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-2106

Course Title: Electrical Machineries Lab

For the students of

Department of Electrical and Electronic Engineering

Experiment No.	**Name of the Experiments**
01	Performance Tests on Single Phase Transformer
02	To determine the regulation of a transformer under different power factor
03	Parallel operation of transformers
04	Study of Three-Phase Transformers and find out the efficiency
05	Determination of Circuit Parameters of a 3 Phase Induction motor
06	Load Characteristics of a 3 Phase Slip Ring Induction Motor
07	Measuring Synchronous Generator Model Parameters
08	Parallel operation of Alternators
09	Plotting of V-curves for Synchronous motor and Drawing Phasor diagram of a Synchronous motor
10	Finding the Efficiency of a Shunt Generator
11	Speed Control of a DC Shunt Motor

Experiment no: **1**
Experiment name: **Performance Tests on Single Phase Transformer.**

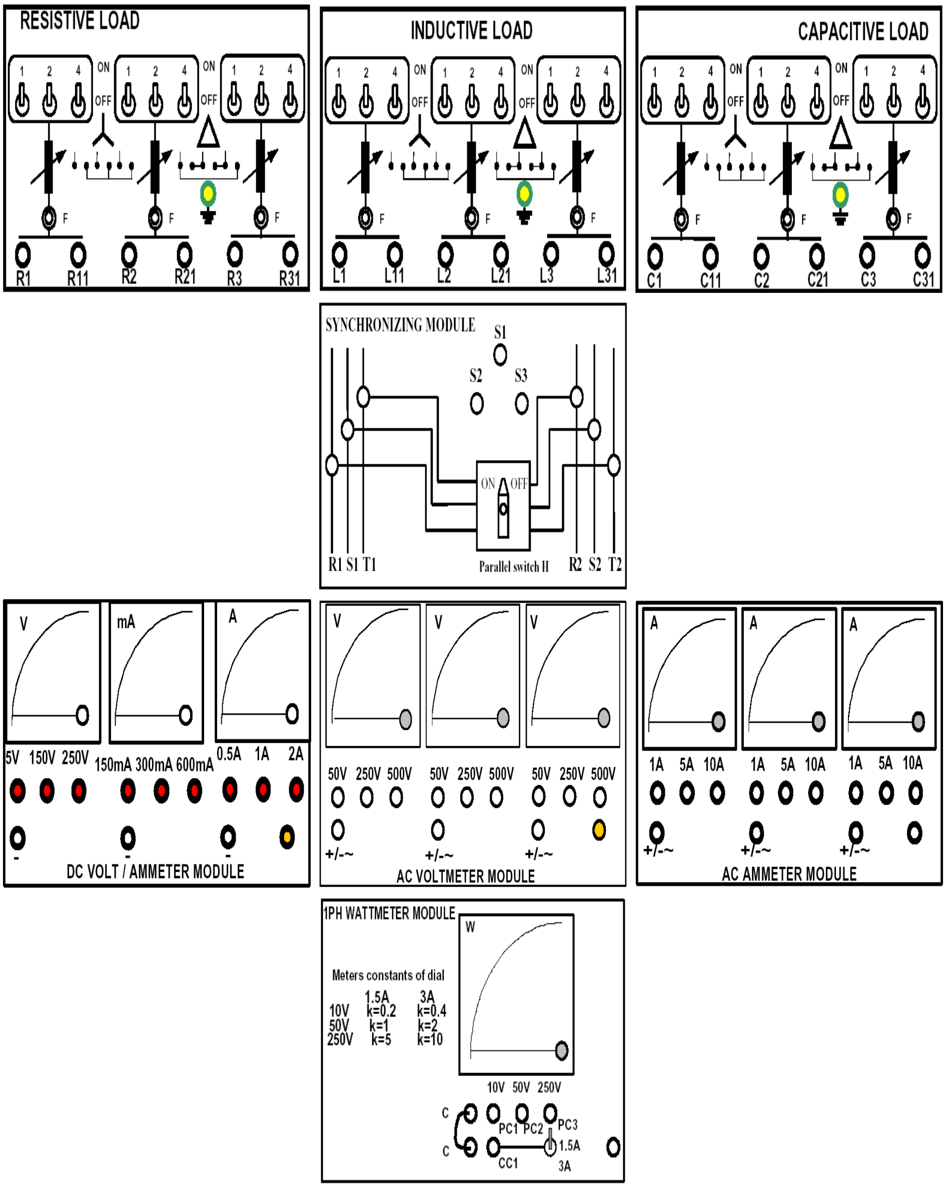
Introduction:
The performances of a transformer can be calculated on the basis of its equivalent circuit, which contains four main parameters:

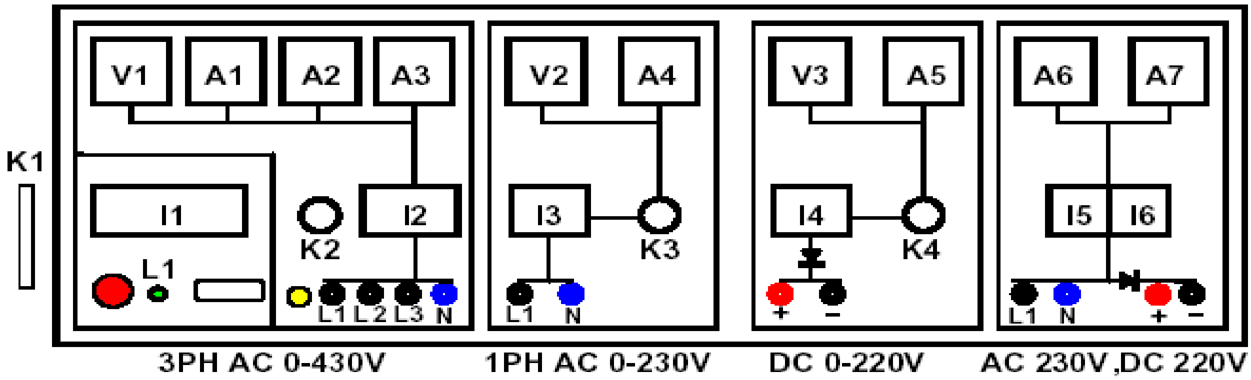
The equivalent resistance R_{01} referred to primary or R_{02} referred secondary side.
Equivalent leakage reactance X_{01} referred to primary or secondary X_{02}.
Core Loss Conductance G_0 or Resistances R_0.
Magnetizing Susceptance B_0 Or Reactance X_0.

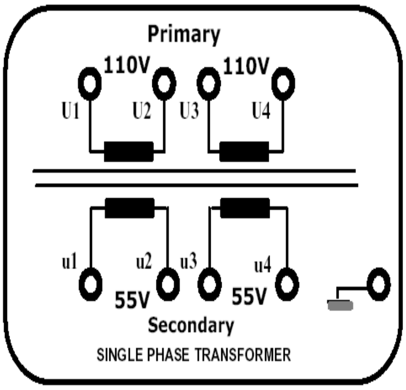
These parameters can be determined by the following two tests:
1. Open-Circuit test
2. Short-circuit test.

Equipments:

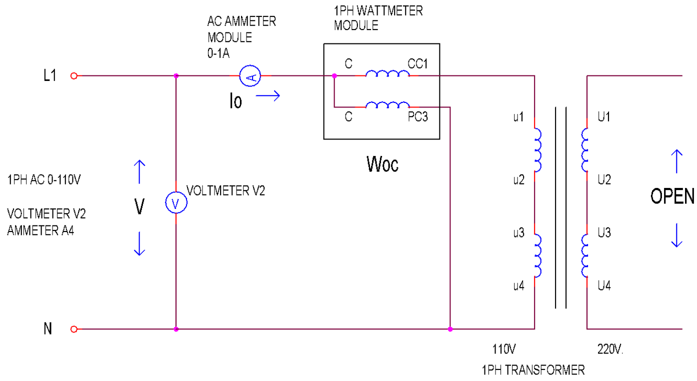
1. Universal Power Supply Module
2. 1PH Transformer
3. AC Ammeter Module 0-1A
4. AC Voltmeter Module 0-250 V
5. 1PH Wattmeter Module
6. Connecting Cables




K1
V1
A1
A2
A3
V2
A4
V3
A5
A6
A7
I1
K2
I2
I3
K3
I4
K4
I5
I6
L1
L1 L2 L3 N
L1 N
+ −
L1 N
+ −
3PH AC 0-430V
1PH AC 0-230V
DC 0-220V
AC 230V ,DC 220V


Primary
110V
110V
U1
U2
U3
U4
u1
u2
u3
u4
55V
55V
Secondary
SINGLE PHASE TRANSFORMER

Open-Circuit Test:
This test determines no-load loss or core loss of the transformer. The no-load current I_0 helps to find X_0 and R_0. The circuit arrangement for this test is shown below:



From the wattmeter, voltmeter, ammeter readings------

$W_{OC} = V^* I_0^* \, COS\varphi_0$ i.e. $COS\varphi_0 = W_{OC}/(V^* I_0)$

Where $COS\varphi_0$ is called the primary power factor under no-load condition.
The no-load current has two components.

1. **Magnetizing current, I_μ** = $I_0 * SIN\varphi_0$
2. **Working component, I_w** = $I_0 * COS\varphi_0$, this current is also called iron loss component.

So, core resistance referred to L.T side is $R_0 = V/I_W$ and Core reactance referred to L.T side is $X_0 = V/I_\mu$

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.

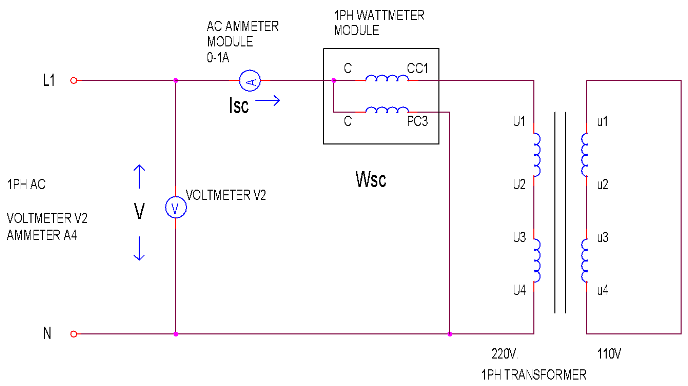
3. Make connections according to the above diagram.
4. Verify the connection by your Lab Teacher

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. Slowly Increase 1PH AC Voltage to **110V**, Turn Knob K3 CW

10. Note the Voltages, Currents on the AC Voltmeter & Ammeter, Power on the Wattmeter Module

2. 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. Draw the equivalent circuit diagram ref. to H.T. side and L.T. side.
2. Why were instruments placed on the H.T. side for short circuit test?
3. Why is it assumed that during short circuit test, all the losses are copper losses?
4. Why the rating of transformer is rated in KVA?

Group No:
Roll no:

Data Sheet

Open Circuit Test

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

Short Circuit Test

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

Calculation

Core loss = W_{OC} =

Φ_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) = $R_{01} = \dfrac{W_{SC}}{\quad}$ =

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:

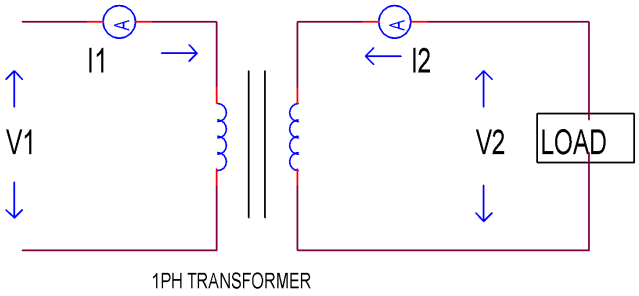
Experiment no: **2**

Experiment name: **To determine the regulation of a transformer under different power factor.**

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

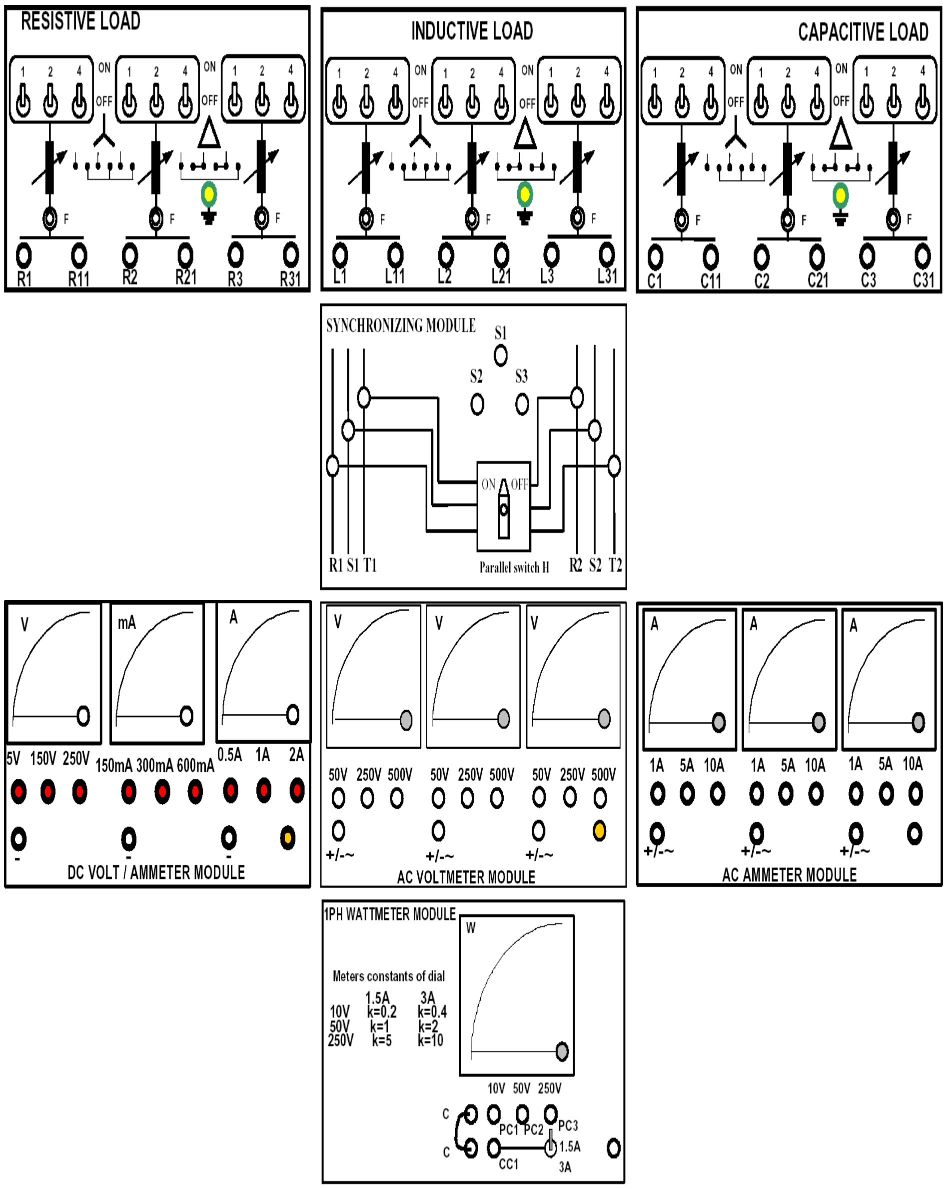
$$\%R = \frac{V_{N.L.} - V_{F.L.}}{V_{F.L.}} \times 100$$

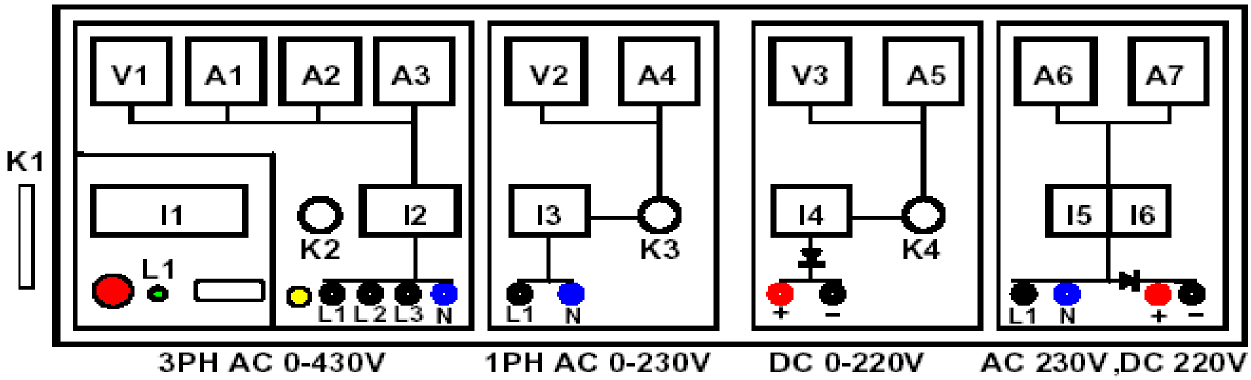


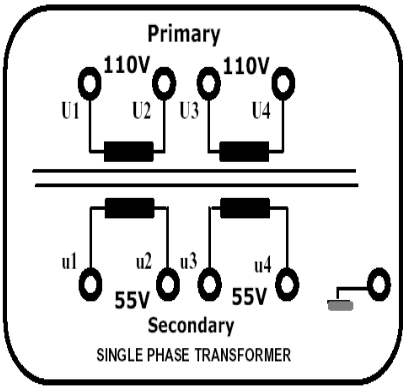
For a transformer, for constant primary voltage as load increases, the voltage at the load decreases, as there is voltage drop due to internal resistance and reactance of the transformer. If we know the resistance and reactance of the transformer, its regulation can be determined under various load conditions.

