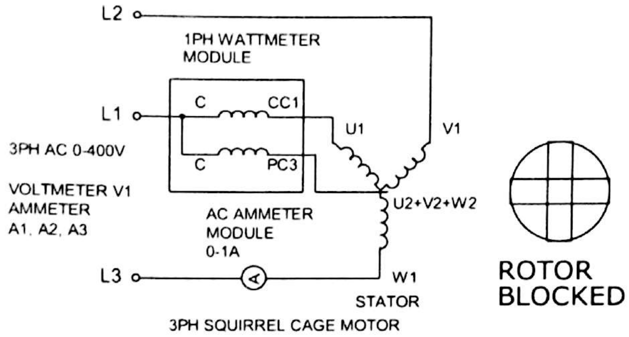
Procedure:

1. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
2. Make sure all the variable knobs (K1, K3, K4) are at the min, counter clock wise (CCW) position.
3. Make connections according to the above diagram.
4. Verify the connection by your Lab Teacher
5. Turn ON Switch I1 (upwards).
6. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.
7. Turn knob K1, Apply **400VAC** on the Stator of the Motor.
8. Turn ON Switch I2 (upwards).
9. 3 Phase Squirrel Cage Motor Starts Running
10. Note the readings on AC Voltmeter, Ammeter and Wattmeter Module

B. Blocked Rotor Test

This is also known as locked rotor or short circuit test. This test is used to find:

(i) Short circuit current with normal voltage applied to the stator.
(ii) Power factor on short circuit
(iii) To plot the circle diagram.
(iv) To find resistance of motor R01 and leakage reactance X01 (ref. to primary).



Procedure:

1. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
2. Make sure all the variable knobs (K1, K3, K4) are at the min, counter clock wise (CCW) position.
3. Make connections according to the above diagram.
4. Verify the connection by your Lab Teacher
5. Turn ON Switch I1 (upwards).
6. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.
7. ****IMPORTANT:** Make the Stator Voltage **0VAC**
8. ****IMPORTANT:** Note the Rated Stator Current of the 3 Phase Squirrel Cage Motor
9. ****IMPORTANT:** Turn ON Switch I2 (upwards).
10. ****IMPORTANT: Block the rotor** and slowly increase the voltage till rated current flows in the stator.
11. Note the readings on AC Voltmeter, Ammeter and Wattmeter Module

Report:

1. What is slip of an induction motor?
2. Draw the approximate equivalent circuit of an induction motor.
3. Explain, "The principle of an induction motor is similar to that of a transformer."

Group No:
Roll no:

Data Sheet

No load test:

W_0 = I_0 = V_0 =

$$R_0 = \frac{V_0^2}{W_0} \qquad Z_0 = \frac{V_0}{I_0} \qquad \therefore X_0 = \sqrt{Z_0^2 - R_0^2}$$

$$W_0 = V_0 I_0 \cos\Phi_0 \qquad \Rightarrow \cos\Phi_0 = \frac{W_0}{V_0 I_0}$$

Blocked rotor test:

W_{SC} = I_{SC} = V_{SC} =

$W_{SC} = V_{SC} I_{SC} \cos\Phi_S$, i.e. Φ_S =

$$W_{SC} = I_{SC}^2 R_{01} \qquad Z_{01} = \frac{V_{SC}}{I_{SC}} \qquad \therefore X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$$

Signature of the lab Teacher

Experiment no: **7**
Experiment name: **Measuring Synchronous Generator Model Parameters.**

Introduction:

Three quantities are required to describe the behavior of a synchronous generator. These are:

1. The relationship between field current and flux, i.e. EA Vs If.

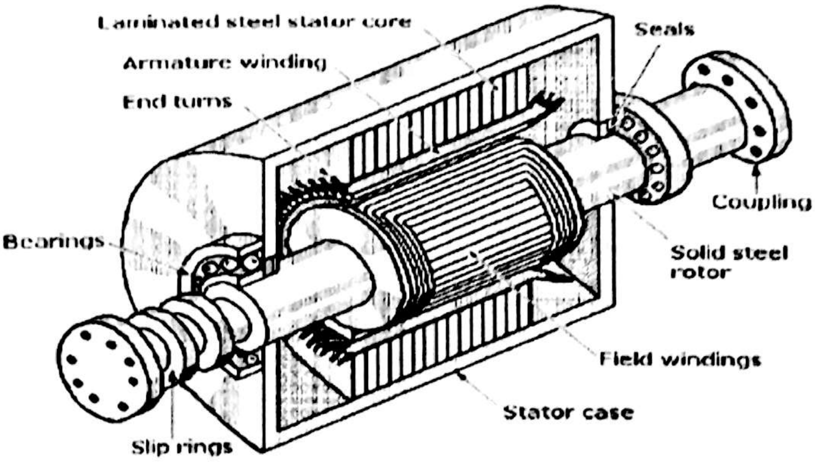
2. Synchronous reactance.

