Date:

Experiment: 1

**AIM : ** To study various symbols used in Electrical Engineering.

Sr. No.	**Particular**	**Symbol**
1.	Positive	
2.	Negative	
3.	A.C. Supply	
4.	D.C. Supply	
5.	Single Phase	
6.	Three Phase	
7.	Crossed Wire	
8.	Connected Wire	
9.	Neutral	
10.	Earth	
11.	Fuse	

12.	Lamp	
13.	Lamps in series	
14.	Lamps in parallel	
15.	Resistance [Fixed] Resistance [Variable]	
16.	Inductor [Fixed] Inductor [Variable]	
17.	Choke Coil	
18.	Capacitor [Fixed] Capacitor [Variable]	
19.	Electrolytic capacitor	
20.	Cell	

21.	Battery	
22.	Ammeter D.C. Ammeter A.C. Ammeter A.C./D.C. Ammeter	
23.	Voltmeter D.C. Voltmeter A.C. Voltmeter A.C./D.C. Voltmeter	
24.	Galvanometer	
25.	Watt meter	
26.	Motor	
27.	Generator	

28.	1-phase Transformer	
29.	Auto Transformer	
30.	Single phase variac	
31.	Delta connected load	
32.	Star connected load with or without neutral	
33.	Mechanical coupling	
34.	Motor generator set	
35.	Single pole single throw switch [SPST Switch]	
36.	Single pole double throw switch [SPDT Switch]	

37.	Double pole double throw switch [DPDT switch]	
38.	Triple pole double throw switch [TPDT switch]	
39.	Two pole switch	
40.	Triple pole switch	
41.	Two pin socket	
42.	Three pin socket	

Date:

Experiment: 2

AIM : To study and verify Kirchhoff's Current Law

APPARATUS:

- 1-ϕ variac
- Rheostat
- AC Ammeter
- AC Voltmeter

Kirchhoff's Current Law (KCL) states that at any junction, algebraic sum of all the currents at any instant of time is zero

This law is also called **Kirchhoff's first law**, **Kirchhoff's Point rule, Kirchhoff's node (or junction) rule**, and **law of conservation of charge**.

The principle of conservation of electric charge implies that

- At any node (junction) in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node, or:
- The algebraic sum of currents in a network of conductors meeting at a point is zero.

Recalling that current is a signed (positive or negative) quantity reflecting direction towards or away from a node; this principle can be stated as:

$$\sum_{k=1}^{n} I_k = 0$$

n is the total number of branches with currents flowing towards or away from the node.

Circuit Diagram:

Procedure for KCL:-

1. Connect the circuit as shown in the diagram.
2. Switch on the supply.
3. Take the readings of Ammeters.

Observation Table:

Sr. No.	Supply current Is (Amp)	Current through Rheostat1 I_1 (Amp)	Current through Rheostat2 I_2 (Amp)	% Error= ([Is-(I_1+ I_2)] / [Is])* 100
1				
2				
3				
4				

Calculation:

Conclusion:

Date:

Experiment: 3

Aim **:** To study and verify Kirchhoff's Voltage law

APPARATUS:

- 1-ϕ variac
- Rheostat
- AC Ammeter
- AC Voltmeter

<u>Kirchhoff's Voltage Law (KVL)</u> states that in any closed loop, algebraic sum of all the voltages at any instant of time is zero

This law is also called **Kirchhoff's second law**, **Kirchhoff's loop (or mesh) rule**, and **law of conservation of energy**.

The principle of conservation of energy implies that

- The directed sum of the electrical potential differences (voltage) around any closed network is zero,
- More simply, the sum of the emfs in any closed loop is equivalent to the sum of the potential drops in that loop, or:
- The algebraic sum of the products of the resistances of the conductors and the currents in them in a closed loop is equal to the total emf available in that loop.

Mathematically it can be stated as:

$$\sum_{k=1}^{n} V_k = 0$$

Circuit Diagram:

Procedure for KVL

1. Connect the circuit as shown in the diagram.
2. Switch on the supply and adjust the voltage to desired value
3. Take the readings of voltmeters.
4. Find error if any.

Observation table:

Sr. No.	Supply voltage Vs (volts)	Voltage across Rheostat1 V1 (volts)	Voltage across Rheostat 2 V2 (volts)	Voltage across Rheostat3 V3 (volts)	% Error= ([Vs-(V1+V2+V3)] / [Vs])*100
1					
2					
3					
4					

Calculation:

Conclusion:

Date:

Experiment: 4

Aim : To verify Superposition theorem.

APPARATUS:

- 1-ϕ variac
- Rheostat
- AC Ammeter
- AC Voltmeter

Theory:

Superposition theorem states that in any linear, active, bilateral network having more than one source, the response across any element is the sum of the responses obtained from each source considered separately and all other sources are replaced by their internal resistance. The superposition theorem is used to solve the network where two or more sources are present and connected.