Equipments:

7. Universal Power Supply Module
8. 1PH Transformer
9. AC Ammeter Module 0-1A
10. AC Voltmeter Module 0-250 V
11. 1PH Wattmeter Module
12. Resistive Load Module
13. Inductive Load Module
14. Capacitive Load Module
15. Connecting Cables

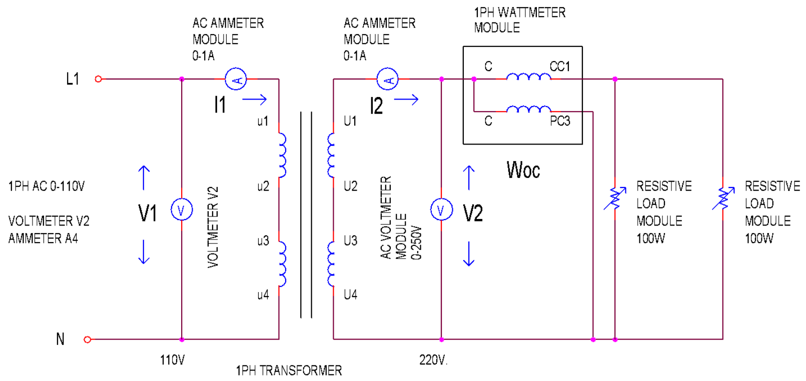

RESISTIVE LOAD
INDUCTIVE LOAD
CAPACITIVE LOAD
1 2 4
ON
OFF
F
R1 R11 R2 R21 R3 R31
L1 L11 L2 L21 L3 L31
C1 C11 C2 C21 C3 C31
SYNCHRONIZING MODULE
S1
S2
S3
ON OFF
Parallel switch II
R1 S1 T1
R2 S2 T2
V
mA
A
5V 150V 250V
150mA 300mA 600mA
0.5A 1A 2A
DC VOLT / AMMETER MODULE
50V 250V 500V
+/-~
AC VOLTMETER MODULE
1A 5A 10A
AC AMMETER MODULE
1PH WATTMETER MODULE
W
Meters constants of dial
1.5A 3A
10V k=0.2 k=0.4
50V k=1 k=2
250V k=5 k=10
10V 50V 250V
C
PC1 PC2 PC3
CC1
1.5A
3A


V1
A1
A2
A3
K1
I1
L1
K2
I2
L1 L2 L3 N
V2
A4
I3
K3
L1 N
V3
A5
I4
K4
+ −
A6
A7
I5
I6
L1 N
+ −
3PH AC 0-430V
1PH AC 0-230V
DC 0-220V
AC 230V ,DC 220V


Primary
110V
110V
U1
U2
U3
U4
u1
u2
u3
u4
55V
55V
Secondary
SINGLE PHASE TRANSFORMER

Short Circuit Test:
From the Short Circuit Test done in Experiment 2, note the value of R_{01}, X_{01} referred to the H.T. side.

With Resistive Load:



Procedure:

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

13. Make connections according to the above diagram.
14. Verify the connection by your Lab Teacher

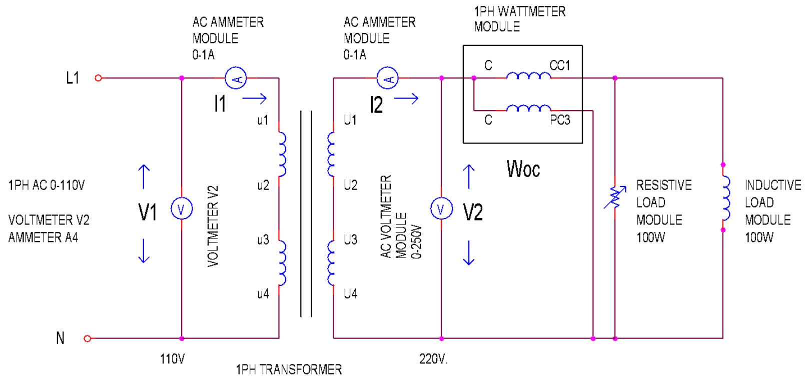
15. Turn ON Switch I1 (upwards).
16. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.

17. Turn Knob K3 at min (CCW)
18. Turn ON switch I3 (upwards).

19. Keep all the Loads at OFF position
20. Apply voltage **110V** on the LT side.
21. Note the readings on AC Voltmeter, Ammeter and Wattmeter Module

22. Now turn ON all the Loads
23. Note the readings on AC Voltmeter, Ammeter and Wattmeter Module

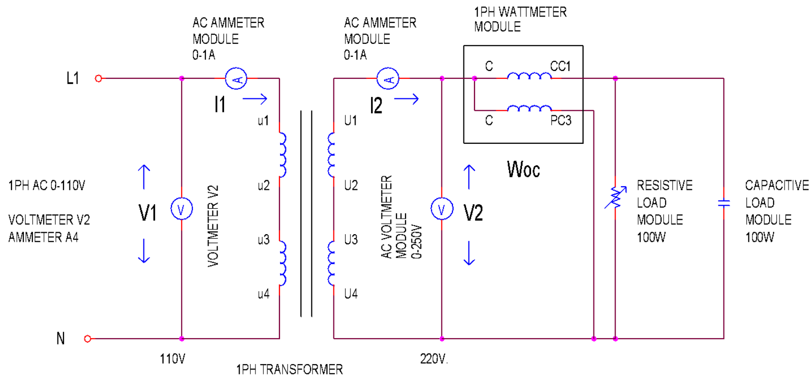
With R-L Load:



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

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.

<u>Data Sheet</u>

Group No:
Roll no:

Short circuit test
W_{SC} = I_{SC} = V_{SC}

Calculate

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

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

With Resistive Load

Terminal Voltage = Load current =

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

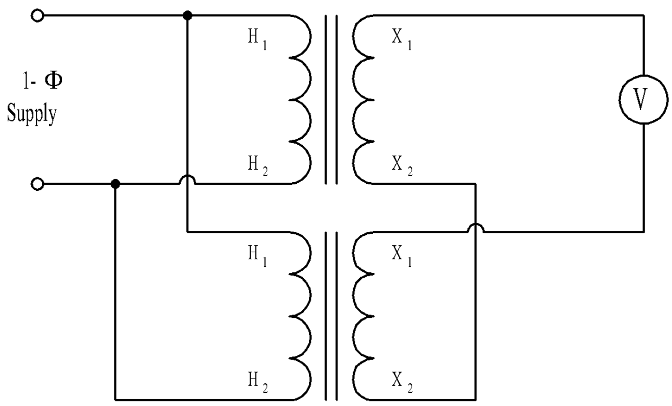
Experiment no: **3**
Experiment name: **Parallel operation of transformers.**

Introduction:

When in a power system the demand for load increases, a single transformer may not be able to supply the extra load. In that case, another transformer is connected in parallel with the existing transformer to share the load. In order to make two transformers parallel, some conditions have to be fulfilled. These are:

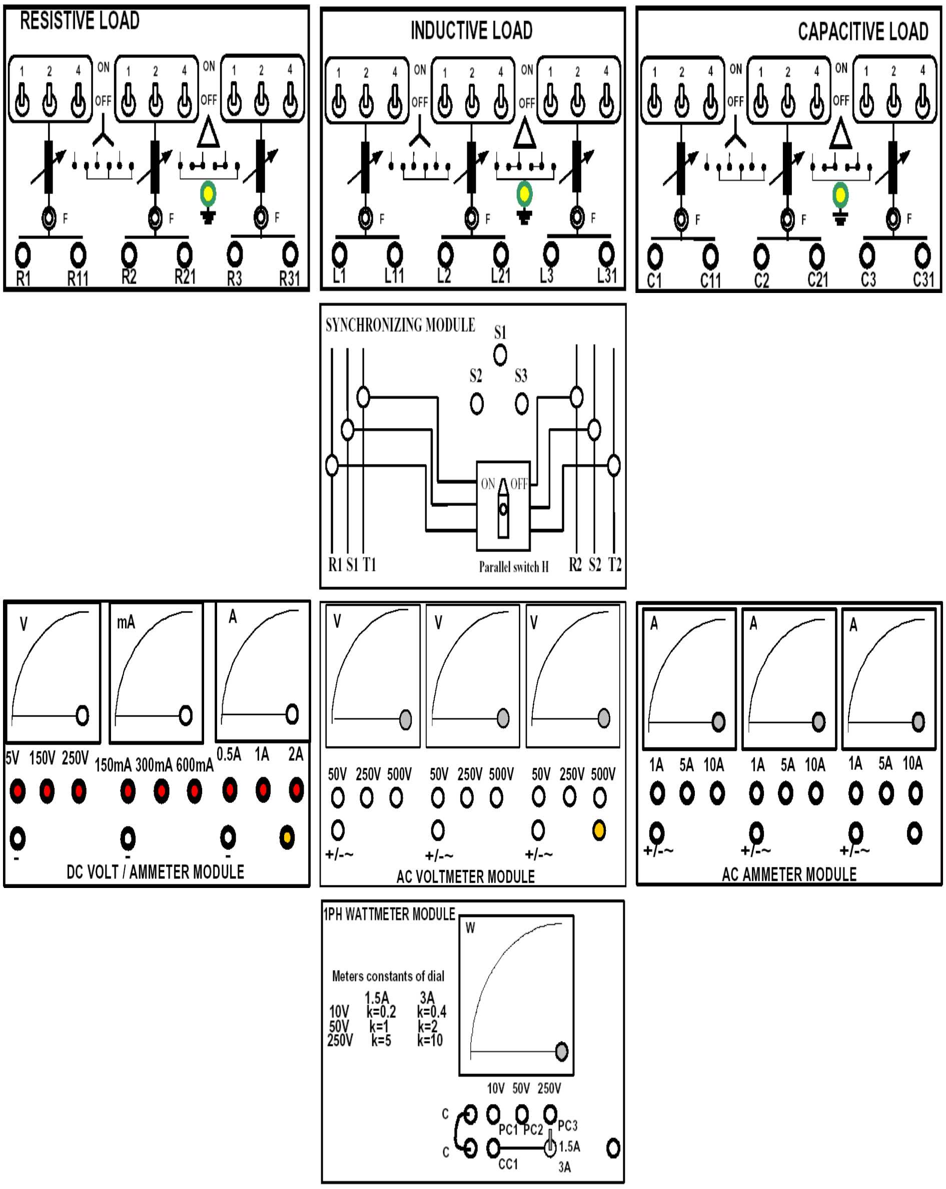
1) Terminal voltages on the primary and secondary side should be identical.
2) The relative polarities on the primary and secondary sides should be identical.
3) Preferably R/X ratio of both the transformers should be same.
4) Primary windings of the transformer should be suitable for the supply system voltage and frequency.

Connection for Parallel Operation:

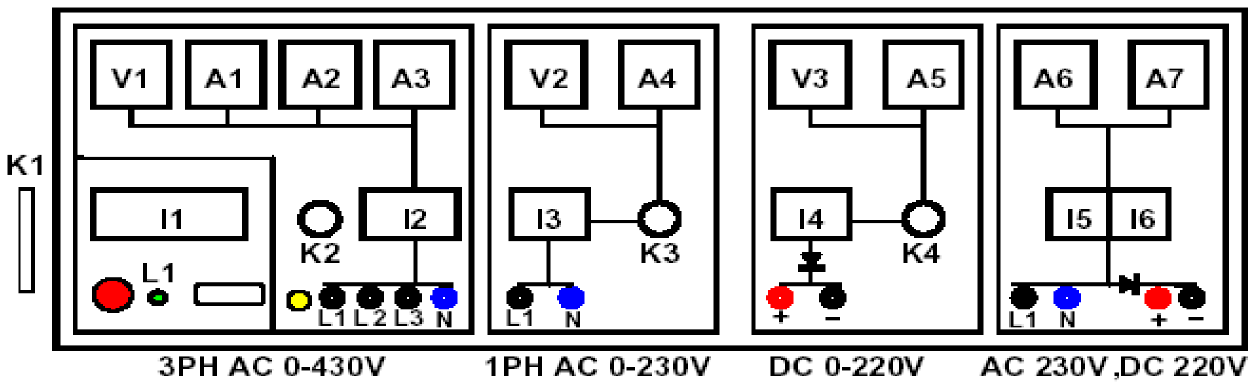


Equipments:

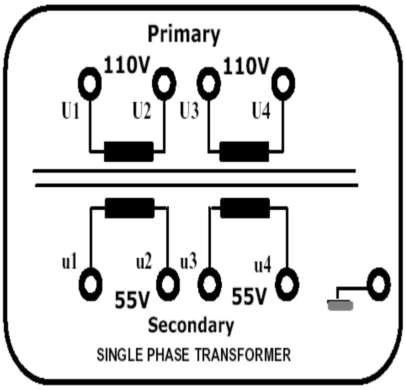
1. 1PH Transformer 2 pieces
2. AC Ammeter Module 0-1A
3. AC Voltmeter Module 0-250 V
4. DC ammeter (0 to 600 mA)
5. Load 100 watts - 2 pieces.
6. Clamp-on-meter -1 piece
7. DC Supply – 9 V
8. Connecting Cables



RESISTIVE LOAD
R1 R11 R2 R21 R3 R31
INDUCTIVE LOAD
L1 L11 L2 L21 L3 L31
CAPACITIVE LOAD
C1 C11 C2 C21 C3 C31
SYNCHRONIZING MODULE
S1 S2 S3
ON OFF
R1 S1 T1
Parallel switch II
R2 S2 T2
5V 150V 250V 150mA 300mA 600mA 0.5A 1A 2A
DC VOLT / AMMETER MODULE
50V 250V 500V
AC VOLTMETER MODULE
1A 5A 10A
AC AMMETER MODULE
1PH WATTMETER MODULE
Meters constants of dial
1.5A 3A
10V k=0.2 k=0.4
50V k=1 k=2
250V k=5 k=10
10V 50V 250V
PC1 PC2 PC3
CC1
1.5A
3A

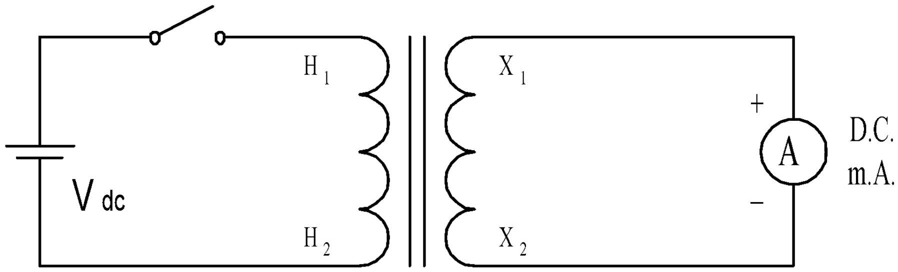


K1
V1 A1 A2 A3
I1 I2
K2
L1
L1 L2 L3 N
V2 A4
I3
K3
L1 N
V3 A5
I4
K4
+ −
A6 A7
I5 I6
L1 N + −
3PH AC 0-430V
1PH AC 0-230V
DC 0-220V
AC 230V ,DC 220V


Primary
110V
110V
U1
U2
U3
U4
u1
u2
u3
u4
55V
55V
Secondary
SINGLE PHASE TRANSFORMER

Procedure:

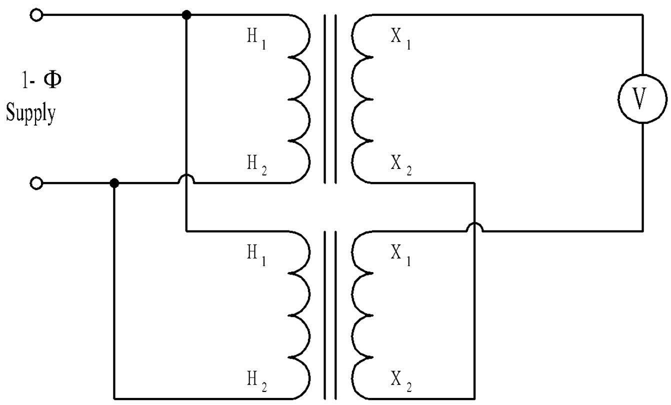
1. Select two 1-φ transformers of identical manufacturer.
2. On the secondary side of the transformer, determine R and X with an R-L-C meter.
3. Determination of Relative Polarity:



Connect a D.C. mA with polarity as shown on the secondary side, and a battery through a switch on the primary side. Push the switch (give a kick). If the mA deflects in the positive direction, then H_1 and X_1 have the same mode of winding.
Repeat the step for TR2 and confirm that the modes of windings are identical.

(<u>If not, report to the teacher.</u>)

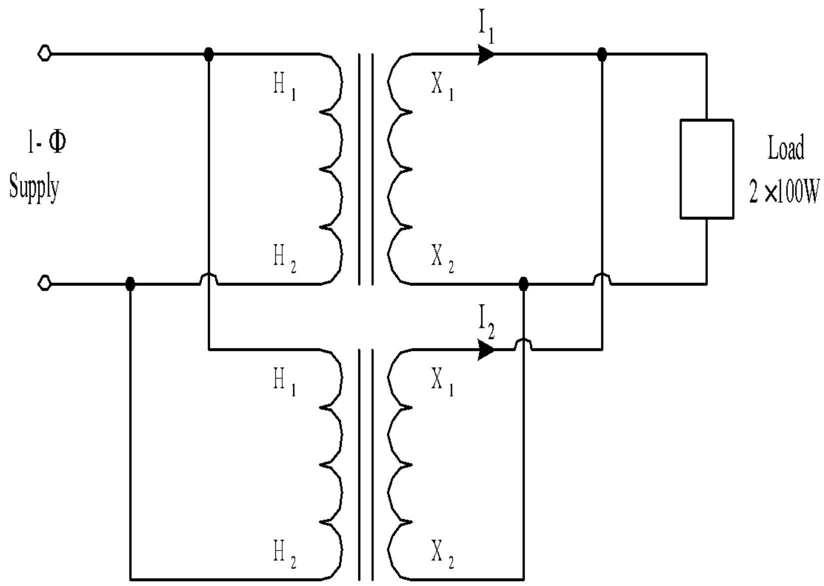
4. Connection for Parallel Operation:



a) Connect a voltmeter and connect the transformers as shown. If the polarities are correct, the voltmeter should read zero.

b) Disconnect the supply, remove the voltmeter and connect the two secondary terminals (X_1, X_1) of TR1 and TR2. With a clamp-on-meter, check if there is any circulating current. If there is any, note this circulating current.

5. Now, re-connect TR1 and TR2 as in step 4(a). On the secondary side, connect 2 load of 100W each.



With clamp-on-meter, determine the currents supplied by TR1 and TR2

Report:

1. Discuss on the value of circulating current found in step 4(c).
2. Why is parallel operation necessary? Why is relative polarity test necessary for parallel operation?
3. Why the voltmeter gives zero reading if the polarities are same at step 4(a)?

<u>Data Sheet</u>

Group No:
Roll no:

For TR1: R1 = X1 =

For TR2: R2 = X2 =

Voltmeter reading on step 4:

clamp-on-meter reading on step 5:

Currents supplied by TR1 =

Currents supplied by TR2 =

Signature of the lab Teacher

Experiment no: **4**

Experiment name: **Study of Three-Phase Transformers and find out the efficiency.**

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

$$V_1 * I_1 = V_2 * I_2$$

$$\text{i.e. } V_1/V_2 = I_2/I_1 \text{ ------------------------ } (1)$$

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

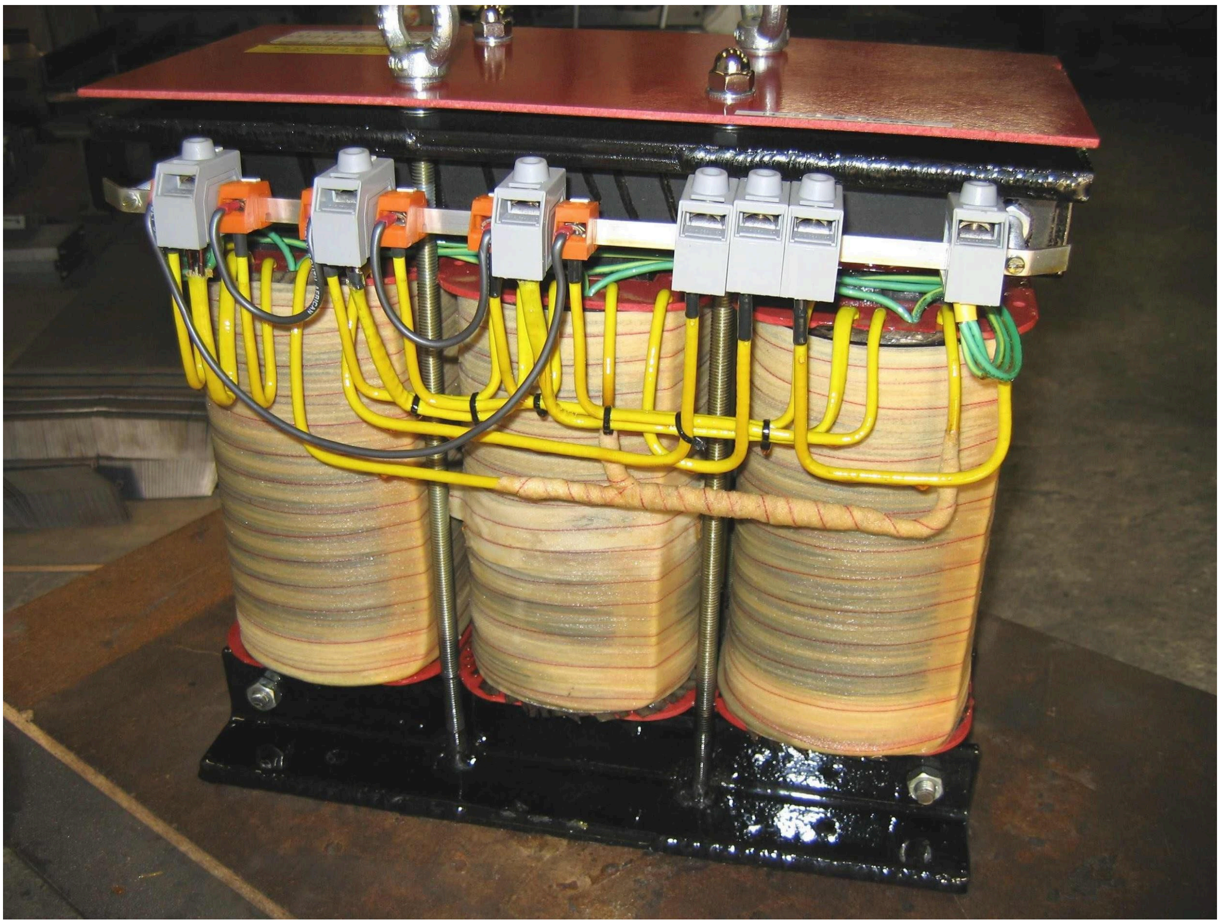
$$V_1 \propto N_1 \quad \text{and} \quad V_2 \propto N_2$$

$$\text{i.e. } V_1/V_2 = N_1/N_2 \text{ -------------------------- } (2)$$

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.



In an ideal transformer, the power in the secondary windings is exactly equal to the power in the primary windings. This is true for transformers with a coefficient of coupling of 1.0 (complete coupling) and no internal losses. In real transformers, however, losses lead to secondary power being less than the primary power. The degree to which a real transformer approaches the ideal conditions is called the efficiency of the transformer:

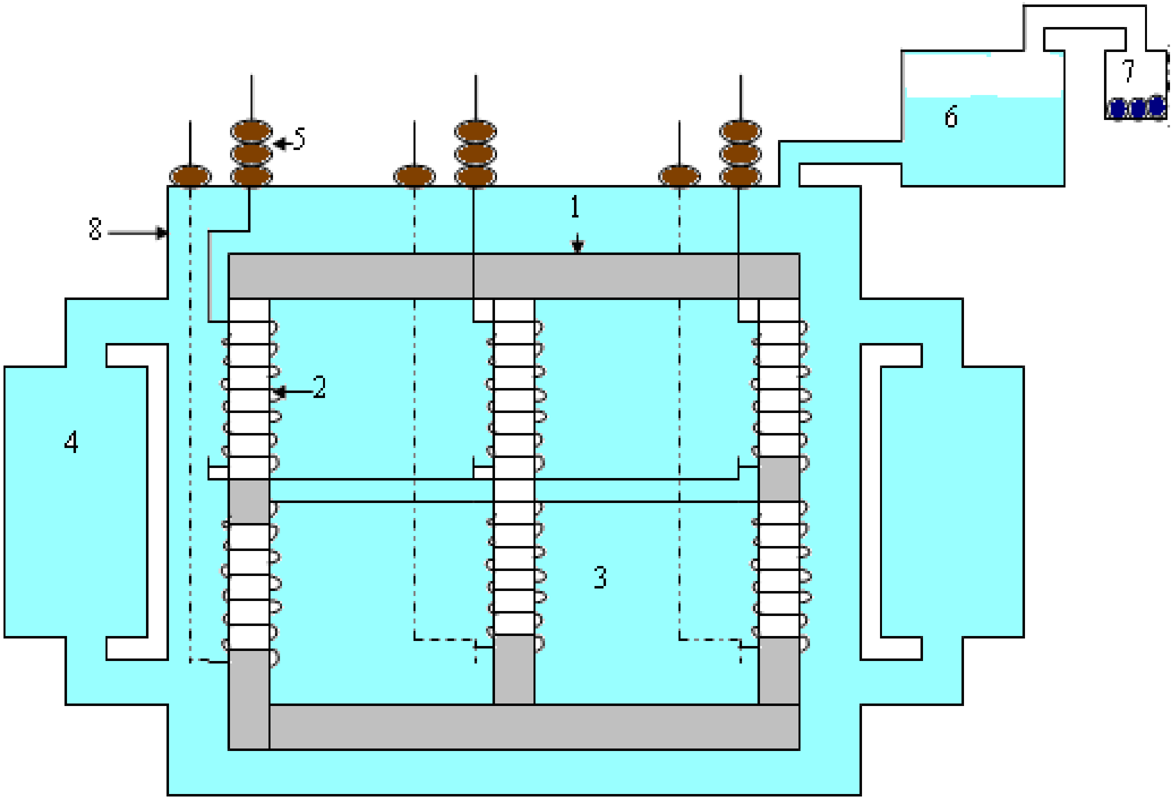
$$Efficiency\ (\%) = \frac{P_{out}}{P_{in}} \cdot 100\%$$

where P_{out} and P_{in} are the real output and the input powers. Apparent and reactive powers are not used in efficiency calculations. Transformers may be connected in parallel to supply currents greater than rated for each transformer. Two requirements must be satisfied:

1) The windings to be connected in parallel must have identical output ratings;
2) The windings to be connected in parallel must have identical polarities.

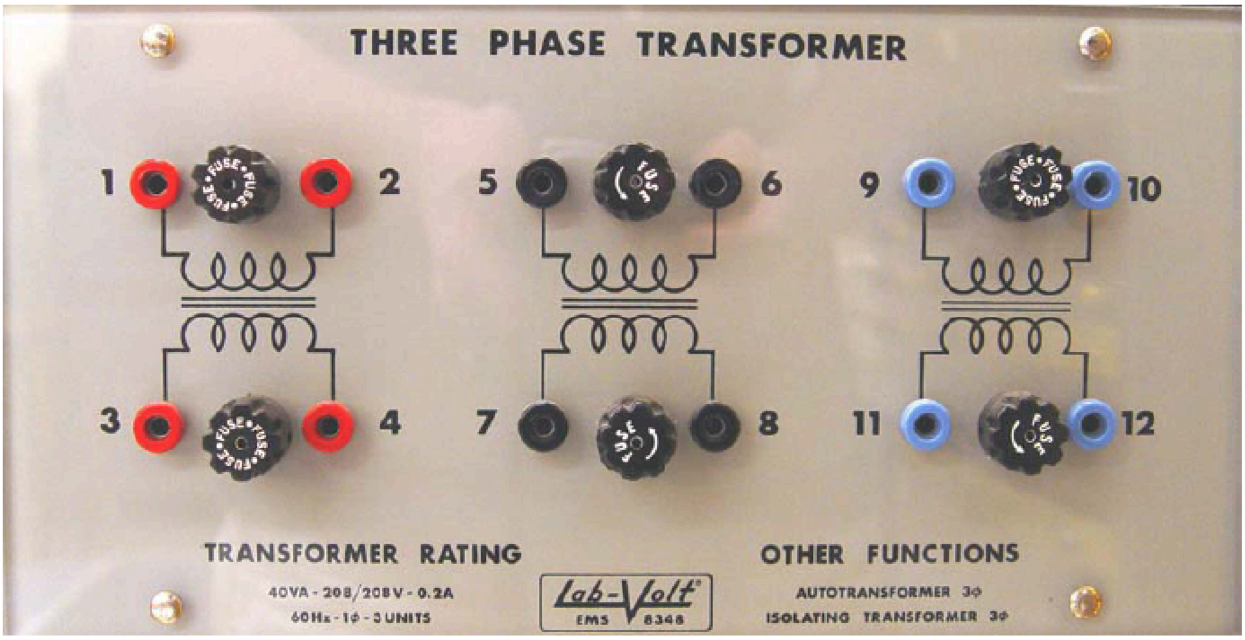
Severe damage may be made to circuitry if these requirements are not satisfied.

Single-phase transformers can be connected to form 3-phase transformer banks for 3-phase power systems. Four common methods of connecting three transformers for 3-phase circuits are Δ-Δ, Y Y, Y-Δ, and Δ-Y connections.

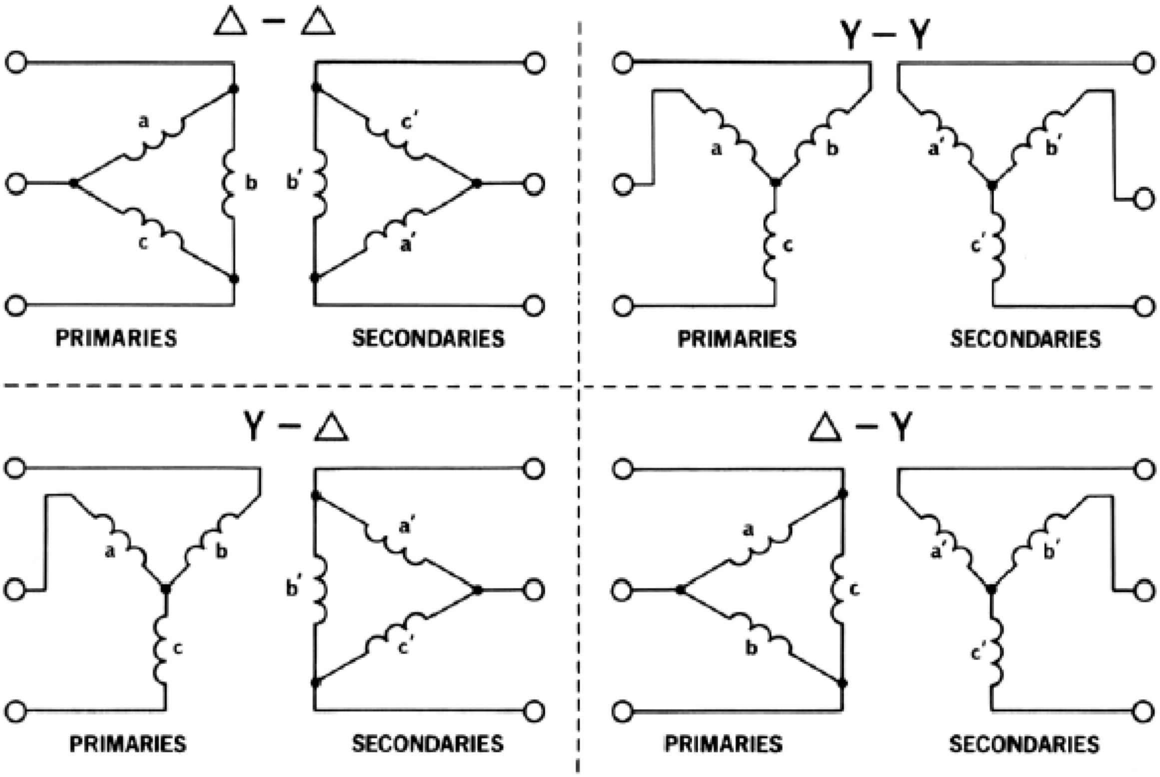


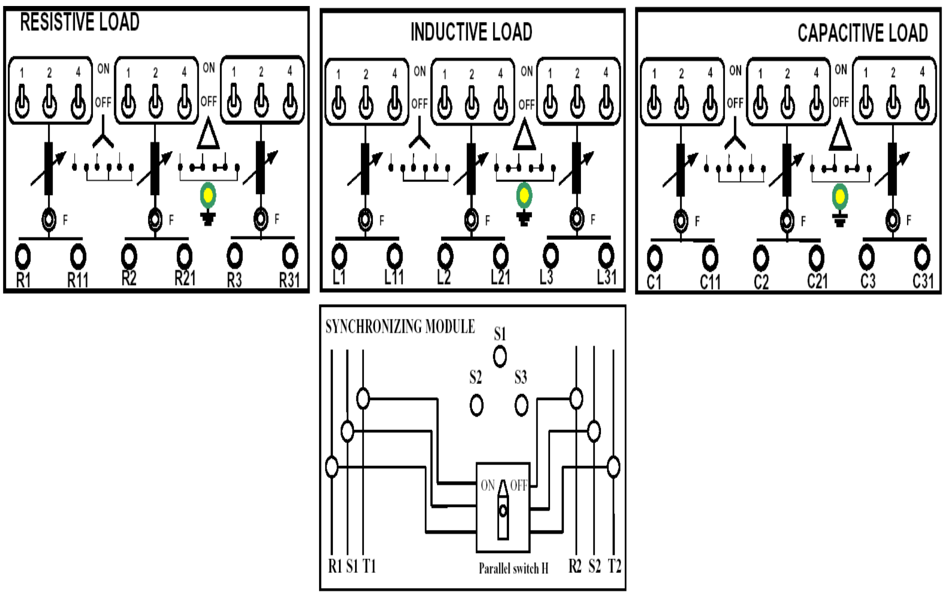
Important parts of a three-phase transformer

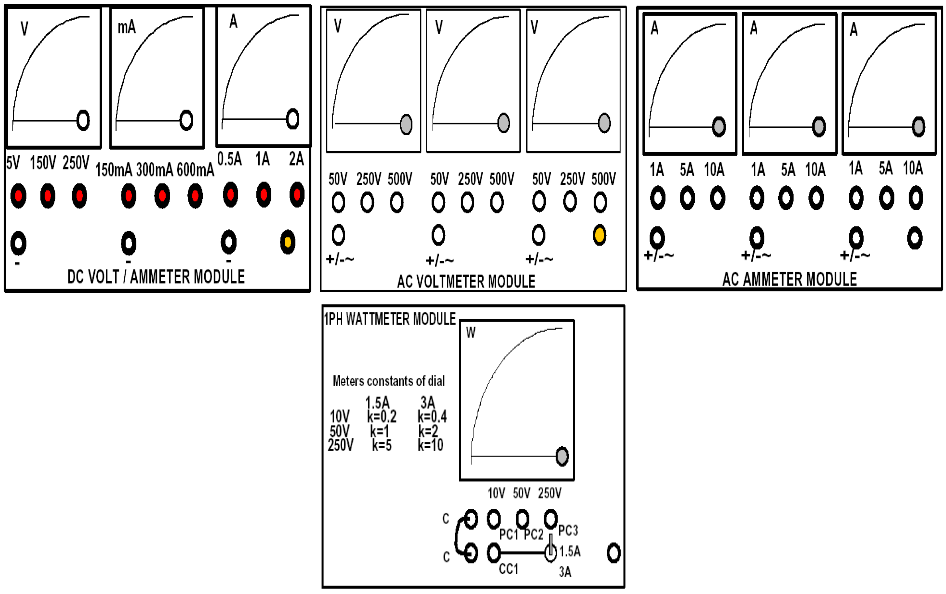
1. **Core**- Core is made by laminated silicon steel
2. **Coil**- Coil(winding) is simply made by insulated copper wire
3. **Transformer oil (mineral oil)** - Transformer oil has two functions one is to provide necessary insulation for the core and coli and other one is to absorb the heat produce by 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.

