<u>AC GENERATOR (ALTERNATOR)</u>

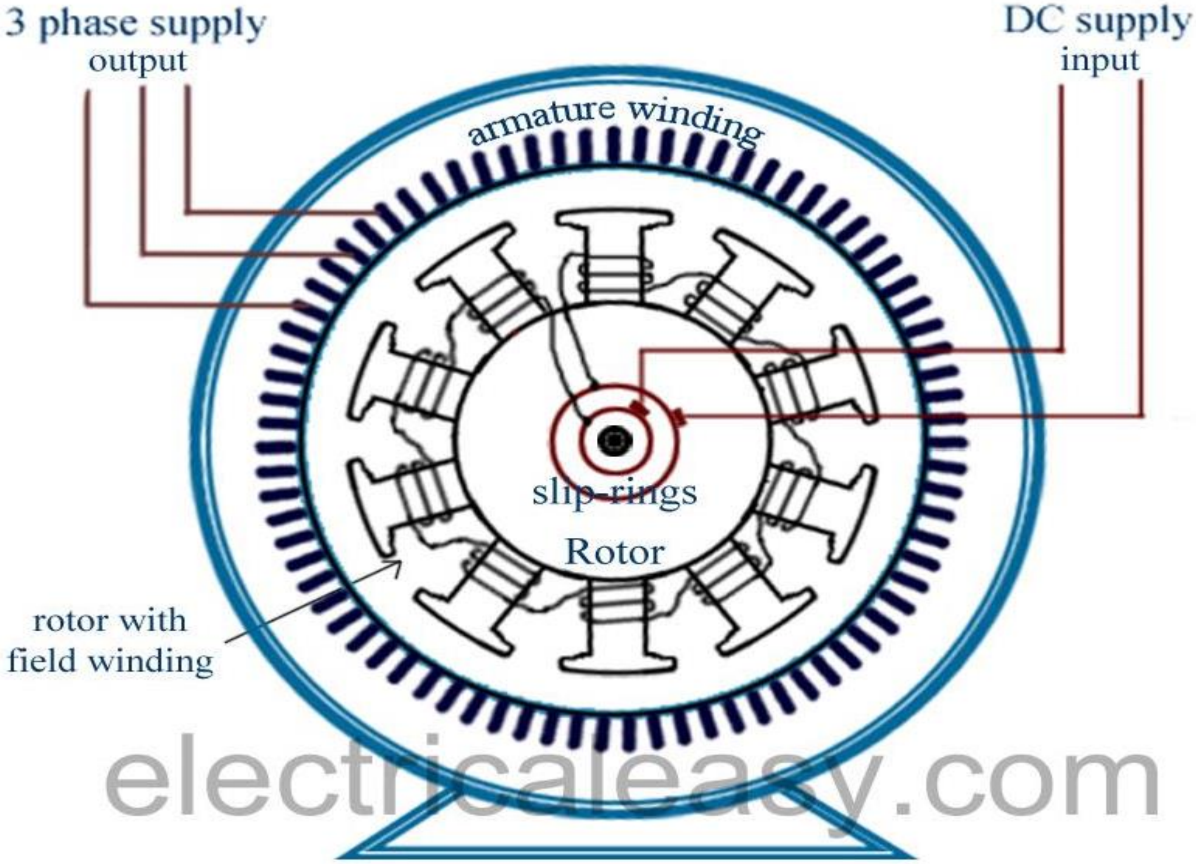
An **alternator** is an electrical machine which converts mechanical energy into alternating electric energy. They are also known as **synchronous generators**,always runs at the constant speed called synchronous speed. The input supply of AC Generator is mechanical energy which is supplied through some prime-mover and the output is alternating energy in the form of alternating voltage & current. It works based on principle of **Faraday' laws of electromagnetic induction**. The Faraday's law states that whenever a conductor is placed in a varying magnetic field, EMF is induced and this induced EMF is equal to the rate of change of flux linkages. This EMF can be generated when there is either relative space or relative time variation between the conductor and magnetic field. So the important elements of a generator are:

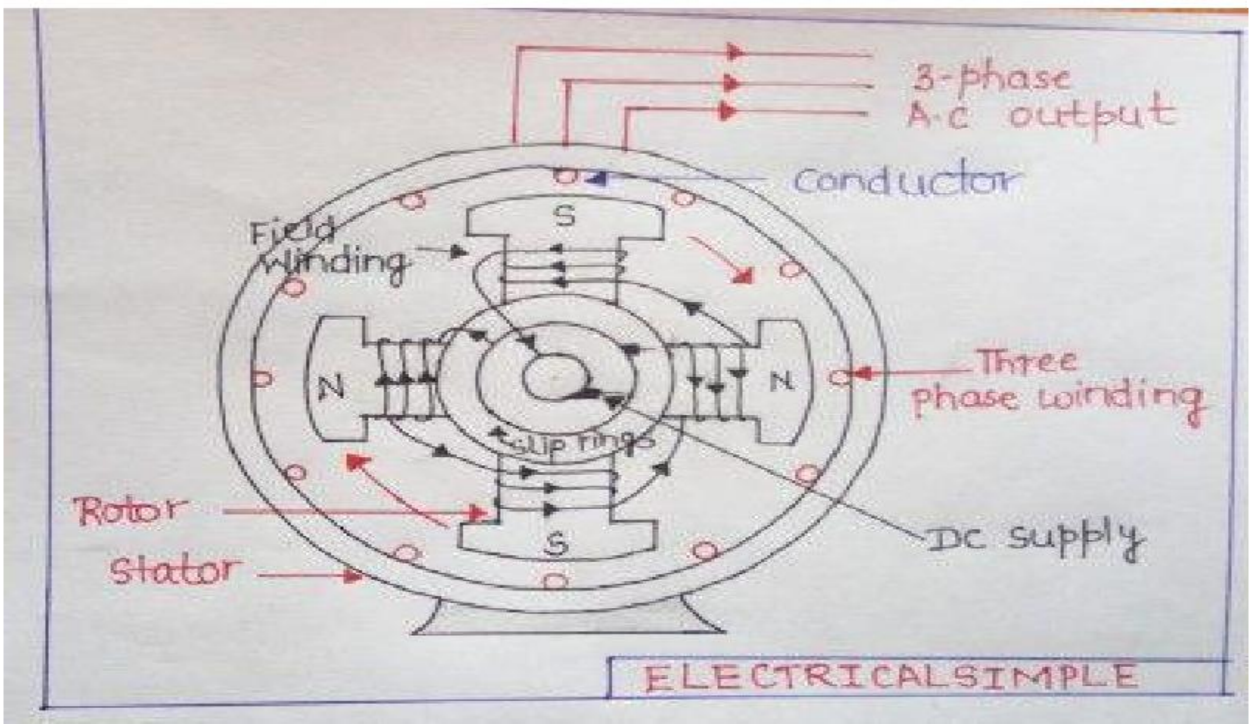
- Magnetic field
- Motion of conductor in magnetic field

WORKING PRINCIPLE OFSYNCHRONOUS GENERATOR:

The synchronous generator works on the principle of **Faraday' laws of electromagnetic induction**. The electromagnetic induction states that electromotive force induced in the armature coil if it is rotating in the uniform magnetic field. The EMF will also be generated if the field rotates and the conductor becomes stationary. Thus, the relative motion between the conductor and the field induces the EMF in the conductor. The wave shape of the induced voltage always a sinusoidal curve.

CONSTRUCTION OF AC GENERATOR





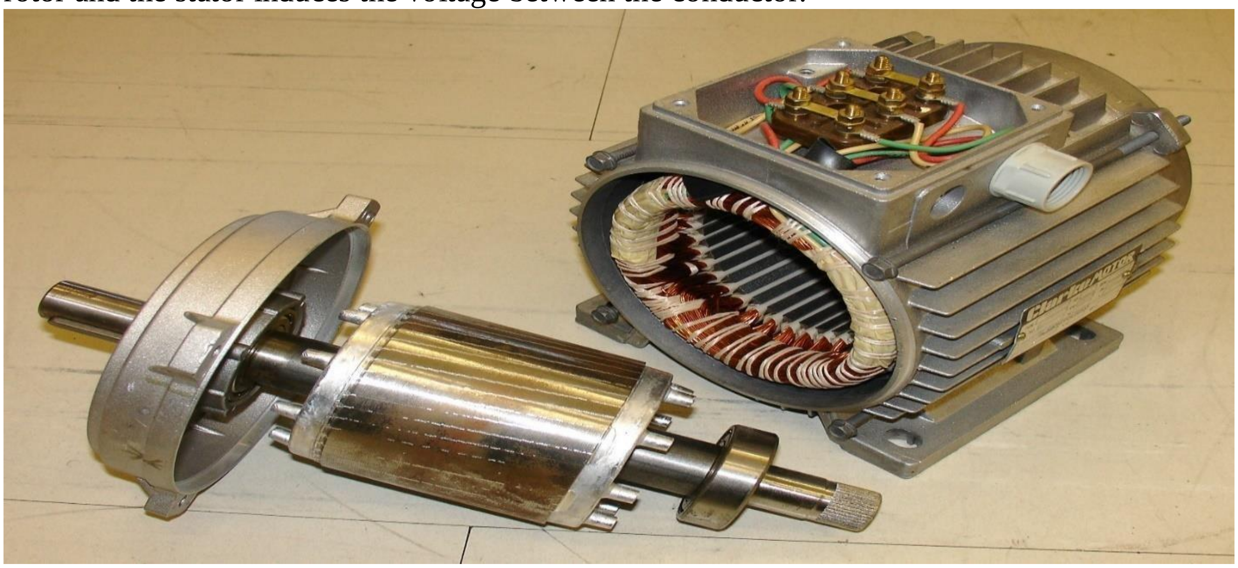
An AC Generator essentially consists of two main parts: Stator and Rotor. Stator is the stationary part of machine whereas rotor is rotating part. A prime mover is coupled to this rotor to supply mechanical energy.

STATOR

Stator is stationary component on which armature winding is wound. Armature winding is the winding which carries load current. Here load means any device or equipment which consumes electrical power. This stator is stack of laminated steel assembled to form a cylindrical structure. Slots for housing stator winding (armature winding) are cut along the periphery of the stator.

ROTOR

Rotor is the rotating component of AC Generator. It is also made of laminated steel. DC Field winding or exciting winding is wound on the rotor to create magnetic poles i.e. North and South Poles. This exciting winding is supplied DC current through an assembly of slip ring and carbon brush. There are basically to designs for rotor. One is **Salient Pole Rotor** and another is **Cylindrical Rotor**. The rotor and stator are the rotating and the stationary part of the synchronous generator. They are the power generating components of the synchronous generator. The rotor has the field pole, and the stator consists the armature conductor. The relative motion between the rotor and the stator induces the voltage between the conductor.

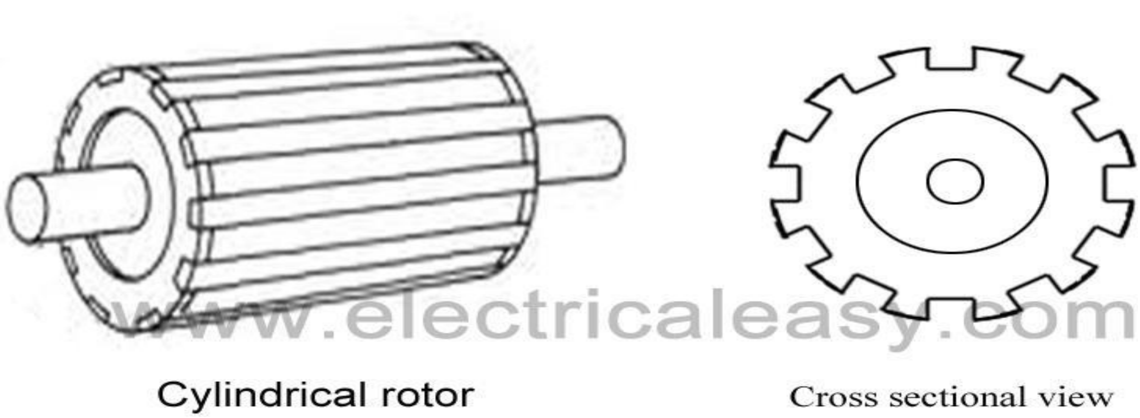


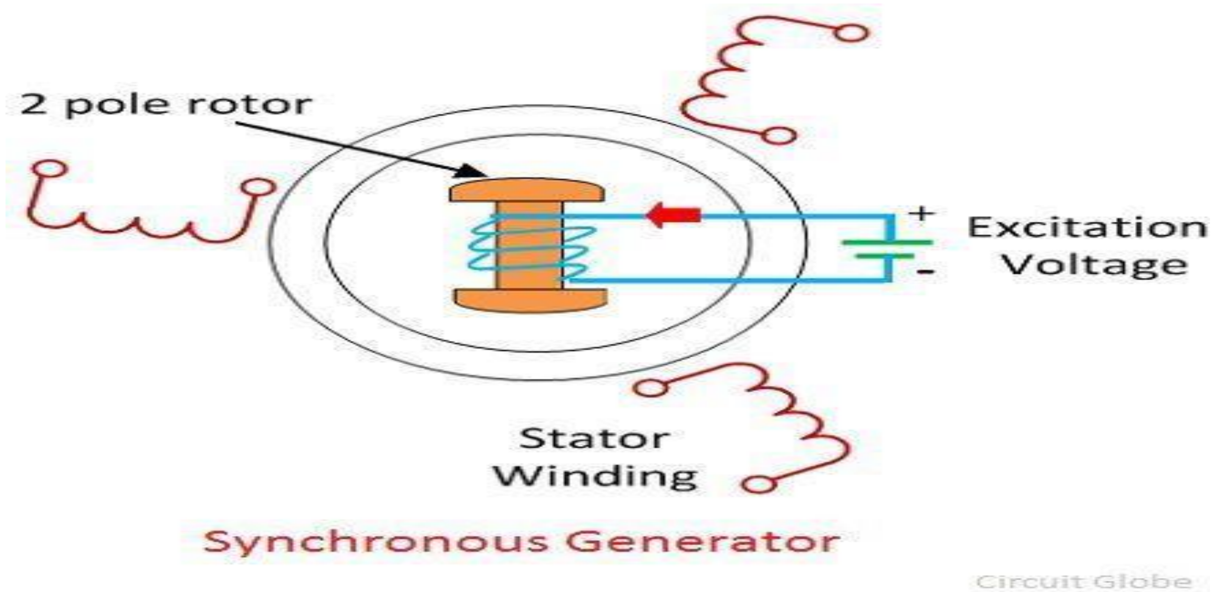
ROTOR: There are two types of rotor used in an AC generator / alternator

(i)Salient (ii) **Cylindrical type**

(i)Salient pole type: Salient pole type rotor is used in low and medium speed alternators. This type of rotor consists of large number of projected poles (called salient poles), bolted on a magnetic wheel. These poles are also laminated to minimize the losses. Alternators featuring this type of rotor are large in diameters and short in axial length.

(ii)Cylindrical type or Non-salient pole:Cylindrical type rotors are used in high speed alternators, especially in turbo alternators. This type of rotor consists of a smooth and solid steel cylinder having slots along its outer periphery. Field windings are placed in these slots. **Non-salient pole rotors** are cylindrical in shape having parallelslots on it to place rotor windings. It is made up of solid steel.





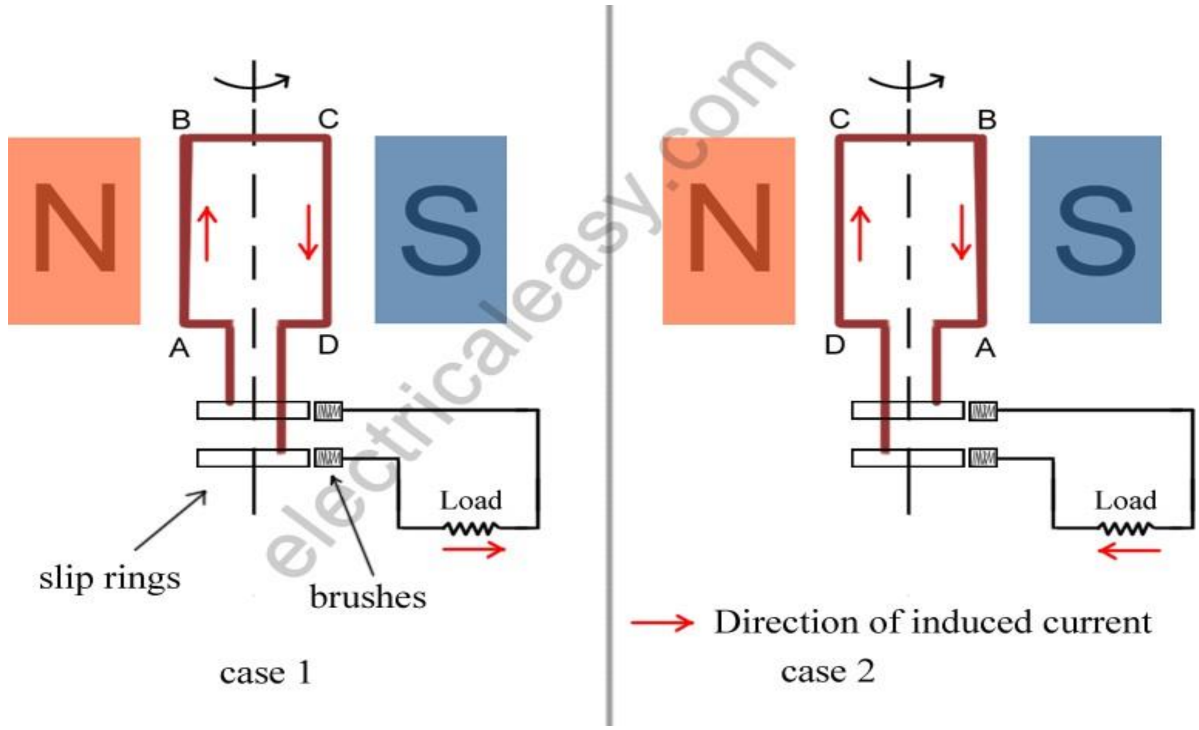
APPLICATIONS OF SYNCHRONOUS GENERATOR

The three-phase synchronous generators have many advantages in generation, transmission and distribution. The large synchronous generators use in the nuclear, thermal and hydropower system for generating the voltages.

The synchronous generators are the primary source of the electrical power. For the heavy power generation, the stator of the synchronous generator design for voltage ratings between 6.6 kV to 33 kV.

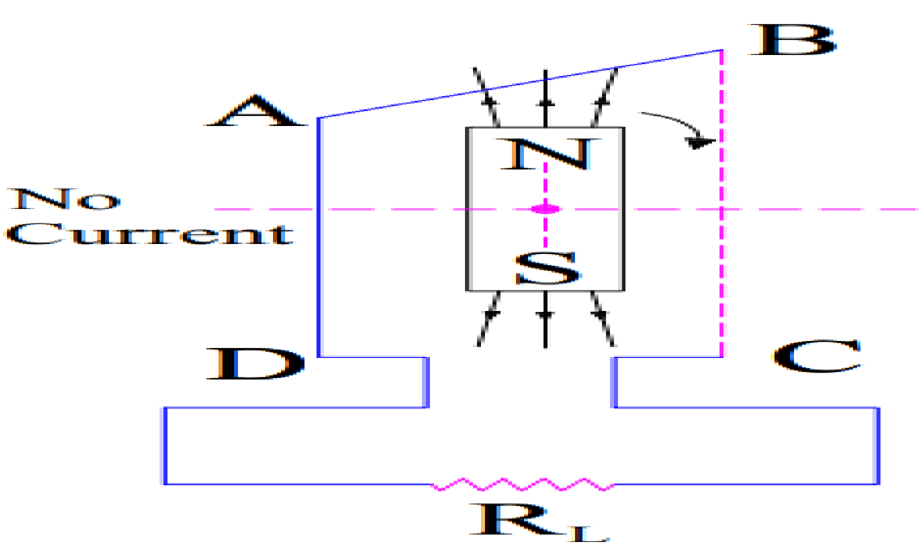
HOW DOES AN AC GENERATOR WORK?

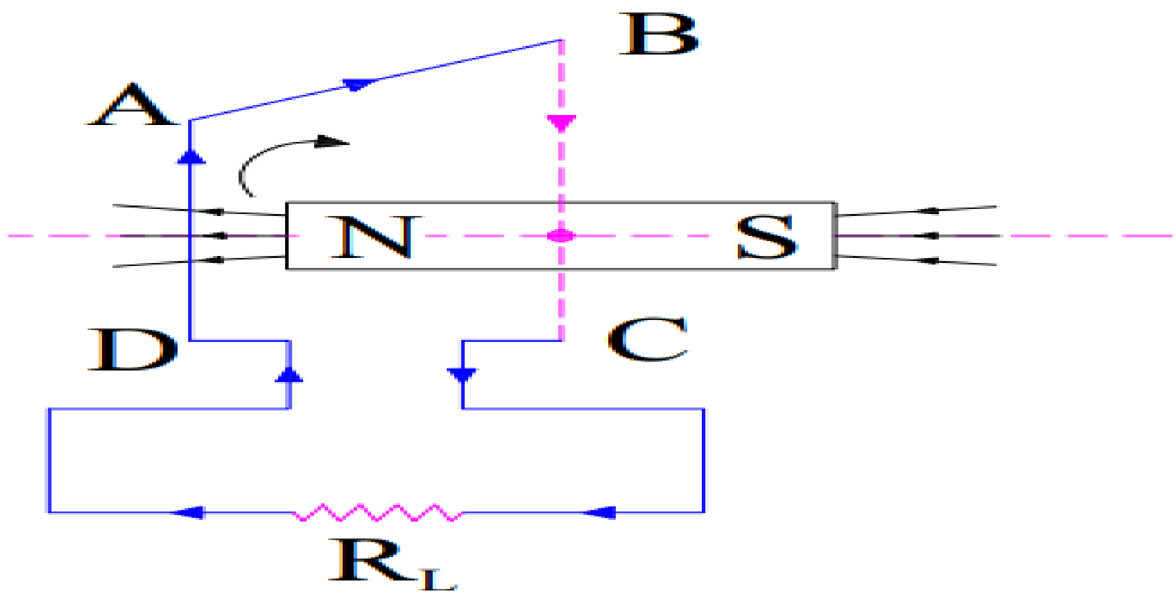
The working principle of an alternator or AC generator is similar to the basic working principle of a DC generator.The basic working principle of AC Generator is based on **Faraday's laws.** When the rotor of AC Generator is rotated by prime-mover, the magnetic flux linkage with the stationary armature winding (mounted on Stator) changes. Due to this an emf is induced in the armature winding. If load is connected, an AC current starts flowing through the load due to the induced emf. This is how an AC Generator works.



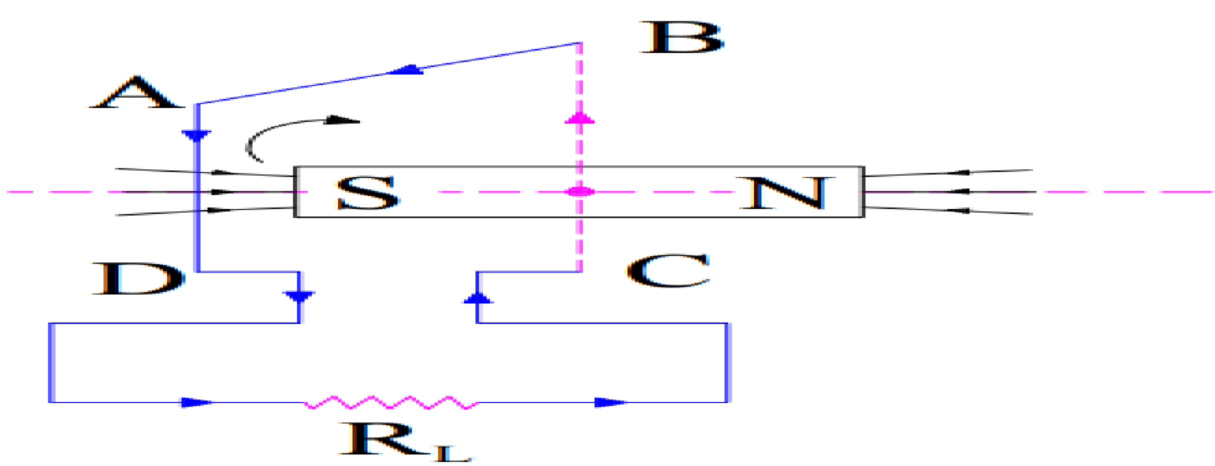
Above figure helps you understanding **how an alternator or AC generator works**. According to the Faraday's law of electromagnetic induction, whenever a conductor moves in a magnetic field EMF gets induced across the conductor. If the close path is provided to the conductor, induced emf causes current to flow in the circuit. Now, see the above figure. Let the conductor coil ABCD is placed in a magnetic field. The direction of magnetic flux will be form N pole to S pole. The coil is connected to slip rings, and the load is connected through brushes resting on the slip rings. Now, consider the case 1 from above figure. The coil is rotating clockwise, in this case the direction of induced current can be given by Fleming's right hand rule, and it will be along A-B-C-D.

As the coil is rotating clockwise, after half of the time period, the position of the coil will be as in second case of above figure. In this case, the direction of the induced current according to Fleming's right hand rule will be along D-C-B-A. It shows that, the direction of the current changes after half of the time period, that means we get an **alternating current.** In the figure, a single armature winding is considered for the sake of simplicity. A permanent magnet is taken as rotor instead of rotor with field winding. Rotor is assumed to be rotating in clockwise direction.



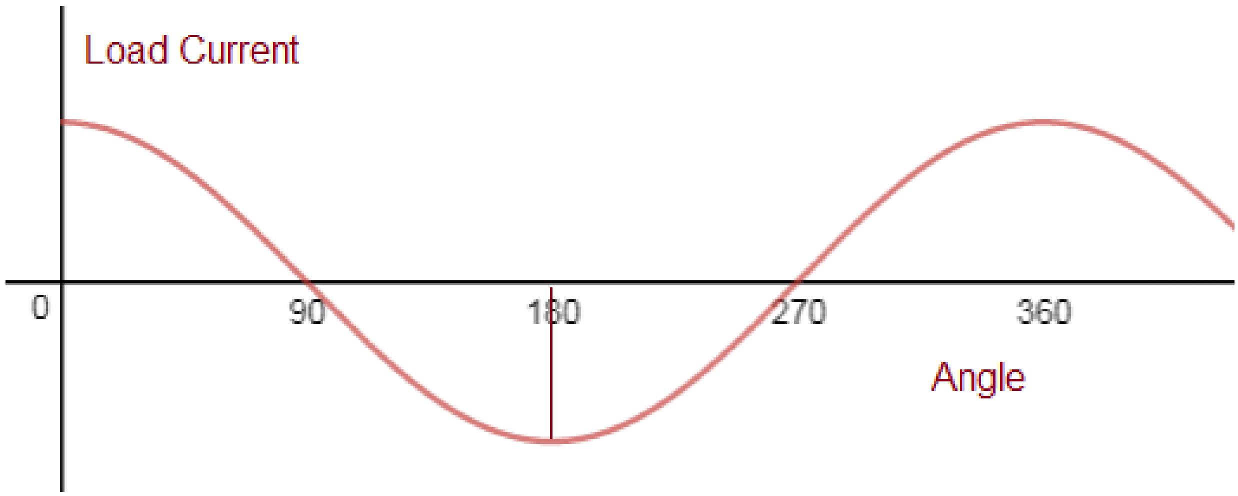


In the above figure, the rotor field axis and armature winding axis coincides. Therefore, the flux linkage is maximum at this instant of time and hence maximum emf will be induced. maximum current will flowthrough the load R_L. The current will flow from D-A-B-C-D. Now, rotor is rotated further by 90 degrees in clockwise direction as shown below.



At this instant, rotor axis and armature winding axis are perpendicular to each other. Therefore, there will not be any mutual coupling between them. Thus no emf will be induced in the stator (armature winding). Hence no current will flow through the load R_L at this instant. A further rotation of rotor by 90 degree causes stator axis and rotor axis to coincide again. Hence flux linkage will again be maximum. Subsequently, maximum current will flow through the load.

But there is one key difference here. In this case, the **current has reversed its direction**. This is just because the direction of flux linkage has reversed as can be seen from the figure. The direction of current is along C-B-A-D-C. The analysis for further rotor rotation can easily be done in the same manner. The AC generator output current waveform with rotor position is shown below.



Thus it is clear that an AC Generator is converting mechanical energy into alternating electrical energy.

E.M.F. EQUATION OF AN ALTERNATOR:

An alternator or AC generator (dynamo) is a device which converts mechanical energy to electrical energy. When we supply the magnetizing current by DC shunt generator through two slip rings because the field magnets are rotating. keep in mind that most alternators use a rotating magnetic field with a stationary armature. When the rotor rotates, the stator conductors which are static in case of alternator cut by magnetic flux , they have induced EMF produced in them (accordingto **Faraday's law of electromagnetic induction** which states that if a conductor or coil links with any changing flux, there must be an induced emf in it.

Let

Φ= Flux per pole, in Wb

P = Number of poles

N_s = Synchronous speed in r.p.m.

f = Frequency of induced e.m.f. in Hz

Z = Total number of conductors

Z = No. of Conductors or Coil sides in series/phase i.e. **Z = 2T**…Where T is the number of coils or turns per phase (Note that one turn or coil has two ends or sides)

Z_{ph} = Conductors per phase connected in series

$\therefore$ $Z_{ph} = Z/3$ as number of phases = 3.

Consider a single conductor placed in a slot.

The average value of e.m.f. induced in a conductor = $d\Phi/dt$ For one revolution of a conductor,

e_{avg} per conductor = (Flux cut in one revolution)/ (time taken for one revolution)

Total flux cut in one revolution is= $\Phi \times P$

Time taken for one revolution is $=60/N_s$ seconds.

$\therefore$ e_{avg} per conductor = $\Phi P / (60/N_s)$

$$= \Phi (PN_s/60) \quad \text{...} (1)$$

But $f=PN_s/120$ but $N_s=120f/P$

$\therefore$ $PN_s/60= 2f$

Substitute in (1),

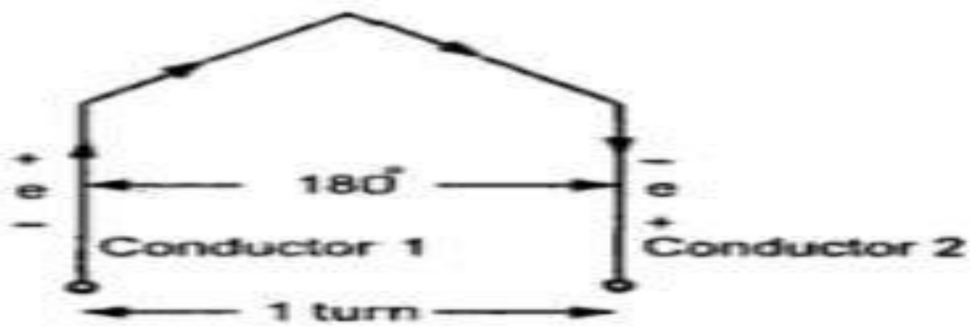
e_{avg} per conductor = $2 f \Phi$ volts

Assume full pitch winding for simplicity i.e. this conductor is connected to a conductor which is 180^{o}electrical apart. So there two e.m.f.s will try to set up a current in the same direction i.e. the two e.m.f. are helping each other and hence resultant e.m.f. per turn will be twice the e.m.f. induced in a conductor.

$\therefore$ e.m.f. per turn = 2 x (e.m.f. per conductor)

$= 2 \times (2 f \Phi)$

$= 4 f \Phi$ volts



Let T_{ph} be the total number of turn per phase connected in series. Assuming concentrated winding, we can say that all are placed in single slot per pole per phase. So induced e.m.f.s in all turns will be in phase as placed in single slot. Hence net e.m.f. per phase will be algebraic sum of the e.m.f.s per turn.

$\therefore$Average $E_{ph} = T_{ph}$ x (Average e.m.f. per turn) $\therefore$ Average Eph = T_{ph} x 4 f Φ

But in a.c. circuits R.M.S. value of an alternating quantity is used for the analysis. The form factor is 1.11 of sinusoidal e.m.f.

K_f =(R.M.S.)/Average=1.11 sinusoidal

R.M.S.valueof E_{ph} =KxAveragevalue

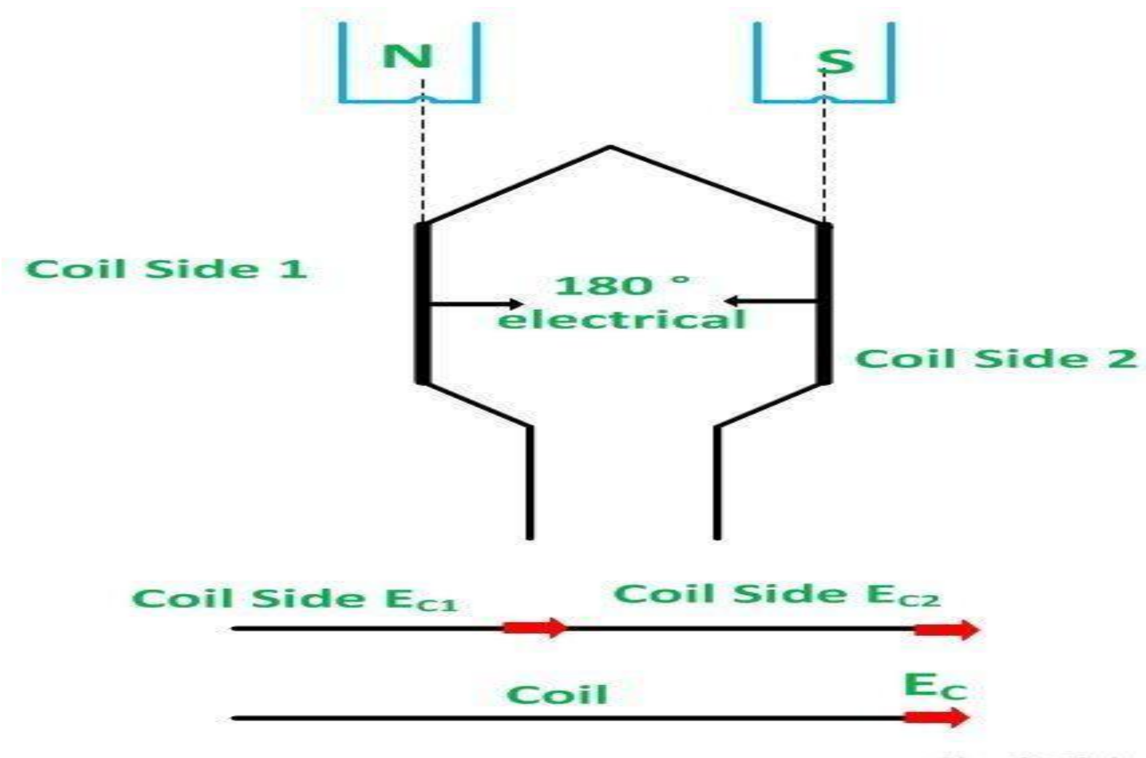
E = 4.44 x f Φ T_{ph} volts ....(2)

Note: This is the basic e.m.f. equation for an induced e.m.f. per phase for full pitch, concentrated type of winding. Where T_{ph} =Number of turns per phase T_{ph} = Z_{ph} /2 .... as 2 conductors constitute 1 turn

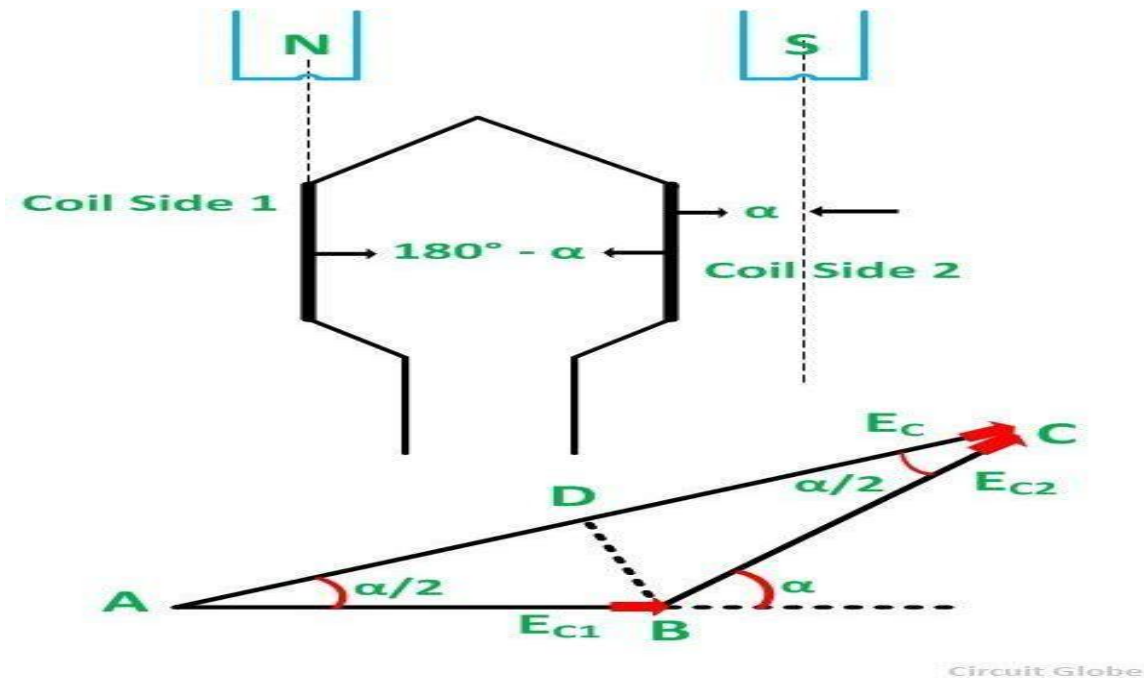
But as mentioned earlier, the winding used for the alternators is distributed and short pitch hence e.m.f. induced slightly gets affected. Let us see now the effect of distributed and short pitch type of winding on the
e.m.f. equation.

COIL SPAN FACTOR or PITCH FACTOR:

The **Coil Span Factor** or **Pitch Factor** K_C is defined as the ratio of the voltage generated in the short pitch coil to the voltage generated in the full pitch coil. The distance between the two sides of a coil is called the **Coil Span** or **Coil Pitch Factor**. It is also known as **Chording Factor.** The angular distance between the central line of one pole to the central line of the next pole is called **Pole Pitch**. A pole pitch is always 180 electrical degrees, regardless of the number of poles on the machine. A coil having a span equal to 180⁰ electrical is called a **full pitch coil** as shown in the figure below.



A Coil having a span less than 180degree electrical is called a **short pitch coil** or fractional pitch coil. It is also called a Chorded coil. The short pitch coil factor is shown in the figure below.



A stator winding using fractional pitch coil is called a chorded winding. If the span of the coil is reduced by an angle α electrical degrees, the coil span will be (180 – α) electrical degrees. In case of a full pitch coil, the distance between the two sides of the coil is exactly equal to the pole pitch of 180º electrical. As a result, the voltage in a full pitch coil is such that the voltage of each side of the coil is in phase. Let E_{C1} and E_{C2} be the voltages generated in the coil sides, and E_C is the resultant coil voltage. Then the equation is given as shown below.

$$E_C = E_{C1} + E_{C2}$$

$$|E_{C1}| = |E_{C2}| = E_1 \quad \text{(Say)}$$

Since E_{C1} and E_{C2} are in phase, the resultant coil voltage E_C is equal to their arithmetic sum. Therefore,

$$E_C = E_{C1} + E_{C2} = 2E_1$$

If the coil span of a single coil is less than the pole pitch of 180 degreeelectrical, the voltages generated on each coil side are not in phase. The resultant coil voltage E_C is equal to the phasor sum of E_{C1} and E_{C2}.If the coil span is reduced by an angle α electrical degrees, the coil span is (180 – α) electrical degrees. The voltage generated E_{C1} and E_{C2} in the two coil sides will be out of phase with respect to each other by an angle α electrical degrees. The phasor sum of E_{C1} and E_{C2} is E_C, which is equal to AC as shown in the phasor diagram above. The coil span factor isrepresented as

$$K_C = \frac{\text{Actual Voltage Generated in the Coil}}{\text{Voltage Generated in the coil of span } 180^\circ \text{ electrical}}$$

$$K_C = \frac{\text{Phasor sum of the voltages of two coil sides}}{\text{Arithmetic sum of the voltages of two coil sides}}$$

$$K_C = \frac{AC}{2AB} = \frac{2AD}{2AB} = \cos\frac{\alpha}{2}$$

$$K_C = \cos\frac{\alpha}{2}$$

For full pitch coil, the value of α will be 0degree, then cos α/2 = 1 and **K_C = 1.** For a short pitch coil **K_C < 1.**

ADVANTAGES OF SHORT PITCH COIL

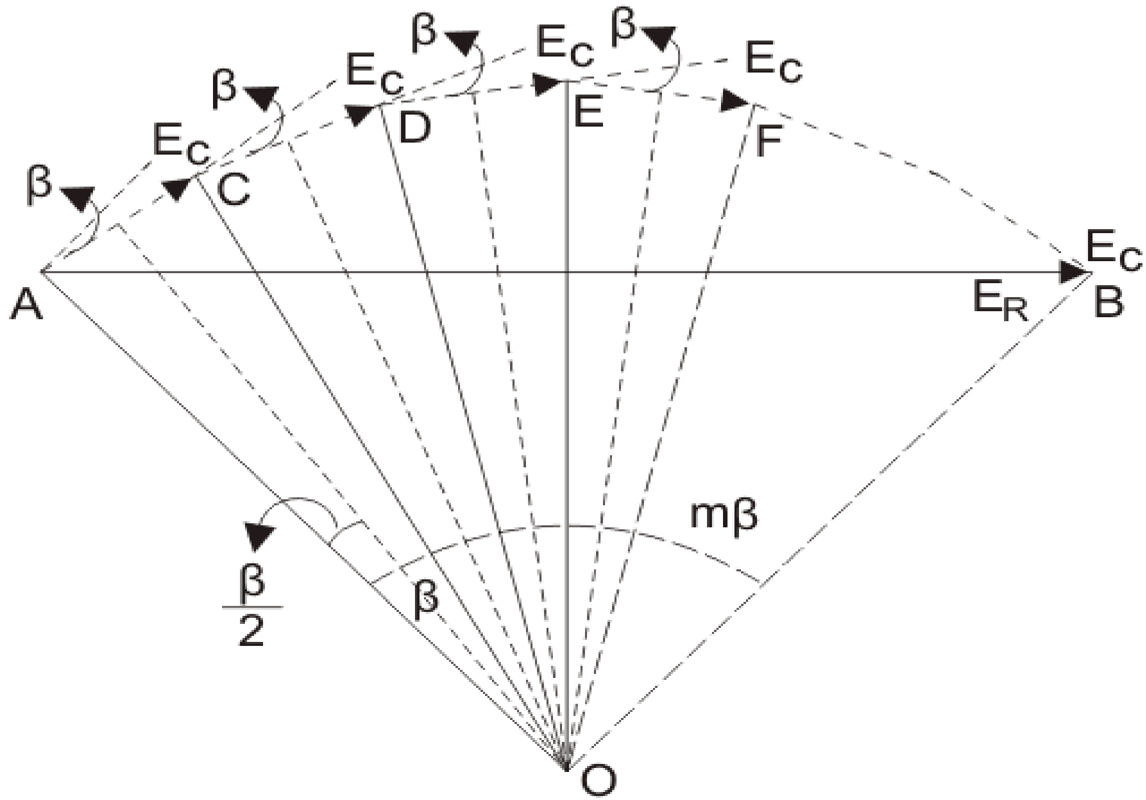
- It shortens the ends of the winding and, therefore, there is a saving in the conductor's material.
- It Reduces the effects of distorting harmonics and thus the waveform of the generated voltage is improved and making it a sine wave.

DISTRIBUTION FACTOR or WINDING FACTOR (K_d):

If all the coil sides of any one phase under one pole are bunched in one slot, the winding obtained is known as **concentrated winding** and the total emf induced is equal to the arithmetic sum of the emfs induced in all the coils of one phase under one pole. But in practical cases, for obtaining smooth sinusoidal voltage waveform, **armature winding of alternator** is not concentrated but distributed among the different slots to form polar groups under each pole. In distributed winding, coil sides per phase are displaced from each other by an angle equal to the angular displacement of the adjacent slots. Hence, the induced emf per coil side is not an angle equal to the angular displacement of the slots. So, the resultant emf of the winding is the phasor sum of the induced emf per coil side. As it is phasor sum, must be less than the arithmetic sum of these induced emfs. Resultant emf would be an arithmetic sum if the winding would have been a concentrated one. As per definition, distribution factor is a measure of resultant emf of a distributed winding in compared to a concentrated winding. We express it as the ratio of the phasor sum of the emfs induced in all the coils distributed in some slots under one pole to the arithmetic sum of the emfs induced. Distribution factor is,

$$k_d = \frac{EMF\ induced\ in\ distributed\ winding}{EMF\ induced\ if\ the\ winding\ would\ have\ been\ concentrated}$$

$$= \frac{Phasor\ sum\ of\ component\ emfs}{Arithmetic\ sum\ of\ component\ emfs}$$



As pitch factor, distribution factor is also always less than unity. Let the number of slots per pole is n. The number of slots per pole per phase is m. Induced emf per coil side is E_c. Angular displacement between the slots, $\beta = \frac{180^o}{n}$ Let us represent the emfs induced in different coils of one phase under one pole as AC, DC, DE, EF and so on. They are equal in magnitude, but they differ from each other by an angle β. If we draw bisectors on AC, CD, DE, EF --------. They would meet at common point

O. Emf induced in each coil side, $E = AC = 2 \cdot OAsin\frac{\beta}{2}$ As the slot per pole per phase is m, the total arithmetic sum of all induced emfs per coil sides per pole per phase, $Arithmetic\ sum = m \times 2 \times OAsin\frac{\beta}{2}$ The resultant emf would be AB, as represented by the figure, Hence, the

$$E_R = AB = 2 \times OA \sin\frac{\angle AOB}{2} = 2 \times OA \sin\frac{m\beta}{2}$$

$$Therefore,\ Distribution\ Factor$$

$$K_d = \frac{Phasor\ sum\ of\ component\ emfs}{Arithmetic\ sum\ of\ component\ emfs}$$

$$= \frac{2 \times OA \sin\frac{m\beta}{2}}{m \times 2 \times OA \sin\frac{\beta}{2}} = \frac{\sin\frac{m\beta}{2}}{m \sin\frac{\beta}{2}}$$

ELECTRIC FUSE

Electric fuse is a protective device which protects electrical equipment in the circuit by breaking the circuit when there is a short circuit. It contains a **fuse wire** which has low resistance, it allows normal current to pass through it safely but if there is any short circuit, fuse will blow out i.e. fuse wire can't withstand the heat produced by that current (infinite current) so it melts and breaks the circuit. Thus, protecting other electrical devices from short circuit current. The fuse wire is made of **zinc**, **copper**, **silver**, **aluminum**, or alloys to provide stable and predictable characteristics. Fuse should be of low resistance and low melting point as per the requirement. In normal operation of the circuit, fuse wire is just a very low resistance component and does not affect the normal operation of the system connected to the power supply.

The **working of the fuse** depends on the heating effect of the current. In normal operating condition, the normal current passes through the fuse. The heat develops in the fuse element because of the normal current and this heat is dissipated by the help of the surrounding air. Thus, the temperature of the fuse is kept below the melting point. When the fault occurs the short circuit current passes through the fuse element. The magnitude of the current is much high as compared to the normal current. The short circuit current generates excessive heat in the fuse element. Thereby, the element becomes melts and break. The fuse protects the machine or apparatus from short circuit or overload current. The fuse element is made of the highly selected metal conductor. The cartridge holds the fuse element. The main function of the fuse element is to allow the normal current to flows through the fuse and break the circuit when the high magnitude current passes through it.

TYPES OF FUSES

There are different types of fuses available in the market and they can be categories on the basis of Different aspects. Fuses are used in AC as well as DC circuits.

DIFFERENT TYPES OF FUSES

Fuses can be divided into two main categories according to the type of input supply voltage.

- **AC fuses**
- **DC fuses**

There is a little difference between AC and DC fuses used in the AC and DC Systems which has been discussed below.

DC FUSES

In a DC system, when the metallic wire melts because of the heat generated by the over current, then arc is produced and it is very difficult to extinct this arc because of DC constant value. So in order to minimize the fuse arcing, DC fuse are little bigger than an AC fuse which increase the distance between the electrodes to reduce the arc in the Fuse.

AC FUSES

On the other hand, i.e. in the AC system, voltage with 60Hz or 50Hz frequency changes it amplitude from zero to 60 times every second, so arc can be extinct easily as compared to DC. Therefore, AC fuses are little bit small in sizes as compared to DC fuses.

Fuses can also be categorized based on **one time** or **multiple Operations**.

- One time use only Fuse
- Resettable Fuses

ONE TIME USE ONLY FUSE

One time use fuses contain a metallic wire, which burns out, when an over current, over load or mismatched load connect event occur, user has to manually replace these fuses, switch fuses are cheap and widely used in almost all the electronics and electrical systems.

Such types of fuses can be categories on the following basis.

- Current carrying Capacity of Fuse.
- Breaking capacity.
- I^2t value of Fuse.
- Response Characteristic.
- Rated voltage of Fuse.

below is the brief explanation of the above categories.

FUSE CURRENT CARRYING CAPACITY

Current carrying capacity is the amount of current which a fuse can easily conduct without interrupting the circuit.

BREAKING CAPACITY

The value of maximum current that can safely be interrupted by the Fuse is called Breaking Capacity and should be higher than the prospective short circuit current.

I^2T VALUE OF FUSE

The I^2t terms related to fuse normally used in short circuit condition. it is the amount of energy which carry the fuse element when the electrical fault is cleared by fuse element.

RESPONSE CHARACTERISTIC

The speed at which fuse blows, depend on the amount of current flowing through its wire. The higher the current flowing through the wire, faster will be the response time. Response characteristic shows the response time for over current event. Fuses which respond rapidly to the over current situation is called **ultra-fast fuses** or **Fast fuses.** They are used in many semiconductor devices because semiconductor devices damaged by over current very rapidly. There is another fuse which is called **slow burn fuse**, such fuses do not respond rapidly to the over current event, but blow after several seconds of over current occurrence. Such fuses found their application in motor control electronics systems because motor takes a lot more current at starting than running.

RATED VOLTAGE OF FUSE

Each fuse has maximum allowed voltage rating, for example, if a fuse is designed for 32 volts it cannot be used with 220 volts, different amount of isolation is required in different fuses working on different voltage levels.

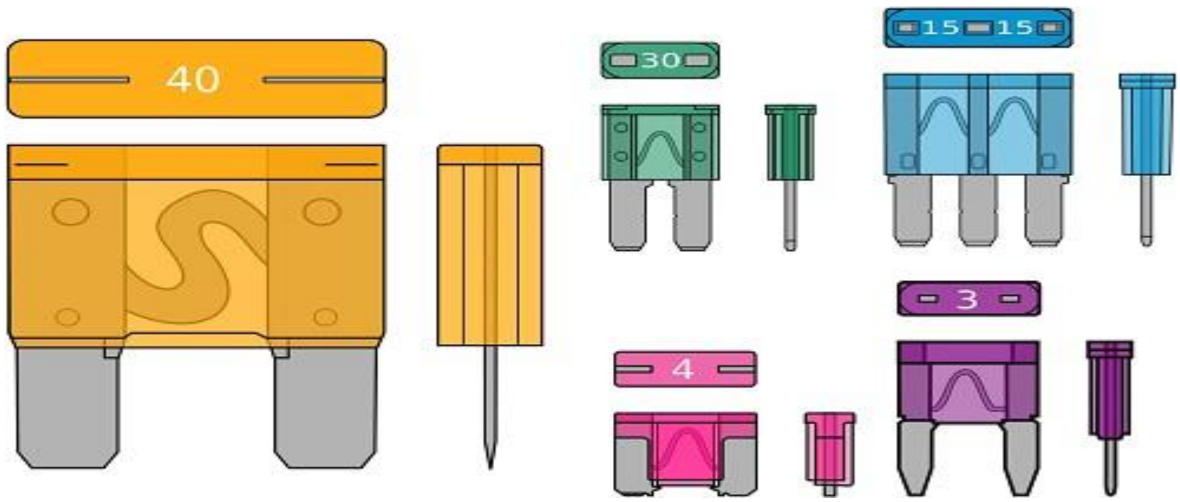
OTHER TYPES OF FUSES

CARTRIDGE FUSES

Cartridge fuses are used to protect electrical appliances such as motors, air-conditions, refrigerator, pumps etc, where high voltage rating and currents required. They are available up to 600A and 600V AC and widely used in industries, commercial as well as home distribution panels.There are two types of Cartridge fuses. 1. **General purpose fuse with no time delay** and 2. **Heavy-duty cartridge fuses with time delay**. Both are available in 250V AC to 600V AC and its rating can be found on the end cap or knife blade.

BLADE TYPE & AUTOMOBILES FUSES

This type of fuses (also known as **spade** or **plug-in fuses**) comes in plastic body and two metal caps to fit in the socket. Mostly, they used in **automobiles** for wiring and short circuit protection.



Blade Type Fuses: Used in Automobiles

HRC (High Rupturing Capacity) Fuse

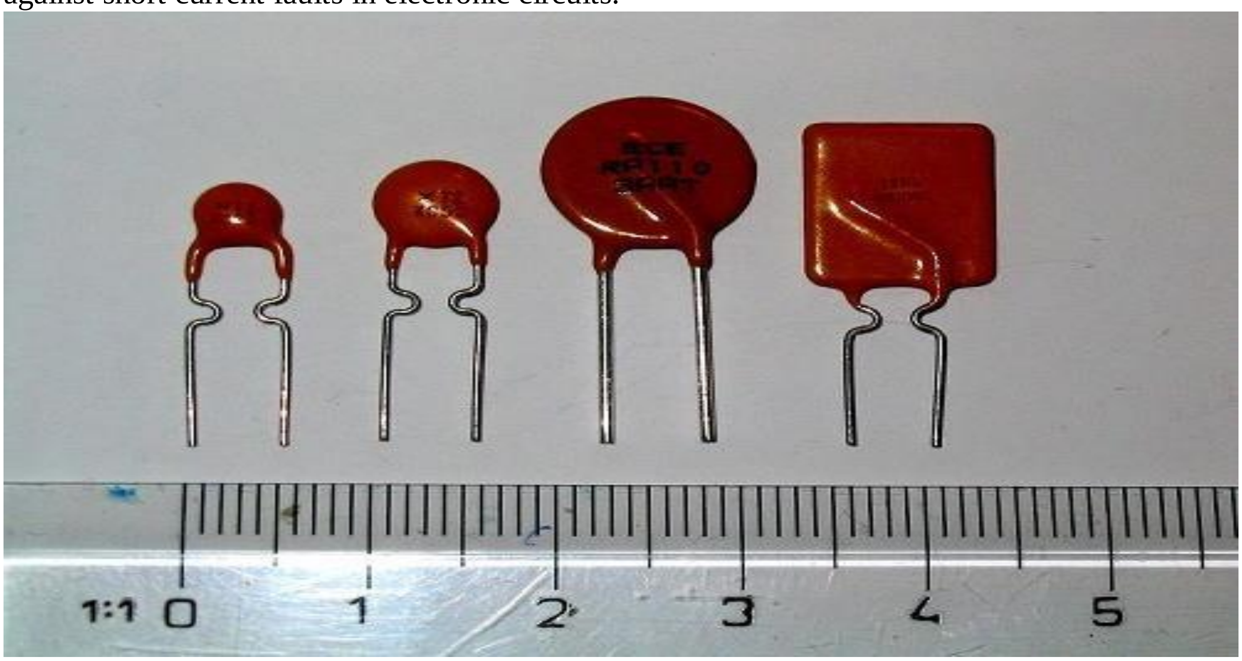
TYPES OF HRC FUSE

Other Types of Fuses like SMD Fuses , Axial Fuses, Thermal Fuses and High Voltage fuses

SMD Fuse and Axial fuse

RESETTABLE FUSES

Resettable fuse is a device, which can be used as multiple times without replacing it. They open the circuit, when an over current event occurs and after some specific time they connect the circuit again. Polymeric positive temperature coefficient device (PPTC, commonly known as a resettable fuse, poly-switch or poly-fuse) is a passive electronic component used to protect against short current faults in electronic circuits.