In other words, it can be stated as if a number of voltage or current sources are acting in a linear network, the resulting current in any branch is the algebraic sum of all the currents that would be produced in it, when each source acts alone, all the other independent sources are replaced by their internal resistances. It is only applicable to the circuit which is valid for the ohm's law (i.e., for the linear circuit).

To ascertain the contribution of each individual source, all of the other sources first must be "turned off" (set to zero) by:

- Replacing all other independent voltage sources with a short circuit keeping any internal impedance if any.
- Replacing all other independent current sources with an open circuit.

This procedure is followed for each source in turn, and then the resultant responses are added to determine the true operation of the circuit. The resultant circuit operation is the superposition of the various voltage and current sources.

Circuit Diagram:

Procedure:

- Connect the circuit shown in Figure 1(a).
- Measure current I' through resistor R_3.
- Connect the circuit shown in Figure 1(b).
- Measure the current I" through resistor R_3.
- Add I' and I".
- Repeat above steps for different values of independent voltage sources.

Observation Table:

SrNo	**I'**	**I''**	**I = I'+I''**	**Theoretical value of I**
1.				
2.				
3.				

Calculation:

Conclusion:

Date:

Experiment: 5

Aim : To verify Thevenin's Theorem.

APPARATUS:

- 1-ϕ variac
- Rheostat
- AC Ammeter
- AC Voltmeter

Theory:

Thevenin's Theorem states that – any complicated network across its load terminals can be substituted by a voltage source with one resistance in series. This theorem helps in the study of the variation of current in a particular branch when the resistance of the branch is varied while the remaining network remains the same for example designing of electronics circuits.

A more general statement of Thevenin's Theorem is that any linear active network consisting of independent or dependent voltage and current source and the network elements can be replaced by an equivalent circuit having a voltage source in series with a resistance, that voltage source being the open circuited voltage across the open circuited load terminals and the resistance being the internal resistance of the source.

In other words, the current flowing through a resistor connected across any two terminals of a network by an equivalent circuit having a voltage source E_{th} in series with a resistor Rth. Where Eth is the open circuit voltage between the required two terminals called the Thevenin voltage and the Rth is the equivalent resistance of the network as seen from the two terminals with all other sources replaced by their internal resistances called Thevenin resistance.

Steps for Solving Thevenin's Theorem

Step 1 – First of all remove the load resistance rL of the given circuit.

Step 2 – Replace all the impedance source by their internal resistance.

Step 3 – If sources are ideal then short circuit the voltage source and open the current source.

Step 4 – Now find the equivalent resistance at the load terminals known as Thevenin's Resistance (RTH).

Step 5 – Draw the Thevenin’s equivalent circuit by connecting the load resistance and after that determine the desired response.

Circuit Diagram:

Calculations:

Conclusion:

Date:

Experiment: 6

AIM: To Measure resonance frequency of an R-L-C Series circuit.

APPARATUS:

- Resistance Decade Box R
- Inductance Decade Box L
- Capacitance Decade Box C
- Ammeter (0-100mA)
- Function generator

THEORY : An AC voltage of R.M.S. value V volts when applied to on R L C series circuit establishes an RMS current I amp, given by

$$I = V/Z$$

Where $Z = \sqrt{R^2 + (X_L - X_C)^2}$ ……………………Eqn. (1)

= Impedance of the circuit

X_C = Capacitive reactance of the capacitance

X_L = Inductive reactance of inductor

Now, for a particular value of frequency, the value of inductive reactance D is equal to the capacitive reactance Xc then reactive drop becomes zero. Hence circuit will offer only resistance. Thus, there will be maximum current. This describes the resonance in an AC circuit, defined as condition when the inductive reactance becomes equal to the capacitive reactance. It can be sensed that at resonance condition power factor of the circuit is unity.

Now as $X = X_C$

Putting in the Eqn (1) $Z = R$

PROCEDURE:

1. Connect the circuit as shown in the figure
2. Switch on the supply and adjust lamp load
3. Now measure the voltage V_l & V_c & V_s
4. Take different readings by varying inductive reactance & by keeping
5. Capacitance & resistance load constant. Resonance is seen at $V_l = V_c$
6. Not down the readings at resonance condition.

CIRCUIT DIAGRAM:

OBSERVATION TABLE:

Sr. No.	V_s (Volts)	V_R (Volts)	V_C (Volts)	V_L (Volts)	SupplyCurrent (Is) (Amp.)