3. Armature resistance.

The first step is to perform the open circuit test. To perform this test, the generator is turned at the rated speed. The terminals are disconnected from load and the field current is set to zero. Then the field current is a gradually increased in step and the corresponding terminals voltage is measured. Plotting of VT Vs If gives the open circuit characteristic of the generator (O.C.C).

Equipments:

1. 3-φ synchronous generator
2. 3-φ induction motor
3. DC ammeter (0-500 mA)
4. AC ammeter (0-2.5 A)
5. AC voltmeter (0-300 V)
6. Rheostat (0- 1000 Ω)
7. Tachometer
8. Wire for connection.



Cutaway view of a synchronous AC generator with a solid cylindrical rotor capable of high-speed rotation.

Connection Diagram:

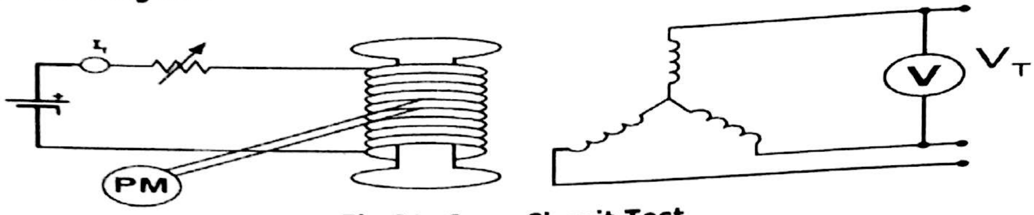


Fig 01: Open Circuit Test

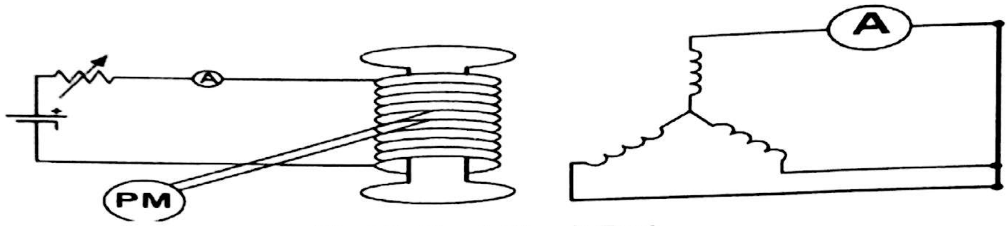
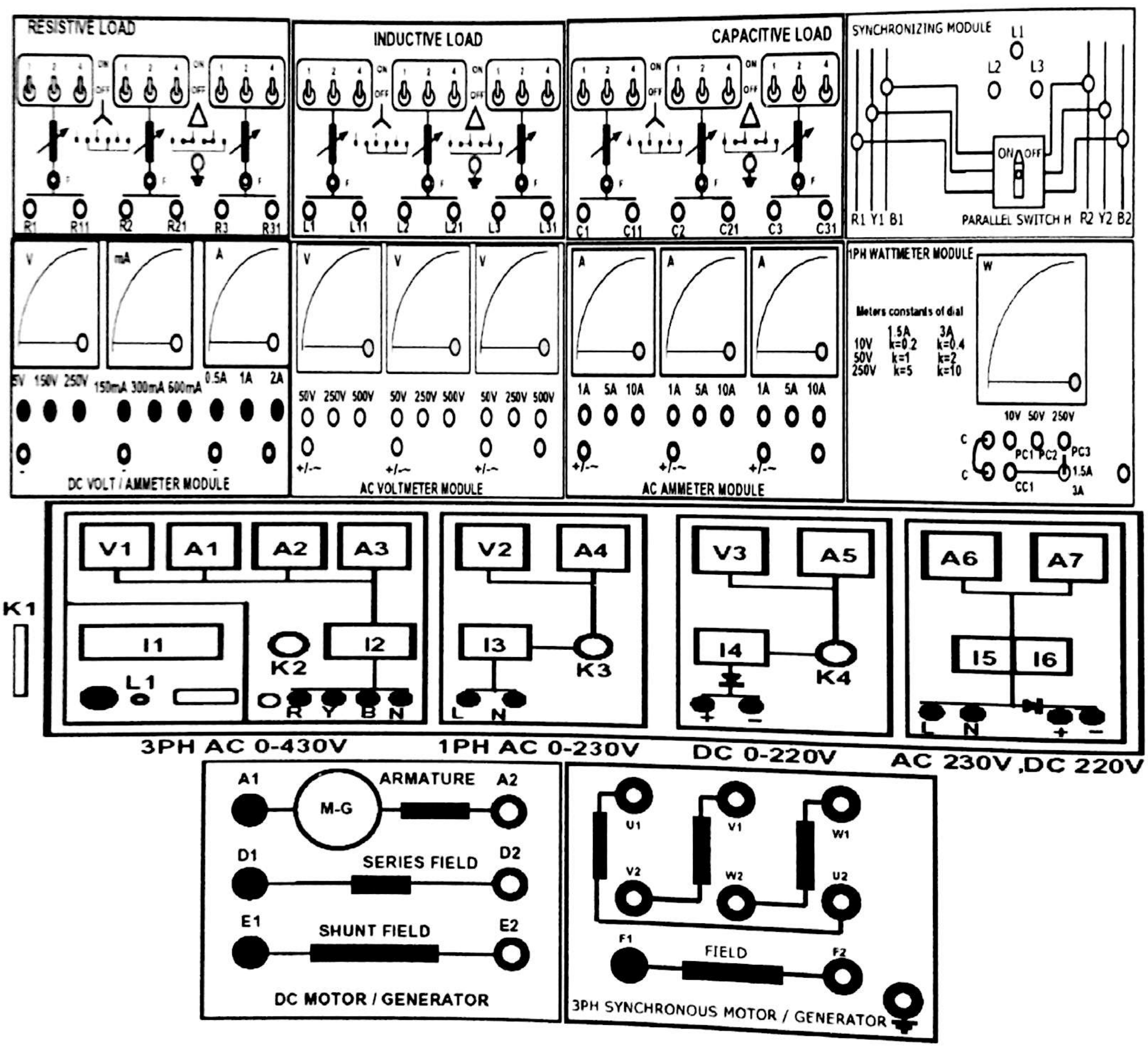


Fig 02: Short Circuit Test



Procedure:

1. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
2. Make sure all the variable knobs (K1, K3, K4) are at the min, counter clock wise (CCW) position.

3. Make connections according to the above diagram.
4. Verify the connection by your Lab Teacher
5. Make sure the 3PH synchronous Motor / Generator is mechanically coupled with DC Motor / Generator through the coupling sleeve.

