LABORATORY MANUAL

of

Electrical Machine Lab-I

(4th Semester)

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Experiment - 1

Aim:- Identification of different terminals of a DC machine by test lamp method and multi-meter method & to measure insulation resistance by megger.

APPARATUS REQUIRED:-

Sl. No.	Name of the Equipment	Specification	Quantity
1	DC Shunt Motor	230 V, 0.5 KW, 1500 RPM, I_A= 2.1 A, I_F =0.2 A	1 no.
2	Insulated Combination Pliers	150mm	1 no.
3	Screw driver	200mm	1 no.
4	Line Tester	1100 V, 6’’	1 no.
5	Ring Spanner`	----------------------	1 no.
6	Megger	----------------------	1 no.

Procedure :-

Test Lamp method:-

- Four terminals can be seen in a DC Shunt motor let’s say A, B, C & D.
- One terminal (D) is connected to the ground of test lamp.
- Then the live terminal shall be connected to other three terminals (A, B, C) one by one.
- Bulb glows for one terminal let’s say C; then C & D terminals form a winding.
- So, A & B form the other winding.
- When bulb glows brighter then that winding will be Armature winding because it has low resistance.
- Dim glow in bulb indicate field winding of the motor is connected.

Multimeter method:-

- By selecting the buzzer in multimeter, we can find out two separate windings.
- Then by selecting the resistance, the winding resistance can be found.
- The higher resistance winding is the field winging whereas the low resistance winding is the armature of motor.

Tabulation:-

Name of methods	Shunt field winding (R_{sh}) in ohm	Armature winding (Ra) in ohm
By Multimeter		

Megger :-

- Any two terminals can be selected randomly and connected to a megger.
- By rotating the megger handle at 160 RPM; if the pointer moves toward ∞ Ohm, then the terminals belongs to different windings.
- If the pointer moves toward 0 Ohm, then the two terminals belongs to same windings.
- It is not possible to distinguish between filed and armature winding using only megger.
- We have to use test lamp or multimeter method to find the distinction between filed and armature winding.

Precaution :-

- Don't touch the terminal in bare hand if supply is ON in test lamp method.
- Before starting megger the supply should be disconnected.
- All connection must be tight in test lamp method.

Conclusion :-

By using test lamp method, the field and armature windings can easily be distinguished. Using megger, two windings can be separated but their resistance can be accurately known. To overcome that problem multimeter method can be employed to successfully check the field and armature winding.

Experiment - 2

Aim: - Dimensional & material study of various part of DC machine.

APPARATUS REQUIRED:

Sl. No.	Name of the Equipment	Specification	Quantity
1	DC Compound Motor	230 V, 0.5 KW, 1500 RPM, I_A= 2.1 A, I_F =0.2 A	1 no.
2	Insulated Combination Pliers	150mm	1 no.
3	Screw driver	200mm	1 no.
4	Line Tester	1100v, 6''	1 no.
5	Double ended Spanner	----------------	1 Set
6	Lamp	100 W	1 no.
7	Multimeter	Digital Type	1 no.
8	Megger (MΩ)	500 V DC, 160 RPM	1 no.
9	Connecting Wires	2.5 sq mm	As Per requirement

Theory:-

Machine:- A piece of equipment with moving parts that is designed to do a particular job. A machine usually needs electricity, gas, steam etc. in order towork.

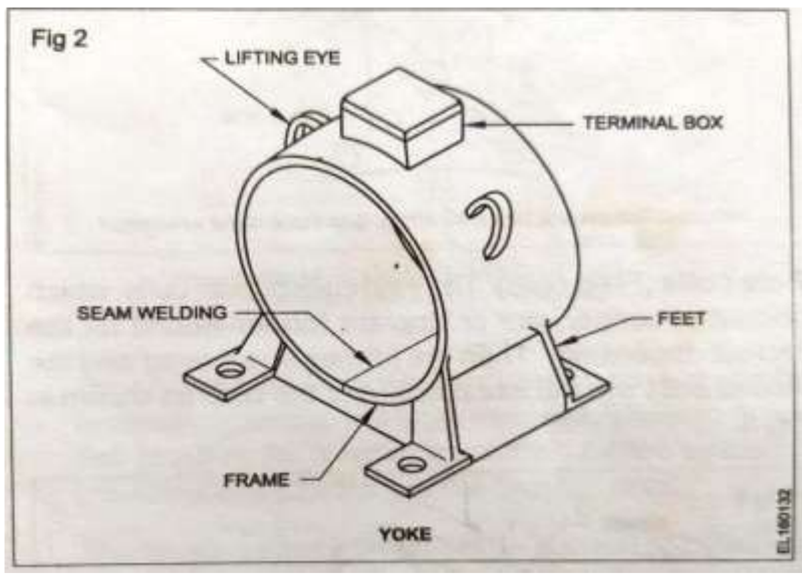
DC Machine:- The machine which works on dc supply is called dc machine.

Parts of DC Machine:-

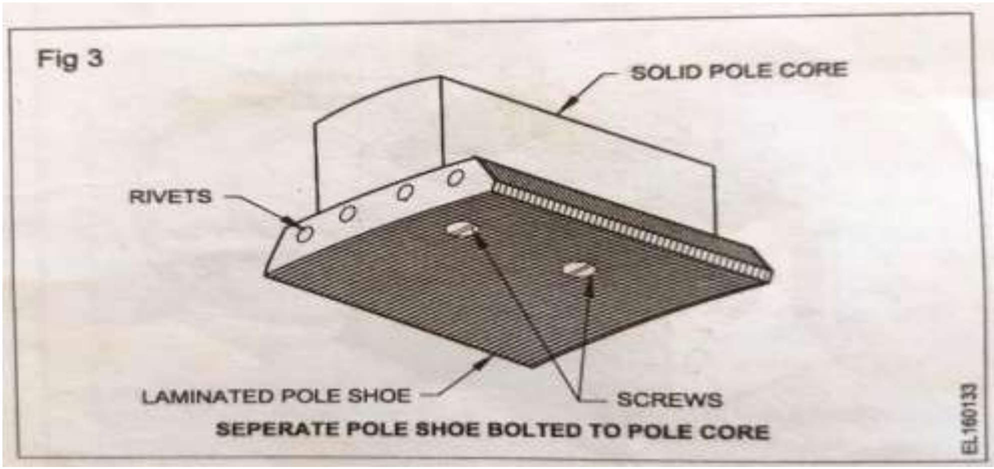
(i) Frame or Yoke
(ii) Field poles and pole-shoes
(iii) Field coils or Field winding
(iv) Armature Core

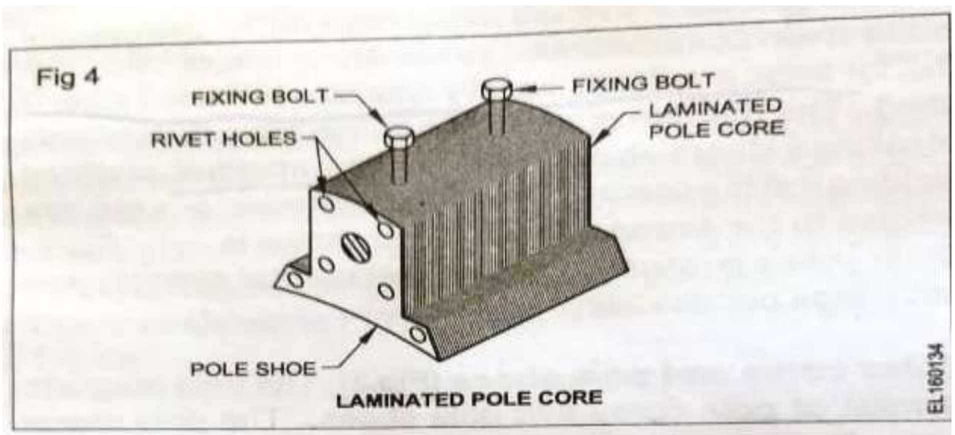
(v) Armature Winding/Armature Conductor
(vi) Commutator
(vii) Brushes
(viii) Bearing & End plate
(ix) Cooling fan
(x) Shaft
(xi) Terminal Box
(xii) Name Plate

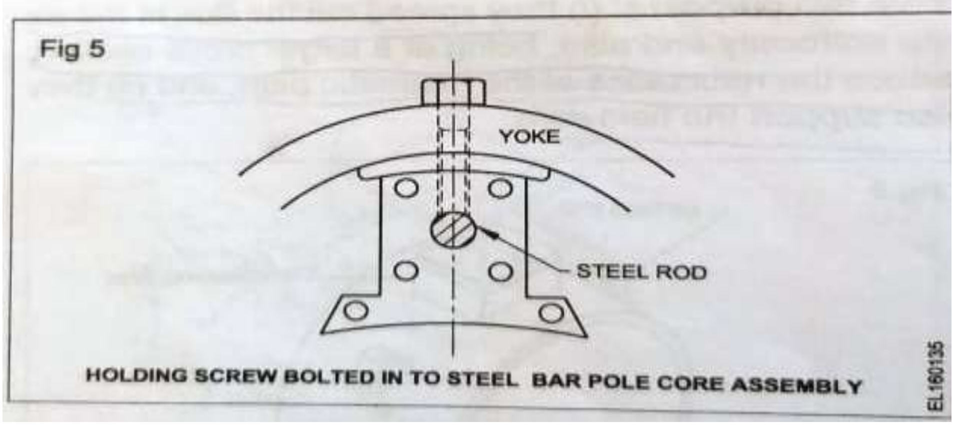
Frame or Yoke:- The outer frame or yoke serves a dual purpose. Firstly, it provides mechanical support for the poles and acts as a protecting cover for the whole machine. Secondly, it allows the magnetic circuit to complete through it. In small generators where cheapness rather than weight is the main consideration, yokes are made of cast iron. But for large machines usually cast steel or rolled steel is used. Yokes possess sufficient mechanical strength and have high permeability.



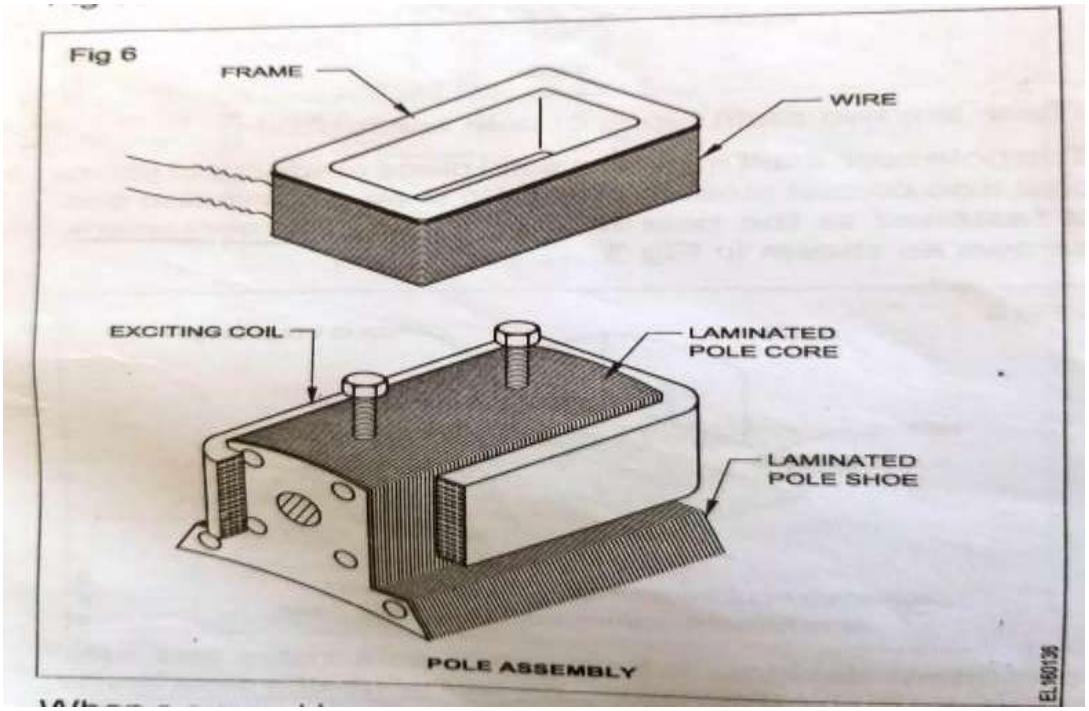
Field poles and pole-shoes:- The field magnets consist of pole cores and pole shoes. The pole shoes serve two purposes; (i) they spread out the flux in the air gap uniformly and also, being of a large cross-section reduce the reluctance of the magnetic path, and (ii) they also support the field coils. There are two main types of pole construction. The pole core itself maybe solid piece made out of either cast iron or cast steel but the pole shoe is laminated and is fastened to the pole face by means of countersunk screws. In modern design, the complete pole cores and pole shoes are built of thin laminations of annealed steel which are riveted together under hydraulic pressure. The thickness of laminations varies from 1mm to 0.25mm.



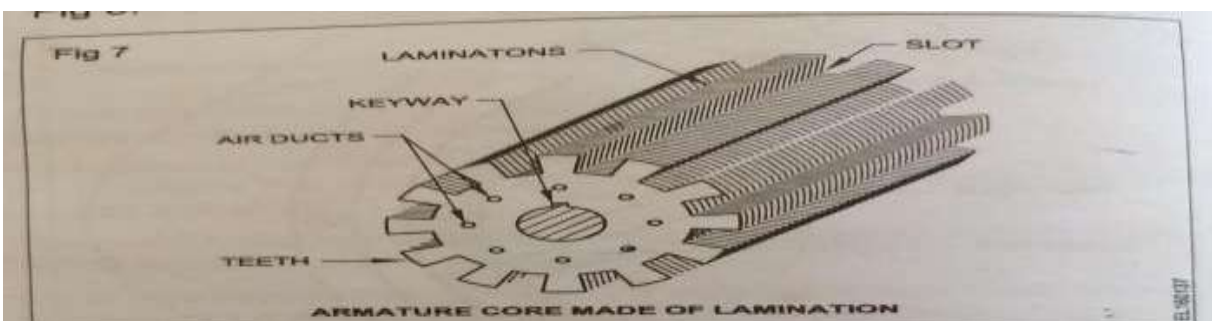


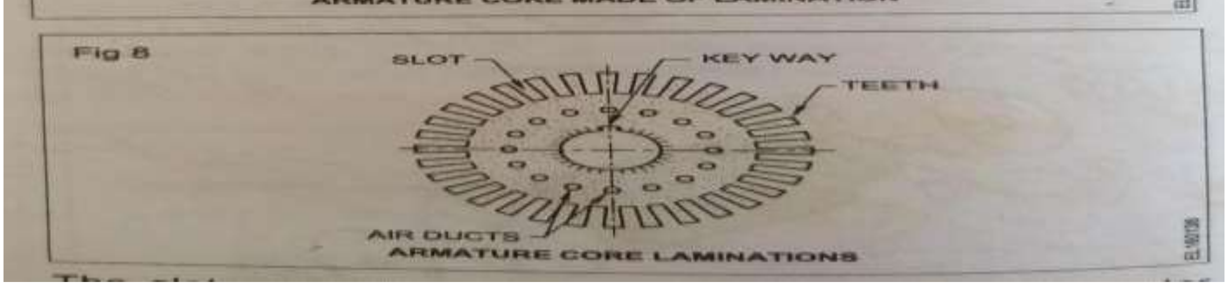


Field coils or Field winding :- The field coils or pole coils which consist of copper wire are wound on a former for correct dimension. Then the former is removed and the wound coils are put into place over the core. When a current is passed through the coils, they magnetize the poles which produce the necessary flux that is cut by revolving armature conductors.



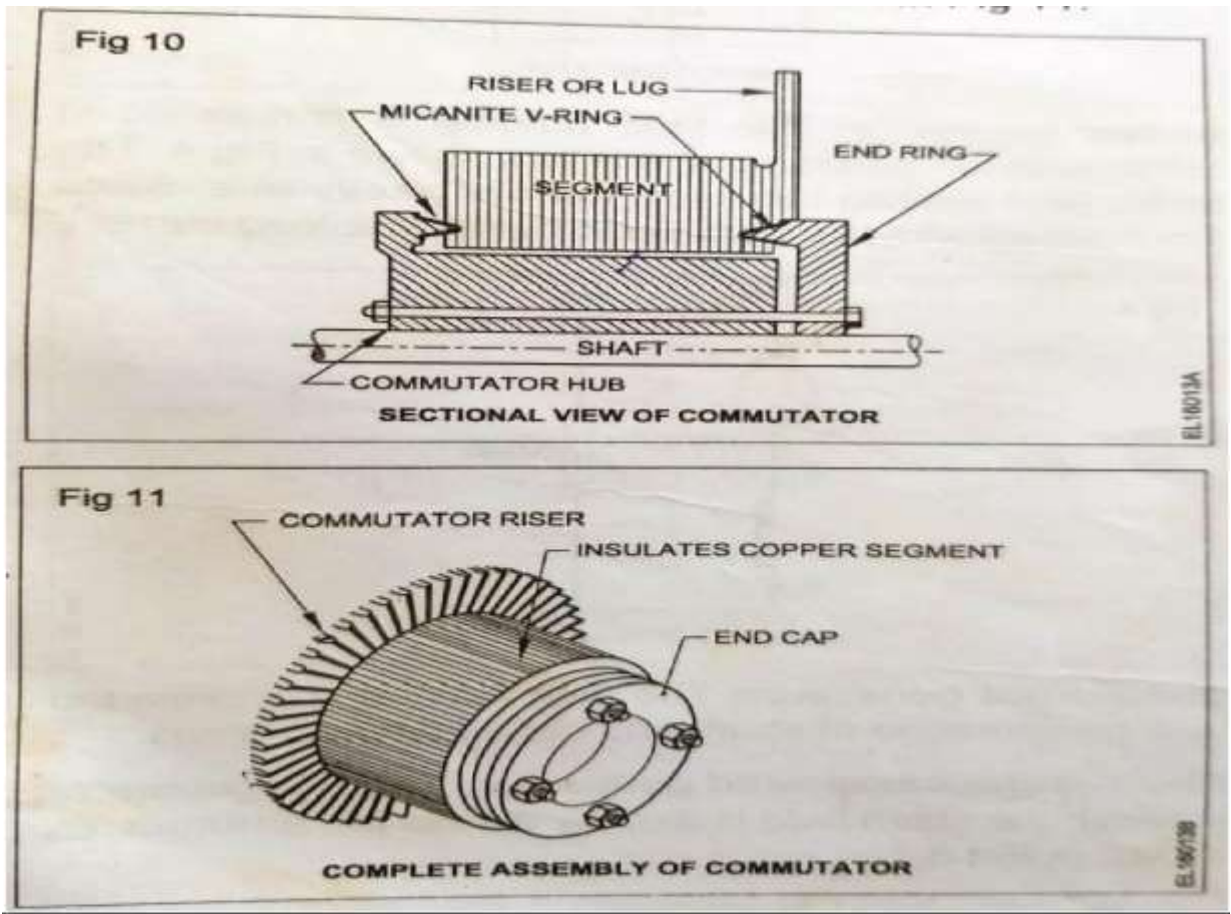
Armature Core :- The armature core houses the armature conductors. Those conductors are rotate in the magnetic field which cut the magnetic flux. The most important function is to provide a path of very low reluctance to the field flux and allowing the magnetic circuit to complete through the yoke and the poles. The armature core is cylindrical or drum shaped and is buildup of circular sheet steel dices or laminations which have 0.5mm thickness.





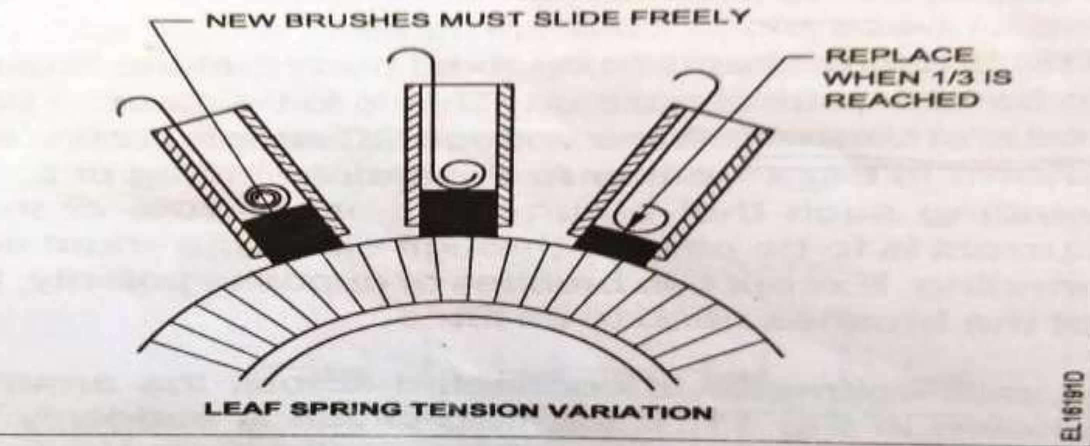
Armature Winding/Armature Conductor:- the armature windings are usually former-wound. These are first wound in the form of flat rectangular coils and are then pulled into their proper shape with a coil puller. Various conductors of the coils are insulated from each other. The conductors are placed in the armature slots which are lined with tough insulating material. After placing the conductors in the slot, this slot insulation is folded over the armature conductors, and is secured in place by special, hard, wooden or fiber wedges.

Commutator:- The function of the commutator is to collection of current from the armature conductors. It rectifies i.e. converts the alternating current induced in the armature conductors into unidirectional current for the external load circuit. It is shape like cylindrical structure and made of hard drawn or drop-forged copper. Its segments are insulated from each other by thin layer of mica.



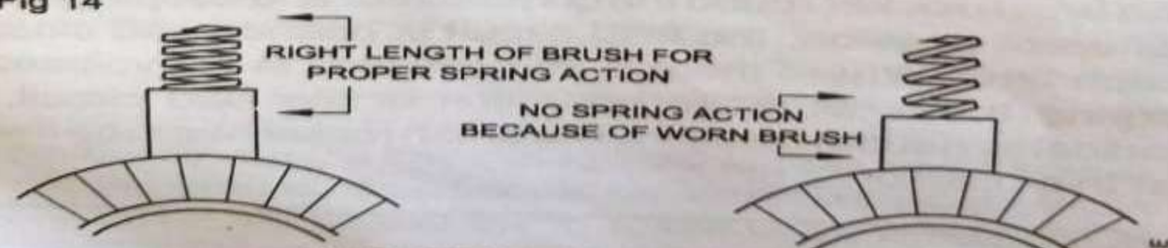
Brush:- The main function of brush is to collect current from the commutator. These are made of carbon and graphite and are in shape of rectangular block.

Fig 13



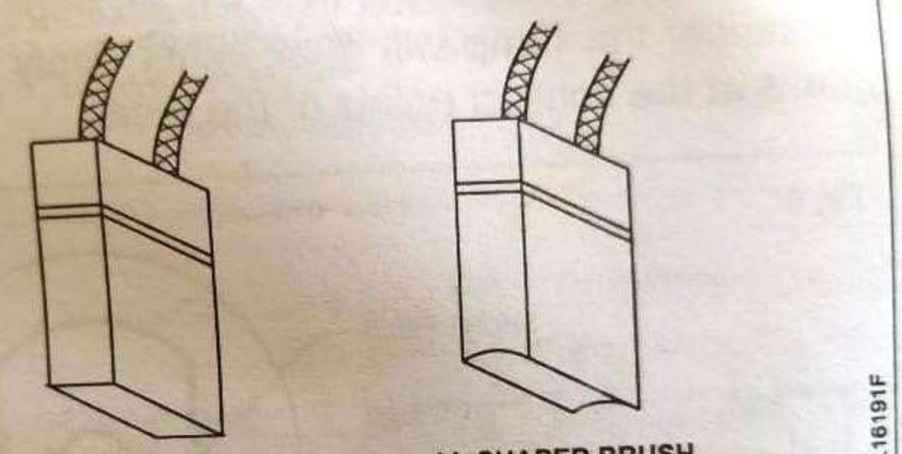
LEAF SPRING TENSION VARIATION

Fig 14



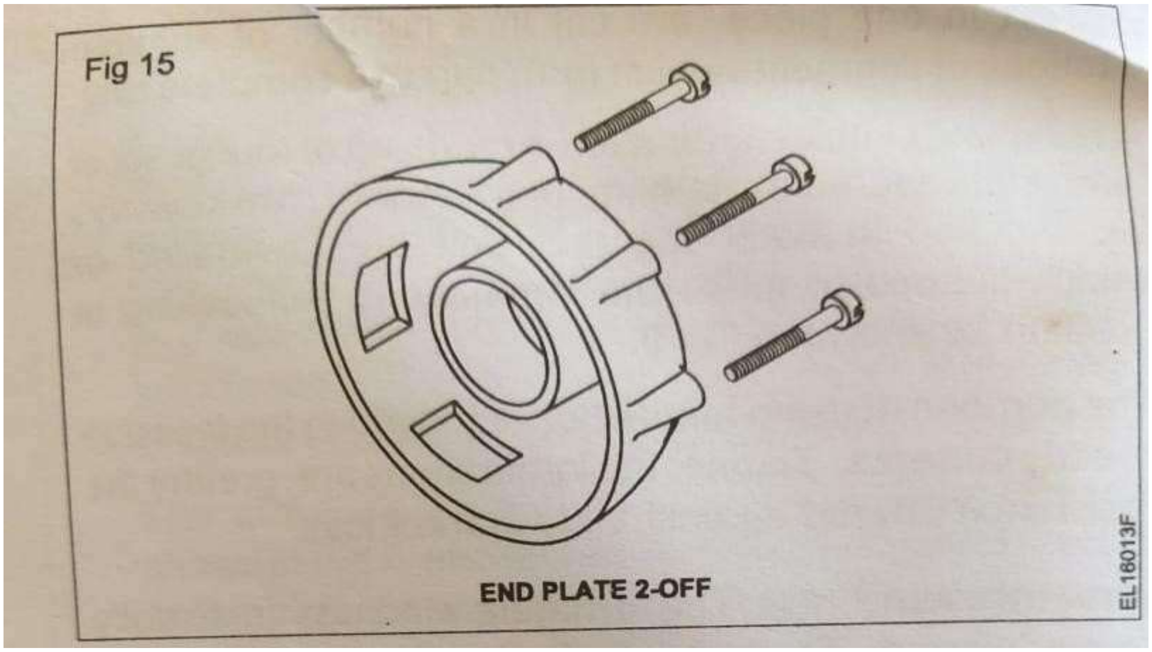
SPIRAL SPRING TENSION VARIATION

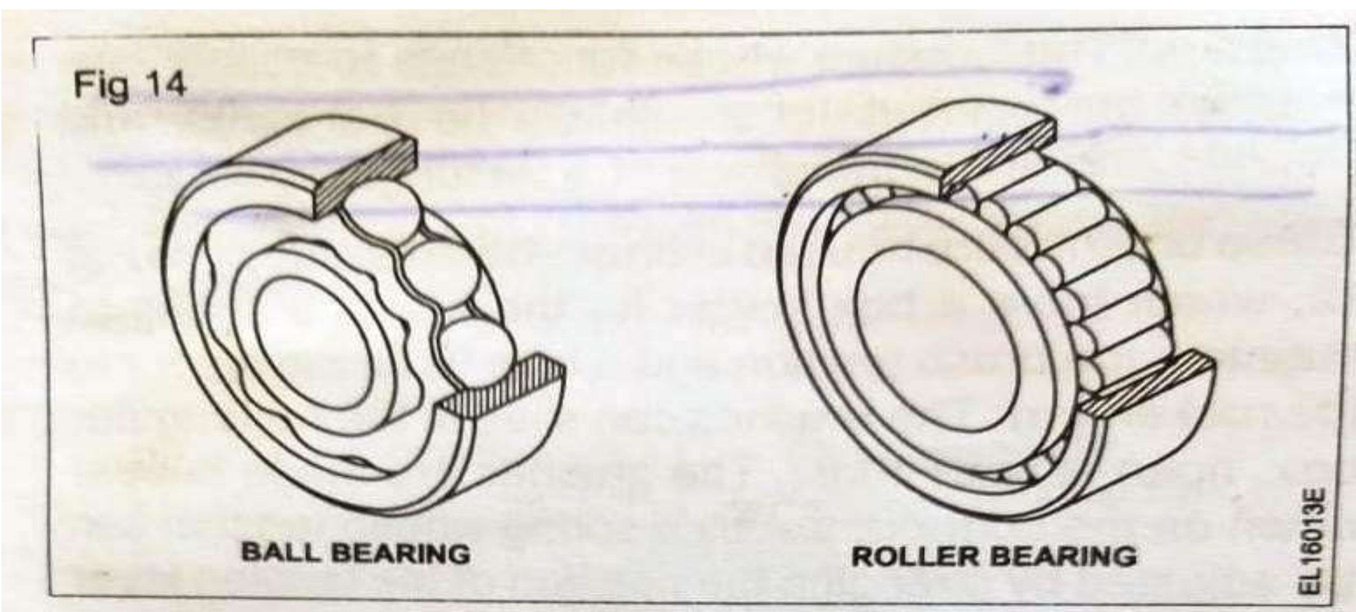
Fig 15



a) FLAT BRUSH b) SHAPED BRUSH

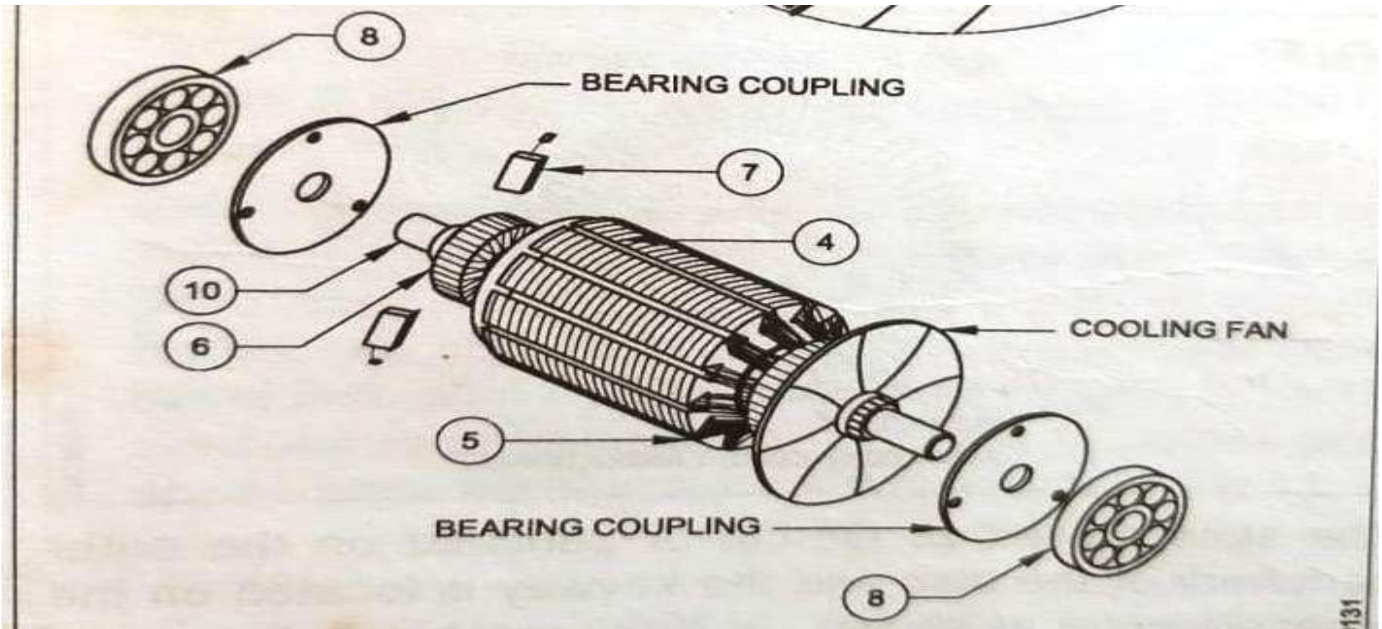
Bearing and End plate:- A bearing is a machine element which are used to reduce friction between moving parts. In DC machines ball and roller bearing are generally used which are filled with grease or lubricating oils. The bearings are housed in these end plates and they are fixed to the yoke. They help the armature for frictionless rotation and to position the armaturein the air gap of the field poles.





Cooling Fan:- Cooling fan are placed on the shaft of Dc machine which mainly used for cooling purpose.

Shaft:- A shaft is a mechanical component for transmitting torque and rotation. It is Cylindrical in shape and made of cold rolled or hot rolled steel.



PARTS OF A DC MACHINE

Terminal Box:- Terminal box in dc machines are placed on the yoke. It is used for connection of machine winding terminal and supply terminal.

Name Plate:- It is placed on the yoke which indicates the machine in formations like capacity,rpm, wattage, insulation class etc.

Conclusion:-

From this experiment, we learnt about the various parts of Dc machine. By using megger the insulation resistance between chassis and winding were checked and found to be ∞ Ohm.

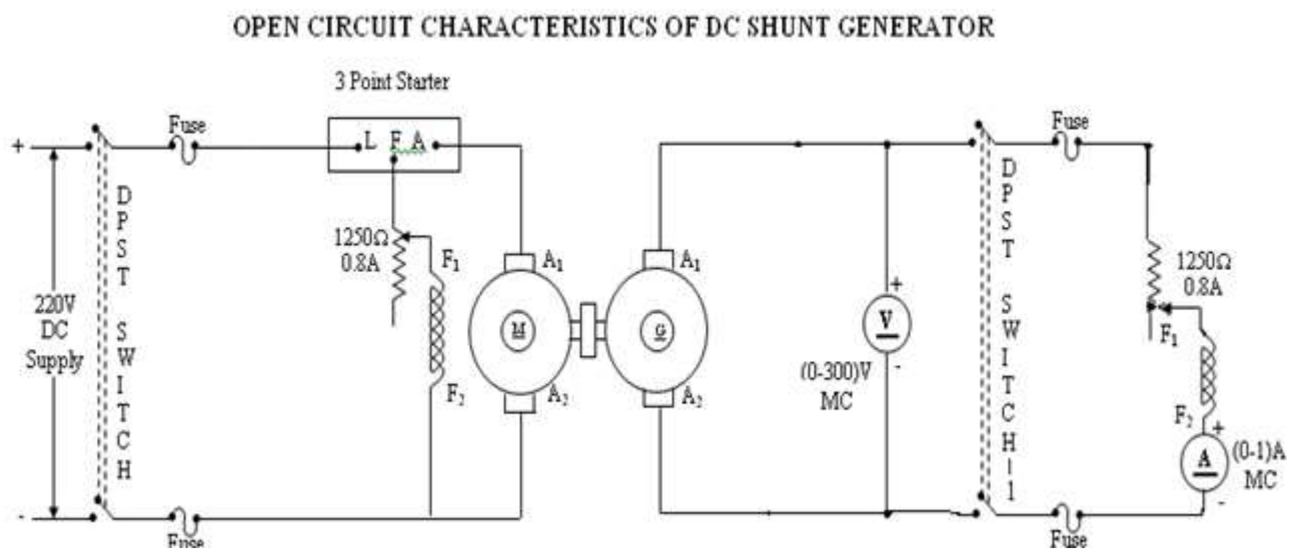
Experiment – 3

AIM:- To obtain the open circuit characteristics of DC shunt generator and find its critical resistance.

Apparatus Required:-

Sl. No.	Apparatus	Specification	Quantity
1	DC shunt generator	3 HP, 230 V, I_A = 8.1 A, I_F =0.8 A, 1500 RPM	1
2	Ammeter	(0-1) A	1
3	Voltmeter	(0-300) V	1
4	Rheostats	1250 Ohm, 0.8A	2
5	DPST Switch	-----	2
6	Tachometer	----	1
7	Connecting Wires	2.5sq.mm.	As per required

Circuit Diagram:-



Procedure:-

1. Connections are made as per the circuit diagram.
2. After checking minimum position of motor field rheostat, maximum position of generator field rheostat, DPST-1 (motor) switch is closed and starting resistance is gradually increased.
3. By adjusting the field rheostat, the motor is brought to its rated speed i.e. 1500 RPM.
4. Voltmeter and ammeter readings are taken when the DPST- 2 switch is kept open.
5. After closing the DPST-2 switch, by varying the generator field rheostat, voltmeter and ammeter readings are taken.
6. After bringing the generator rheostat to maximum position, field rheostat of motor to minimum position, both DPST-2 and DPST-1 switches are opened.

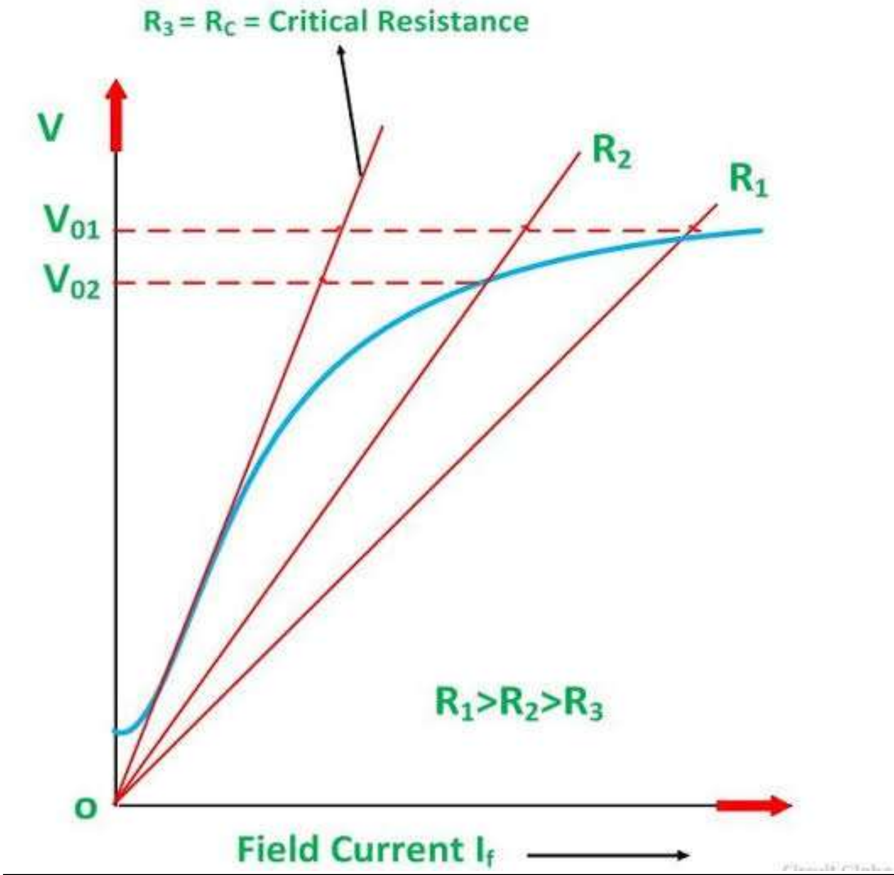
Precautions:-

1. The field rheostat of motor should be in minimum resistance position at the timeof starting and stopping of the machine.
2. The field rheostat of generator should be in maximum resistance position at thetime of starting and stopping of the machine.
3. DPST-2 (Generator) should be kept open during starting and stopping of the machine.

Tabulation:-

Sl. No.	Field Current I_f (Amps)	Armature Voltage E_o (Volts)
1.		
2.		
3.		
4.		

Graph :-



Critical resistance at rated speed (R_c) = E_O / I_F

Conclusion:-

From this experiment, it is concluded that the terminal voltage od DC generator is directly proportional to the field current till a limit, beyond that the voltage gets almost constant due to magnetic saturation.

Experiment No: 04

AIM:- Plot External characteristics of a DC shunt generator at constant speed.

Apparatus Required:-

Sl. No	Name of the apparatus	Specification	Quantity
1	DC Shunt Generator	3 HP, 230 V, I_A = 8.1 A, I_F =0.8 A, 1500 RPM	1
2	Ammeter	0-10A MC	1
3	Ammeter	0-2A MC	1
4	Voltmeter	0-300V MC	1
5	Tachometer	digital	1
6	Connecting Wires	2.5sq.mm.	As per required

Fuse rating: For Open Circuit test 10% of rated full load current

Theory :

Load characteristics are study of voltage when the load on a generator is increased from no load or decreased from full load.

There are two types of characteristics

(i) External characteristics

(ii) Internal characteristics

External characteristics

A plot of the terminal voltage V_T and load current I_L with preset values of field current and speed gives External characteristics curve. The drop in terminal voltage V_T is due to armature reaction and further reduction is due reduction in field current I_f, since the terminal voltage fallen because of the above two reasons.

Circuit Diagram:-

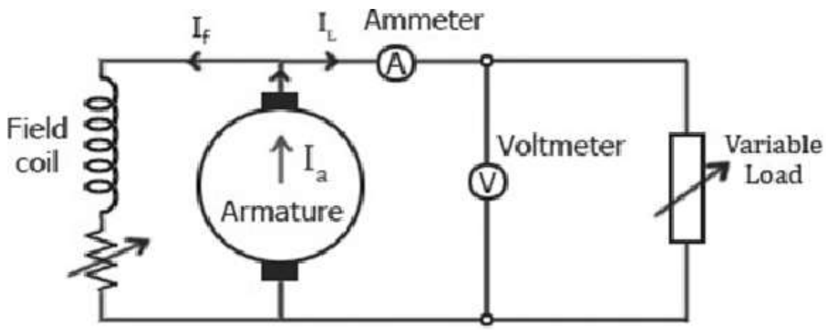


Fig.- 1

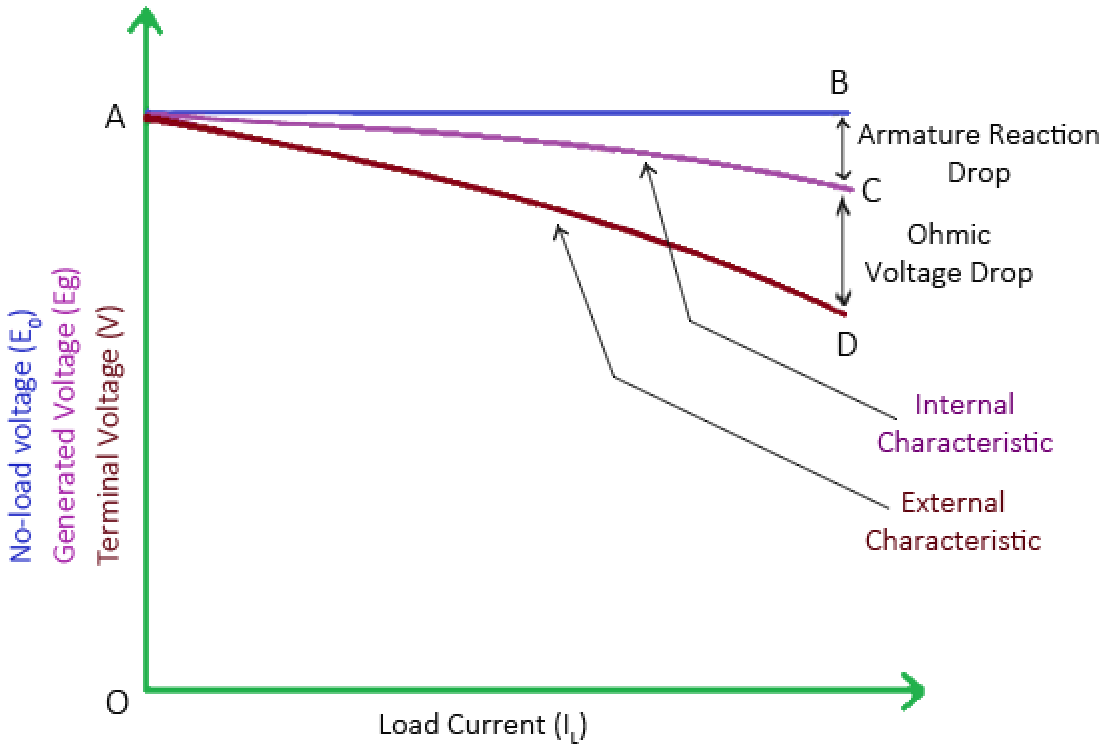
Procedure:-

1. Connections are made as shown in fig-1.
2. Ensuring the field resistance of motor in minimum position and generator field resistance in maximum position. Motor is switched ON by dragging the starters handle slowly still it attains ON position Adjust the field of motor to run the generator with rated speed
3. by adjusting the field of generator keep the terminal voltage V_L around 220V (rated voltage)
4. Load the generator by keeping the speed of generator constant and note the values of V_L, I_L, and If.
5. Repeat step 4 till the rated load current is attained.
6. Reduce the load and switch off the supply.
7. Plot the load characteristics as external and internal characteristics.

Tabulation:-

Sl. No.	Load Current (I_L) in ampere	Terminal Voltage (V_T) in Volt
1		
2		
3		
4		

Graph:



Conclusion:-

From the experiment it is concluded that the terminal voltage of D C generator decreases with increase in the load current.

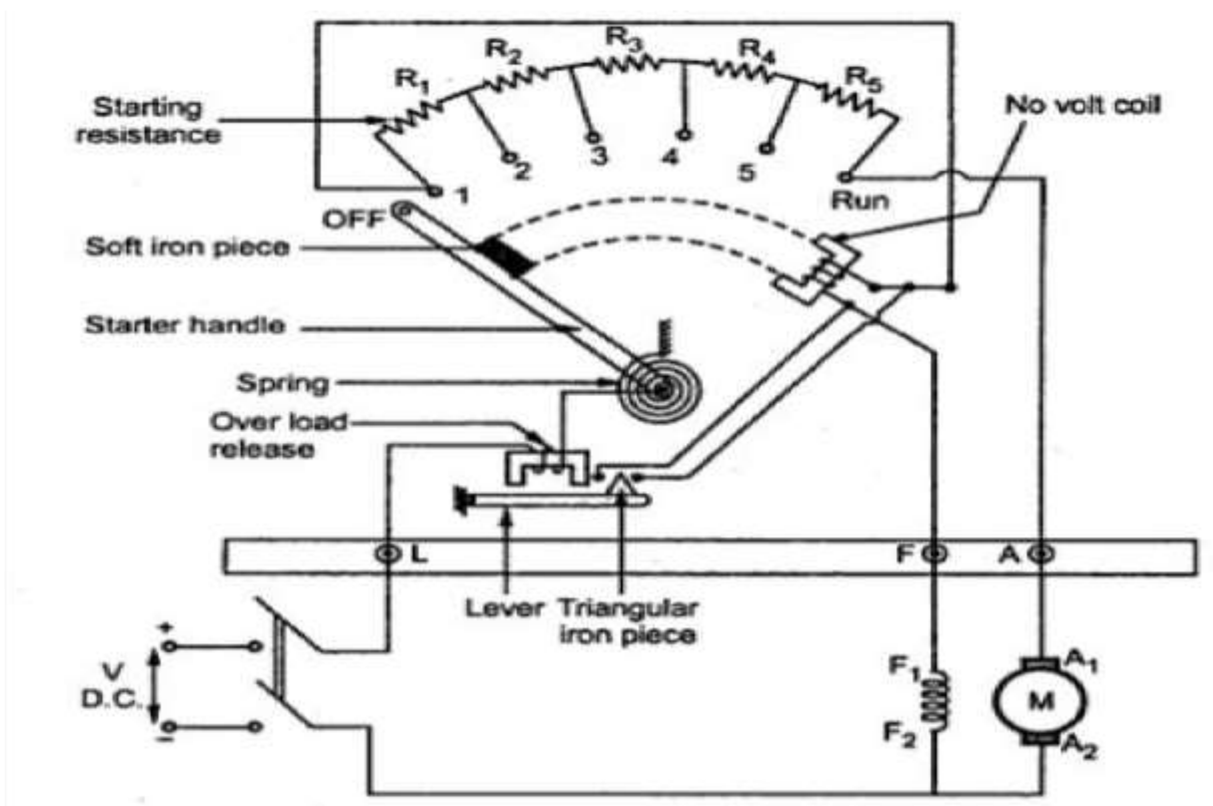
Experiment – 5

Aim:- Study of three Point Starter, connect and run a DC shunt motor and measure no load current.

Apparatus Required:-

Sl. No.	Name of the Equipment	Specification	Quantity
1	DC shunt Motor	3 HP, 1500 RPM, 220 V, I_A =12 A, I_F= 0.7 A	1no
2	Three Point starter	3 HP, 12 A	1no
3	DC Ammeter	(0-15) A	1no
4	DC Voltmeter	(0-300) V	1no
5	Connecting Wires	2.5 sq. mm	As Per Required

Circuit Diagram:-



Theory:-

Necessity of Starter:-

(i) Starter is used to protect DC motor from damage which can be caused by very high current and torque during starting.

(ii) Starting of DC motor, the armature is stationary, thus the back emf is zero.

(iii) As armature resistance is very small, if the voltage is applied to it, it will draw around 10 times of the full load current.

(iv) This may cause heavy damage to the armature, so the starting current should be limited to a safe value.

(v) This can be done by inserting a resistance in series with the armature at the time of starting for a period of 5 to 10 sec.

Three- Point Starter:-

1. It is used to start the dc shunt motor.
2. The series resistance is connected to the armature
3. The shunt field in series with the holding coil.
4. It has also overload coil, which is connected series with the supply which is used to protect the motor from over load current
5. The starter has insulated handle or knob for the operator's use.

Procedure:-

I. We should take all the tools & instrument for this experiment.
II. Connect the Starter as per circuit diagram with DC shunt Motor.
III. Check all the connection.
IV. Switch on the D.C. Supply start the motor with the help of starter.
V. Gradually increase the starter handle to the holding coil.
VI. Measure the starting No load current.

Tabulation:-

Peak starting current	**Steady state current**

Conclusion:-

From this experiment we learnt about the connection of three point starter.

It is observed that the DC shunt motor is started smoothly with the help of a three point starter.

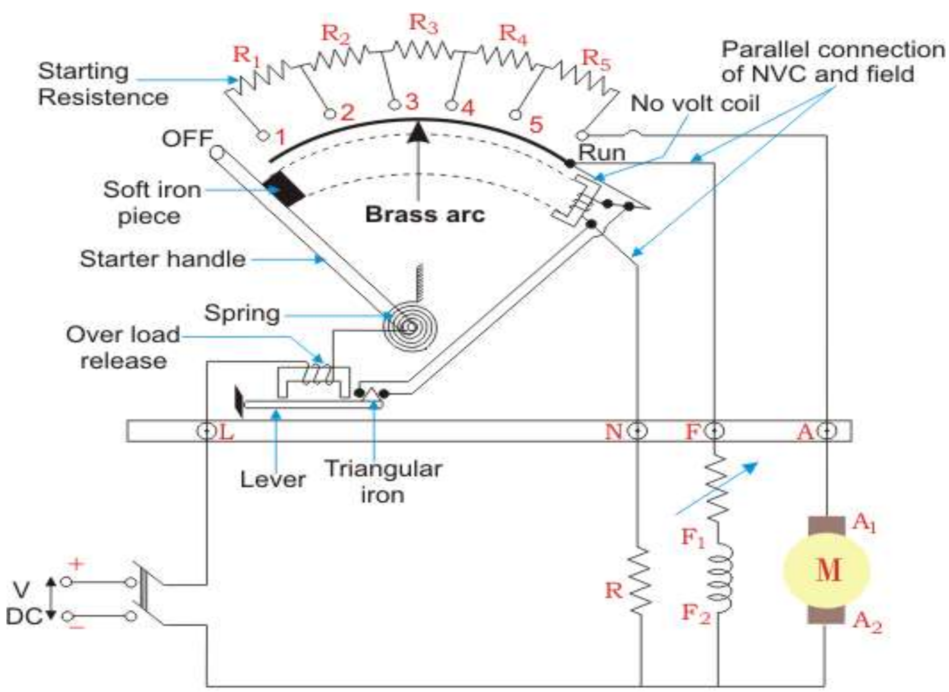
Experiment – 6

Aim:- Study of Four Point Starter, connect and run a DC compound motor & measure no load current.

Apparatus Required:-

Sl. No.	Name of the Equipment	Specification	Quantity
1	DC Compound Motor	3 HP, 1500 RPM, 220 V, I_A =12 A, I_F= 0.7 A	1no
2	Four Point starter	3 HP, 12 A	1no
3	DC Ammeter	(0-15) A	1no
4	DC Voltmeter	(0-300) V	1no
5	Connecting Wires	2.5 sq mm	As Per Required

Circuit Diagram:-



Four Point Starter

Theory:-

Necessity of Starter:-

(i) Starter is used to protect Dc motor from damage which can be caused by very highcurrent and torque during starting.

(ii) Starting of DC motor, the armature is stationary, thus the back emf is also zero which is proportional to speed.

(iii) As armature resistance is very small, if the voltage is applied to it, it will draw manytimes of full load current.

(iv) This can cause heavy damage to the armature, so the starting current should be limited to a safe value.

(v) This can be done by inserting a resistance in series with the armature at the time ofstarting for a period of 5 to 10 secs.

Four- Point Starter:-

(i) It is used to start the dc compound motor.

(ii) It is similar to 3-point starter but here the holding coil is not connected in series with the shunt field.

(iii) It is connected across the supply in series with a resistor. This resistor limits the current in the holding coil to the desired value.

(iv) If the line voltage drops below the desired value, the magnetic attraction of the holding coil is decreased and then the spring pulls the starter handle back to the 'off' position.

Procedure:-

1. We should take all the tools & instrument for this experiment.
2. Connect the Starter as per circuit diagram with DC compound Motor.
3. Check all the connection.
4. Switch on the D.C. Supply start the motor with the help of starter.
5. Gradually increase the starter handle to the holding coil.
6. Measure the starting No load current.

Tabulation:-

Peak starting current	Steady state current

Conclusion:-

From this experiment we learnt about the connection of four point starter.

It is observed that the DC compound motor is started smoothly with the help of a four point starter.

Experiment-7

Aim:-

Control the speed of a DC shunt motor by field flux control method & armature voltage control method.

Apparatus Required:

Sl. No.	Apparatus	Specification	Quantity
1	DC shunt motor	3 HP, 1500 RPM, 220 V, I_A =12 A, I_F= 0.7 A	1
2	Ammeter	(0-15) A	1
3	Voltmeter	(0-300) V	1
4	Rheostats	50 ohms, 10 A	1
5	Rheostats	500 ohms, 1 A	1
6	Tachometer	Digital	1
7	Connecting Wires	2.5sq.mm.	As per requirement

Theory:-

The speed equation of DC motor shows that,

$$N = \frac{E_b}{\Phi} = \frac{V - I_a R_a}{\Phi}$$

$$\Rightarrow N \ \alpha \ \frac{V}{\Phi}$$

Procedure:-

1. Connections are made as per the circuit diagram.
2. After checking the maximum position of armature rheostat and minimum

position of field rheostat, DPST switch is closed

(i) Armature Control:

1. Adjust the rheostat connected in series with armature to change the armature voltage.
2. Repeat step 1 to get at least five readings.
3. Note down the speed (N) and armature voltage (V_a).
4. Plot graph between speed (N) and armature voltage (V_a).

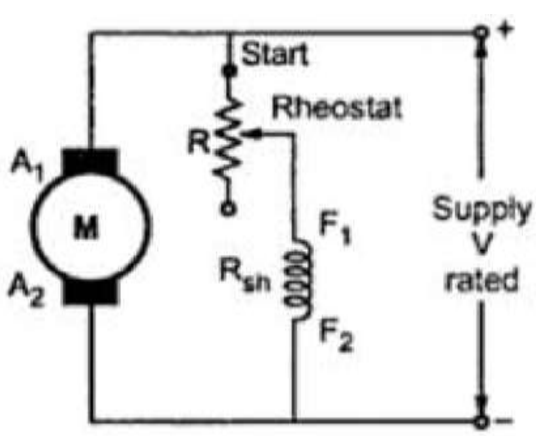
(ii) Field Control:

1. Adjust the rheostat connected in series with field winding to change the field current.
2. Repeat the step 1 to get at least five different reading.
3. Note down speed (N) and field current (I_f).
4. Plot the graph between speed (N) and field current (I_f).