SAMPLE CALCULATION:

$X_L = V_L / I$

$X_C = V_C / I$

$L = X_L / 2\pi f$

$C = 1/2\pi f X_c$

$2\pi f_o L = 1/2\pi f_o C$

$\boldsymbol{f_o = 1/2\pi\sqrt{LC}}$ is called resonance Frequency

Conclusion:

Date:

Experiment: 7

AIM : To verify phase & line relationship of voltage and current in star and delta connections.

APPARATUS:

- Voltmeter
- Ammeter
- Lamp bank
- Three phase variac

THEORY :

Star connection

In this method of inter-connection, the similar ends of three coils are joined together at point N. The point N is known as the star point or the neutral point. The Three conductors meeting at point N are replaced by a single conductor known as neutral conductor. If a three – phase balanced voltage is applied across a balanced symmetrical load, the neutral wire will be carrying three currents which are exactly equal in magnitude but are 120° out of phase with each other. Hence their vector sum is zero i.e.

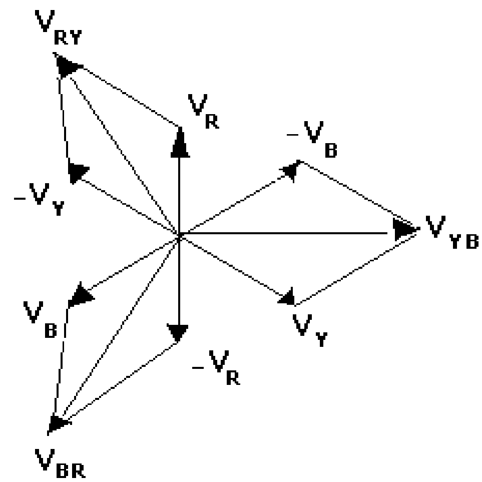
$$I_R + I_Y + I_B = 0$$

The voltage induced in each winding is called the phase voltage and current in each winding is likewise known as phase current. However, the voltage available between any pair of terminals (or lines is called in line voltage VL and the current flowing in each line is called line current IL. Hence line voltage VRY between line 1 and 2 is the vector difference of E_{RL} & E_{YL}, Similarly, V_{YB} is vector difference of E_{YL} and E_{BL} and V_{BR} is vector difference of E_{BL} & E_{RL}. The potential difference between the lines 1 and 2.

$$V_{RY} = E_R - E_Y \text{ vector difference.}$$

Hence V_{RY} is found by compounding E_R and E_Y reversed and its value is given by the diagonal of the parallelogram. Let $E_R = E_Y = E_B = E_{PH}$ (Phase EMF) then V_L

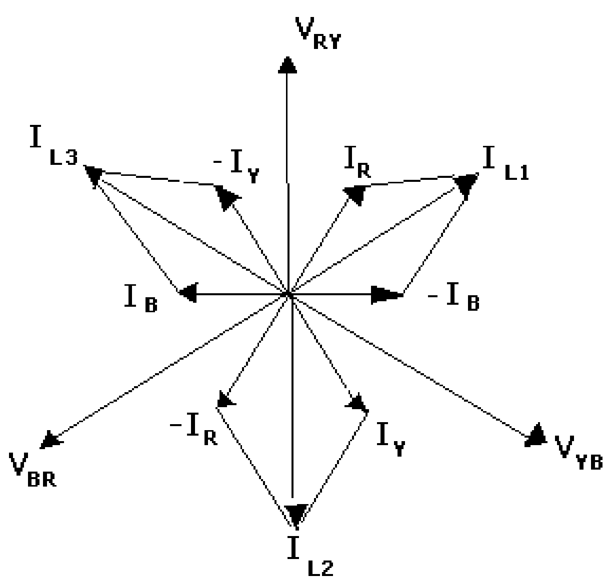
$$\begin{aligned} V_{RY} &= 2E_{PH} \cos(60/2) \\ &= 2E_{PH} \cos 30 \\ &= 2E_{PH} \sqrt{3}/2 \\ &= \sqrt{3}\, E_{PH} \end{aligned}$$



Voltage Vectors for Star connection

Delta connection:

In this form of interconnection, dissimilar ends of the three phase winding are joined together i.e the "starting" end of one phase is joined to the finishing end of the other phase and so on. In other words the three windings are joined in series to form a closed mesh as shown in fig. three loads are taken out from three junctions as shown and outwards directions are taken as positive. It is cleared from the Figure that there is only one phase winding completely included between any paid of terminals. Hence in delta connection the voltage of the phase winding connected between the two lines considered.



Voltage and Current Vectors for Star connection

PROCEDURE:

- Connect the circuit as shown in the fig (1) Voltmeter V_1 measures the line voltage while voltmeter V_2 which is connected between any phase and neutral measure the phase voltage.
- In case of star connection as line current is equal to the phase current, the ammeter measure the line current (or phase current)
- Note down the reading of star connection and fill them in the observation table.
- Now switch off the supply and reconnect the circuit as shown in fig. (2) Ammeter A_1 measures the line current while ammeter A_2 which is connected in any one of the three phases measures phase current.
- As this is a delta connection line voltage is equal to the phase voltage. Here voltmeter measures the line voltage (or phase voltage).
- Note down the reading of delta connection fill them in the observation table.