6. Turn ON Switch I1 (upwards).
7. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.
8. Make the 3PH supply at **400VAC** by turning Knob K1, Voltmeter V1
9. ****Starting the Prime Mover**
10. Keep the Field Rheostat of the DC Motor at **Maximum**
11. Turn ON Switch I6 (upwards).
    Obtain speed 3000 RPM by varying the Field Rheostat, measure the speed with Tachometer

For Open circuit test:

12. Put highest resistance in the rotor of the alternator.
13. Open the stator terminals. Apply voltage on the rotor while the prime mover is rotating at the rated speed.
14. Slowly increase the field current and fill up the table for O.C test.

For Short circuit test:

15. Put highest resistance in the rotor of the alternator.
16. Short the stator terminals. Apply voltage on the rotor while the prime mover is rotating at the rated speed.
17. Slowly increase the field current and fill up the table for S.C. test.
18. For each step, at constant If, divide V_T by I_{SC} to determine X_S.

Report:
1. On the same graph paper draw V_T Vs I_f, I_{SC} Vs I_f and X_S Vs I_f.
2. Why the value of X_S does not remain constant?
3. Why do you get a linear relationship between I_A Vs I_f during short circuit test?

Group No:
Roll no:

Data Sheet

O.C.C. Test

I_f	V_T

Short Circuit Test

I_f	I_{SC}

By Calculation

I_f	X_S

Signature of the Lab teacher: