DC Machine & Transformer Lab Manual

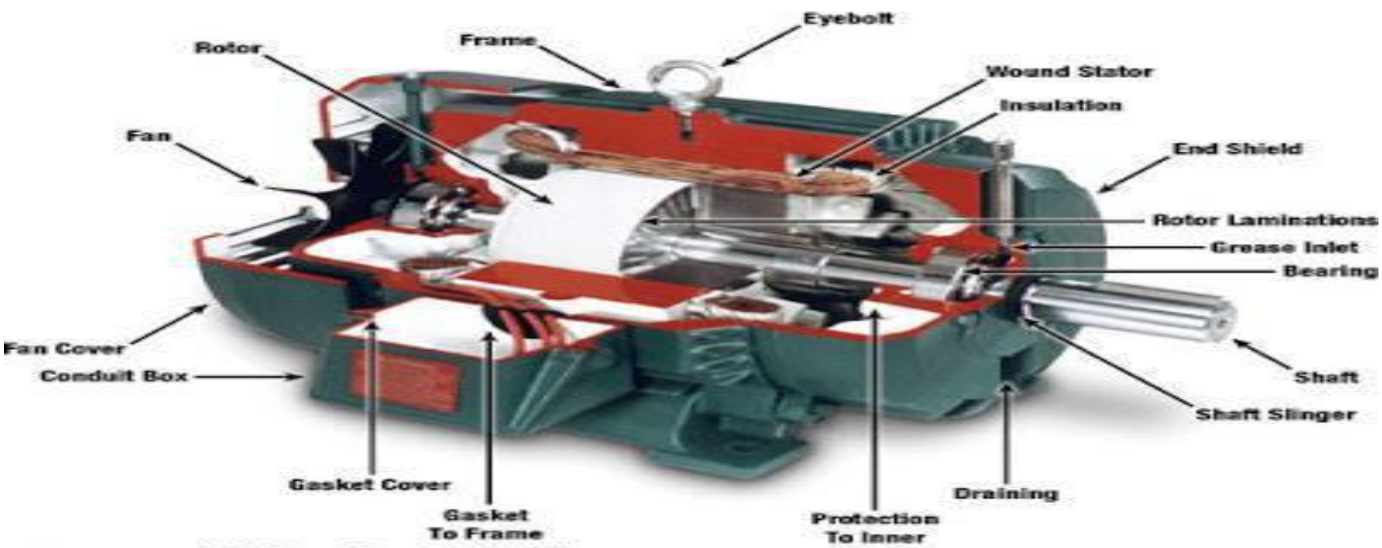


Figure 8 – Motor Construction

Diploma

IVth Semester

Electrical Engineering

List of Experiments

1. To study the construction of a D C Machine.
2. To study the construction of 3 point starter of a D C Machine.
3. To Measure power in a 3 phases circuit by 3 wattmeter method.
4. To Measure power in a 3 phases circuit by two wattmeter method.
5. To study the construction of single phase transformer.
6. To study the construction of three phase transformer.
7. To find the efficiency of a single phase Transformer by Direct loading.
8. To Start DC shunt motor by using three point starter.
9. To reverse the direction of DC motor.
10. To obtain the Speed control of DC shunt motor (Armature and Field control).

<u>Experiment no : 1</u>

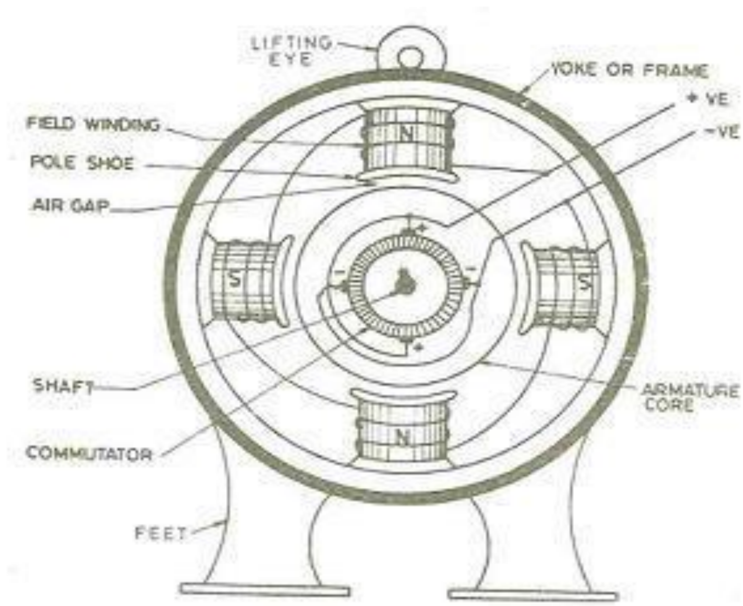
AIM: To study the construction of D.C. machine

APPARATUS: D.C. machine assembly

THEORY: D.C. Machine: DC Machines are of two types:

1. D.C. motor

2. D.C. generator



Parts of a DC Machine

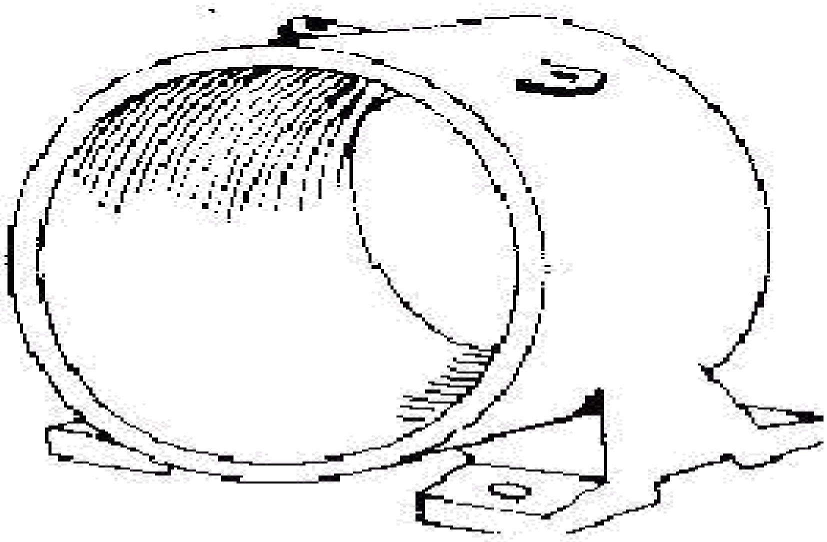
Main parts of D.C. machines:

1. Magnetic Yoke 2. Pole core and pole shoes 3. Pole coils 4. Armature core

5. Armature coils 6. Commutator 7. Brushes and bearings

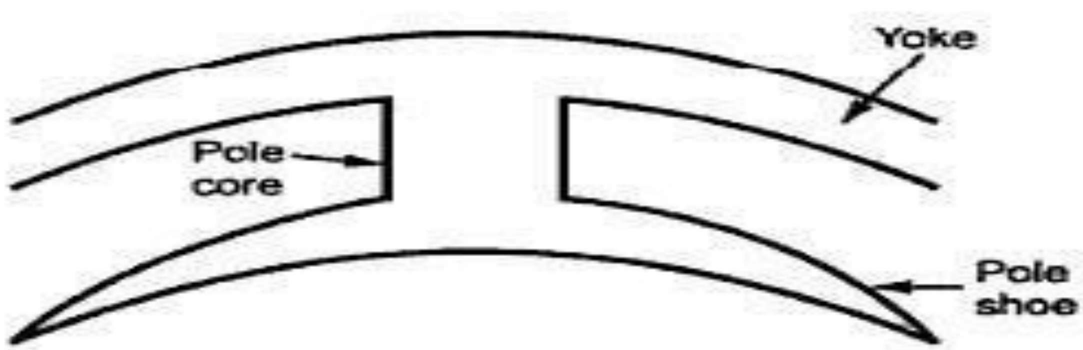
a) It carries the magnetic flux produced by the poles.

b) It provides the mechanical support for the pole and acts as a protecting cover for the whole machine.



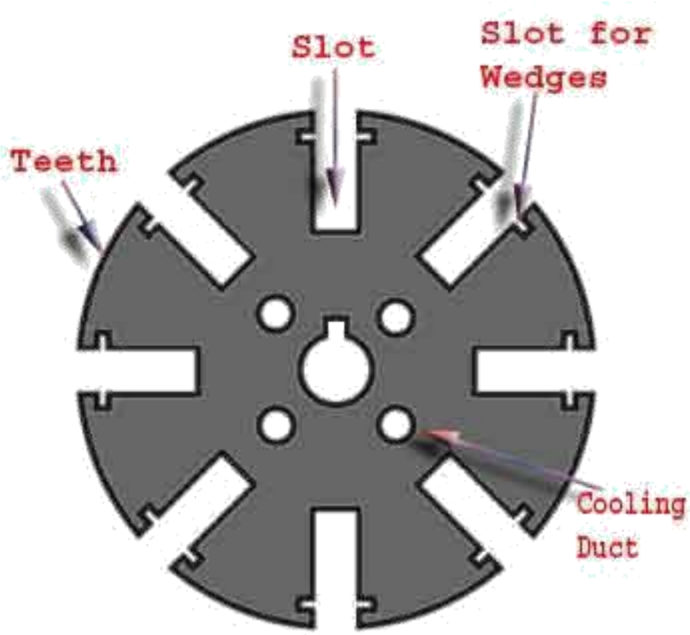
Pole Core & Pole Shoe : Pole core and Pole shoes serve the following purpose

Pole shoe spreads the flux in the air gap to reduce the reluctance of magnetic path. Pole shoes provide the support for the pole coils

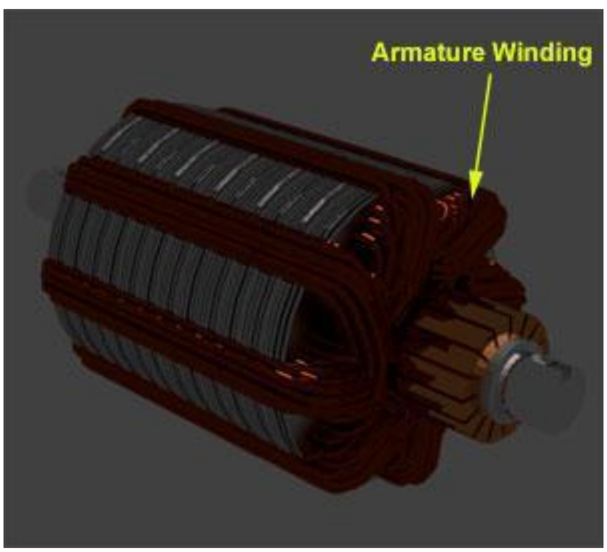


Pole Coils: Pole coils are made up of copper wire. These are placed on pole core.

Armature Core: It houses armature coils & causes them to rotate, hence cuts the flux produced by field winding. It is cylindrical & made up of laminations of approx 0.5mm thickness. It is keyed to the shaft laminations are used to reduce the eddy currents.

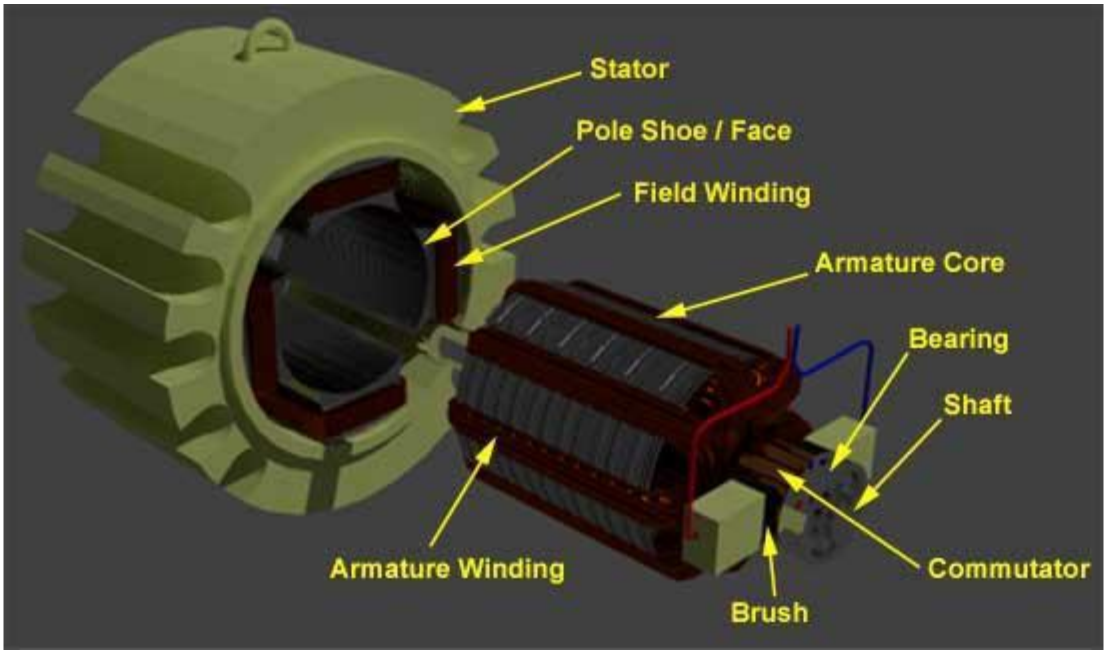


Armature Windings: These are usually former wound. Various conductors are placed in armature slots, which are lined with insulating material.



Commutator: The function of commutator is to collect the current from the armature conductors.

It converts the a.c. of armature conductor into unidirectional current in external load. It is cylindrical structure with wedge shaped segments insulated from each other by thin sheets of mica. Number of segments is equal to number of armature conductors.



7. Brushes & Bearings: Brushes collect the current from commutator. They are made of carbon & are of rectangular shape. Brush holder is mounted on spindle & brushes can slide. Ball bearings are used for less wear and tear.

RESULT: The assembly of D.C. machine is observed and construction of all the parts is studied in detail.

Experiment no : 2

AIM: To study the construction of three point starter of a DC Machine.

APPARATUS: Three point starter model

THEORY: Three point starter is shown in the figure 1, when motor is started, starting arm is moved slowly towards the ON position

1)As soon as arm touches the stud no. 1 full starting resistance get connected in the armature circuit.

1) Field current receives supply directly

The starting armature current is equal to,

$$Ia = V / (Ra + R_{st})$$

2) The arm is moved against the spring force towards the ON position.
3) When the arm travels towards ON position , the starting resistance is gradually removed from armature circuit . since motor takes full speed, motor develops full back E.M.F. the starting arm carries a soft iron piece which is held by attraction of the hold on coil. starter remains in ON position because the electromagnetism formed by NO VOLT COIL.

Function of hold on (no volt coil)

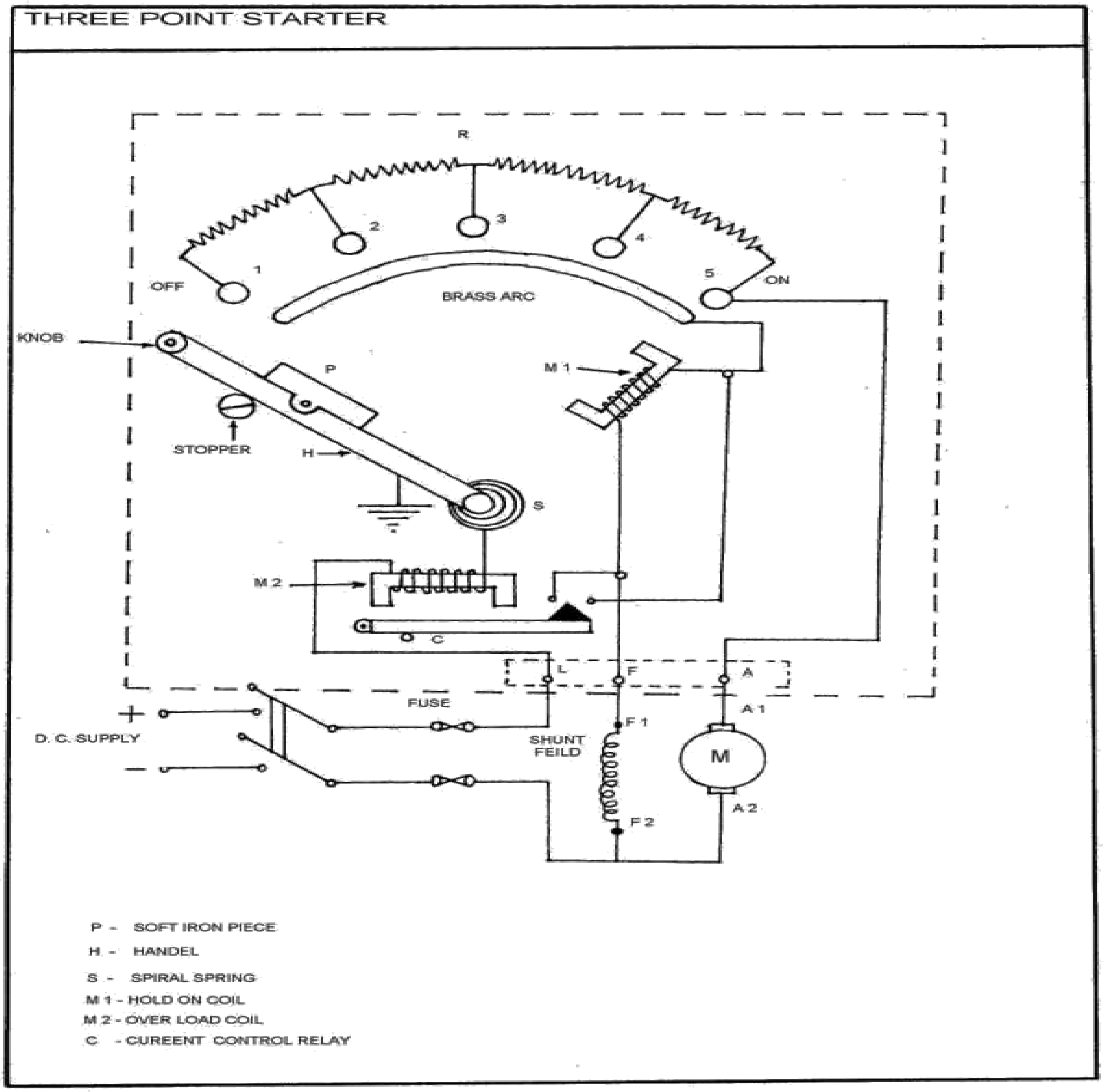
1) In case of supply failure NO VOLT COIL gets de-energized and the starting arm will be released to OFF position. This is automatically done by spring action.
2) It hold the plunger in ON position
3) It gives the protection against field failure

Function of overload coil

Overload coil is a electromagnet connected in series with armature. when current exceeds beyond certain predetermined value the electromagnet will become strong and it attracts plunger. Due to this voltage across NO VOLT COIL becomes zero. this will make hold on coil de – energized due to which arm gets to OFF position and motor gets disconnected from supply.