CIRCUIT DIAGRAM: STAR CONNECTION

CIRCUIT DIAGRAM: DELTA CONNECTION

OBSERVATION TABLE:

Star Connection:

Delta Connection:

$I_1 = I_{ph}$ (Amp)	V_L (Volts)	V_{ph} (Volts)	$V_{ph} = V_L/\sqrt{3}$ calculated (Volts)

$V_L = V_{ph}$ (Volts)	I_L (Amp)	I_{ph} observed (Amp)	$I_{ph} = I_L/\sqrt{3}$ calculated (Amp)

CALCULATIONS:

CONCLUSION:

Date:

Experiment: 8

AIM : TO Measure three phase power by two wattmeter method.

APPARATUS :

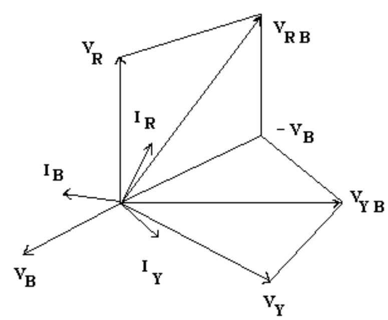
- Voltmeter
- Ammeter
- Wattmeter
- 3-ϕ load bank

THEORY : We can measure power in 3 phase circuits by following methods

1. Three wattmeter's method
2. Two wattmeter's method
3. One wattmeter's method

Out of these method two wattmeter method is most common which gives true power in three phase circuit irrespective of load condition whether balance or not.

As shown in figure current coil of two wattmeter are inserted in any two lines and potential coil of each joined to the third line . It can be proved that sum of instantaneous powers indicated by W_1 W_2 gives instantaneous powers absorbed by three phase loads L_1, L_2, L_3.



V_R V_Y and V_B are rms values of 3 phase voltages.

I_R I_Y and I_B are rms values of line currents.

Phasor Diagram of 3 phase star connected system

Instantaneous current through current coil of $W_1 = \mathbf{i_R}$

Instantaneous Potential difference across $W_1 = \mathbf{e_{RB} = V_R - V_B}$

Power read by wattmeter 1 $W_1 = \mathbf{i_R (V_R - V_B)}$

Instantaneous current through current coil of $W_2 = \mathbf{i_Y}$

Instantaneous Potential difference across $W_2 = \mathbf{e_{YB} = V_Y - V_B}$

Instantaneous Power read by wattmeter $W_2 = \mathbf{i_Y (V_Y - V_B)}$

Total Power $W_1 + W_2 = \mathbf{i_R (V_R - V_B) + i_Y (V_Y - V_B)}$

$= \mathbf{i_R V_R + i_Y V_Y - V_B (i_R + i_Y)}$

Here $\mathbf{i_R + i_Y + i_B = 0}$

Hence $\mathbf{i_R + i_Y = - i_B}$

Which leads to $W1 + W2 = \mathbf{i_R V_R + i_Y V_Y + i_B V_B}$

= P1+P2+ P3

= Total power

For balanced load power factor of load can also be found from two wattmeter reading. If load is inductive, the vector diagram for such balanced Y connected load is as shown in figure.

EFFECT OF POWER FACTOR:-

(1) When PF is unity i.e. COS Ø = 1, the both wattmeter will give same reading.
$W_1 = W_2 = V_L I_L \text{COS } 30$

(2) When PF is 0.5 i.e. COS Ø = 0.5, Ø=60, power will be measured by W_1 alone
$W_2 = V_L I_L \text{COS } (30+60) = 0$

(3) When PF is 0 i.e. Ø=90 (Pure inductive or capacitive Load)

$W_1 = V_L I_L \text{COS } (30-90) = 0 \ V_L I_L \sin 30$

CIRCUIT DIAGRAM:

PROCEDURE:

1. Connect the meters as shown in circuit diagram.
2. Switch on the supply and adjust load as per requirement
3. Measure the reading and calculate the total power.

OBSERVATION TABLE:

Sr No.	Voltage V_L	Current I_L	Watt meter		W=W1+W2
			W1	W2	

CALCULATIONS:

Conclusion:

Date:

Experiment: 9

AIM **:** To study MCB, MCCB, ELCB & RCCB.

APPARATUS: MCB, MCCB, ELCB & RCCB

THEORY **:**

Electrical circuit breaker is a one kind of switching device which can be activated automatically as well as manually to control and protect an electrical power system respectively.