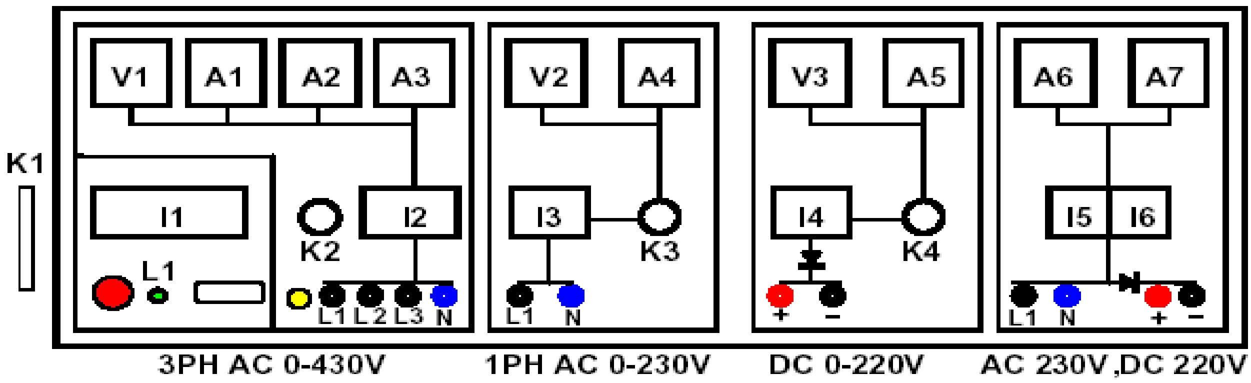


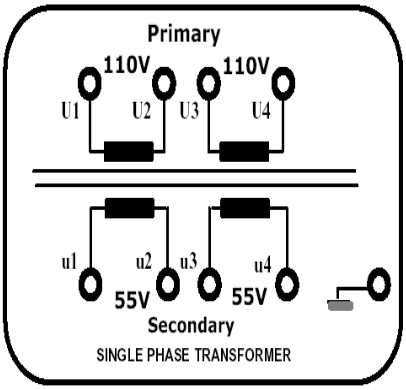
Connection to form three-phase transformer:

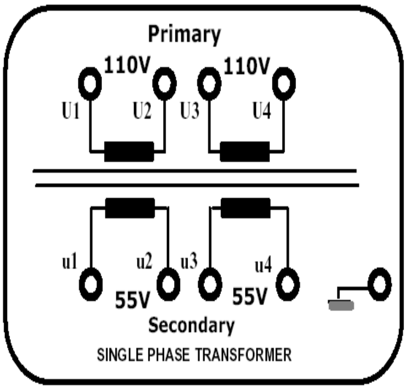

Δ – Δ
a
b
c
b′
c′
a′
PRIMARIES
SECONDARIES
Y – Y
a
b
c
a′
b′
c′
PRIMARIES
SECONDARIES
Y – Δ
a
b
c
a′
b′
c′
PRIMARIES
SECONDARIES
Δ – Y
a
b
c
a′
b′
c′
PRIMARIES
SECONDARIES

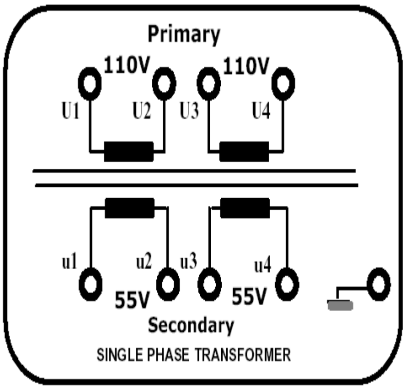

RESISTIVE LOAD
R1 R11 R2 R21 R3 R31
INDUCTIVE LOAD
L1 L11 L2 L21 L3 L31
CAPACITIVE LOAD
C1 C11 C2 C21 C3 C31
1 2 4
ON
OFF
F
SYNCHRONIZING MODULE
S1
S2
S3
ON OFF
Parallel switch II
R1 S1 T1
R2 S2 T2


DC VOLT / AMMETER MODULE
AC VOLTMETER MODULE
AC AMMETER MODULE
1PH WATTMETER MODULE
Meters constants of dial
1.5A 3A
10V k=0.2 k=0.4
50V k=1 k=2
250V k=5 k=10
10V 50V 250V
PC1 PC2 PC3
CC1
1.5A
3A


K1
V1 A1 A2 A3
I1 I2 K2 L1
L1 L2 L3 N
V2 A4
I3 K3
L1 N
V3 A5
I4 K4
+ -
A6 A7
I5 I6
L1 N + -
3PH AC 0-430V
1PH AC 0-230V
DC 0-220V
AC 230V,DC 220V







Procedure:

1. Select a 3-φ transformer of identical manufacturer.
2. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
3. Make sure all the variable knobs (K3, K4) are at the min, counter clock wise (CCW) position.
4. Make connections according to the above diagram.
5. Verify the various part of the transformer and make their combinations with the help of your Lab Teacher.
6. Now verify the advantages for each type of combination.
7. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
8. Make sure all the variable knobs (K3, K4) are at the min, counter clock wise (CCW) position.
9. Make connections according to the above diagram.
10. Verify the connection by your Lab Teacher
11. Keep all the Loads at OFF position
12. Apply voltage **110V** on the LT side.
13. Note the readings on AC Voltmeter, Ammeter and Wattmeter Module.

14. Now turn ON all the Loads.
15. Note the readings on AC Voltmeter, Ammeter and Wattmeter Module.
16. With constant resistive load determine the efficiency for each combination.

Group No:
Roll no:

Data Sheet

With Δ-Δ connection

Terminal Voltage = Load current = Load power =

With Y Y connection

Terminal Voltage = Load current = Load power =

With Y-Δ connection

Terminal Voltage = Load current = Load power =

With Δ-Y connection

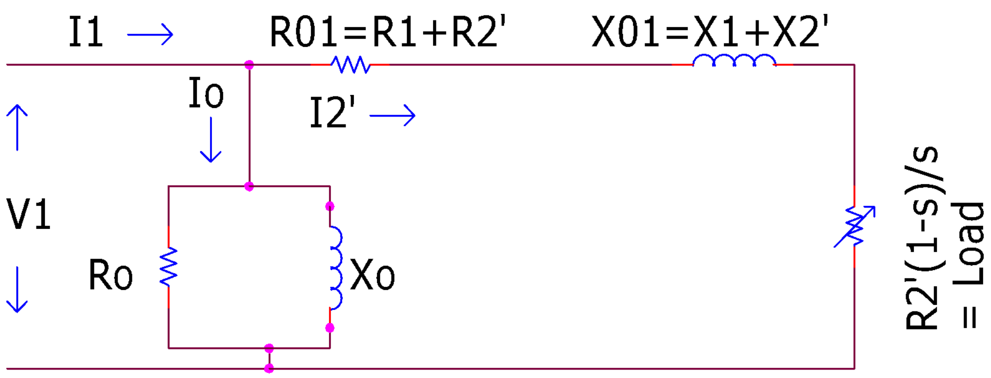
Terminal Voltage =　　　　Load current =　　　　Load power =

Signature of the lab Teacher

Experiment no: **5**
Experiment name: **Determination of Circuit Parameters of a 3 Phase Induction Motor.**

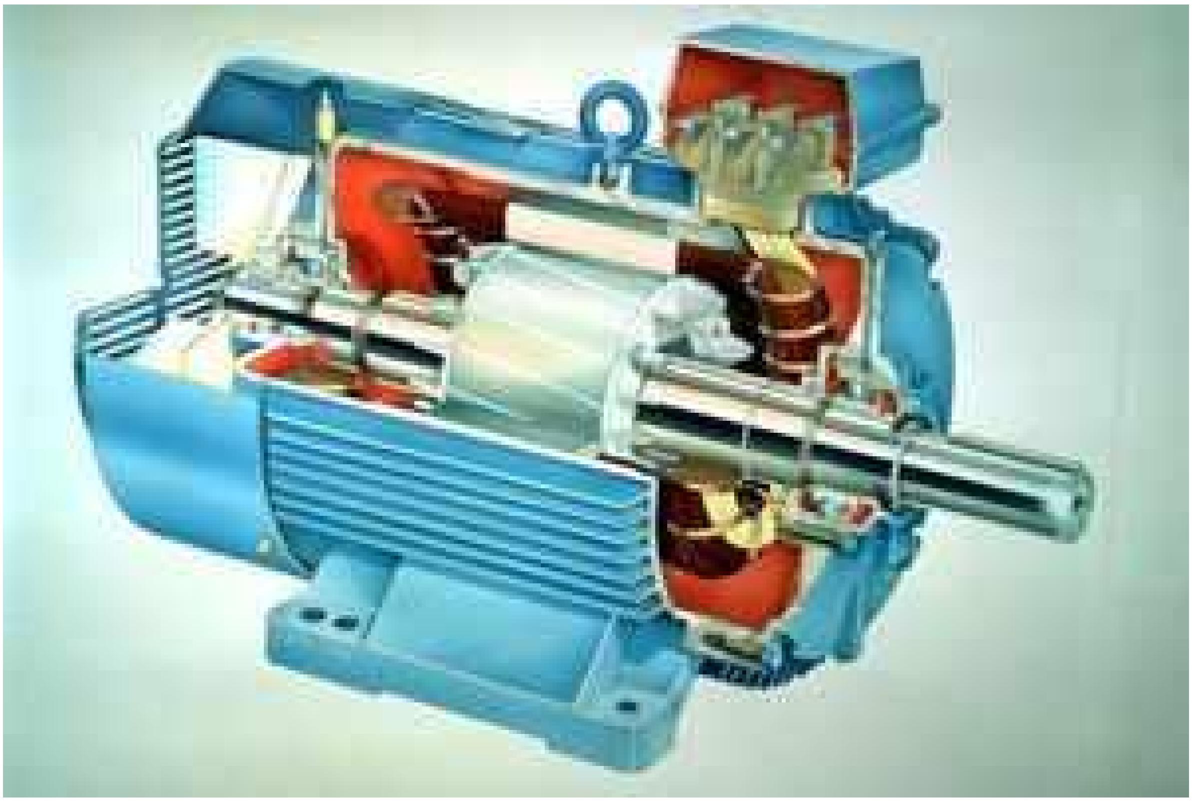
Introduction:

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.



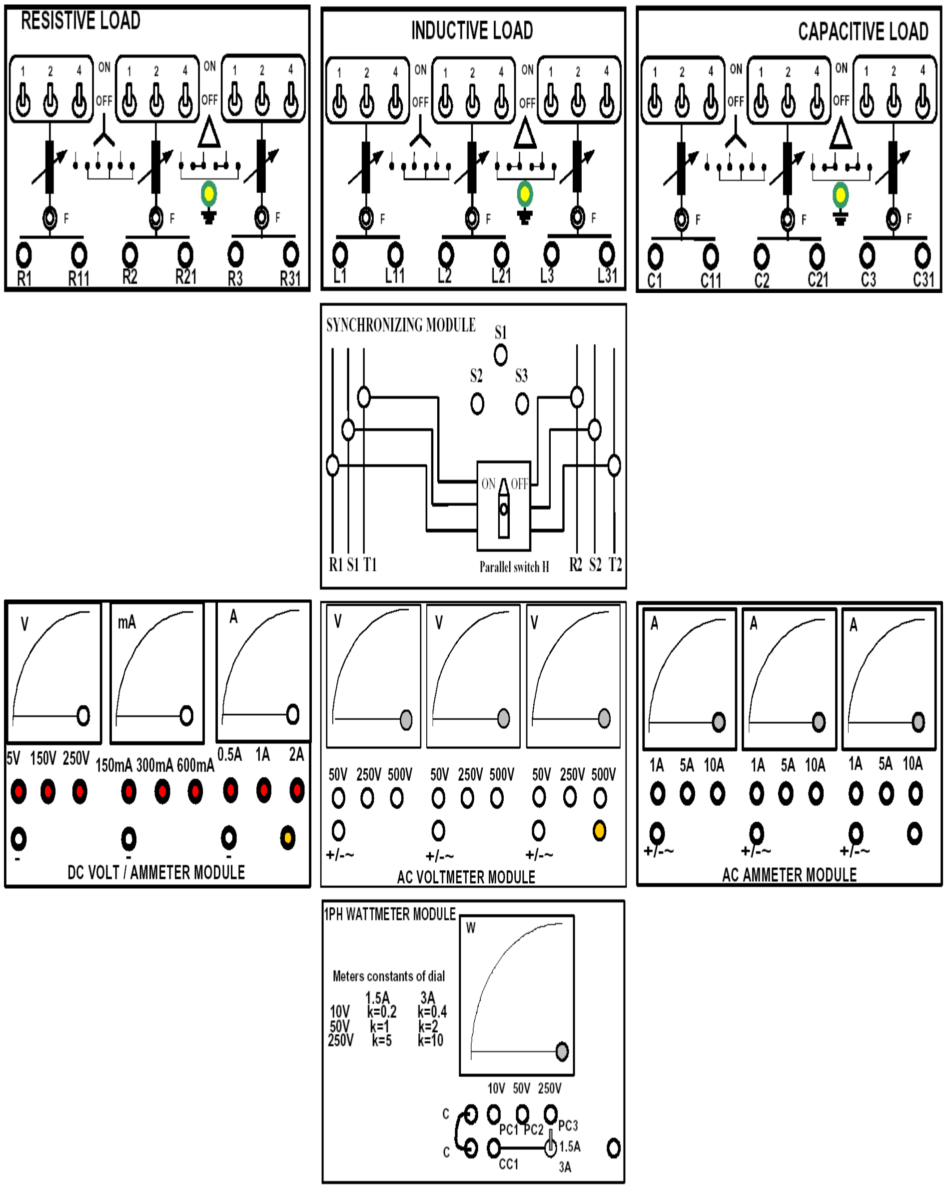
The following tests are required to determine the circuit constants.

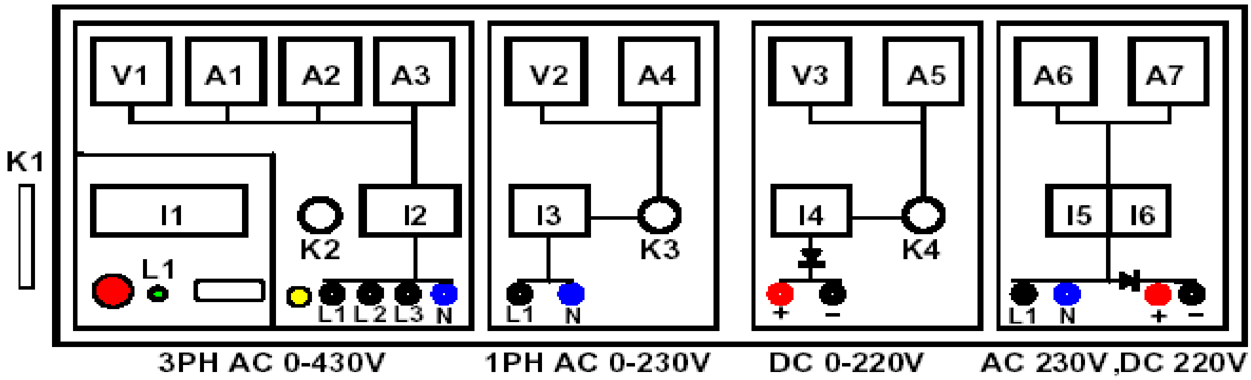
1. No- load test
2. Blocked rotor test

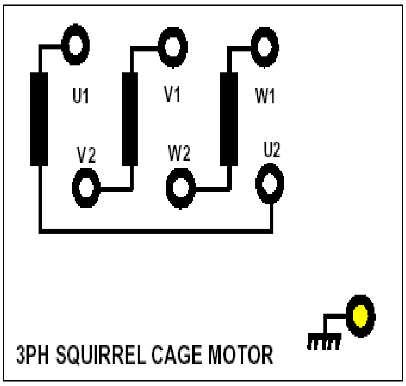


Equipments:

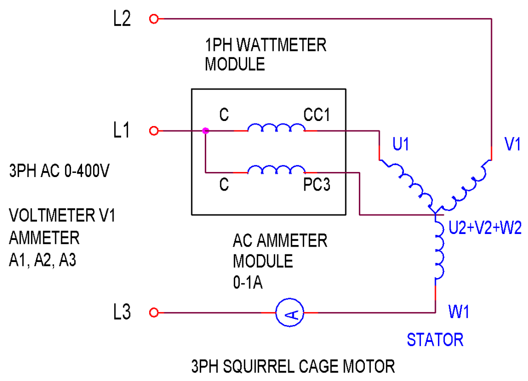
16. Universal Power Supply Module
17. 3 Phase Squirrel Cage Induction Motor
18. AC Ammeter Module 0-1A
19. AC Voltmeter Module 0-250 V
20. 1PH Wattmeter Module
21. Connecting Cables




K1
V1
A1
A2
A3
I1
K2
I2
L1
L1 L2 L3 N
V2
A4
I3
K3
L1 N
V3
A5
I4
K4
+ −
A6
A7
I5
I6
L1 N
+ −
3PH AC 0-430V
1PH AC 0-230V
DC 0-220V
AC 230V,DC 220V


U1
V1
W1
V2
W2
U2
3PH SQUIRREL CAGE MOTOR

A. No-Load Test:



Procedure:

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

26. Make connections according to the above diagram.
27. Verify the connection by your Lab Teacher

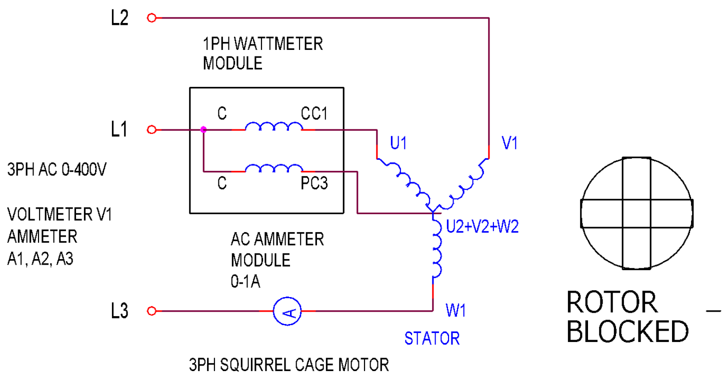
28. Turn ON Switch I1 (upwards).
29. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.