Limitations of three point starter

1) When motor is in ON position the starting resistance gets remove form armature circuit at the same time it gets attached to field circuit, which is dangerous to the motor.
2) When we control speed of motor by field control method, resistance in field circuit reduces field current which increases the speed of motor at the same time there is chance under ON condition motor could disconnect from supply due to de energisation of HOLD ON COIL, due to less field current.



PROCEDURE :

1. Design the starter as per circuit diagram.
2. Design the soft iron piece, spiral spring, hold on coil & over load coil.
3. Design all the knob with resistor.
4. Connect all the devices properly.

RESULT: Studied the detailed construction of three point starter.

Experiment no : 3

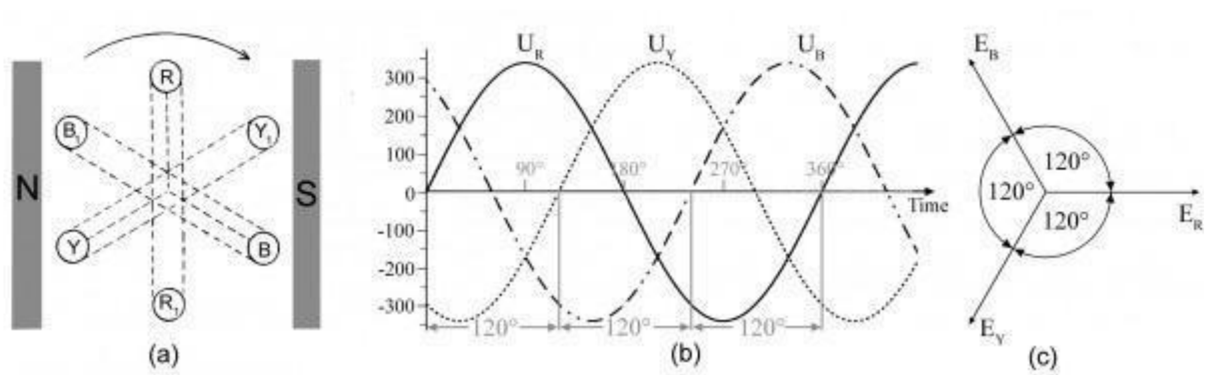
AIM: - Measurement of Power in 3 phase circuit by 3 Wattmeter method

Apparatus Required:-

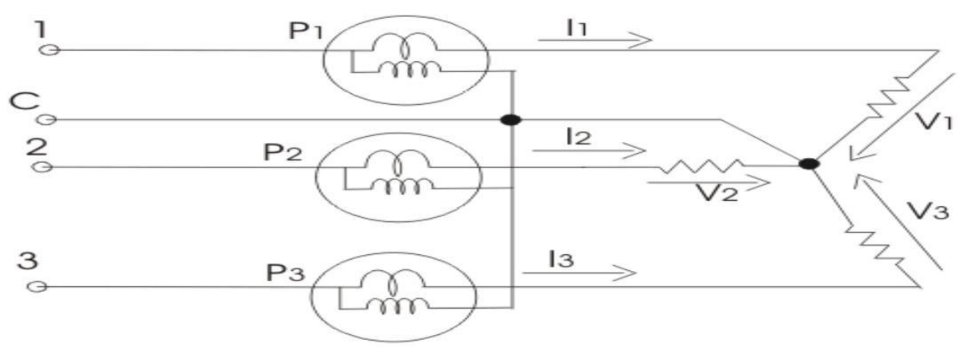
Apparatus	Range	Quantity
Voltmeter	0-500 V	1
Ammeter	0-5 A	1
Wattmeter	0-1500 W	3

Theory:-

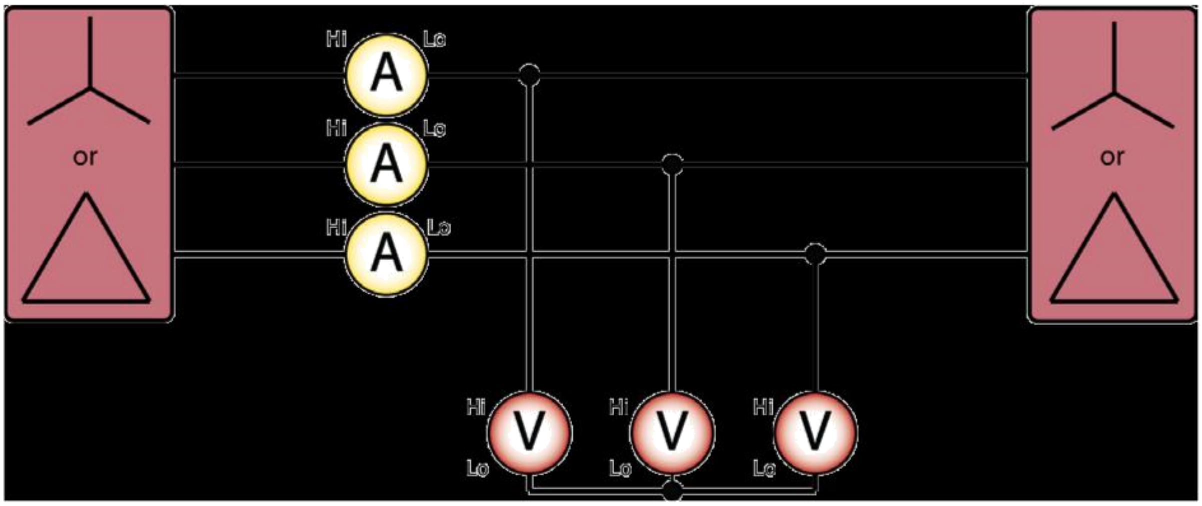
Three-phase electricity consists of three ac voltages of identical frequency and similar amplitude. Each ac voltage ‘phase’ is separated by 120° from the other. This
Can be represented diagrammatically by both waveforms and a vector diagram



Three wattmeters are required to measure total watts in a four-wire system. The voltages measured are the true phase to neutral voltages. The phase to phase voltages can be accurately calculated from the phase to neutral voltages’ amplitude and phase using vector mathematics. A modern power analyzer will also use Kirchoff’s law to calculate the current flowing in the neutral line



$$P = P_1 + P_2 + P_3 = V_1 I_1 + V_2 I_2 + V_3 I_3$$



PROCEDURE:-

1. Connect the circuit as per Circuit diagram
2. Ensure that the output of 3 phase variac at zero or low.
3. Switch on the 3 phase ac supply.
4. Apply a certain load to the circuit and note down the reading of all meters connected in the circuit.
5. Repeat step 4
6. Remove the applied load then switch off the supply.

OBSEVATIONS:

SL NO	V	A	W1	W2	W3	P=W1+W2+W3

Conclusions: The Power in all the three phases are observed by three wattmeter method.

Experiment no : 4

AIM : - Measurement of Power in 3 phase circuit by two wattmeter method

Appratus Required :-

1. Two AC Watt meters of different ranges (1500W).
2. One AC Voltmeters (moving coil) ranges (0-500V).
3. One AC Ammeters (moving coil) ranges (0-5A).

THEORY:-

Power consumed by a balanced or unbalanced load (star delta connected) can be measured by using two wattmeter properly connected in the load circuit. The current coils of the wattmeter are connected in series with the load in any two lines, whereas the two pressure coils are connected between these lines and the third lone as shown in fig.(1)

The phasor diagramed of this circuit, assuming balanced lagging load has been shown in fig. (1) as such rms values of current I_R, T_Y, and I_B are taken equal in magnitude and lagging by an angle with respect to its own phase voltage, similarly, rms values of phase voltage are also equal on magnitude but displaced by 120^0. The phase sequence has been assumed as R Y B. Based on the phasor diagram, power consumed and the power factor of load can be calculate from the reading of two wattmeter W_1 and W_2 as explained below.

(i) Power consumed the current coil of wattmeter, $W_1 = I_R$
Current through across the pressure coil of wattmeter, $W_1 = V_{RB}$
Phase different between IR and VRB (ref phasor diagrame) = 30-

Hence, reading of wattmeter, W1 = IR VRB cos (30-) (i)
Similarly, reading of wattmeter, W2 = Iy VRB cos (30+) (ii)
More over, IR = IY = IB = IL (line current)
(iii)
Also, VRY = VRB = VL= VL (line voltage) (iv)

Substitution eqns, (iii) and (iv) into eqns. (i) and (ii) and then adding these

W1 + W2 + $\sqrt{3}$ V_L I_L cos = Power drawn by 3 phase load (v)

Hence, the sum of two wattmeter reading is equal to the total power drawn by a 3 phase balanced load.