MCB (Miniature Circuit Breaker)

MCB is an electromechanical device which guards an electrical circuit from an over current, that may effect from short circuit, overload or imperfect design. This is a better option to a Fuse since it doesn't require alternate once an overload is identified. An MCB can be simply rearranged and thus gives a better operational protection and greater handiness without incurring huge operating cost. The operating principle of MCB is simple.

An MCB function by interrupting the stability of electrical flow through the circuit once an error is detected. In simple conditions this circuit breaker is a switch which routinely turns off when the current flows through it and passes the maximum acceptable limit. Generally, these are designed to guard against over current and overheating.

MCB is substituting the rewirable switch-fuse units for low power domestic and industrial applications in a very quick manner. In wiring system, the MCB is a blend of all three functions such as protection of short circuit, overload and switching. Protection of overload by using a bimetallic strip & short circuit protection by used solenoid.

The characteristics of an MCB mainly include the following:

- Rated current is not more than 100 amperes
- Normally, trip characteristics are not adjustable
- Thermal/thermal magnetic operation

MCCB (Molded Case Circuit Breaker):-

The MCCB is used to control electric energy in distribution n/k and is having short circuit and overload protection. This circuit Breaker is an electromechanical device which guards a circuit from short circuit and over current. They offer short circuit and over current protection for circuits ranges from 63 Amps-3000 Amps. The primary functions of MCCB is to give a means to manually open a circuit, automatically open a circuit under short circuit or overload conditions. In an electrical circuit, the over current may result faulty design

The MCCB is an option to a fuse since it doesn’t need an alternate once an overload is noticed. Unlike a fuse, this circuit breaker can be simply reset after a mistake and offers enhanced operator safety and ease without acquiring operating cost. Generally, these circuits have thermal current for over current and the magnetic element for short circuit release to work faster.

The characteristics of an MCCB mainly include the following:

- The range of rated current us up to 1000 amperes
- Trip current may be adjusted
- Thermal/thermal magnetic operation

ELCB (Earth Leakage Circuit Breaker)

The ELCB is used to protect the circuit from the electrical leakage. When someone gets an electric shock, then this circuit breaker cuts off the power at the time of 0.1 secs for protecting the personal safety and avoiding the gear from the circuit against short circuit and overload.

ELCB is a security device used in electrical system with high Earth impedance to avoid shock. It notices small stray voltages on the metal fields of electrical gear, and interrupt the circuit if an unsafe voltage is detected. The main principle of Earth leakage protectors is to stop injury to humans and nature due to electric shock.

This circuit breaker is a specialized kind of latching relay that has structures incoming mains power connected through its switching contacts so that this circuit breaker disconnects the power supply in an unsafe condition.

The ELCB notices fault currents from live to the ground wire inside the installation it guards. If enough voltage emerges across the sense coil in the circuit breaker, it will turn off the supply, and stay off until reset by hand. A voltage-sensing earth leakage circuit breaker doesn't detect fault currents from exist to any other ground body.

The characteristics of an ELCB mainly include the following:

- This circuit breaker connects the phase, earth wire and neutral
- The working of this circuit breaker depends on current leakage

RCCB (Residual Current Circuit Breaker)

A RCCB is essential current sensing equipment used to guard a low voltage circuit from the fault. It comprises of a switch device used to turn off the circuit when a fault occurs in the circuit. RCCB is aimed at guarding a person from the electrical shocks. Fires and electrocution are caused due to the wrong wiring or any earth faults. This type of circuit breaker is used in situations where there is a sudden shock or fault happening in the circuit.

For instance, a person suddenly enters in contact with an open live wire in an electrical circuit. In that situation, in the absence of this circuit breaker, a ground fault may occur and an individual is at the hazardous situation of receiving a shock. But, if the similar circuit is defended with the circuit breaker, it will tour the circuit in a second therefore, avoiding a person from the electric shock. Therefore, this circuit breaker is good to install in an electrical circuit.

The characteristics of an RCCB mainly include the following:

- Both wires phase and neutral are connected through RCCB
- Whenever there is any ground fault occurs, then it trips the circuit
- The amount of current supplies through the line should go back through neutral
- These are a very effective type of shock protection

CONCLUSION:-

Date:

Experiment: 10

Aim: To Study Parts of DC Machine.

Theory:

DC Machines can be used as generator also as motor without any structural change.

The following are main parts of DC machine. Figure A shows the construction of the 2 – Pole DC machine.