30. Turn knob K1, Apply **400VAC** on the Stator of the Motor.
31. Turn ON Switch I2 (upwards).
32. 3 Phase Squirrel Cage Motor Starts Running
33. 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 =

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

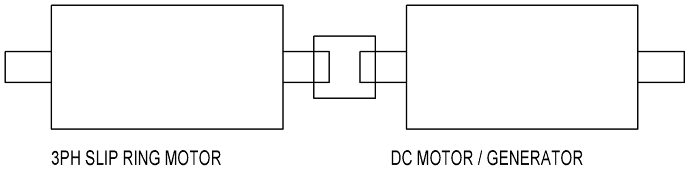
Signature of the lab Teacher

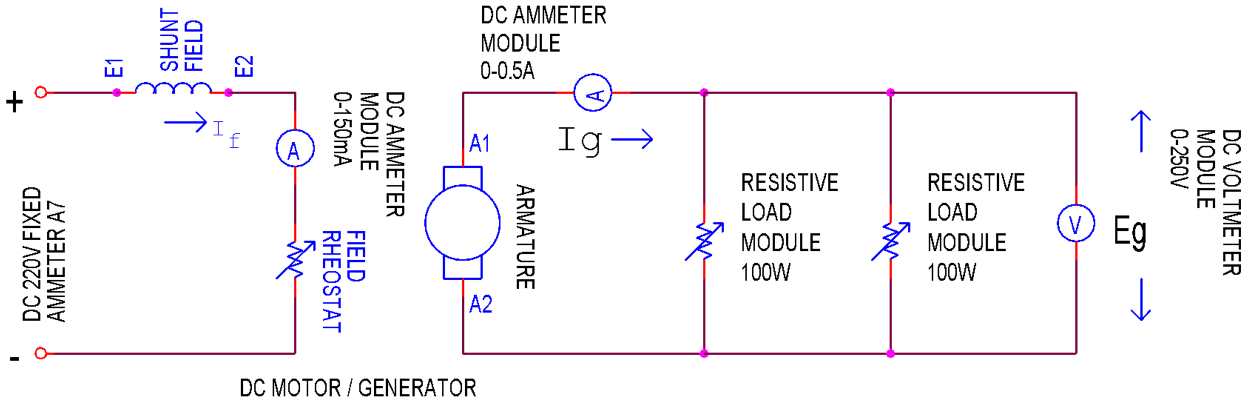
Experiment no: **6**
Experiment name: **Load Characteristics of a 3 Phase Slip Ring Induction Motor.**

Introduction:

Slip ring induction motor is an induction type motor where a three-phase resistance is externally connected to the rotor circuit. Improving its power factor by adding the external resistance increases the starting torque of such a motor. Slip ring motors maintain a slip with respect to the synchronous speed.

For a motor with P poles the synchronous speed, N_S is given by 120f/P, where f is the supply frequency. Slip, S is defined by $(N_S-N)/N_S$, where N is the speed of rotation of the motor. Measurement of Torque is done by measuring input and output power of the motor.



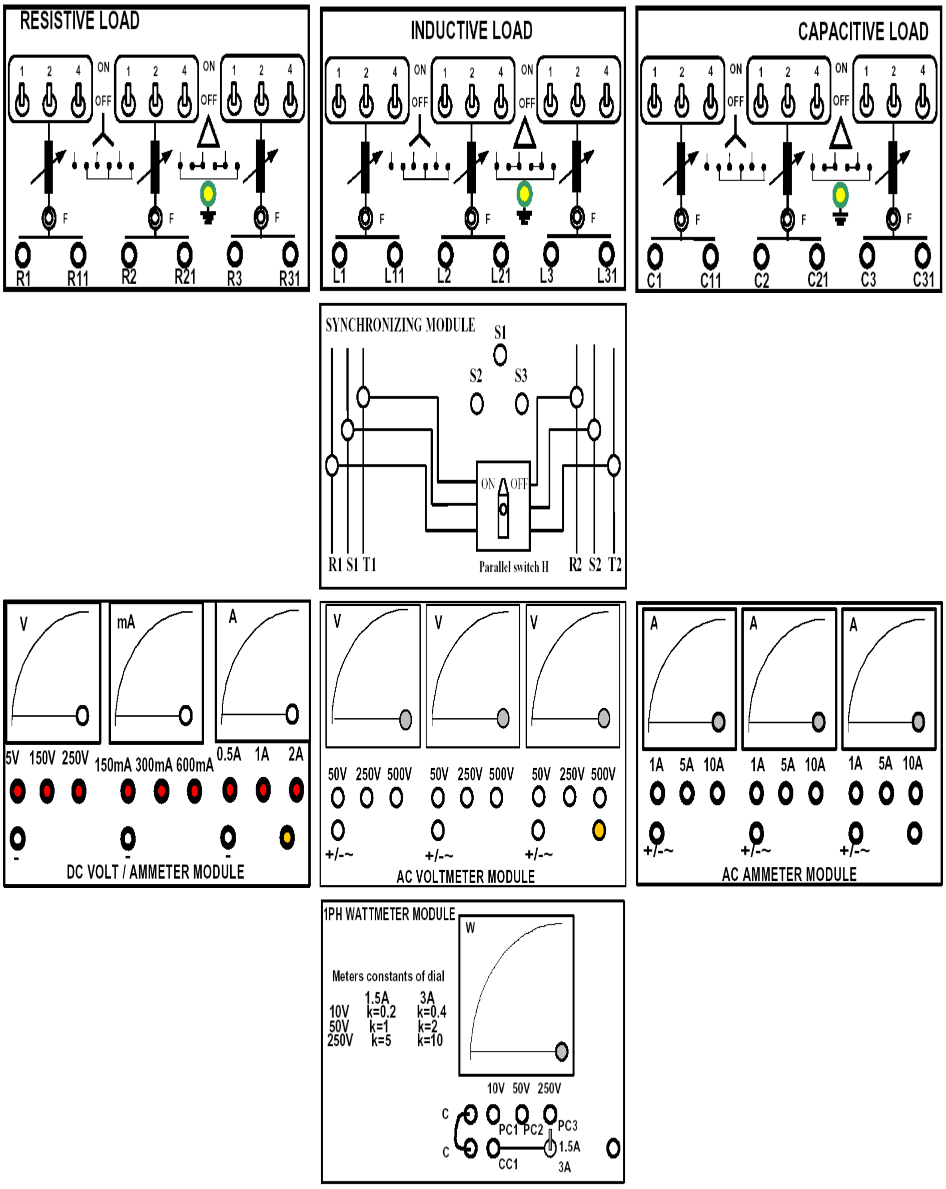


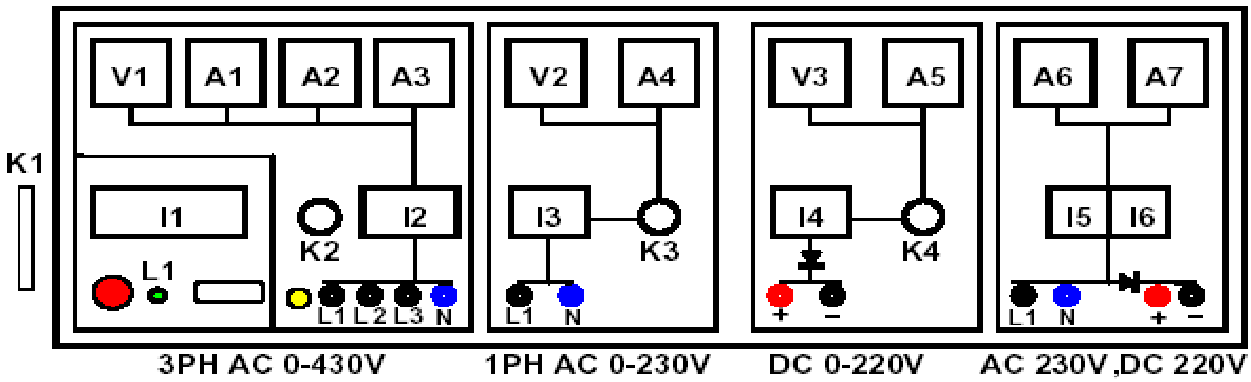
If the electrical power input to the motor is denoted as Pm, mechanical power output of the motor is shown as Po (which is assumed to be equal to the DC generator's electrical output) and the angular speed is given by Wm then Torque, T = PO/ Wm. Input and output powers can be measured as given below:

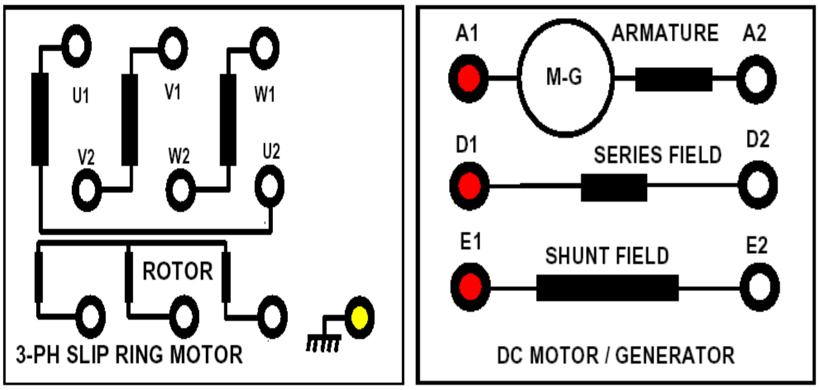
Pm = 3W where W is the readings of the wattmeter shown in the setup. Po = Ig.Eg where Ig, Eg are generator current, voltage at generator terminal.

Equipments:

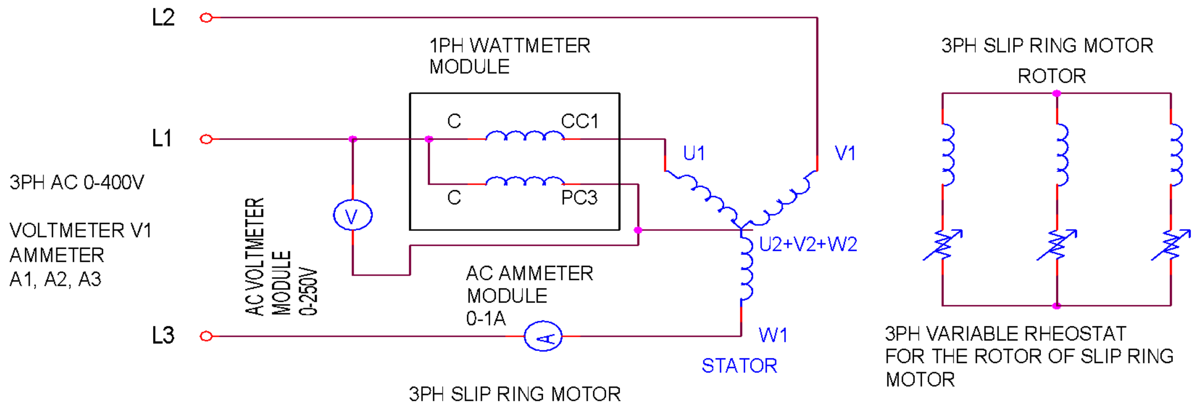
22. Universal Power Supply Module
23. 3 Phase Slip Ring Induction Motor
24. DC Motor / Generator
25. Field Rheostat
26. DC Voltmeter / Ammeter Module
27. 1PH Wattmeter Module
28. Connecting Cables

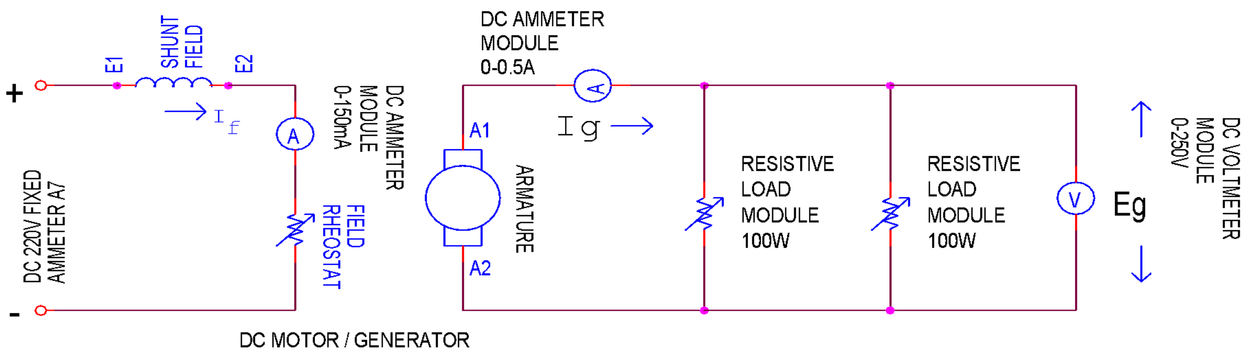






Circuit Diagram:





Procedure:

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

19. Make connections according to the above diagram.
20. Verify the connection by your Lab Teacher

21. Turn ON Switch I1 (upwards).
22. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.
23. ****IMPORTANT: KEEP Switch I6 OFF (downwards).**

24. Turn knob K1, Apply **400VAC** on the Stator of the Motor.
25. Turn ON Switch I2 (upwards).
26. 3 Phase Slip Ring Motor Starts Running

27. Turn ON Switch I6 (upwards).
28. Vary the field rheostat of the DC Generator, make terminal voltage **200VDC**
29. Now vary the torque, and fill the table

Report:

1. Plot power factor vs. torque for both motors.
2. Discuss various characteristics of slip ring induction motor

Group No: **Roll no:**

<u>Data Sheet</u>

Power input, P_M=3W=

Power output =$P_O = I_g.E_g$ =
Angular speed W_m=2*pi*N=

Torque, T=P_O/W_m =
Line current, I=
Line voltage, V=
Power factor, pf=$P_M/\sqrt{3}VI$=

Power input, P_M=3W	Power output $P_O = I_q.E_q$	Angular speed W_m=2ΠN	Torque, T=P_O/W_m	Line current, I	Line voltage, V	Power factor, pf=$P_M/\sqrt{3}VI$

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.

Circuit Diagram:

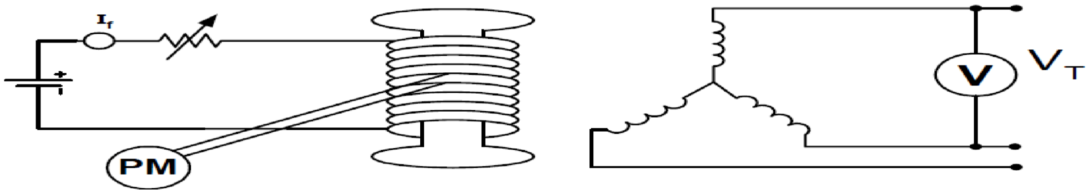


Fig 01: Open Circuit Test

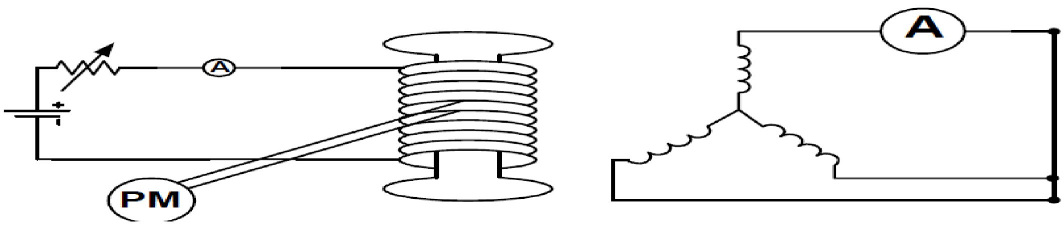
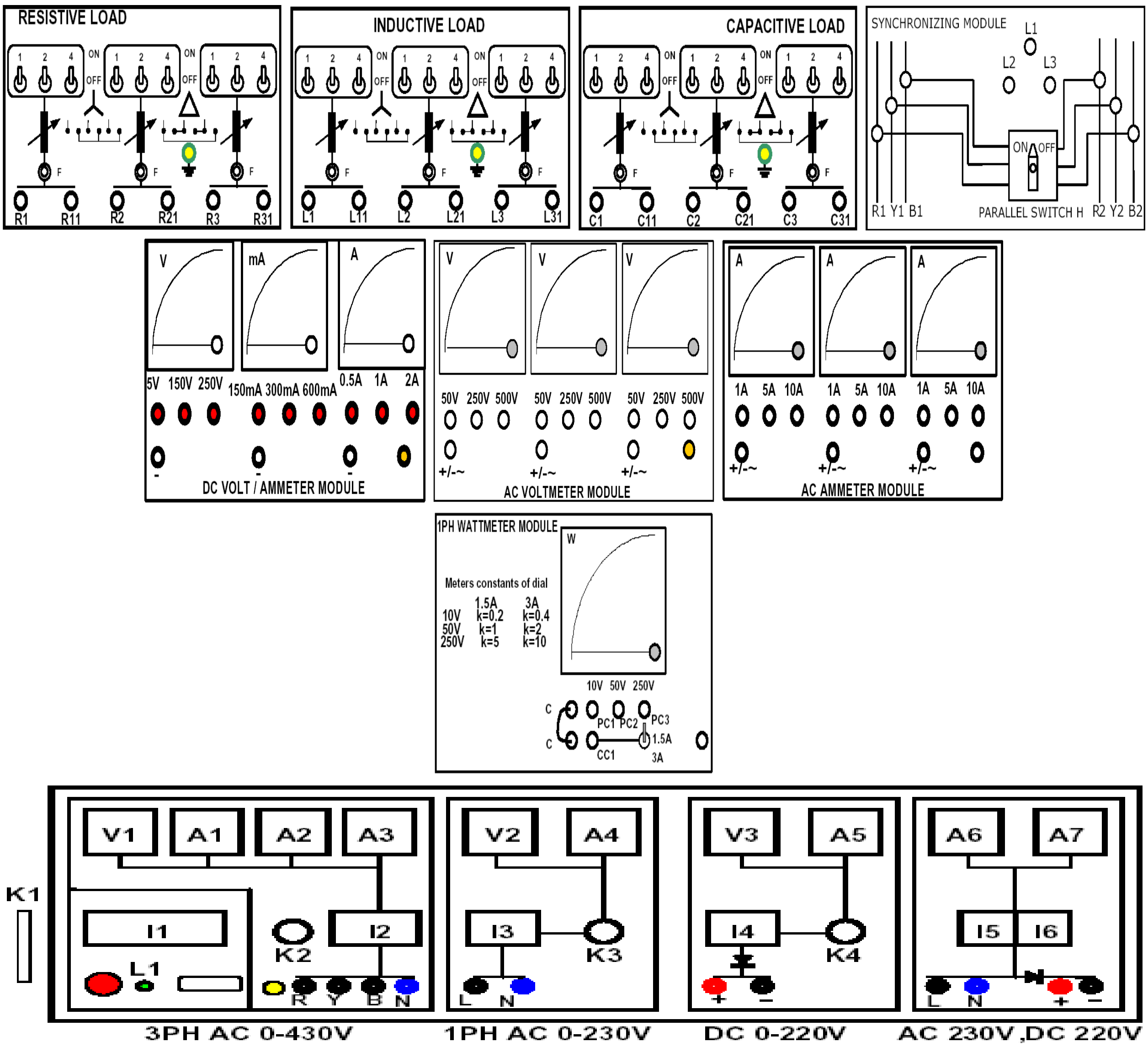
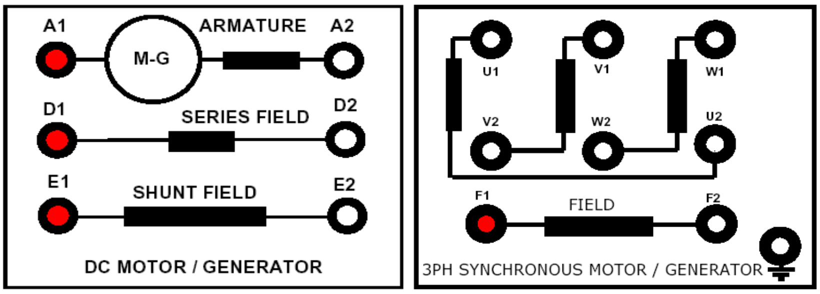


Fig 02: Short Circuit Test





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?