(ii) Power factor of load:
Subtracting eqn. (ii) and (i),

W1 – w2 = I_R VRB cos (30-)-IY V_{RB} cos (30+) = V_L I_L

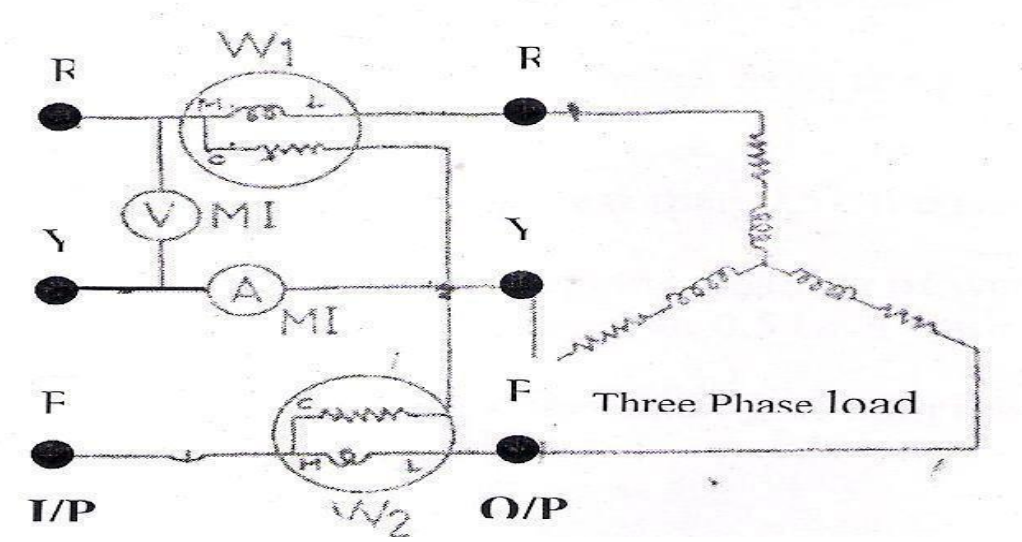
Dividing eqn. (vi) and (v),

$$\tan = \sqrt{3}\,\frac{W_1 W_2}{W_1 W_2}$$

Thus, power factor of a load,= $\frac{1}{\sqrt{1/3(W_1 W_2 / W_1 W_2)^2}}$

Hence, the power factor of the load also can be drawn from the reading of the two wattmeter.

CIRCUIT DIAGRAM:-



The circuit to perform to perform the experimental has been shown in fig. (1). The various details of the same have been already explained above.

PROCEDURE:-

1. Connect the circuit as per Circuit diagram
2. Ensure that the output of 3 phase variac at zero or low.
3. Switch on the 3 phase ac supply.
4. Apply a certain voltage to the circuit and note down the reading of all meters connected in the circuit.
5. Repeat step 4 from various values of applied voltage till the supply voltage.
6. Reduced the voltage applied to 3 phase load then switch off the supply.

OBSEVATIONS: May be tabulated as follows:-

S. No.	V	I	W_1	W_2	W_1+W2	W1-W2	Cos

Conclusions: Following important conclusions can be drawn from the above derivations, regarding the balanced inductive load.

1. When the power factor of the load is low (less then 0.5), the reading of wattmeter W_2 will be negative.
2. When the power factor of the load is 0.5 lagging, reading of wattmeter W_2 will be zero.
3. When the power factor of the load is greater then 0.5 both wattmeter will record positive reading
4. When the power factor of the load unity, the reading of both the wattmeter will be the same.

Experiment no : 5

Aim: To study the construction of single phase Transformer.

APPARATUS REQUIRED: Single phase transformer model 230/230 volts.

THEORY: Two coils of wire (called windings) are wound on some type of core material. In some cases the coils of wire are wound on a cylindrical or rectangular cardboard form. In effect, the core material is air and the transformer is called an AIR-CORE TRANSFORMER. Transformers used at low frequencies, such as 60 hertz and 400 hertz, require a core of low-reluctance magnetic material, usually iron. This type of transformer is called an IRON-CORE TRANSFORMER. Most power transformers are of the iron-core type.

The principle parts of a transformer and their functions are:

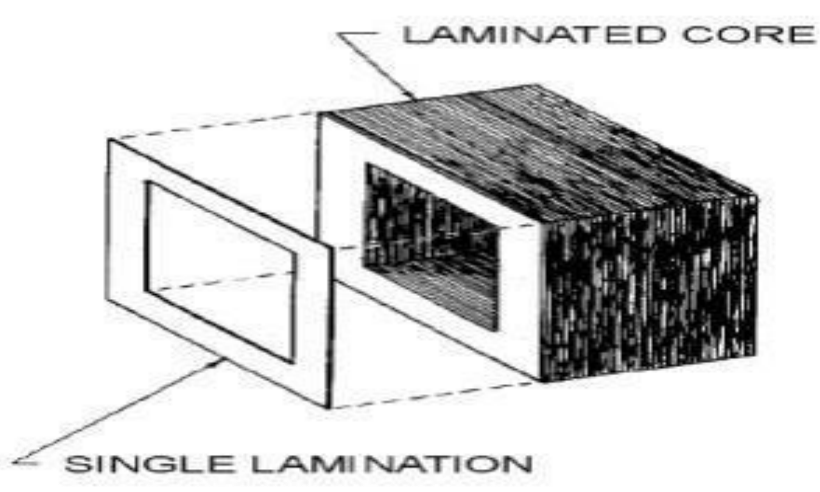
The CORE, which provides a path for the magnetic lines of flux.

The PRIMARY WINDING, which receives energy from the ac source.

The SECONDARY WINDING, which receives energy from the primary winding and delivers it to the load.

The ENCLOSURE, which protects the above components from dirt, moisture, and mechanical damage.

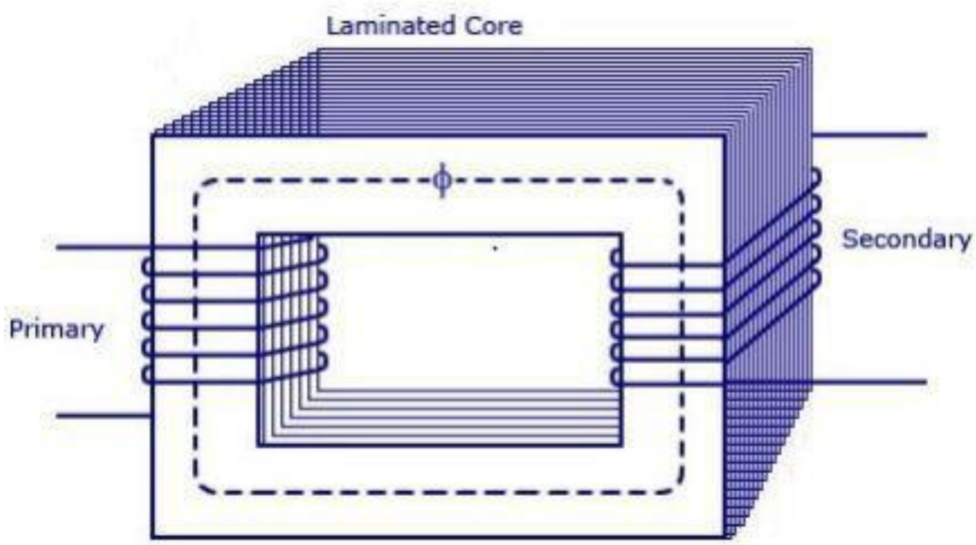
(i) CORE



There are two main shapes of cores used in laminated-steel-core transformers. One is the HOLLOWCORE, so named because the core is shaped with a hollow square through the center. This shape of core. Notice that the core is made up of many laminations of steel it shows how the transformer windings are wrapped around both sides of the core.

(ii) WINDINGS

As stated above, the transformer consists of two coils called WINDINGS which are wrapped around a core. The transformer operates when a source of ac voltage is connected to one of the windings and a load device is connected to the other. The winding that is connected to the source is called the PRIMARY WINDING. The winding that is connected to the load is called the SECONDARY WINDING. The primary is wound in layers directly on a rectangular cardboard form.



PROCEDURE:

1. Design the transformer core with proper lamination to reduce the hysteresis and eddy current losses in the transformer due to emf induced in the transformer core.
2. Each limb of the transformer core properly punched to have a transformer core.
3. Properly wound primary and secondary winding around the core.
4. All the bushings, cooling tubes, oil gauge, breather and buccholz’s relay must be properly designed and installed.

PRECAUTIONS:

1. Core must be laminated.
2. Properly connect all the windings and other accessories.
3. Properly wound primary and secondary winding around the core.
4. Check the transformer oil quality.

RESULT: Studied the detailed construction of single phase transformer.

Experiment no : 6

Aim: To study the construction of three phase Transformer.

APPARATUS REQUIRED: Three phase auto transformer model.

THEORY: Consider a three single phase core type transformer positioned at 120° to each other as shown in the figure below. If the balanced three-phase sinusoidal voltages are applied to the windings, the fluxes ϕ_a, ϕ_b and ϕ_c will also be sinusoidal and balanced. If the three legs carrying these fluxes are combined, the total flux in the merged leg becomes zero. This leg can, therefore, be removed because it carries the no flux. This structure is not convenient for the core.