- Yoke or Frame
- Pole cores and pole – shoes
- Field coils
- Armature
- Commutator
- Brush and Brush-holder
- Bearings

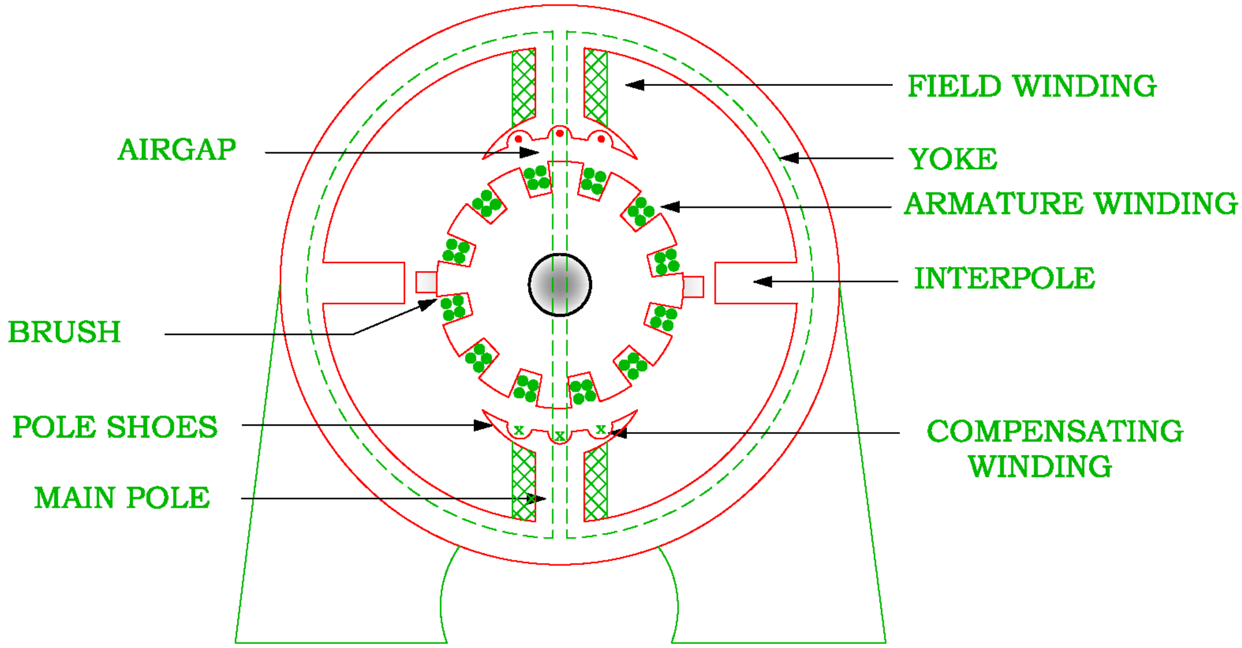


FIG A : CONSTRUCTION OF GENERATOR

- **Yoke or Frame**

The main function of the yoke is to provide protection for whole machine. The yoke is a stationary and outer cylindrical part of DC machines. The cheapness is main consideration therefore yoke is made up of cast iron in the small DC machines but it is made up of cast still or rolled still in the large DC machines.

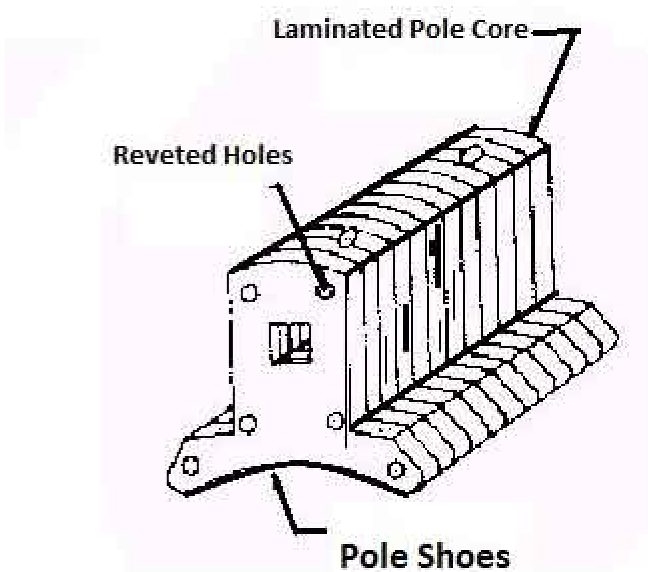
The function of the yoke is

- To Carry the magnetic flux produced by the poles
- To provide support for main poles and inter poles
- To provide protection for whole machine

The yoke was made up of cast iron earlier but now it is replaced by cast steel. This is due to fact that cast iron is saturated by a flux density of 0.8 Weber / meter^2 whereas the saturation flux density of cast steel is about 1.5 Weber / meter^2. Therefore the working flux density of cast steel is approximately twice than that of cast iron. Thus the cross section area and hence weight of cast steel is one half that of cast iron. The mechanical and magnetic properties of cast iron are uncertain due to blow holes in the material.