Data Sheet

Group No:
Roll no:

O.C.C. Test

I_f	V_T

Short Circuit Test

I_f	I_{SC}

By Calculation

I_f	X_S

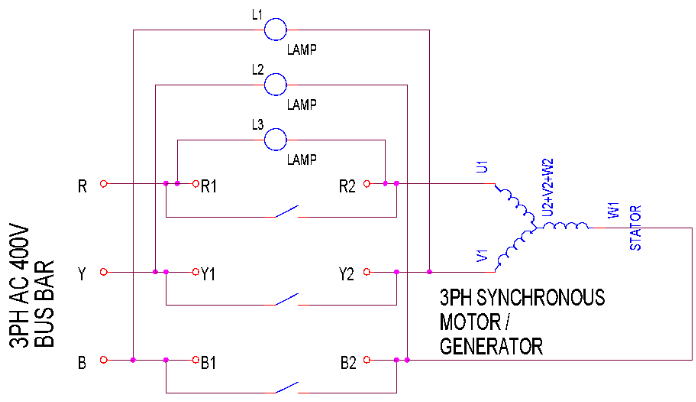
Signature of the Lab teacher:

Experiment no: **8**
Experiment name: **Parallel Operation of Alternators.**

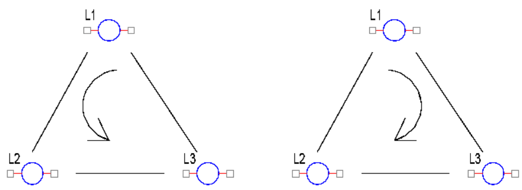
Introduction:
Due to increase in loads in the power system, a single generator cannot operate alone. To share the loads properly more than one generator operates in parallel. To achieve this, the following paralleling condition must be met:

1. The terminal voltage of the incoming generator must be equal to the bus bar voltage
2. The frequency of the incoming generator must be equal to the frequency of the bus bar.
3. The phase sequence of the incoming generators voltage must be same as the bus bar voltage phase sequence.
4. The phase angles of two corresponding phases must be equal.

Condition 1 can be verified easily by a Voltmeter. For condition 2, 3, 4 Synchronizing Lamp is used for paralleling Generators with the bus bar. Below is the circuit diagram with synchronizing lamp L1, L2, L3. **This is called Two BRIGHT and One DARK method suggested by Siemens and Halske.**



Two BRIGHT and One DARK method
By Siemens & Halske



Below are the steps for synchronizing generator with the bus bar:

1. By varying the field excitation make the stator voltage of the 3 phase synchronous generator equal to the bus bar 400VAC

2. Observe the lamps L1, L2 and L3; when the lamps becomes dark and bright sequentially which give the impression of a "rotation" of the lights. That is the lamps will light up one after another in the order Clock Wise 1,2,3 or Anti Clock Wise 1,3,2.

3. The speed of this rotation of light is proportional on the difference of the frequency of the generator voltage and the bus bar.

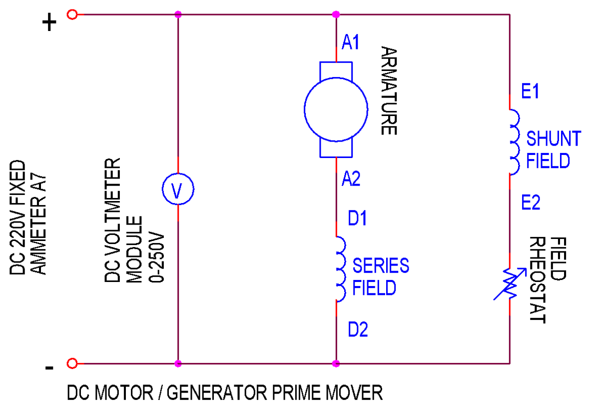
4. **If all the Three Lamps L1, L2, L3 becomes DARK and BRIGHT at the same time then interchange Y2, B2

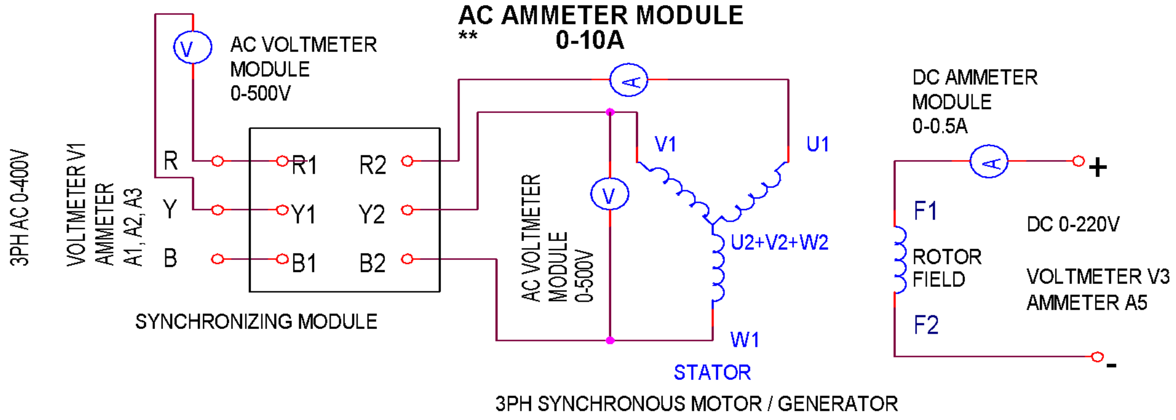
5. Now slightly readjust (increase or decrease) the speed of the prime mover so that the rotation becomes slow. When L3 becomes DARK and L1, L2 becomes dim but equally bright, now the generator is ready to be paralleled with the bus bar.

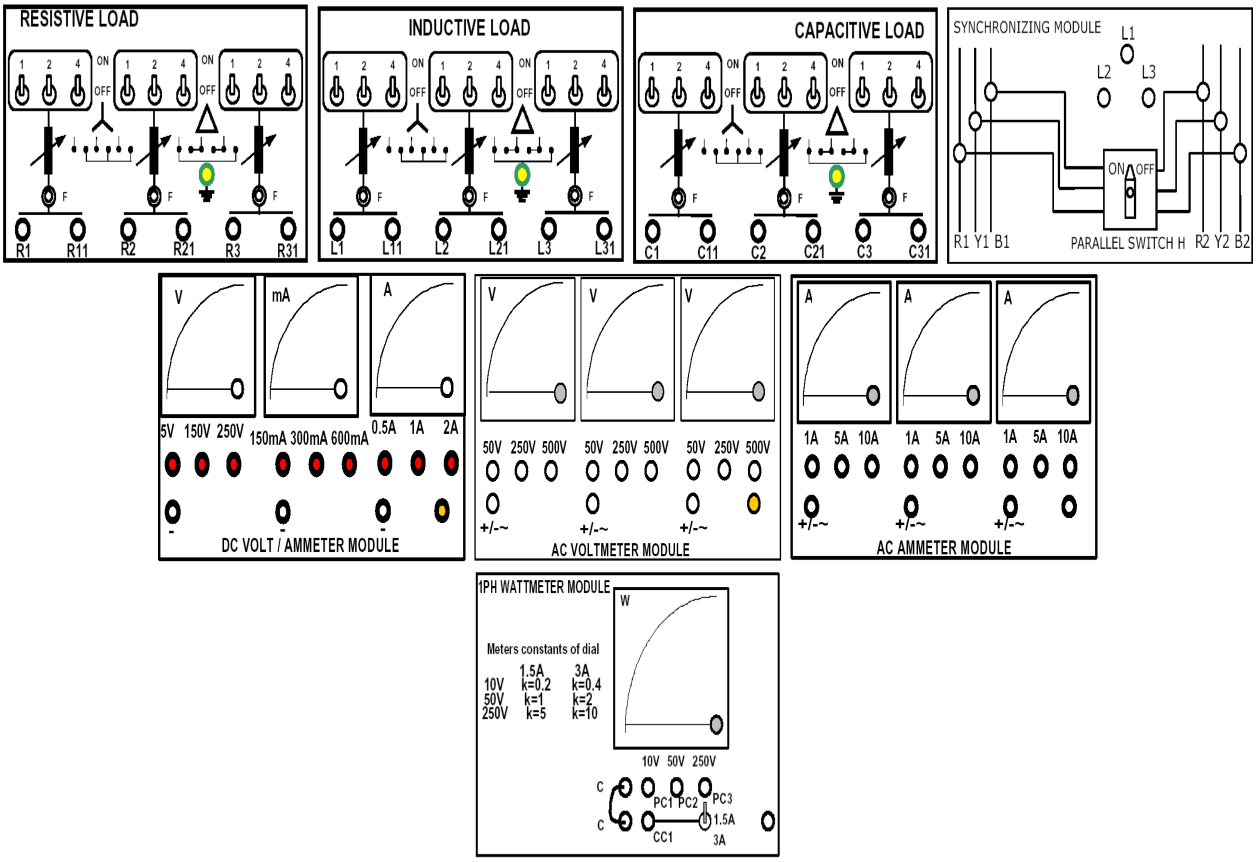
Equipments:

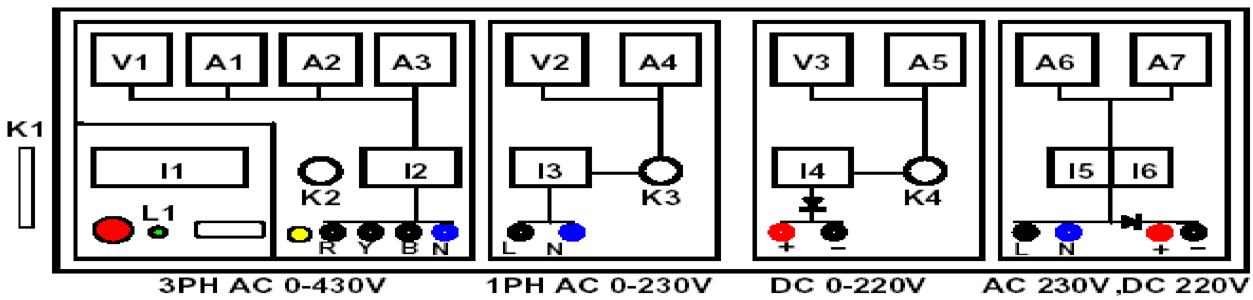
1. Universal Power Supply
2. DC Motor / Generator
3. 3 Phase Synchronous Motor Generator
4. Synchronizing Module
5. DC Voltmeter / Ammeter Module
6. AC Ammeter Module 0-1A
7. AC Voltmeter Module 0-250 V
8. Tachometer
9. Coupling Sleeve
10. Connecting Cables

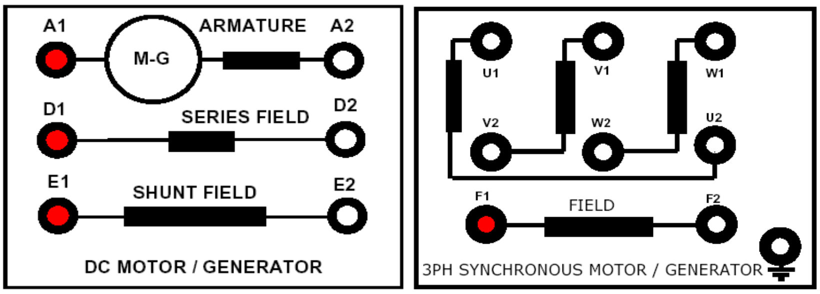
Connection Diagram:




AC AMMETER MODULE
** 0-10A
AC VOLTMETER MODULE 0-500V
DC AMMETER MODULE 0-0.5A
3PH AC 0-400V
VOLTMETER V1
AMMETER A1, A2, A3
R
Y
B
R1
Y1
B1
R2
Y2
B2
SYNCHRONIZING MODULE
AC VOLTMETER MODULE 0-500V
V1
U1
U2+V2+W2
W1
STATOR
3PH SYNCHRONOUS MOTOR / GENERATOR
F1
ROTOR FIELD
F2
DC 0-220V
VOLTMETER V3
AMMETER A5
+
-


RESISTIVE LOAD
INDUCTIVE LOAD
CAPACITIVE LOAD
SYNCHRONIZING MODULE
PARALLEL SWITCH H
DC VOLT / AMMETER MODULE
AC VOLTMETER MODULE
AC AMMETER MODULE
1PH WATTMETER MODULE
Meters constants of dial


K1
V1
A1
A2
A3
I1
I2
K2
L1
V2
A4
I3
K3
V3
A5
I4
K4
A6
A7
I5
I6
3PH AC 0-430V
1PH AC 0-230V
DC 0-220V
AC 230V ,DC 220V



Procedure:

11. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
12. Make sure all the variable knobs (K1, K3, K4) are at the min, counter clock wise (CCW) position.
13. Make connections according to the above diagram.
14. Verify the connection by your Lab Teacher
15. Make sure the 3PH synchronous Motor / Generator is mechanically coupled with DC Motor / Generator through the coupling sleeve.
16. Turn ON Switch I1 (upwards).
17. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.
18. ****CAUTION: Turn OFF the Parallel Switch H of the Synchronizing Module**
19. ****CAUTION: Turn OFF Switch I4 (downwards).**
20. ****Starting the Prime Mover**
21. Keep the Field Rheostat of the DC Motor at **Maximum**
22. Turn ON Switch I6 (upwards).
23. Obtain speed 3000 RPM by varying the Field Rheostat, measure the speed with Tachometer
24. ****Connecting the Bus Bar**
25. Make the 3PH supply at **400VAC** by turning Knob K1, Voltmeter V1.
26. ****CAUTION: The Parallel Switch H of the Synchronizing Module must be turned OFF**
27. Turn ON Switch I2 (upwards).
28. ****Adjusting Terminal Voltage of the 3PH Generator**
29. Turn Knob K4 at min (CCW)
30. Turn ON switch I4 (upwards).
31. Increase the Rotor Field Voltage so that the 3PH AC Output of the Generator becomes equal to the Bus Bar **400VAC**.
32. ****Synchronizing the Generator with the Bus Bar**
33. Now Observe the lamps L1, L2 and L3 on the synchronizing module; when the lamps becomes **DARK** and **BRIGHT** sequentially which give the impression of a "**rotation**" of the lights. That is the triangle of three lamps will light up one after another in the order of **Clock Wise** 1,2,3 or Anti **Clock Wise** 1,3,2
34. The speed of this rotation of light is proportional to the difference between the frequency of the generator voltage and the bus bar.
35. **If all the Three Lamps L1, L2, L3 becomes DARK and BRIGHT at the same time then interchange Y2, B2 and Verify again the step 23.

36. Now slightly readjust (increase or decrease) the speed of the prime mover so that the rotation speed of the lamps becomes slow. When L3 becomes DARK and L1, L2 becomes **Dim But Equally Bright**, now the generator is ready to be paralleled with the bus bar.
37. ****CAUTION: Carefully Turn ON the Parallel Switch H of the Synchronizing Module, if a high current shows on AC Ammeter Module 0-10A then Turn OFF the Switch H.**

Report:

1. What will happen if the prime mover on the field excitation of the on-coming generator fails? Explain.
2. Why is paralleling necessary in a power system?

Experiment no: **9**

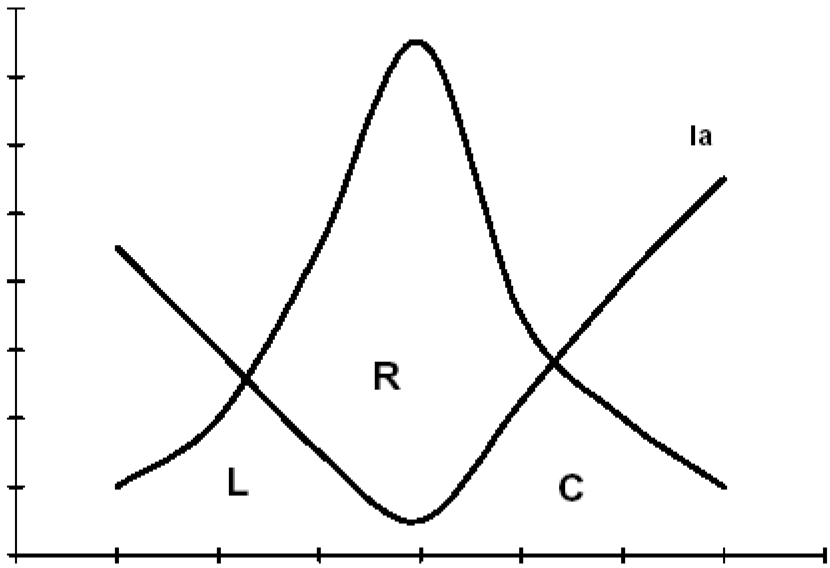
Experiment name: **Plotting of V-curves for Synchronous motor and Drawing Phasor diagram of a Synchronous motor.**

Introduction:

When the rotor of the synchronous motor is locked with the rotating magnetic field; then the variation of field current does not change the speed of the motor.

However, interesting changes take place in the stator side. When the motor is over-excited the system Pf leads and reactive power is supplied to the system. Under excited machine consumes reactive power and Pf lags.

If Pf Vs If is plotted it gives a V-shaped curve.