The principle parts of a transformer and their functions are:

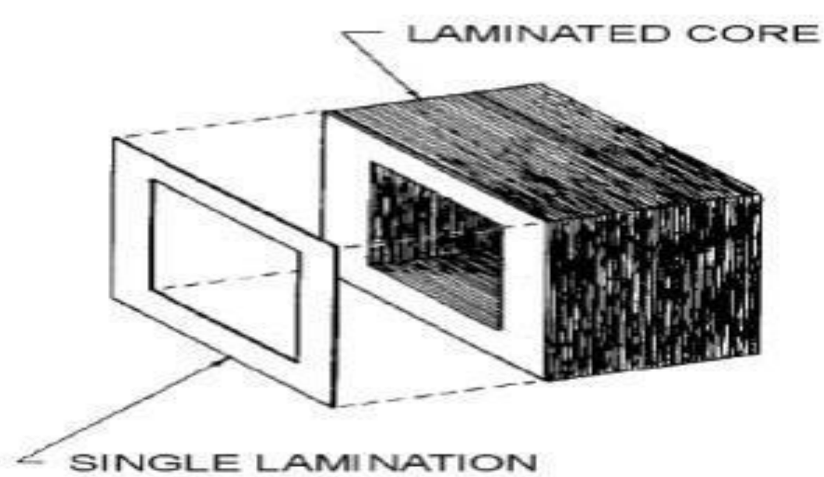
The CORE, which provides a path for the magnetic lines of flux.

The PRIMARY WINDING, which receives energy from the ac source.

The SECONDARY WINDING, which receives energy from the primary winding and delivers it to the load.

The ENCLOSURE, which protects the above components from dirt, moisture, and mechanical damage.

(iii)CORE



There are two main shapes of cores used in laminated-steel-core transformers. One is the HOLLOWCORE, so named because the core is shaped with a hollow square through the center. This shape of core. Notice that the core is made up of many laminations of steel it shows how the transformer windings are wrapped around both sides of the core.

(iv) WINDINGS

As stated above, the transformer consists of two coils called WINDINGS which are wrapped around a core. The transformer operates when a source of ac voltage is connected to one of the windings and a load device is connected to the other. The winding that is connected to the source is called the PRIMARY WINDING. The winding that is connected to the load is called the SECONDARY WINDING. The primary is wound in layers directly on a rectangular cardboard form.

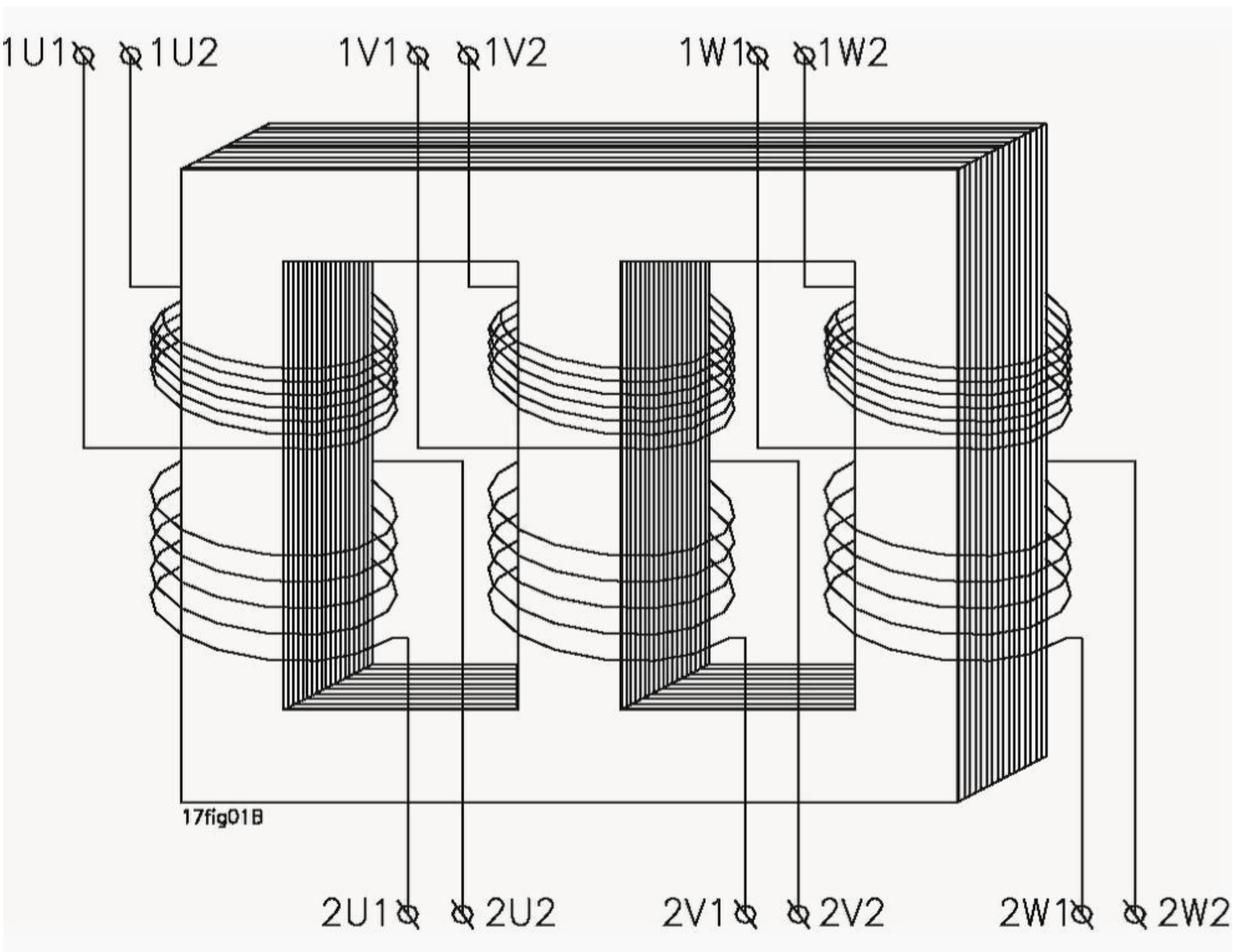


Figure-Three Phase Transformer (Star Connection)

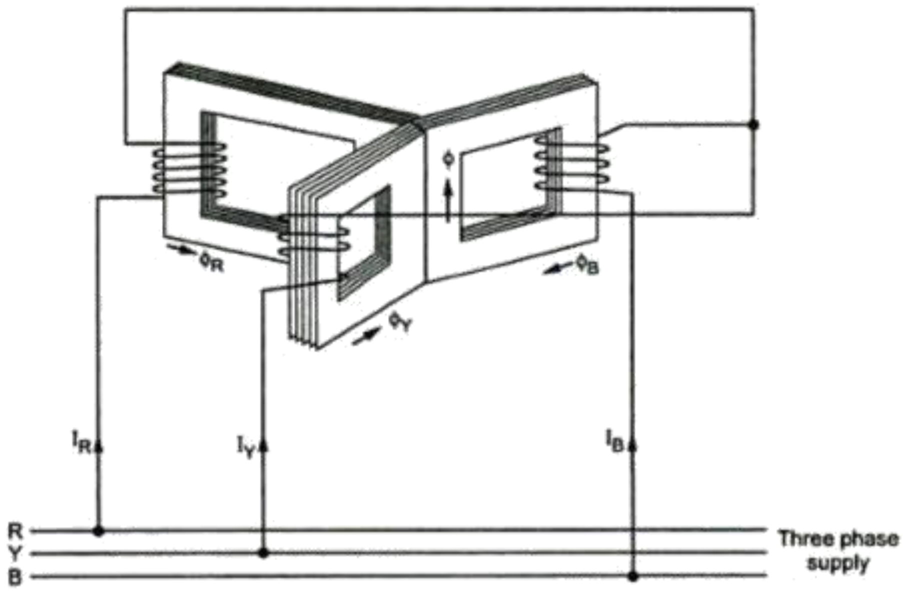


Figure-Three Phase Transformer (Delta Connection)

PROCEDURE:

5. Design the transformer core with proper lamination to reduce the hysteresis and eddy current losses in the transformer due to emf induced in the transformer core.

6. Each limb of the transformer core properly punched to have a transformer core.

7. Properly wound primary and secondary winding around the core.

8. All the bushings, cooling tubes, oil gauge, breather and buccholz's relay must be properly designed and installed.

5. Core must be laminated.

6. Properly connect all the windings and other accessories.

7. Properly wound primary and secondary winding around the core.

8. Check the transformer oil quality.

RESULT: Studied the detailed construction of three phase transformer.

Experiment no : 7

Aim: To find the efficiency of single phase Transformer by Direct loading.