- **Pole Cores and Pole Shoes**

The pole cores are made up of either cast iron or cast steel. The poles are secured to the yoke by means of screws bolted through the yoke. The pole cores are either laminated or solid piece. The thickness of pole cores laminations may be 0.4 mm - 0.5 mm in large size DC machines. The pole cores and pole shoes are built of these laminations of annealed steel.

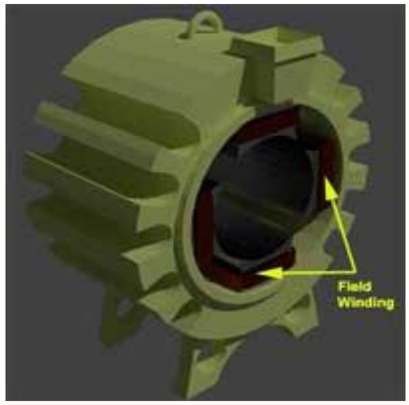


The functions of the pole shoe is

- To Support the field winding.
- To spread out the flux in the air gap and also reduces the reluctance of the magnetic path.

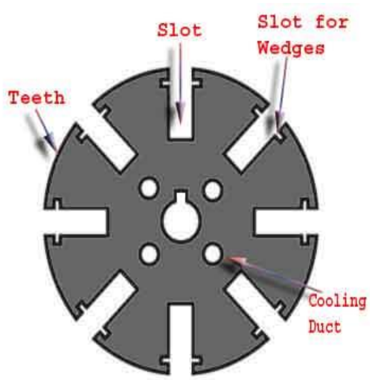
- **Field coils or Pole coils**

The poles are surrounded by the field coils. The field winding is in the form of the copper wire or rectangle strips. The number of ampere – turns of the field winding is required to required proper flux which induces the desired voltage in armature winding. When the field coils are excited by DC supply, the flux passes through pole, air gap, armature and yoke (or frame) of DC machines (Figure A)



- **Armature**

It houses the armature conductors. When an armature is rotated in the magnetic field, its function is to provide low reluctance path to the magnetic flux. The armature core is made up of thin laminations of low loss silicon steel.
Each lamination is about 0.5 mm thick. The laminations are punched in single piece and it is directly keyed to shaft in the small machines. Some ventilating ducts are provided on lamination sheets to permit axial flow of air for cooling purposes. It is not economical to punch the laminations in one piece in the large machines so it is made in segments. Each laminations have dove – tailed or wedge – shaped which are keyed into spiders.



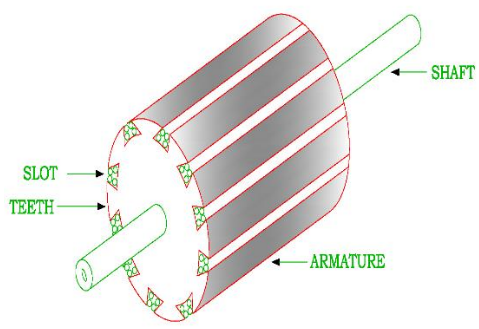
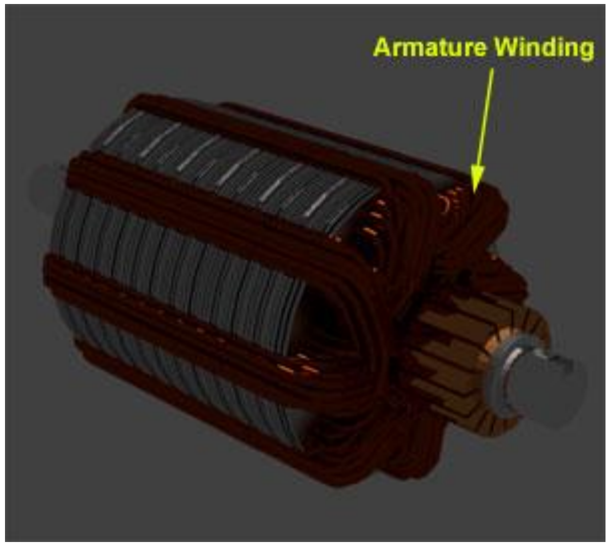


FIG D : ARMATURE

- **Armature winding:**

It is usually a former wound copper coil which rests in armature slots. The armature conductors are insulated from each other and also from the armature core. Armature winding can be wound by one of the two methods; lap winding or wave winding. Double layer lap or wave windings are generally used. A double layer winding means that each armature slot will carry two different coils.



- **Commutator**

The function of the Commutator is to collect current from the armature coils and converts the alternating current into unidirectional current for the external load circuit. Each coil of armature winding is connected to Commutator bar therefore the number of Commutator segments are equal to number of coils. The armature conductors are connected to the Commutator with the help of risers. The Commutator segments are made from silvered copper (copper + 0.05% silver). The advantage of silvered copper material is that it can withstand very high temperature when the armature coil ends are soldered to Commutator risers. The Commutator segments are wedge shaped and each segments are insulated from each other by thin layers of mica (Usually 0.5 to 0.8 mm thickness). The Commutator segments are wedge shaped and each segment is held together by means of V – shaped steel rings.