A synchronous machine (motor) needs two sets of supply for its operation. A D.C voltage is applied across the rotor terminals and a 3-phase voltage is impressed across the stator. The equivalent circuit can be drawn as follows:

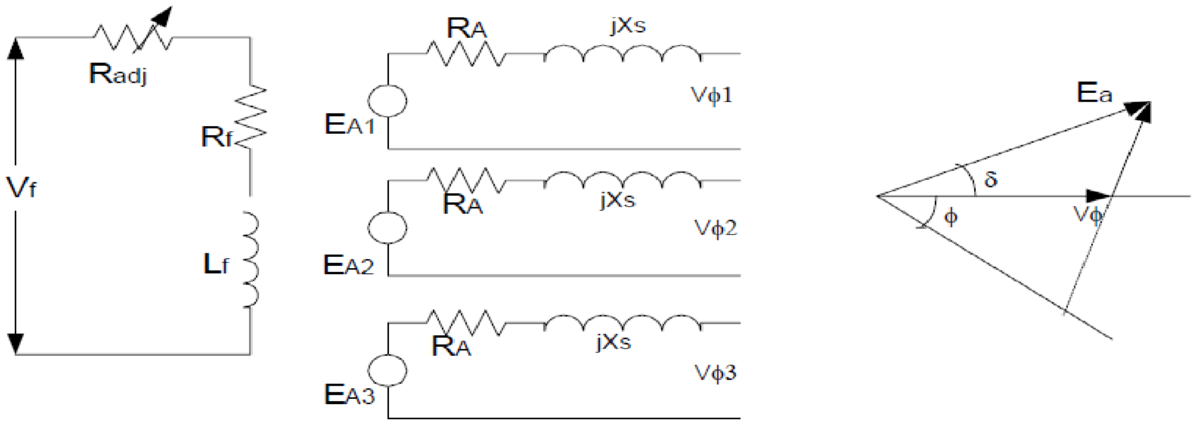
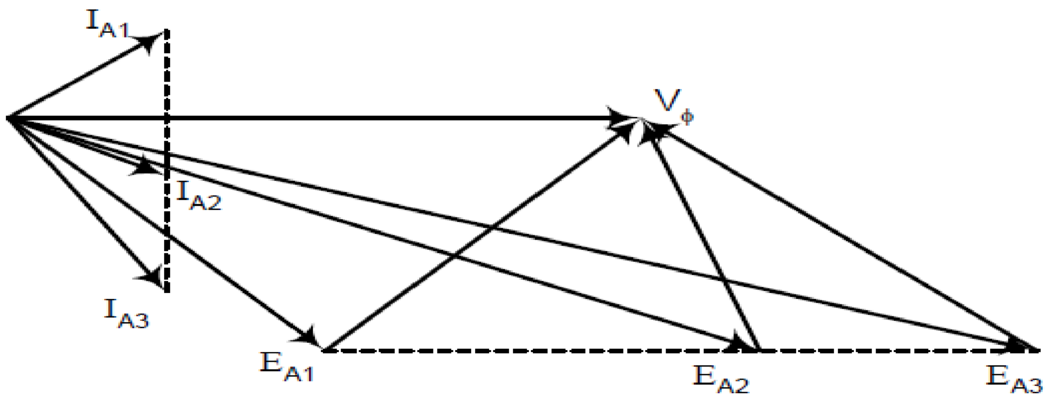


Figure no: 1

$P_{in} = 3*V_\varphi*I_a \cos\theta = 3*V_\varphi*E_A \sin\delta$ where, $E_A \sin\delta = I_a*X_S*\sin(90-\varphi)$
If excitation is increased (i,e; IF is increased), EA tends to increase. However as no extraload is added to the motor shaft, EAsinδ & IAcosθ remains constant. So, tip of EA and IA **moves along the dashed line as shown below.**

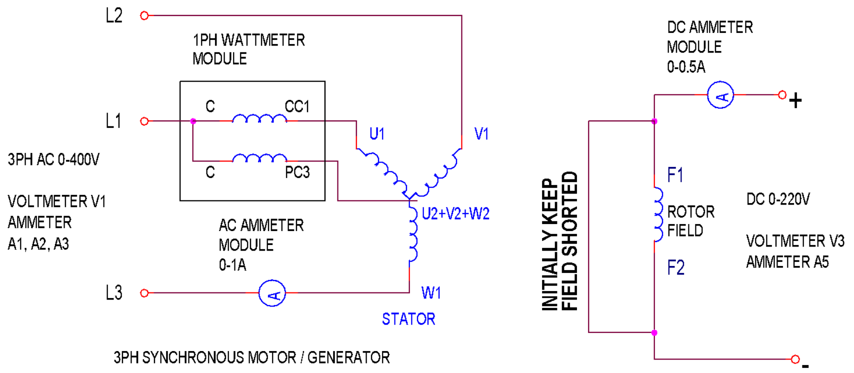


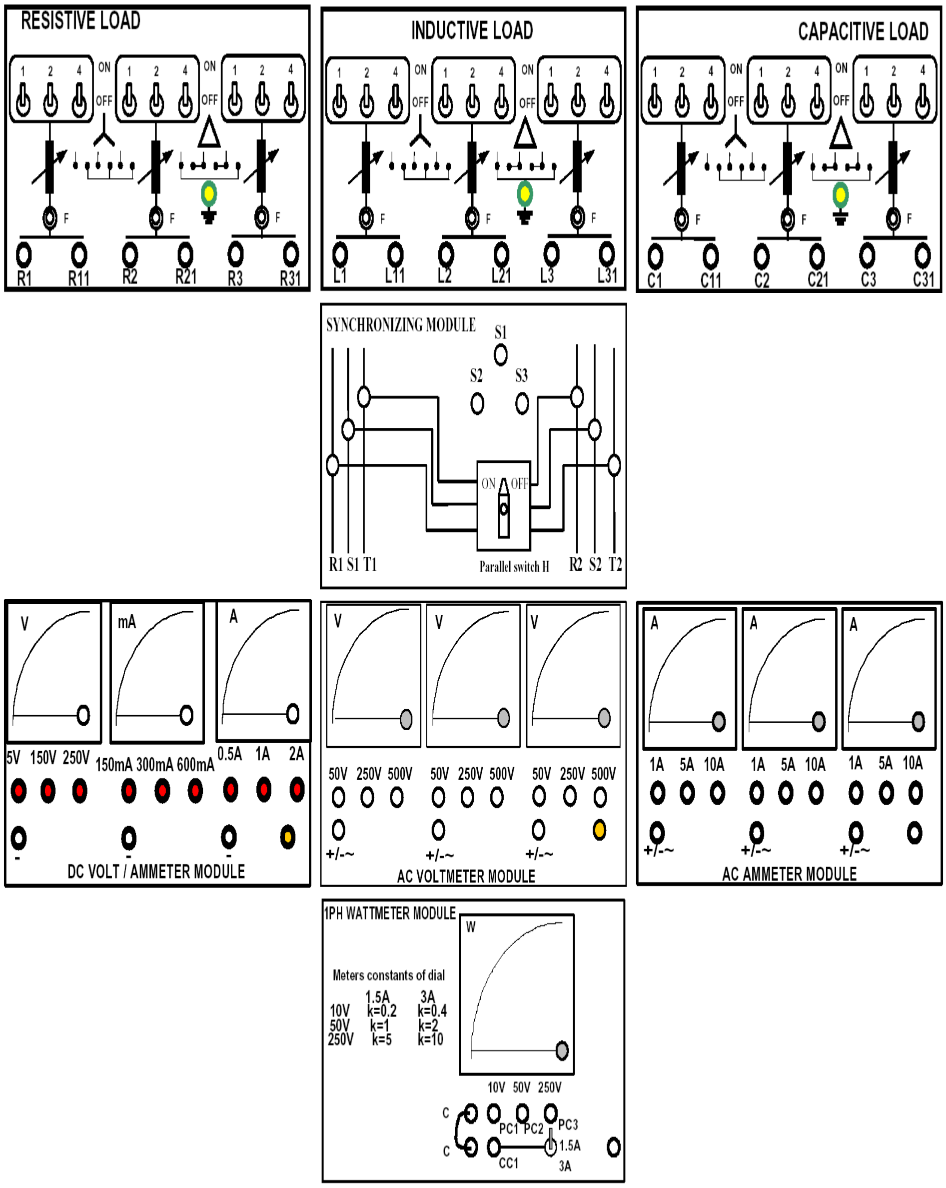
The purpose of the experiment is to draw the phasor diagram under different excitation conditions.

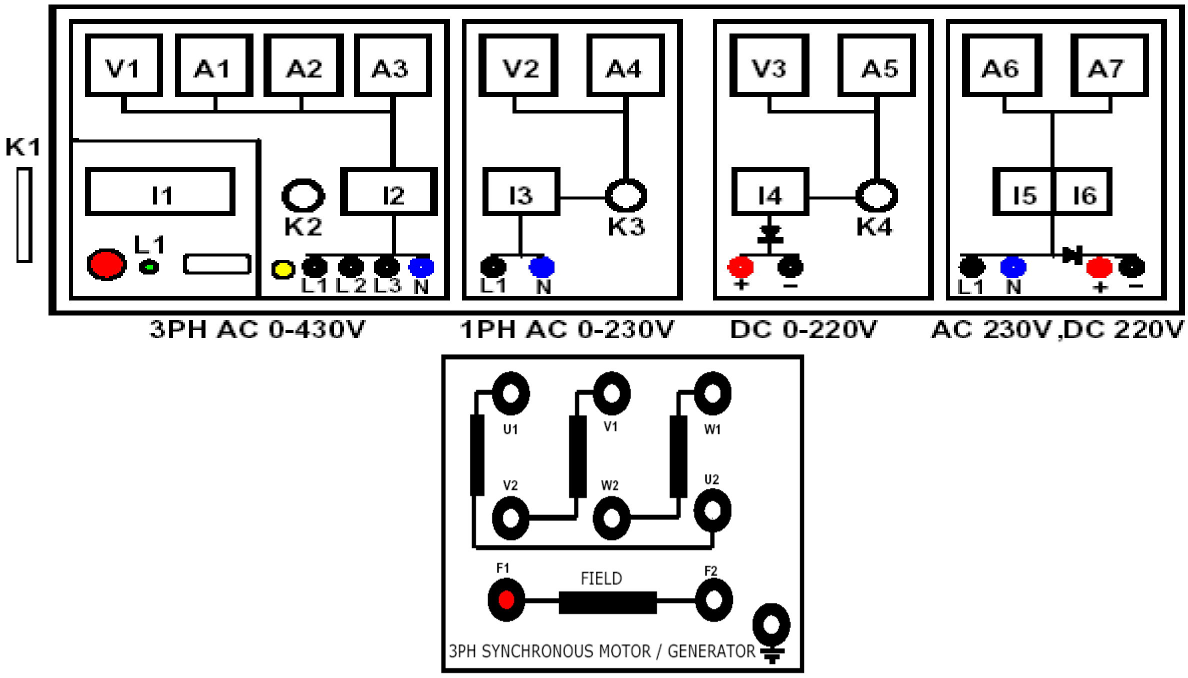
Equipments:

1. Universal Power Supply
2. 3PH Synchronous Motor / Generator
3. 1PH Wattmeter Module
4. AC Ammeter Module 0-1A
5. DC Voltmeter / Ammeter Module
6. Tachometer
7. Connecting Cables

Connection Diagram:


L2
1PH WATTMETER MODULE
C
CC1
L1
C
PC3
U1
V1
3PH AC 0-400V
VOLTMETER V1
AMMETER
A1, A2, A3
U2+V2+W2
AC AMMETER MODULE
0-1A
L3
W1
STATOR
3PH SYNCHRONOUS MOTOR / GENERATOR
DC AMMETER MODULE
0-0.5A
+
INITIALLY KEEP FIELD SHORTED
F1
ROTOR FIELD
F2
DC 0-220V
VOLTMETER V3
AMMETER A5
-


RESISTIVE LOAD
R1 R11 R2 R21 R3 R31
INDUCTIVE LOAD
L1 L11 L2 L21 L3 L31
CAPACITIVE LOAD
C1 C11 C2 C21 C3 C31
ON
OFF
SYNCHRONIZING MODULE
S1
S2
S3
R1 S1 T1
Parallel switch II
R2 S2 T2
V
mA
A
5V 150V 250V
150mA 300mA 600mA
0.5A 1A 2A
DC VOLT / AMMETER MODULE
50V 250V 500V
+/-~
AC VOLTMETER MODULE
1A 5A 10A
AC AMMETER MODULE
1PH WATTMETER MODULE
W
Meters constants of dial
1.5A
3A
10V k=0.2 k=0.4
50V k=1 k=2
250V k=5 k=10
10V 50V 250V
PC1 PC2 PC3
CC1
1.5A
3A



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. ****CAUTION: Initially SHORT Field F1 & F2 of the 3PH Synchronous Motor**

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 **400V** by turning Knob K1, Voltmeter V1.

9. ****CAUTION: Make sure Field F1 & F2 of the 3PH Synchronous Motor are SHORTED**
10. Turn ON Switch I2 (upwards).

11. 3PH Synchronous Motor should start running at this point.

12. Turn Knob K4 at min (CCW)
13. ****CAUTION: Open the SHORTED Field F1 & F2 of 3PH Synchronous Motor and Turn ON switch I4 (upwards).**

14. Turn Knob K4 apply 200VDC to the Rotor Field

15. Now make the machine run at Synchronous speed by varying the Field EXCITATION. When the machine becomes synchronized with the Supply frequency then the speed becomes constant. The speed will not change if the field excitation is further varied.

16. Now vary the Field Excitation from **200VDC - 220VDC** and measure the field current $\mathbf{I_f}$ and fill up the Table-1.

Report:

1. Explain with vector diagram how the reactive power can be supplied or consumed with the help of field current of synchronous motor.
2. For a total load of 5 kw at 0.95 lagging how much reactive power should be supplied by the motor to make the power factor =1. What should be the value of field current under this condition?
3. Suppose the rotor is running at synchronous speed. Suddenly D.C supply is disconnected, will the motor continue to run? Give reasons for your answer.

Group No:
Roll no:

Data Sheet

Table1:

V_L (L-L)	Field Current If	Armature Current Ia	Wattmeter Reading W	Pt = 3W	PF = Pt/√3V_LIa	Q_T = √3V_LIaSin θ

Graph:

1. Draw Ia Vs If and P.f Vs If on the same graph paper. Clearly mark the zones of lagging, leading & unity power factor.

2. Draw PT Vs If and QT and If on the same graph paper.

Signature of the Lab Teacher

Group No:
Roll no:

Data Sheet

1. Rotor resistance R_F =
2. Rotor Inductance L_F =
3. Stator resistance/Phase R_A =
4. Stator Induction/Phase L_A=
5. X_S = 2пfLS =
6. **Fill up the table**

$P_{in} = 3\times W$	V_ϕ	I_A	$Cos\theta = P_{in}/ 3V_\phi I_A$	$E_A = V_\phi - jI_A X_S$	$Sin\delta = P_{in} * X_S / 3 V_\phi E_A$

Signature of the Lab Teacher

Experiment no: **10**
Experiment name: **To Find the Efficiency of a Shunt Generator**

Introduction:

The efficiency of a generator is defined by,

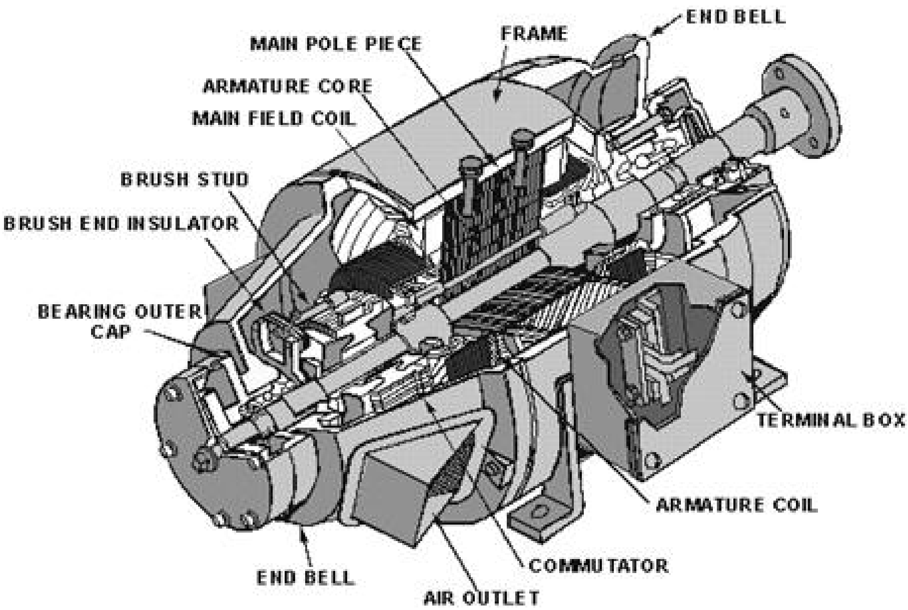
η= Output/input.
= Watts available in load/Total watts generated.

If the load voltage is V and load current is I then generator output is VI watts.
So generator input = Output + losses.
$= V*I + I_a^2 *R_a + W_C$
$= V*I + (I+I_{sh})^2 *R_a + W_C$
$= V*I + I^2 *R_a + W_C$ as I_a is approximately equals to I

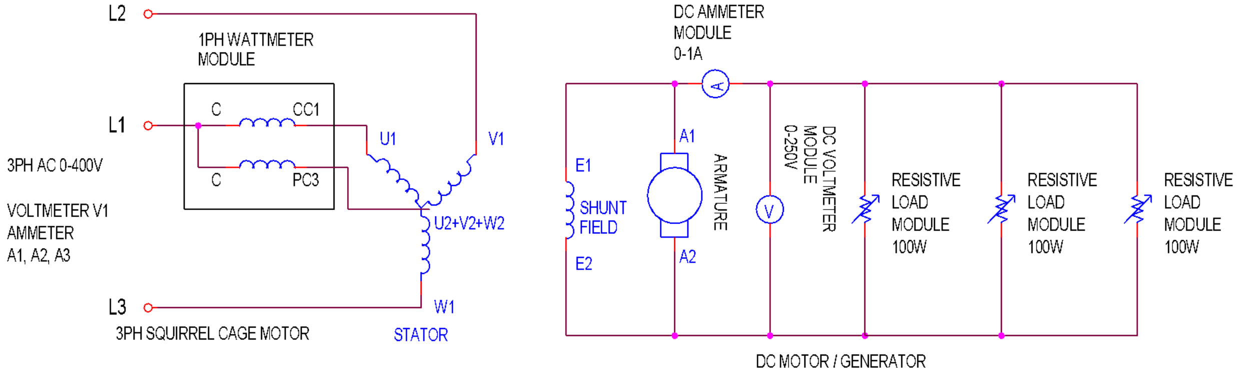
Where, I_a = Armature current.
I_{sh} = Shunt field current.
R_a = Armature resistance.
W_c = Constant losses = Magnetic losses + Mechanical losses.