APPARATUS REQUIRED:

1. Two Nos. of Moving Coil Voltmeter of Range 300V AC and ONE 0-500 V of size 96*96 mm provided with
2. Ammeter of Range 10A AC of size 96*96mm provided with Input Terminals.
3. Wattmeter of Range 1.5KW of size 96*96mm provided with Input Terminals.
4. One No of Miniature Circuit Breaker of Range 10Amps (MCB/ DP) Provided on the Input Side.
5. Circuit Diagram Printed on Bakelite Sheet front panel with instrument connecting terminals.
6. Panel board of portable wooden panel box is in Tappered shape for better view angle.
7. Power Requirement : Single Phase 220V AC.

THEORY

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled conductors - the transformer's coils. A varying current in the first or primary winding creates a varying magnetic flux in the transformer's core, and thus a varying magnetic field through the *secondary* winding. This varying magnetic field induces a varying electromotive force (EMF) or "voltage" in the secondary winding. This effect is called mutual induction.

If a load is connected to the secondary, an electric current will flow in the secondary winding and electrical energy will be transferred from the primary circuit through the transformer to the load. In an ideal transformer, the induced voltage in the secondary winding (*VS*) is in proportion to the primary voltage (*VP*), and is given by the ratio of the number of turns in the secondary (*NS*) to the number of turns in the primary (*NP*) as follows:

- By appropriate selection of the ratio of turns, a transformer thus allows an alternating current (AC)voltage to be "stepped up" by making NS greater than NP, or "stepped down" by making NS less than NP.

- In the vast majority of transformers, the coils are wound around a ferromagnetic core, air-core transformers being a notable exception.

The operation of a transformer is based on 'Faraday's Law of Induction'. By the right choice of power level and location it is possible to establish an optimal use of transformers. In contrast to the ideal transformer the real transformer has losses. These are open circuit or iron losses and short circuit or copper losses.

The open circuit losses are independent of the power which is consumed by the transformer. These losses can be reduced by construction i.e. raising the cross section of limb or using novel ferromagnetic material. The short circuit losses increase with the square of power. They can only be lowered by increasing the cross section of the conductors of the windings

Normally the open circuit losses are of the order of 0.2 to 0.5 % of the nominal power; whereas the short circuit losses are 0.7 to 2.1% of the nominal power. Because it is unusual to operate transformers always at full load it is some times more important to decrease the open circuit losses than short circuit losses.

With the help of transformer audit, it is possible to provide better quality of power to different load centers in the plant at high overall efficiency. Transformers should always be loaded optimally to get better utilization of the transformers. Proper load management of the transformers will lead to substantial savings in energy bills. This software will help to decide the proper transformer load management to achieve better transformer performance. By improving the power factor, the reactive power requirement of the plant can be reduced and hence the energy bill.

The following points can be helpful for energy savings:

1. Transformers can be switched off on holidays or periods of no load.
2. Transformers should be always loaded to optimum level.
3. Transformers should not be oversized.
4. Improvement of P.F on LT side would reduce current and reduce losses.
5. Amorphous core distribution transformers are more energy efficient than transformers made with silicon iron cores.

· While iron losses of transformers cannot be reduced, the load losses in transformers and cable losses reduce with demand control and with improvement of load power factor.

With the help of transformer audit, it is possible to provide better quality of power to different load centers in the plant at high overall efficiency. Transformers should always be loaded optimally to get better utilization of the transformers. Proper load management of the transformers will lead to substantial savings in energy bills.

% Loading, % Iron losses, % Copper Losses and All day Efficiency of a transformer can be calculated using following formulas:

5. **Loading = Primary side Voltage (V) x Primary side Current / KVA of Transformer**

6. **Iron Loss = % Loading x Designed Iron loss in KW**

7. **Copper Loss = (1/% Loading) x Designed Copper loss in KW**

Efficiency = [1 - (% Iron Loss + % Copper Loss) / ((PF x 100) + % Iron Loss + % Cu loss)] x 100

Where PF - Power Factor

The efficiency of a transformer (or any other device) is defined as the ratio of output power to input power.

Efficiency = Output power/Input power

$= V_2 I_2 \cos\phi_2 / (V_2 I_2 \cos\phi_2 + P_c + I_2 r e_2)$

V_2 = output voltage

I_2 = output current

$Cos\phi_2$ = output power fector

Pc = core losses

I_2re_2 = Ohmic losses = P2/P1

P_1 = p_2+total losses

efficiency = P_2/P_2+total losses

We can calculate total losses from open circuit and short circuit test but here we ere directly measured values of P_1 and P_2 i.e. input and output powers respectively from here we can also calculate total losses occurring in the transformer. We can load transformer in different ratio and calculate efficiency with that load and type of load.

VOLTAGE REGULATION

Voltage regulation of transformer is defined as the change in secondary terminal voltage expressed as percentage (or per unit) of the secondary rated voltage when load at a given power factor is reduced to zero with primary applied voltage held constant.

If V_2 = secondary terminal voltage at any load.

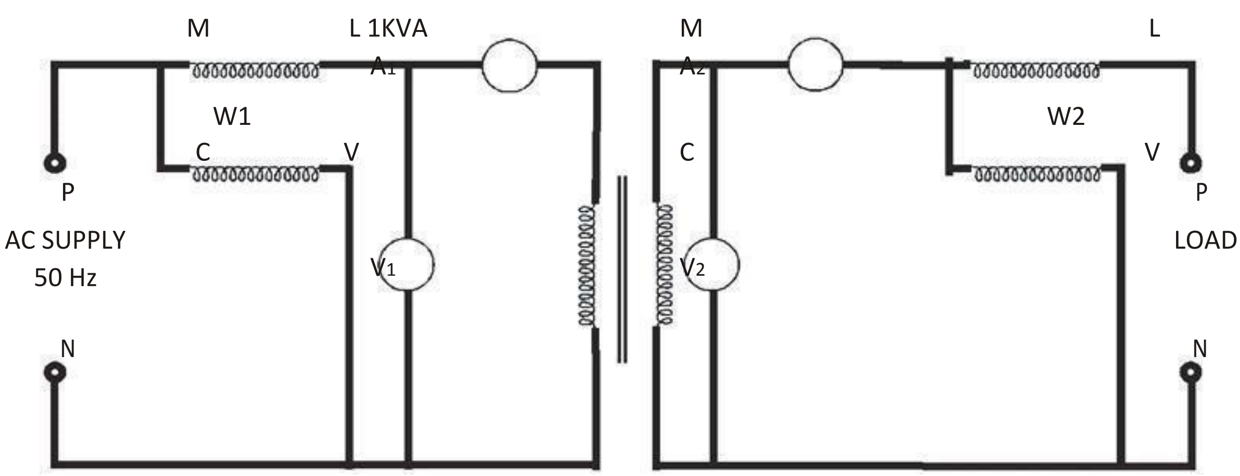
And E_2 = secondary terminal voltage at no load.

Then at a given power factor and specified load, the voltage regulations is given

by Voltage Regulation = E_2- V_2 /secondary rated voltage (in PU).

As per IS the secondary rated voltage transformer = Secondary terminal voltage at no load i.e. E_2 Therefore Voltage Regulation = $E_2 – V_2 / E_2$ in PU.
= $E_2 – V_2 / E_2$ x 100 in percentage

CIRCUIT DIAGRAM:



PROCEDURE

9. Connect the Ammeters, Voltmeters and Wattmeter's to their respective terminals on the panel.
10. Connect the Single Phase Variac to the Input Terminals of the panel Provided on the left hand side.
11. Connect the Single Phase External Load to the Output terminals of the Panel provided on the Right hand side.
12. Ensure the load is at OFF or minimum position. Switch ON the supply and Vary the voltage upto 230V AC so that E2 should be of rated volume.
13. Now switch ON the load in steps and note down their corresponding Input and Output Powers from W_1 and W_2. Note down values in observation table.
14. Also note secondary voltage V_2. at corresponding loading for voltage regulation.
15. Calculate corresponding power factor using.

$$P = VI \cos \phi$$

$$\cos \phi = P / V I$$

OBSERVATION TABLES

SAMPLE OBSERVATIONS						
VOLTMETER	VOLTMETER	AMMETER	AMMETER	WATTMETER	WATTMETER	LOAD
V_1(V)	V_2(V)	A1(Amp)	A2(Amp)	W1(Watt)	W2(Watt)	PER STEP

Efficiency:

S.no	power input (P1)	power output (P2	Efficiency

VOLTAGE REGULATION

S. No.	E2 (Output Voltage at No Load	V2 (Output Voltage at Load)	Voltage Regulation	V.R. %
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

We can also calculate transformer factor K

By using, V2 / V1 = K = N2 / N1

Also turn ratio of transformer can be calculated.

PRECAUTIONS

9. All meters should be connected in correct polarity.
10. Supply should be switched OFF while making connections.
11. Do not touch terminals on panel while supply is ON.
12. Load should be introduced in steps.
13. Do not exceed beyond rated values.
14. All connections should be tight and clean.

Observation: The efficiency of single phase transformer has calculated according to observation table value.

Experiment: 08

AIM: - To start DC shunt motor by using three point starter.

Apparatus: DC power supply, DC motor, Connection wires, Starter.