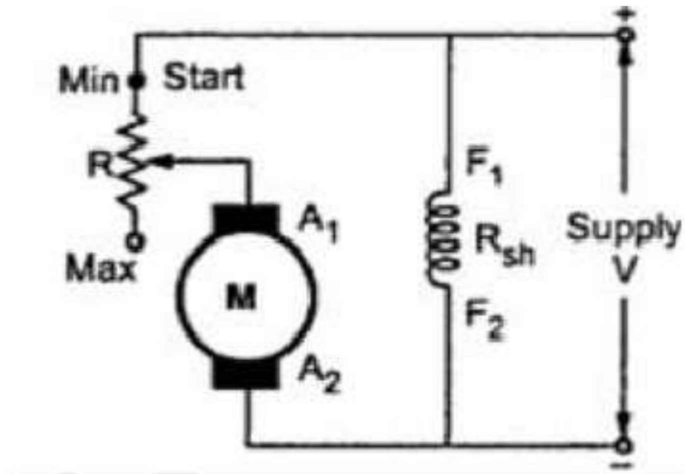
Precaution:-

1. Field Rheostat should be kept in the minimum resistance position at the time of starting and stopping the motor.
2. Armature Rheostat should be kept in the maximum resistance position at the time of starting and stopping the motor.

Circuit Diagram:-



[Circuit Diagram of Field Flux control Method]



[Circuit Diagram of Armature Voltage control Method]

Tabulation:-

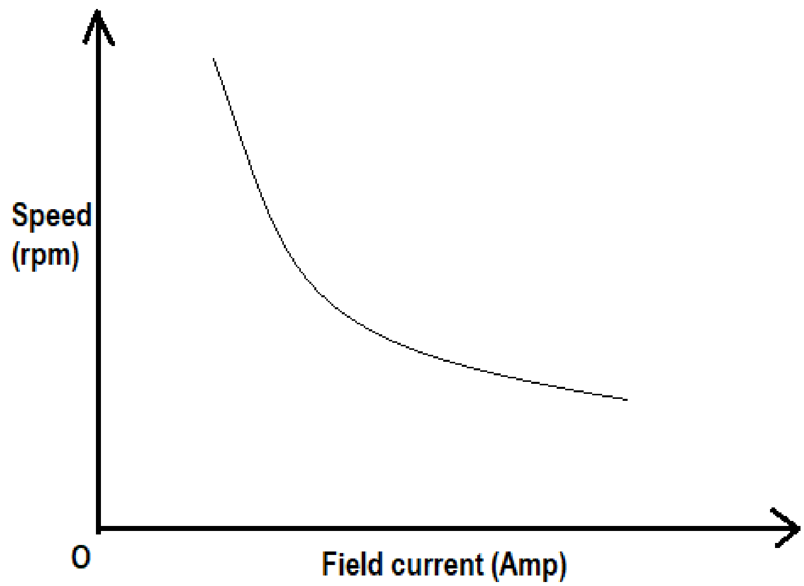
Armature voltage control method

Sl. No.	Armature Voltage (in Volt)	Speed (in RPM)
1.		
2.		
3.		
4.		
5.		

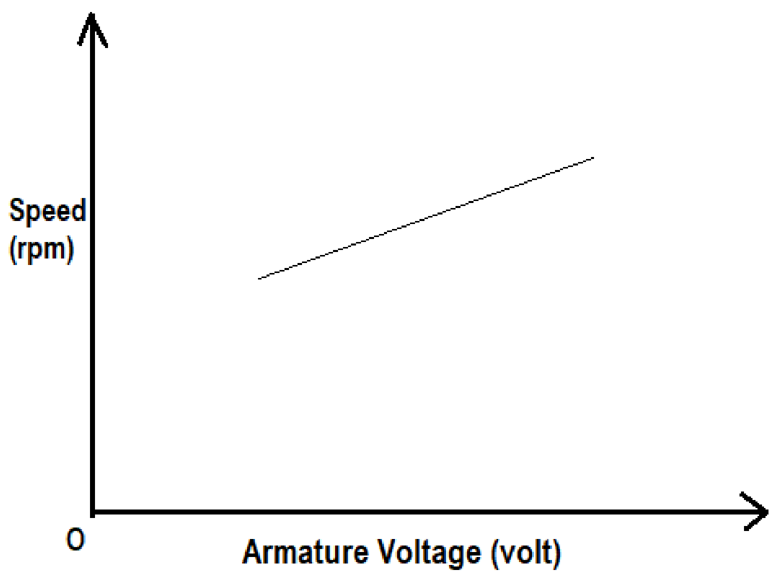
Flux control method

Sl. No.	Filed current (in Amp)	Speed (in RPM)
1.		
2.		
3.		
4.		
5.		

Graph:-



[Plot of Speed vs field current]



[Plot of Speed vs Armature voltage]

Conclusion:-

From this experiment it is concluded that, the speed is directly proportional to armature voltage whereas inversely proportional to filed current.

Experiment-08

Aim: - Determine the armature current vs. speed characteristic of a DC motor.

Apparatus Required:-

Sl. No.	Name of the Equipment	Specification	Quantity
1	DC Series Motor	220 V, 1500 RPM, 3 HP, I_A =12 A	1no
2	DC Shunt Motor	3 HP, 1500 RPM, 220 V, I_A =12 A, I_F= 0.7 A	1no
3	DC Compound Motor	3 HP, 1500 RPM, 220 V, I_A =12 A, I_F= 0.7 A	1no
4	Tachometer	Digital Type, (0-9999) rpm	1no
5	DC Ammeter	(0-15) A	1no
6	DC Voltmeter	(0-300) V	1no
7	Connecting Wires	2.5 sq. mm	As Per Required

Theory:-

DC Series Motor:-

We know the relation,

$$N \propto E_b/\phi$$

For small load current (and hence for small armature current) change in back emf Eb is small and it may be neglected. Hence, for small currents speed is inversely proportional to ϕ. As we know, flux is directly proportional to Ia, speed is inversely proportional to Ia. Therefore, when armature current is very small the speed becomes dangerously high. That is why a series motor should never be started without some mechanical load.

But, at heavy loads, armature current I_a is large. And hence, speed is low which results in decreased back emf E_b. Due to decreased E_b, more armature current is allowed.

DC Shunt Motor:-

As flux ϕ is assumed to be constant, we can say N a Eb. But, as back emf is also almost constant, the speed should remain constant. But practically, ϕ as well as Eb decreases with increase in load. Back emf Eb decreases slightly more than ϕ, therefore, the speed decreases slightly. Generally, the speed decreases only by 5 to 15% of full load speed. Therefore, a shunt motor can be assumed as a constant speed motor. In speed vs. armature current characteristic in the following figure, the straight horizontal line represents the ideal characteristic and the actual characteristic is shown by the dotted line

DC Compound Motor:-

DC compound motors have both series as well as shunt winding. In a compound motor, if series and shunt windings are connected such that series flux is in direction as that of the shunt flux then the motor is said to be cumulatively compounded. And if the series flux is opposite to the direction of the shunt flux, then the motor is said to be differentially compounded. Characteristics of both these compound motors are explained below.

(a) Cumulative compound motor

Cumulative compound motors are used where series characteristics are required but the load is likely to be removed completely. Series winding takes care of the heavy load, whereas the shunt winding prevents the motor from running at dangerously high speed when the load is suddenly removed. These motors have generally employed a flywheel, where sudden and temporary loads are applied like in rolling mills.

(b) Differential compound motor

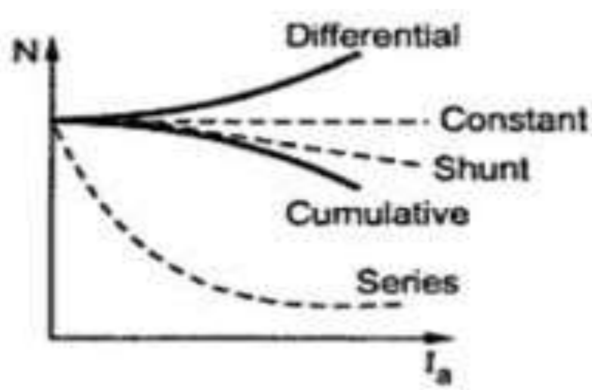
Since in differential field motors, series flux opposes shunt flux, the total flux decreases with increase in load. Due to this, the speed remains almost constant or even it may increase slightly with increase in load ($N \propto E_b/\phi$). Differential compound motors are not commonly used, but they find limited applications in experimental and research work.

<u>Procedure:-</u>

1. We should take all the tools & instrument for this experiment.
2. Connect all the motors as per circuit diagram.
3. Check all the connection.
4. Switch on the D.C. Supply start the motor with the help of starter.
5. Gradually increase the starter handle to the holding coil.
6. Measure the starting No load current and full load current of all motors.
7. Measure the speed of all motors with the help of tachometer.

Tabulation:-

Sl. No.	DC Series Motor		DC Shunt Motor		DC Compound Motor	
	Speed(N)	Armature Current(I_a)	Speed(N)	Armature Current(I_a)	Speed(N)	Armature Current(I_a)
1						
2						
3						
4						
5						



<u>Conclusion:-</u>

From the above experiment, we learnt all the characteristics of all the DC motors.

Experiment No- 09

AIM :- Determine the efficiency of a DC machine by brake test method.

Apparatus Required:-

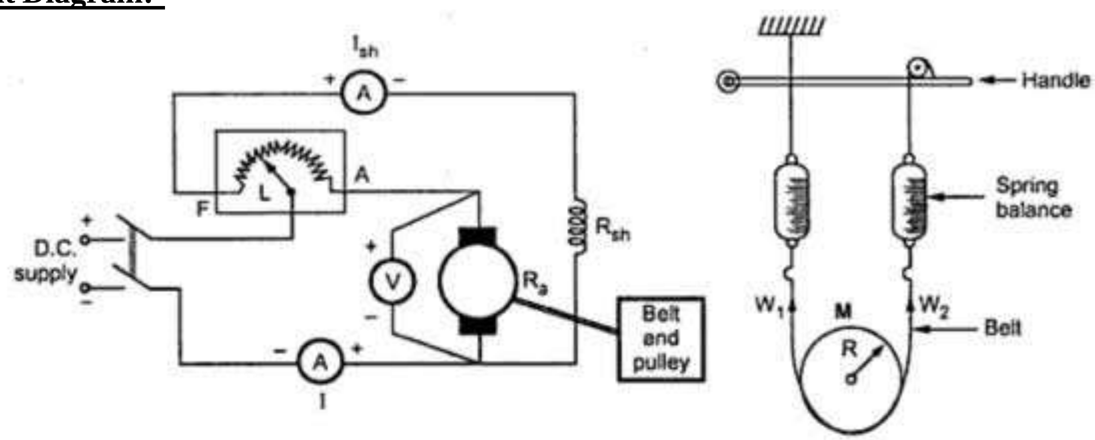
Sl. No.	Equipment	Specification	Quantity
1	DC Shunt Motor with pully system	3 HP, 1500 RPM, 220 V, I_A =12 A, I_F= 0.7 A	1 No.
2	Ammeter	(0-25A)	1 No.
3	Voltmeter	(0-300V)	1 No.
4	Tachometer	Digital (0-9999rpm)	1 No.
5	Connecting wires	2.5 sq. mm	As per required

Theory:-

There are several tests that are conducted upon a DC machine (Motor or Generator) to judge its performance. One important test is performed to measure the efficiency of the DC machine. Efficiency depends on its losses. The smaller the losses the greater is its efficiency and vice versa. The consideration of losses in a DC machine is important because they determine the efficiency of the machine and appreciably influences its operating cost. And also, they determine heating of the machine and hence the power output that may be obtained without undue deterioration of the insulation.

In this method a brake drum is connected in the shaft of the motor with spring balances to measure the load. The mechanical output of the motor is calculated with the help of spring balances readings and speed of the machine.

Circuit Diagram:-



(a) Experimental setup (b) Belt and pulley arrangement

Procedure:-

1. Make the connections as per circuit diagram.
2. Keep the field regulator of the Motor at minimum Resistance position.
3. At the time of starting check that the belt on the pulley is free, so that there is noload on the pulley.
4. Start the motor slowly by using starter
5. Adjust the field regulator so that motor runs at its rated speed.
6. Apply load on the pulley gradually in steps by adjusting of tension of the spring Balance.
7. Take the readings of the Ammeter and Voltmeter and two spring balance readings and the speed for each step.
8. Cool the pulley throughout the loading period by pouring water.
9. Continue the experiment till full load of the motor is reached.

Tabulation:-

Sl. No.	**V_L (V)**	**I_L (A)**	**S_1 (kg)**	**S_2 (kg)**	**Speed 'N' in RPM**	**Input Power (Watt)**	**Torque (T) in Nm**	**Output Power (in Watts)**		**% Efficiency**
1										
2										
3										

Calculation:-

Motor output power (M_o) = Torque * Angular speed

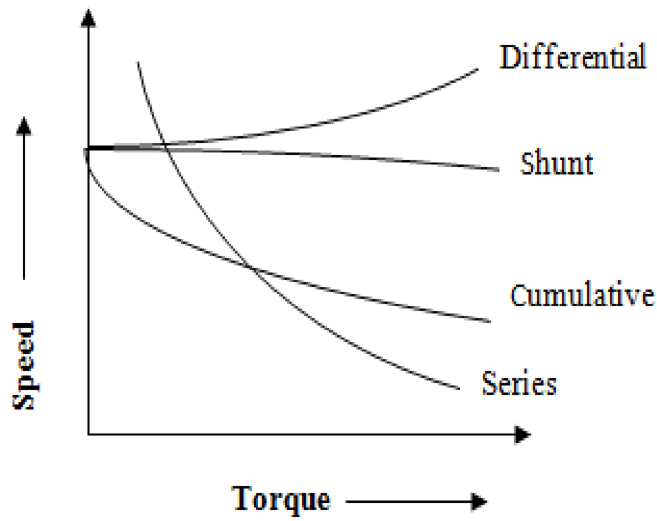
= Force * Radius * ω

= $(S_1 - S_2) * g * R * \omega$

Motor input power (M_I) = $V_T * I_L$

Efficiency $= 100 * (M_I) / (M_o)$

Graph:-



Conclusion:-

From the above experiment, we learnt the load test on the given D.C seriesmotor was conducted and its performance characteristics were drawn and conclusion can be given based on the performance curves.

Experiment-10

Aim: - Identification of terminals, determination of voltage transformation ratio of a single phase transformer.

Apparatus Required:

Sl. No.	Apparatus	Range	Quantity
1	1-ϕ Transformer	1 KVA, 220 V/110 V, 50 Hz	1
2	Voltmeter	600 V AC	1
3	Connecting Wires	2.5 sq.mm	As per required
4	1 phase variac	0-270 V AC	1

Theory:-

Transformation Ratio (K) is defined as the ratio of the EMF in the secondary coil to that in the primary coil.

K = E2/E1 = (4.44(Φm)fN2)/(4.44(Φm)fN1)

Therefore,

K = E2/E1 = N2/N1….(1)

Now,

V_1 = E1 + voltage dropE2 = V_2 + voltage drop

Due to the resistance in the windings and some leakage flux, there is some loss in voltage. This is called as Voltage Drop.

But, in ideal case, voltage drop can be neglected.

Hence,

E2/E1 = V_2/ V_1**…..(2)**

Also, in a transformer, the power across the primary as well as the secondary winding is same.

Hence,

$V_1 . I_1 = V_2 . I_2$

$V_1 / V_2 = I_2 / I_1$........... (3)

Now, combining (1), (2) & (3), we get,

$K = E2/E1 = N2/N1 = V_2 / V_1 = I_2 / I_1$

Where,

1 represents the primary coil

2 represent the secondary coil

E is emf in the respective coil

V is the voltage in the respective coilI is the current in the respective coil

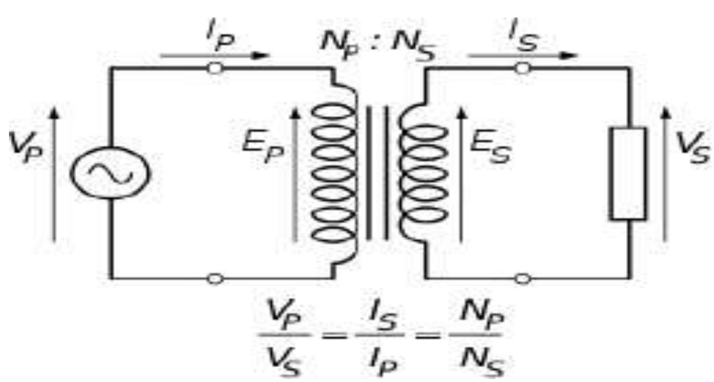
N is number of turns of the respective coils

Φm is the mutual flux in the core.

<u>Procedure:-</u>

1. Using a megger; terminals of two windings can be identified.
2. If megger shows 0 Ohm reading, then the two terminals belongs to same winding.

   If megger shows ∞ Ohm reading, then the two terminals belongs to different winding.
3. Supply one winding with a low voltage through a single phase variac and measure voltage across other winding wit ha voltmeter.
4. Repeat step 3 atleast five times and obtain different readings.
5. Then find out the transformation ratio i.e. output voltage to input voltage.



Tabulation:-

Sl. No.	Input Voltage (V_I)	Output Voltage (V_O)	Ratio (=V_O /V_I)
1			
2			
3			
4			
5			

Conclusion:-

From the above experiment, we learnt about the transformation ratio oftransformer.

Experiment-11

Aim:- Perform OC test and SC test of a single phase transformer.

Apparatus Required:-

Sl. No.	Apparatus	Specification	Quantity
1	Single Phase Transformer	1 KVA, 220 V/110 V, 50 Hz	1
2	Ammeter	(0-2) A (0-5) A	1 1
3	Voltmeter	(0-300) V	1
4	Wattmeter	UPF 250V, 4A, 1000 W LPF	1 1
5	Connecting Wires	2.5sq.mm	As per requirement
6	Single phase Variac	0-270 V	1

Theory:-

Open Circuit Test: - The purpose of the open circuit test is to determine the no-load current and losses of the transformer because of which their no-load parameter are determined. This test is performed on the primary winding of the transformer.

The wattmeter, ammeter and thevoltage are connected to their primary winding.

The nominal rated voltage is supplied to their primary winding with the help of the ac source.

The secondary winding of the transformer is kept open and the voltmeter is connected to their terminal. This voltmeter measures the secondary induced voltage.

As the secondary of the transformer is open the no-load current flows through the primary winding.

The value of no-load current is very small as compared to the full rated current. T

he copper loss occurs only on the primary winding of the transformer because the secondary winding is open. The reading of the wattmeter only represents the core and iron losses. The core loss of the transformer is same for all types of loads.

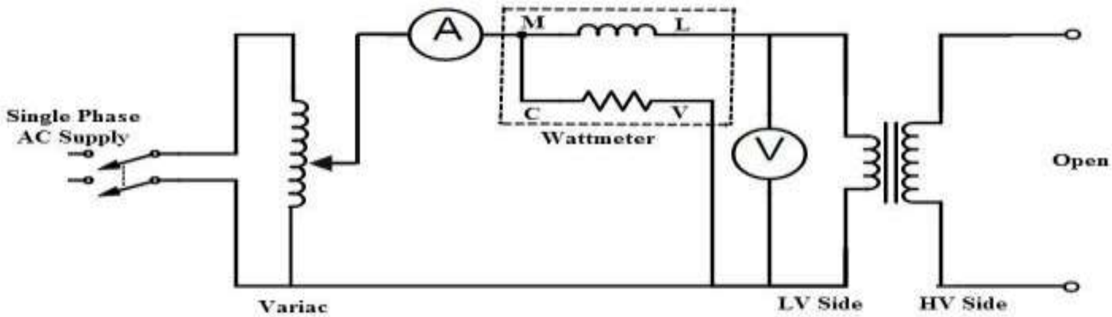


Fig- 11.1 Open Circuit Test

Short Circuit Test: - The short circuit test is performed for determining the below mention parameter of the transformer.

- It determines the copper loss occur on the full load. The copper loss is used for finding the efficiency of the transformer.
- The equivalent resistance, impedance, and leakage reactance are known by the short circuit test.

The short circuit test is performed on the secondary or high voltage winding of the transformer.The measuring instrument like wattmeter, voltmeter and ammeter are connected to the High voltage winding of the transformer. Their primary winding is short circuited by the help of thick strip or ammeter which is connected to their terminal.

The low voltage source is connected across the secondary winding because of which the full load current flows from both the secondary and the primary winding of the transformer. The full load current is measured by the ammeter connected across their secondary winding.
The low voltage source is applied across the secondary winding which is approximately 5 to 10% of the normal rated voltage. The flux is set up in the core of the transformer. The magnitude of the flux is small as compared to the normal flux.

The iron loss of the transformer depends on the flux. It is less occurred in the short circuit test because of the low value of flux. The reading of the wattmeter only determines the copper loss occur on their windings. The voltmeter measures the voltage applied to their high voltage winding. The secondary current induces in the transformer because of the applied voltage.

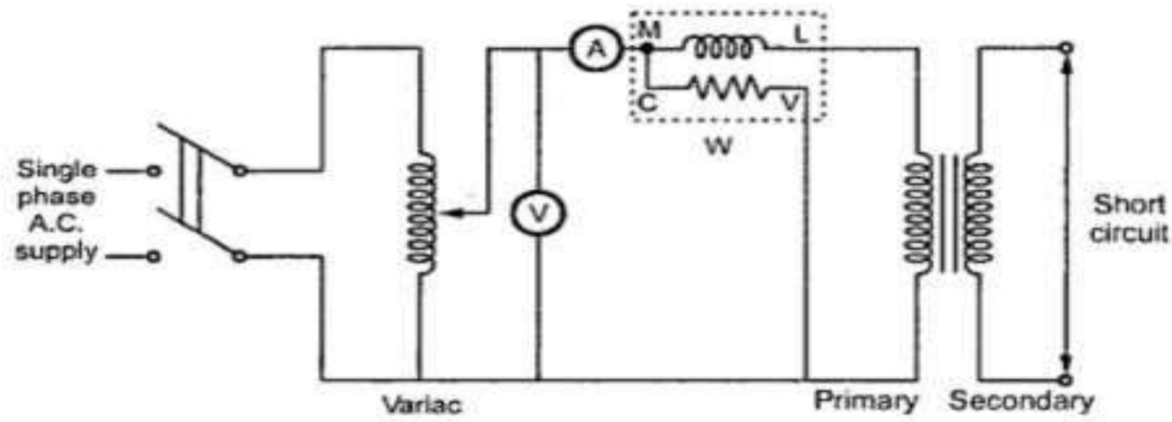


Fig.- 11.2 Short Circuit Test

Procedure:-

Open Circuit Test:

1. Connections are made as per the circuit diagram fig. 11.1.
2. After checking the minimum position of Autotransformer, DPST switch is closed.
3. Auto transformer (variac) is adjusted get the rated primary voltage.
4. Voltmeter, Ammeter and Wattmeter readings on primary side are noted.
5. Auto transformer is again brought to minimum position and DPST switch is opened.

Short Circuit Test:

1. Connections are made as per the circuit diagram fig. 11.2.
2. After checking the minimum position of Autotransformer, DPST switch is closed.
3. Auto transformer (variac) is adjusted get the rated primary current.
4. Voltmeter, Ammeter and Wattmeter readings on primary side are noted.
5. Auto transformer is again brought to minimum position and DPST switch is opened.

Tabulation:-

Short Circuit Test:

V_{sc} (Volts)	I_{sc} (Amps)	W_{sc} (Watts)

Open Circuit Test:

V_o (Volts)	I_o (Amps)	W_o (Watts)

Calculation:-

At rated load, (i.e. 1 KVA)

$$\textbf{Efficiency} = \frac{P_0}{P_I} * 100 = \frac{P_{I-W_{SC}-W_O}}{P_I} * 100$$

Conclusion:-

From the above experiment, we leant the OC test gives the core loss of transformer which is constant and the SC test gives the copper loss of the transformer which is variable depending upon the load.

Experiment-12

Aim:- Determine the voltage regulation of a single phase transformer at differentloads.

Apparatus Required:-

Sl. No.	Apparatus	Specification	Quantity
1	Single Phase Transformer	1 KVA, 220 V/110 V, 50 Hz	1
2	Ammeter	(0-2) A (0-5) A	1 1
3	Voltmeter	(0-300) V	1
4	Wattmeter	UPF 250V, 4A, 1000 W UPF 250V, 4A, 1000 W	1 1
5	Connecting Wires	2.5sq.mm	As per requirement
6	Single phase Variac	0-270 V	1
7	Resistive load bank	3 KW, 415 V	1

Procedure:-

1. Connections are made as per the circuit diagram.
2. After checking the no load condition, minimum position of auto transformer and DPST switch is closed.
3. Ammeter, Voltmeter and Wattmeter readings on both primary side and secondary side are noted.
4. The load is increased and for each load, Voltmeter, Ammeter and Wattmeter readings on both primary and secondary sides are noted.
5. Again, no load condition is obtained and DPST switch is opened.

Precautions:-

1. Auto Transformer should be in minimum position.
2. The AC supply is given and removed from the transformer under no load condition.

Formula:-

$$\text{Voltage regulation} = \frac{V_{NL} - V_{FL}}{V_{NL}} * 100$$

Tabulation:-

Sl. No.	Primary side			Secondary side			η	VR
	V_1	I_1	W_1	V_2	I_2	W_2		
1								
2								
3								
4								
5								

Conclusion:-

From the experiment it is observed that when the load is increased the output terminal voltage is decreased as a result the voltage regulation increased.

The efficiency of transformer increases with the increased in load till a point beyond that the efficiency decreases.

Experiment-13

Aim- Polarity test of single phase transformer and parallel operation of two single phase transformer.

Apparatus Required:-

Sl. No.	Apparatus	Specification	Quantity
1	Single Phase Transformer	1 KVA, 220 V/110 V, 50 Hz	1
2	Ammeter	(0-2) A (0-5) A	1 1
3	Voltmeter	(0-300) V	1
4	Connecting Wires	2.5sq.mm	As per requirement
5	Single phase Variac	0-270 V	1

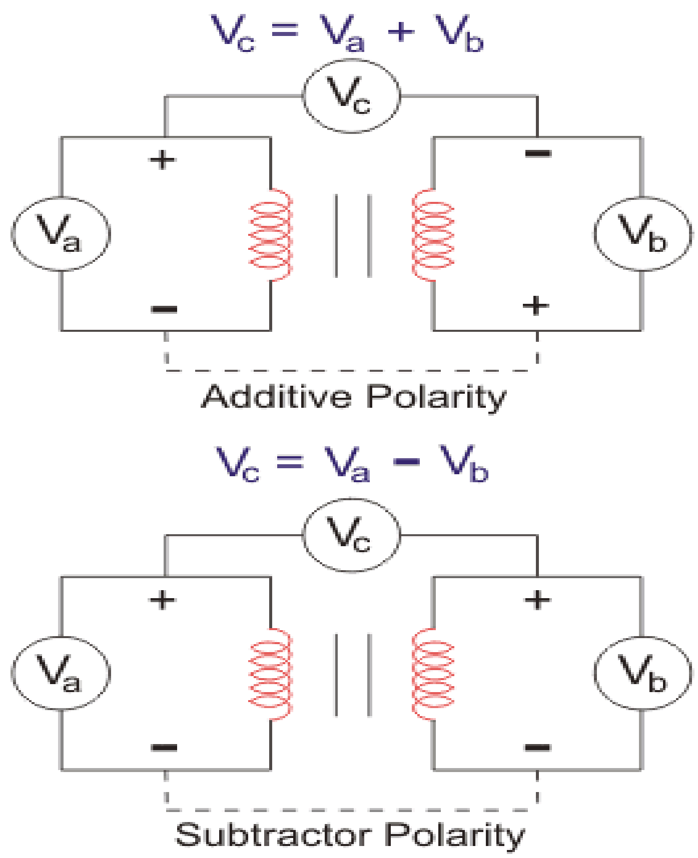
Theory:-

Polarity Test of Transformer :- Polarity means the direction of the induced voltages in the primary and the secondary winding of the transformer. If the two transformers are connected in parallel, then the polarity should be known for the proper connection of the transformer. There are two types of polarity one is **Additive**, and another is **Subtractive**.

Additive Polarity: In additive polarity the opposite (+ to -) terminals of the primary and the secondarywindings of the transformer are connected

Subtractive Polarity: In subtractive polarity same (+ to +) terminals of the primary and secondary side of the transformer is connected.

Each of the terminals of the primary as well as the secondary winding of a transformer is alternatively positive and negative with respect to each other as shown in the figure below.



It is essential to know the relative polarities at any instant of the primary and the secondary terminals for making the correct connections if the transformers are to be connected in parallel or they are used in a three phase circuit.

Advantages of Parallel Operation of Two Single Phase Transformers:-

1. Parallel operation of two or more Transformers means that all the Transformers Primary is connected with the common supply and their Secondary are feeding to a common bus through which load is connected. Parallel operation of Transformers requires that their Primaries as well as Secondaries are connected in parallel.

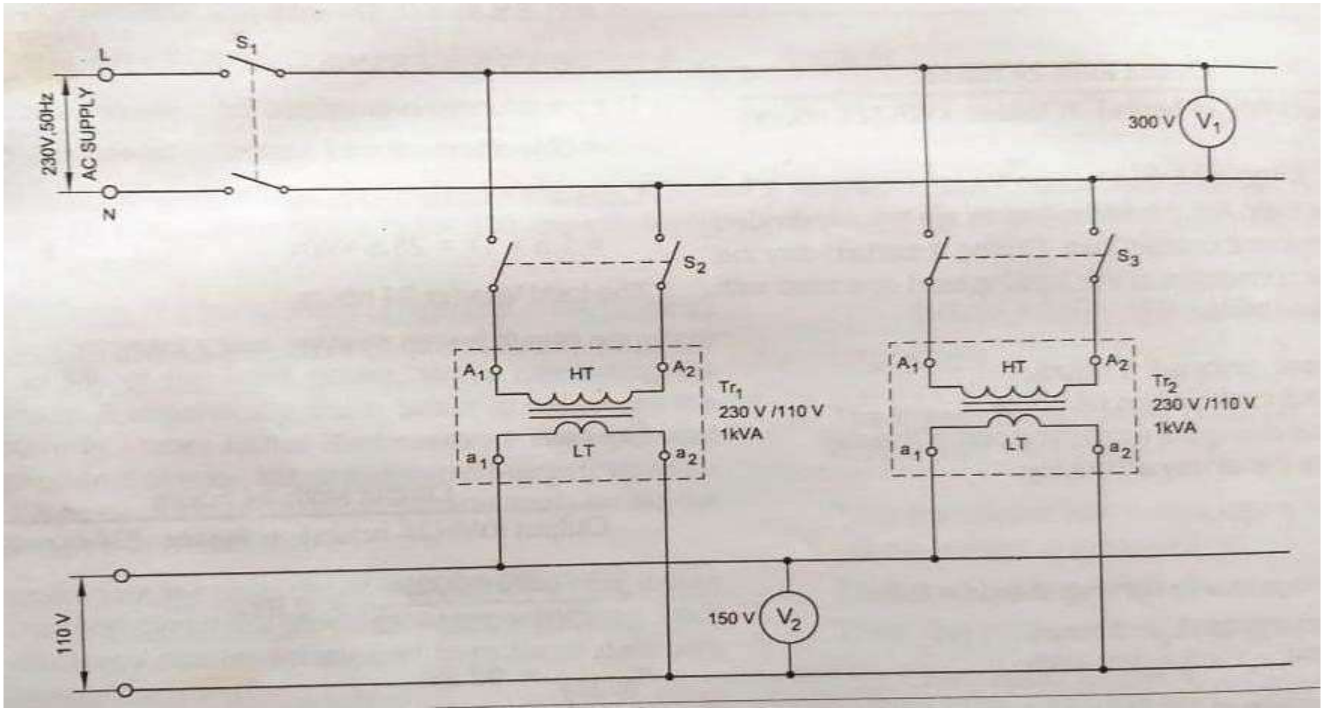
2. Parallel operation of two or more Transformers has many advantages when compared with a single large Transformer. Though using single large Transformer instead of two or more Transformers connected in parallel are cheap but still due to the following advantages, paralleloperation of Transformers are preferred where required

3. With two or Transformers, the Power System becomes more reliable. Let one Transformer develops a fault, then the faulty Transformer can be removed from the circuit while maintaining the power supply at a reduced level through healthy Transformers. Thus, in this way, Power System becomes more reliable.

4. Depending upon the load, Transformers can be switched ON / OFF. In this way, Transformer

losses are reduced and the system becomes more efficient and economical.

5. If the power demand increases with time then extra spare Transformer can be taken into service to meet the power demand.



[Parallel Operation of Single Phase Transformer]

Condition for Parallel Operation of Transformers:-

When operating two or more transformers in parallel satisfactory performance conditions should be met.

A) The same voltage ratio.
B) The same per unit (or percentage) impedance [Desirable]
C) The same polarity
D) zero relative phase displacement

Procedure:- Polarity Test:-

1. Connect the circuit as shown in the above circuit diagram figure and set the autotransformerto zero position.
2. Switch on the single phase supply.
3. Records the values of the voltages as shown by the voltmeter V_1, V_2 and V_3.
4. If the reading of the V_3 shows the addition of the value of V_1 and V_2 that is $V_2 = V_1+V_2$, then the transformer is said to be connected in additive polarity.
5. If the reading of the V_3 is the subtraction of the readings of V_1 and V_2, then the transformer issaid to be connected in subtractive or negative polarity.

Parallel Operation:-

1. First, perform the polarity test on each of the units and label or note down terminals with the same polarity
2. Also, confirm that no-load secondary voltages of both transformers match in magnitude. If possible, also check the respective instantaneous phase angles.
3. Slowly increase the autotransformer voltage until rated voltage appears across the primaries of each transformer.

Conclusion:-

From this experiment, we learnt about the polarity test and parallel operation of single phase transformers.