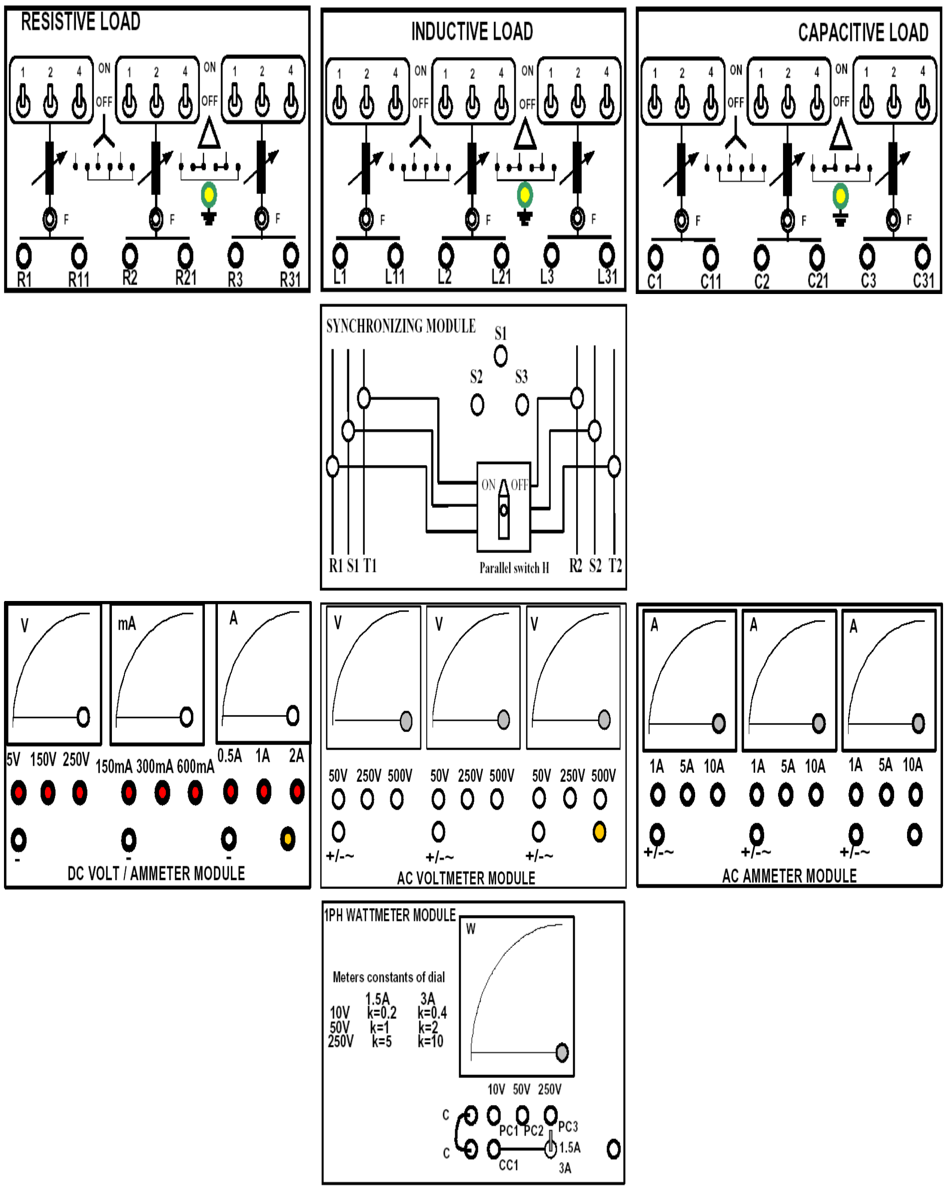
Equipments:

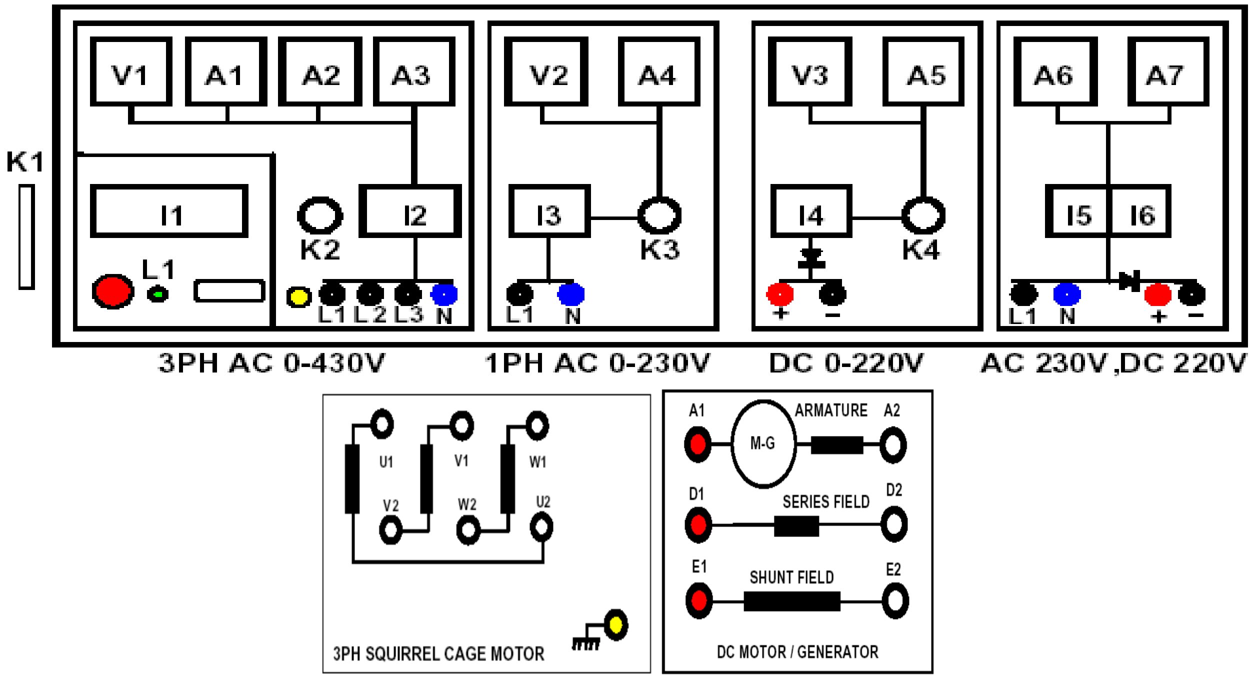
1. Universal Power Supply
2. 3PH Squirrel Cage Induction Motor (Prime Mover)
3. DC Motor / Generator
4. DC Voltmeter / Ammeter Module
5. 1PH Wattmeter Module
6. Resistive Load Module
7. Coupling Sleeve
8. Connecting Cables
9. Multi-meter



Circuit 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 (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. Turn OFF (downwards) all the loads connected to DC Generator
14. Make sure that **200VDC** is developed at the generator terminals at no-load. Note down the wattmeter reading on the data sheet and treat this power as no-load loss for the generator.

15. Note down the rated current of the generator. Run the generator at half of the full load rated current.
16. Now load the generator at full load current and fill up the data sheet.

Report:

1. Comment on the efficiencies in steps Half-Load and Full-Load
2. Determine the condition for which maximum efficiency will occur for this generator. Calculate the numerical value of this efficiency.

Group No:
Roll no:

Data Sheet

1. Armature resistance, R_a =
2. Shunt Field Resistance, R_f =

At no load

1-φ input power into motor, W =
3-φ input power into motor, W_c = 3×W =

At half full load

Terminal voltage of generator, V =
Load current, I_L =

Calculate

1. Armature Cu-loss =
2. Output power =
3. Efficiency =

At full load

Terminal voltage of generator, V =
Load current, I_L =

Calculate

1. Armature Cu-loss =
2. Output power =
3. Efficiency =

Signature of the Lab teacher:

Experiment no: **11**
Experiment name: **Speed Control of a DC Shunt Motor**

Introduction:

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

$E_g = \varphi ZN/60 *(P/A)$ volt

The same equation can be written for motor replacing E_g **by** E_b **---**

$E_b = \varphi ZN/60 *(P/A)$ volt -------------------- (1)

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

The simple diagram of a DC motor is shown below:

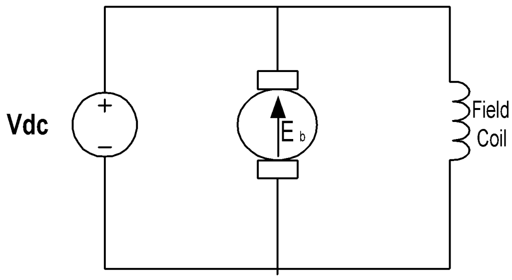


Figure 1: DC Motor

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 ---- $Eb = \varphi*N$ **(**$Z*P/60*A$)
$= \varphi*N*K$, where K is constant

i.e. $N = (1/K)* E_b/\varphi$
$= K_m * (V- I_a*R_a)/\varphi$ 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.

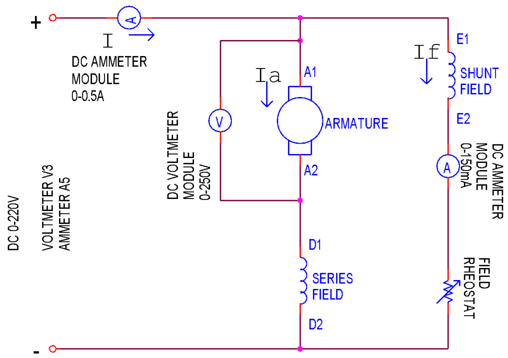
So, the speed of the DC motor can be controlled by three methods. They are-

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

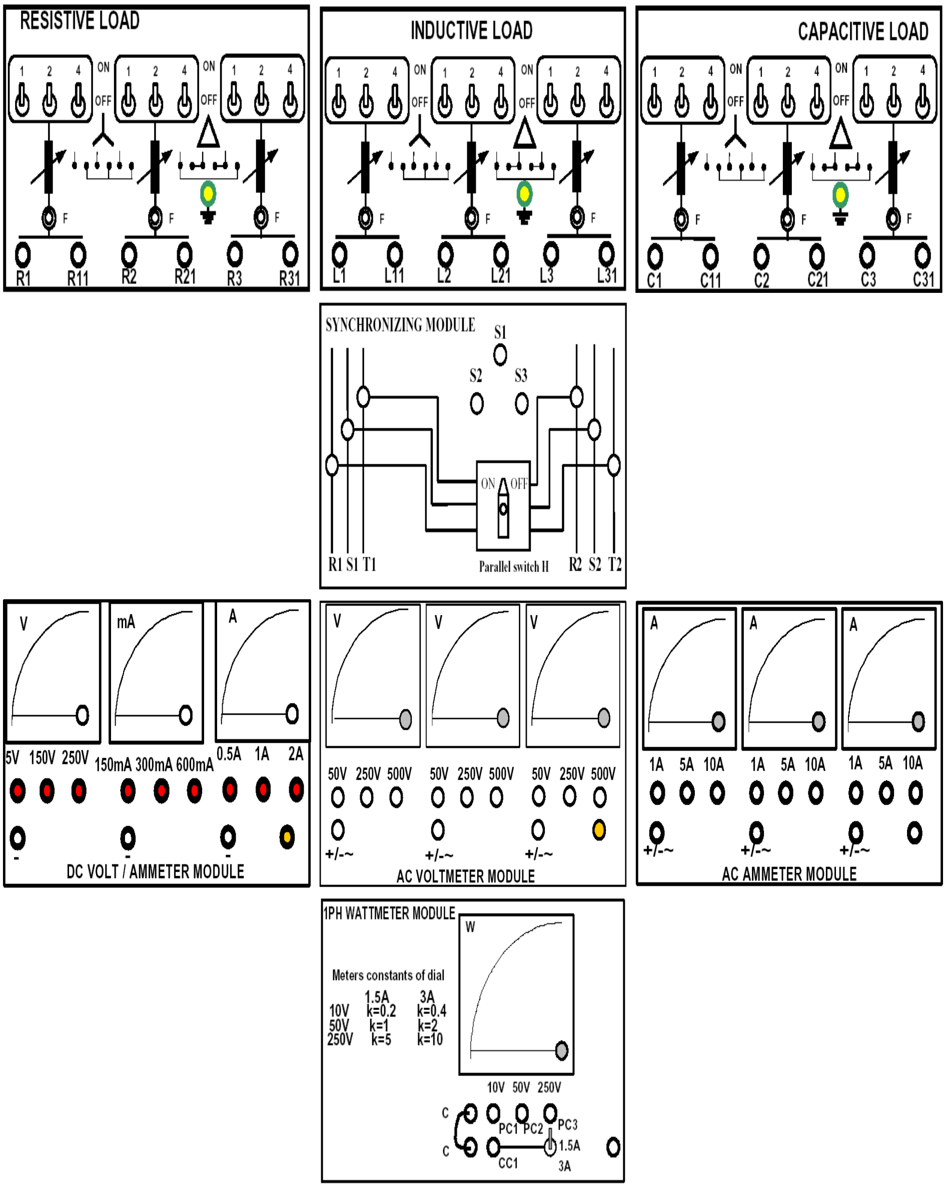
Equipments:

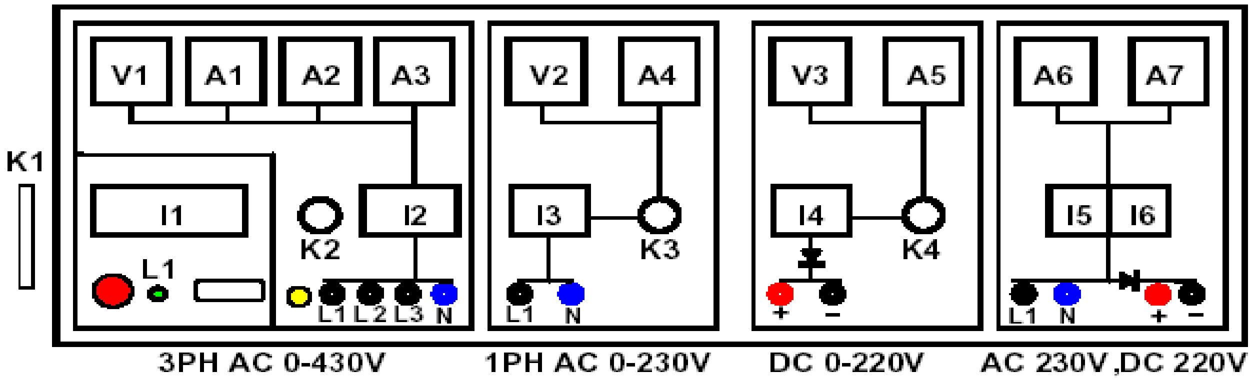
10. Universal Power Supply
11. DC Motor / Generator
12. Field Rheostat
13. DC Voltmeter / Ammeter Module
14. Coupling Sleeve
15. Connecting Cables
16. Multimeter

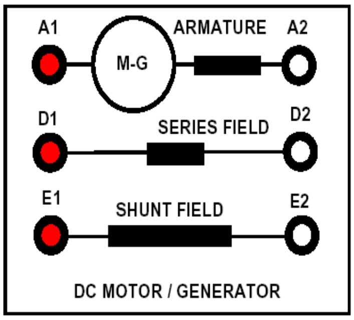
Flux Control Method:



DC MOTOR / GENERATOR







Procedure:

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

19. With a sensitive Multi-meter, measure the Series, Shunt field and Armature resistance; write the values on the data sheet.

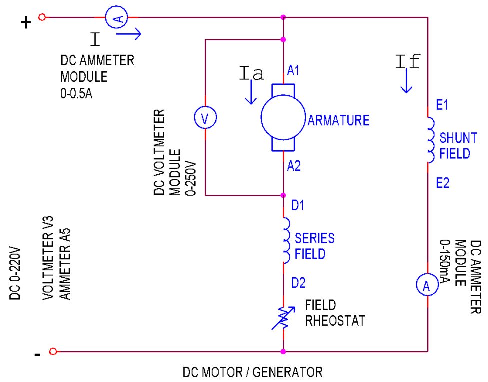
20. Make connections according to the above diagram.
21. Verify the connection by your Lab Teacher

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

24. Turn Knob K4 at min (CCW)
25. Turn ON switch I4 (upwards).
26. Keep the Field Rheostat to the Min
27. Make the Motor running by increasing the voltage to 200VDC

28. Make the supply voltage at **200VDC** and keep Field Rheostat at minimum position.
29. 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**:



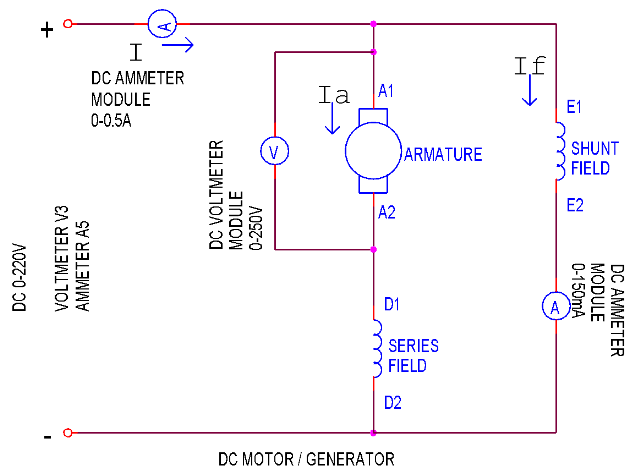
Procedure:

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. **1.** Explain the curves plotted on the graph paper.
2. **2.** Variation of which parameter affects the speed most? Why?
3. **3.** Explain the relative merits and demerits of each method.
4. **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