Theory:

At starting, Eb =0 because speed of motor is zero. Armature current of motor is equal
to, Ia = V- Eb / Ra
so Ia =V/ Ra (Eb = 0)
Since Ra is very small so motor will draw large armature current. To limit the armature current in safe value we add some external resistance in armature circuit. A mechanism which adds resistance during starting only is known as starter.
There are two types of starters which are commonly used for d.c. shunt motor

1. 3-point starter
2. 4 - point starter

3- point starter

Three point starter is shown in the figure 1, when motor is started, starting arm is moved slowly towards the ON position

1)As soon as arm touches the stud no. 1 full starting resistance get connected in the armature circuit.

2) Field current receives supply directly

The starting armature current is equal to,

$$I_a = V / (R_a + R_{st})$$

4) The arm is moved against the spring force towards the ON position.

5) When the arm travels towards ON position , the starting resistance is gradually removed from armature circuit . since motor takes full speed, motor develops full back E.M.F. the starting arm carries a soft iron piece which is held by attraction of the hold on coil. starter remains in ON position because the electromagnetism formed by NO VOLT COIL

Function of hold on (no volt coil)

4) In case of supply failure NO VOLT COIL gets de-energized and the starting arm will be released to OFF position. This is automatically done by spring action.
5) It hold the plunger in ON position
6) It gives the protection against field failure

Function of overload coil

Overload coil is a electromagnet connected in series with armature. when current exceeds beyond certain predetermined value the electromagnet will become strong and it attracts plunger. Due to this voltage across NO VOLT COIL becomes zero. this will make hold on coil de – energized due to which arm gets to OFF position and motor gets disconnected from supply.

Limitations of three point starter

3) When motor is in ON position the starting resistance gets remove form armature circuit at the same time it gets attached to field circuit, which is dangerous to the motor.

4) When we control speed of motor by field control method, resistance in field circuit reduces field current which increases the speed of motor at the same time there is chance under ON condition motor could disconnect from supply due to de energisation of HOLD ON COIL, due to less field current.

5) **4- Point starter**

4- point starter with brass arc covers limitations of 3- point starter; using brass arc covers first limitation. Making field circuit path independent of hold coil circuit by making forth point in addition with 3-point circuit covers second limitation.

When field current is reduced while controlling speed of motor will not effect on magnetic field of hold on coil because circuit of hold coil is separate than field coil circuit as shown in the fig.2.

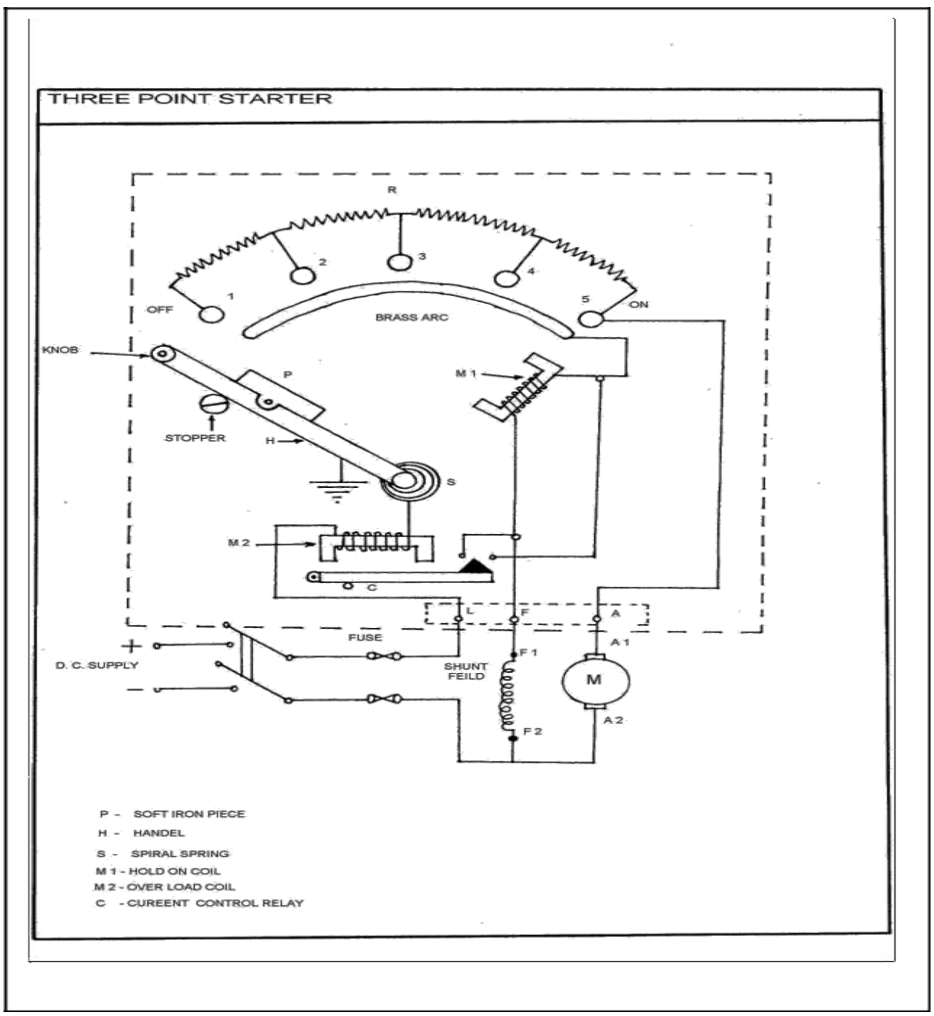
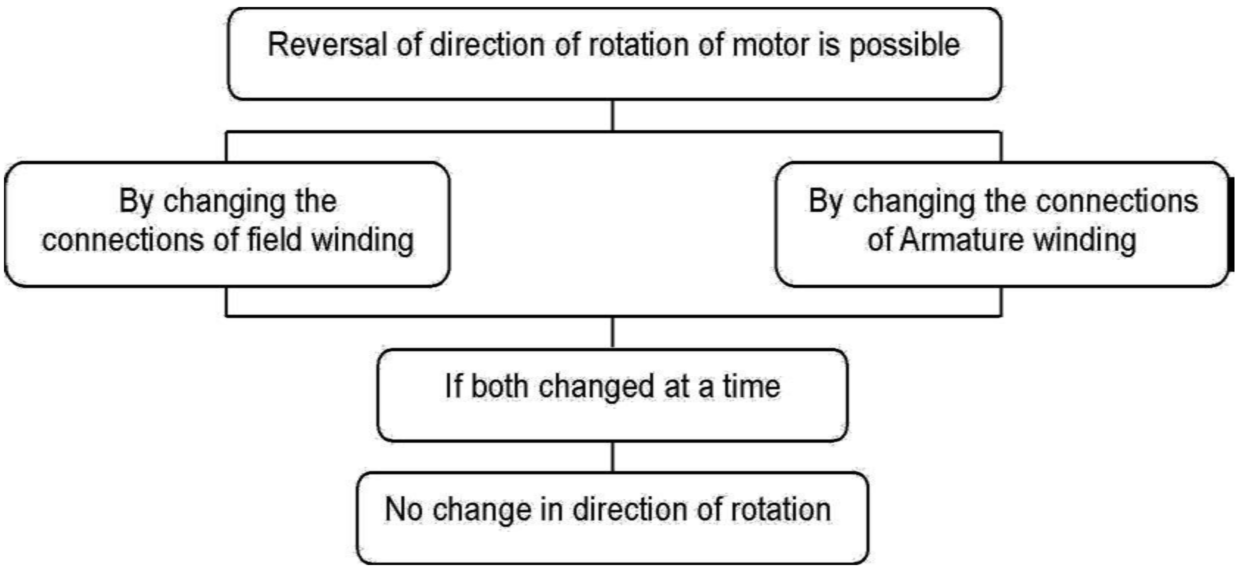


Figure-Three point starter

Reversal of direction of Rotation of D.C. shunt motor.

It means changing the direction of rotation of motor either in clockwise or anticlockwise direction. This is achieved by changing the field connections or armature connections.



EQUIPMENTS :

D.C. Motor rating …………….V, ………………A, ………………KW

Three point starter.