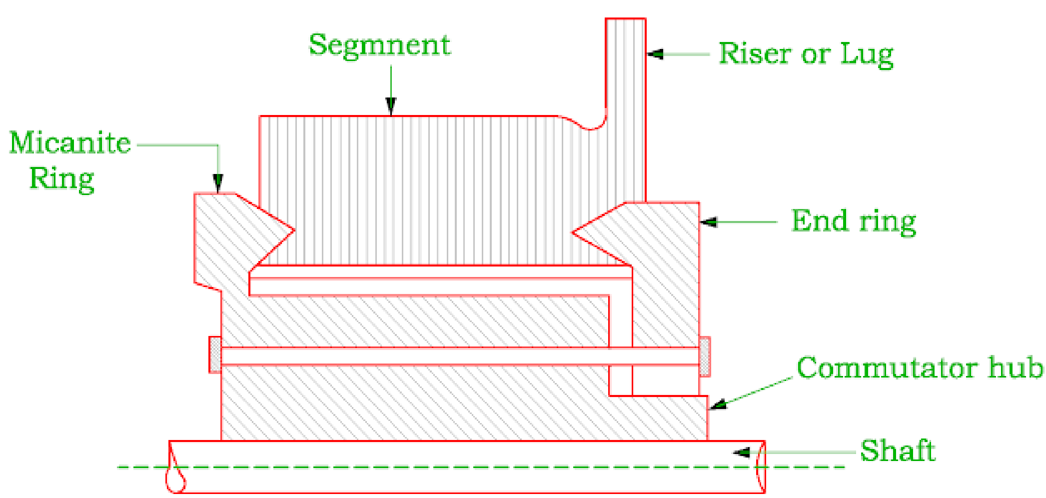


FIG G : COMMUTATOR

- **Brush and Brush Holder**

The function of the brush is to collect current from the Commutator for the external circuit. The brushes are made up of hard carbon or metal and are in the shape of rectangle which are metal box type. The pressure on the brush can be adjusted by a spring whose tension can be adjusted by changing the position of brush lever as shown in the Figure H. The copper wire which is connected to brush is called as “Pig – tail ". The number of brushes per spindle depends upon the magnitude of current to be collected.

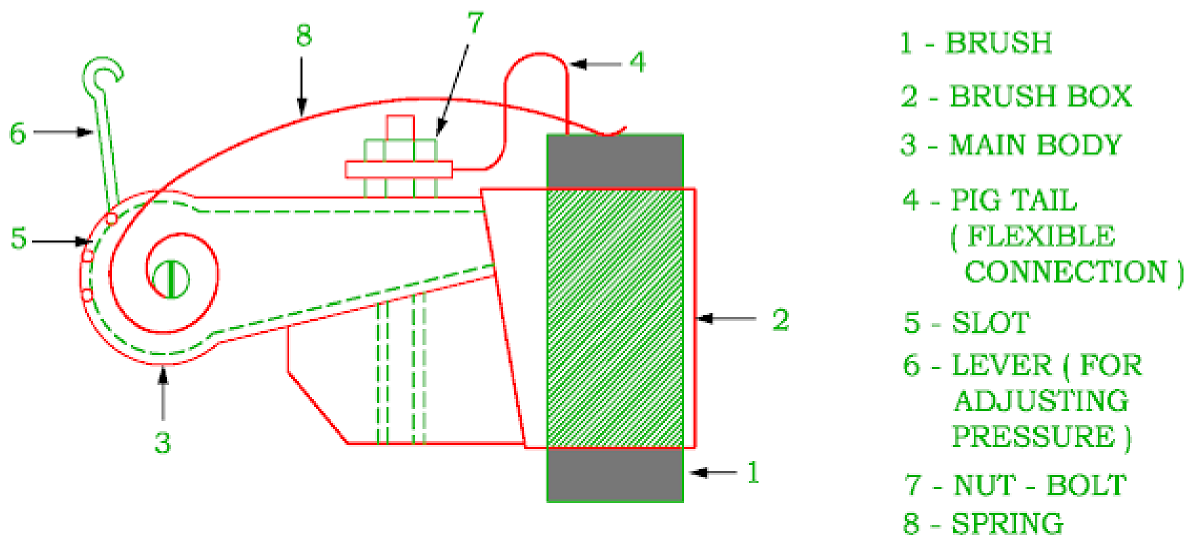


FIG H : BRUSH AND BRUSH HOLDER