CIRCUIT DIAGRAM

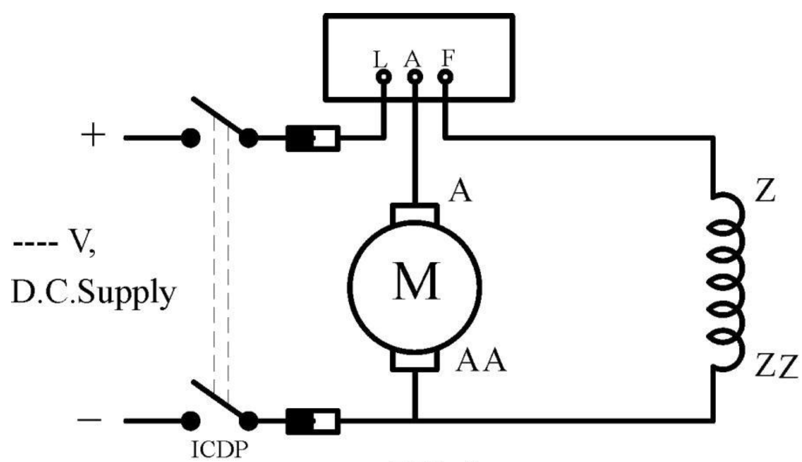


FIG. 1

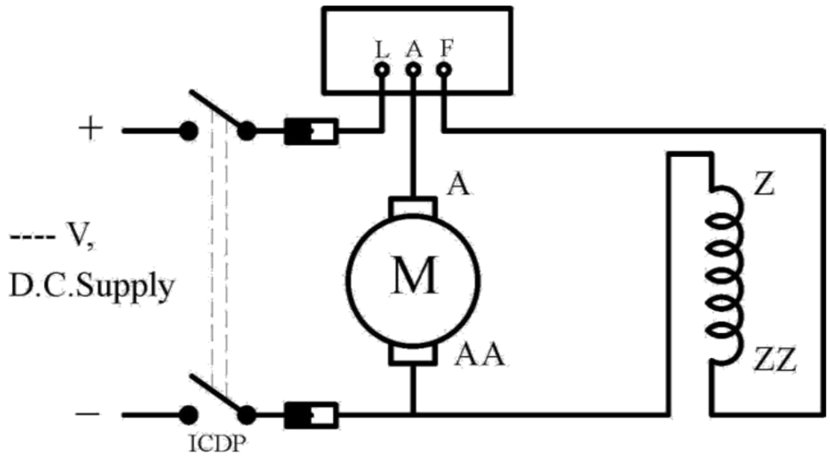


FIG. 2

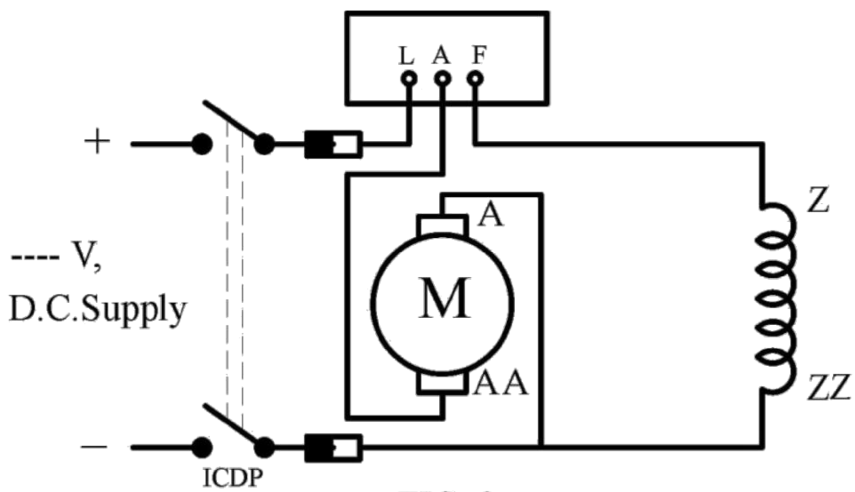


FIG. 3

PROCEDURE :

1. Make the connection as per circuit diagram.
2. Switch on the D.C.Supply and start the motor by moving arm of the three point starter.
3. Observe the direction of rotation.
4. Switch off the supply.
5. Change the the field winding connections as per Fig.2 and by switching on the supply observe the direction of rotation of rotation of the motor.
6. Change the armature winding connections as per Fig.3 and by switching on the supply observe the direction of rotation of rotation of the motor.

OBSERVATIONS :

1. Table of readings for connections as shown in Fig.1.

Sr.No.	Position of the observer	Direction of rotation of motor

2. Table of readings for connections as shown in Fig.2.

Sr.No.	Position of the observer	Direction of rotation of motor

3. Table of readings for connections as shown in Fig.3.

Sr.No.	Position of the observer	Direction of rotation of motor

CONCLUSION:

a. When field winding and armature windings are connected normally to the supply terminals The D.C.motor rotates in ……………………Direction.

b. When Field winding and armature windings are connected as shown in Fig.2 to the supply terminals the D.C.motor rotates in ……………………Direction.

c. When Field winding and armature windings are connected as shown in Fig.3 to the supply terminals the D.C.motor rotates in ……………………Direction

Experiment no : 10

Aim: To obtain the speed control of DC shunt motor (Armature & Field Control).

Name Plate Details:

Power	= 5.0 hp	Speed	=1500 rpm
Armature voltage	= 220 volts	Field voltage	=220 volts
Armature current	= 19.0 amps	Field current	=1.0 amps
Field Winding	= shunt		

Apparatus:

Name	Range	Quantity
DC Voltmeter	0-300V	1 No.
DC Ammeter	0-20A	1 No.
DC Ammeter	0-2A	1 No.
Variable rheostat	0-150Ω	1 No.
Variable rheostat	0-200Ω	1 No.
Speed Indicator	0-2000rpm	1 No.

Theory:

Any D.C. motor can be made to have smooth and effective control of speed over a wide range. The shunt motor runs at a speed defined by the expressions.

$$E_b = NP\phi Z / 60A \qquad \& \qquad E_b = V - I_a R_a$$

Where N is the speed, V is applied voltage, Ia is the armature current, and Ra is the armature resistance and Φ is the field flux.

Speed control methods of shunt motor:

7. Applied voltage control.
8. Armature rheostat control.
9. Field flux control.

Applied voltage control:

In the past, Ward-Leonard method is used for Voltage control method. At present, variable voltage is achieved by SCR controlled AC to DC converter unit is used to control the speed of a motor. In this method, speed control is possible from rated speed to low speeds.

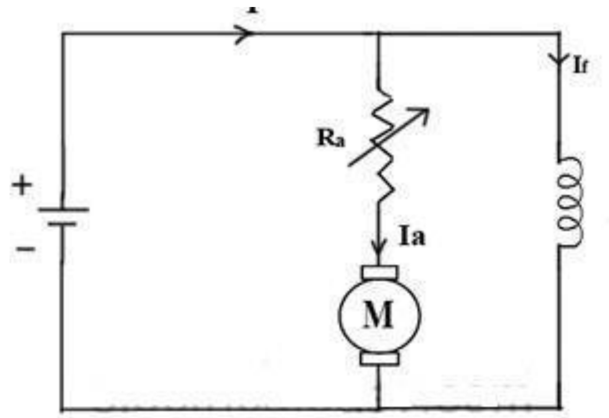
Armature rheostat control:

Speed control is achieved by adding an external resistance in the armature circuit. This method is used where a fixed voltage is available. In this method, a high current rating rheostat is required.

Disadvantages:

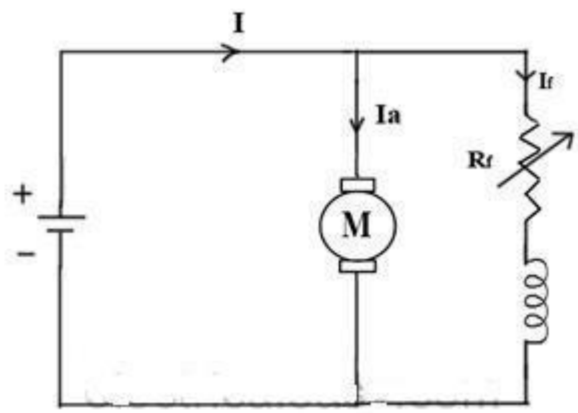
2. Large amount of power is lost as heat in the rheostat. Hence, the efficiency is low.

3. Speed above the rated speed is not possible. The motor can be run from its rated speed to low speeds.



Field flux control:

Speed control by adjusting the air gap flux is achieved by means of adjusting the field current i.e., by adding an external resistance in the field circuit. The disadvantage of this method is that at low field flux, the armature current will be high for the same load. This method is used to run the motor above its rated speed only.



Procedure:

1. Voltage Control Method:
   - Make the connections as per the given circuit diagram.
   - Keep the External resistances in the Armature and Fields circuits at minimum resistance (zero) position.
   - Switch on the supply and increase the voltage gradually to its rated voltage i.e. 220V.
   - Gradually decrease the voltage and note down the speed at different supply voltages.
2. External Resistance Control in the Armature Circuit:
   - Make the connections as shown in the circuit diagram.
   - Keep the External Resistances in the Armature and field circuit at minimum resistance position.

- Gradually, increase the voltage till the motor attains the rated voltage.
- Increase the External resistance in the Armature circuit and record the speed at various armature currents.

3. External Resistance Control in the Field Circuit:
   - Make the connections as shown in the circuit diagram.
   - Keep the External Resistances in the Armature and field circuit at minimum resistance position.
   - Gradually, increase the voltage till the motor attains the rated voltage.
   - Increase the External resistance in the Field circuit and record the speed at various field currents.
   - Do not exceed the speed above 1800rpm.

Observations:

Voltage Control Method:

Field current = A

S.No	Applied Voltage	Armature Current	Speed
1			
2			
3			
4			
5			

Resistance control in the armature circuit:

Applied voltage = V.

Field current = A.

S. No.	Supply Voltage	Armature Voltage	Armature Current	Speed(Rpm)	External Resistance(Ohms)
1					
2					
3					

.

Flux Control Method:

Rext = Ω,

V_a = V.

S. No.	Field current I_f (amp)	Armature current I_f (amp)	Speed (rpm)
1			
2			
3			
4			
5			

Conclusions:

Armature Rheostat control method and voltage control methods are useful to obtain the speed less than the rated speed.

Among the above two methods voltage control method is preferable than Armature Rheostat control since large amount of power is wasted in the external resistance.

Field control or Flux control method is used to obtain the speed more than the rated speed.