Resettable Fuses

USES AND APPLICATIONS OF FUSES

Electronic Fuses can be used in all types of electrical and electronic applications including:

- Motors
- Air-conditions
- Home distribution boards
- General electrical appliances and devices
- Laptops
- Cell phones
- Game systems
- Printers
- Digital cameras
- DVD players
- Portable Electronics
- LCD monitors
- Scanners
- Battery packs
- Hard disk drives
- Power convertors

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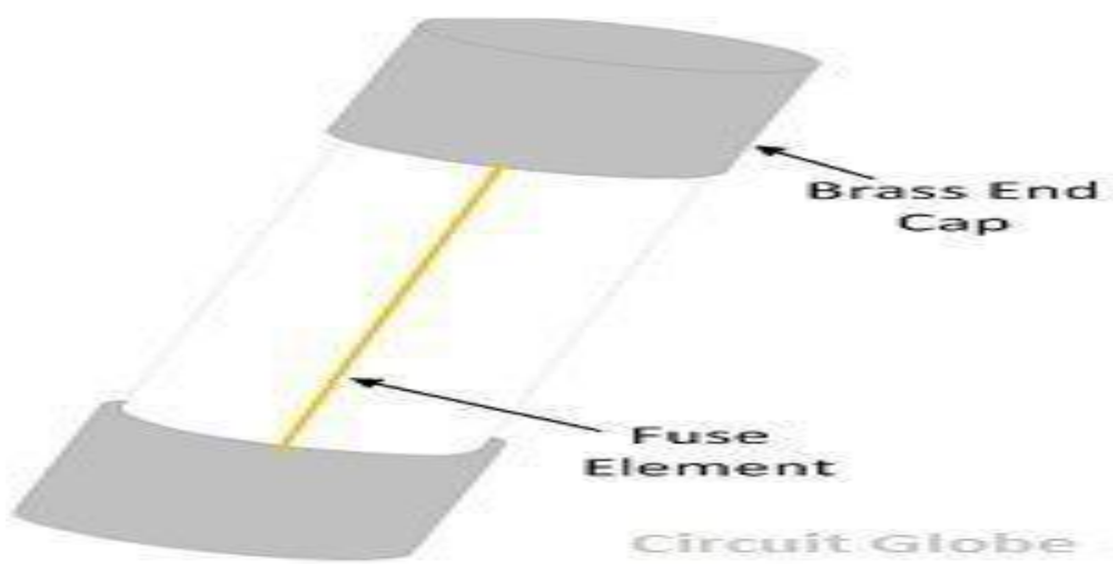


ADVANTAGES OF AN ELECTRICAL FUSE

- It is the cheapest form of protection, and it does need any maintenance.
- Its operation is completely automatic and requires less time as compared to circuit breakers.

DISADVANTAGES OF AN ELECTRICAL FUSE

- Considerable time is required in replacing a fuse after the operation.
- Fuses are used for the protection of the cables in low voltages light, and power circuits and for transformers of rating not exceeding 200 KVA, in the primary distribution system. Fuses are used in low and moderate voltage applications where the frequent operation is not expected or where the use of a circuit breaker is uneconomical.

CIRCUIT BREAKER:

The **Circuit Breaker** also performs the similar function as that of the fuse but by electromagnetism principle. The circuit breaker also protects the appliances from getting damaged due to overload current. A circuit breaker is a mechanical device used to perform switching operations in an electrical circuit under normal as well as abnormal conditions. When a circuit breaker is employed in the protection of an electrical circuit, they are equipped with a trip coil connected to a relay arrangement, which is designed to sense the abnormal conditions and close the breaker trip circuit. Therefore, an additional relay arrangement is always required for the automated operation of a circuit breaker. For breakers of very small capacity, for example, low voltage circuit breakers up to 100A, have thermal couple arrangement instead of fault sensing relays.

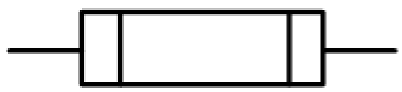
OPERATING PRINCIPLE OF CIRCUIT BREAKERS

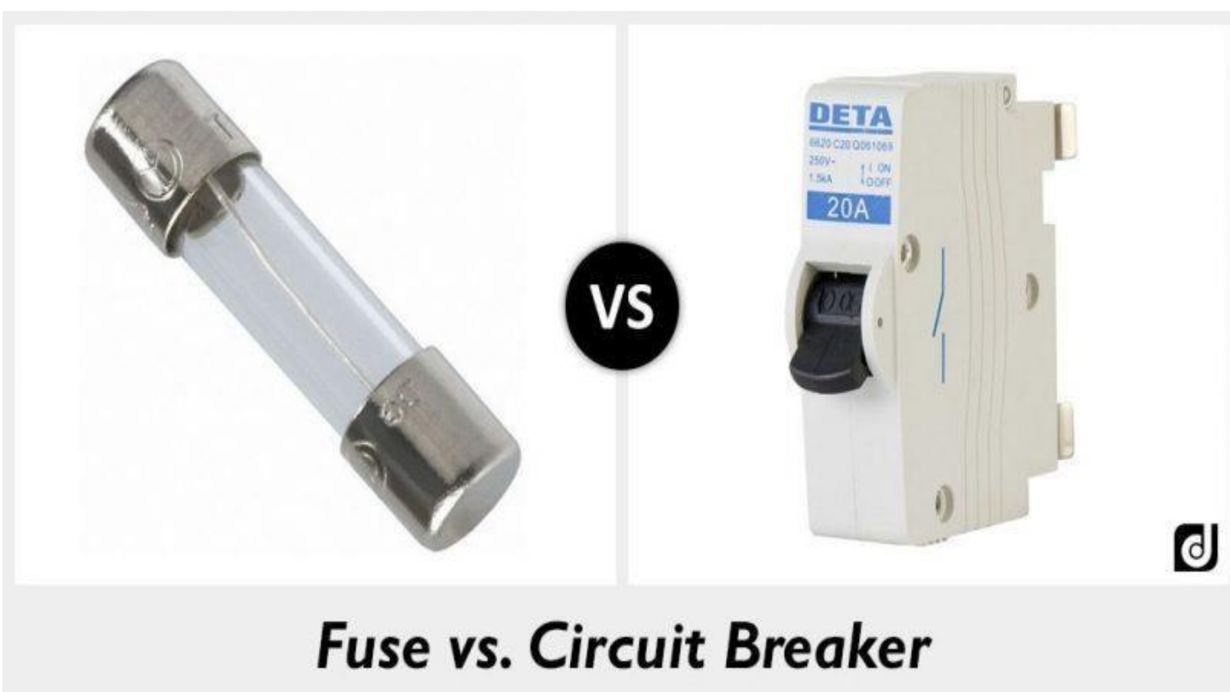
A circuit breaker consists of a fixed contact and a moving contact. Under normal conditions, these contacts will be closed allowing current to flow through it. When an abnormal condition is sensed by the relay arrangement provided, it energizes the trip coils and pulls back the moving contact apart and opens the circuit breaker, thereby interrupting the flow of current. The circuit breaker is reset manually or automatically after the clearance of fault. Circuit breakers can also be operated manually.

<u>THE DIFFERENCE BETWEEN FUSE AND CIRCUIT BREAKER</u>:

BASIS	**FUSE**	**CIRCUIT BREAKER**
Working Principle	Fuse works on the electrical and thermal properties of the conducting materials.	Circuit breaker works on the electromagnetism and switching principle.
Reusability	Fuses can be used only once.	Circuit breakers can be used a number of times.

Status indication	It does not give any indication.	It gives an indication of the status
Switching Action	Fuse cannot be used as as an ON/OFF switch.	The Circuit breaker is used as an ON/OFF switches.
Temperature	They are independent of ambient temperature	Circuit breaker Depends on ambient temperature
Protection	The Fuse provides protection against only short circuits.	Circuit breaker provides protection against power overloads and short circuits.
Cost	Cost of fuse is low.	Cost of the circuit breaker is high
Operating time	Very small like 0.002 sec or even less	Comparatively large (ranges between 0.1 and 0.2 seconds)
Operation Mode	Inherently completely automatic operation	Needs comprehensive equipment such as relays for automatic operation
Operation principle	It’s operation is based on the heating property of a conducting material	It’s operation is based on switching mechanism (which is electromechanical in nature)

Application	Used extensively in an electronic equipment’s which draw low current	Used in power equipment's such as in motors and other heavy machines which draw a large amount of current
Representation		



BATTERIES:

BATTERY

Batteries are the most common power source for basic handheld devices to large scale industrial applications. A battery can be defined as a combination of one or more electro chemical cells that are capable of converting stored chemical energy into electrical energy.

TYPES OF BATTERIES

1) PRIMARY BATTERIES

As the name indicates these batteries are meant for **single usage**. Once these batteries are used they cannot be recharged as the devices are not easily reversible and active materials may not return to their original forms. Battery manufacturers recommend against recharge of primary cells. Some of the examples for the disposable batteries are the normal AA, AAA batteries which we use in wall clocks, television remote etc. Other name for these batteries is disposable batteries.

2) SECONDARY BATTERIES

Secondary batteries are also called as **rechargeable batteries**. These batteries can be used and recharged simultaneously. They are usually assembled with active materials with active in the discharged state. Rechargeable batteries are recharged by applying electric current, which reverses the chemical reactions that occur during discharge. Chargers are devices which supply the required current. Some examples for these rechargeable batteries are the batteries used in mobile phones, MP3 players etc.

TYPES OF SECONDARY (RECHARGEABLE) BATTERIES NICKEL CADMIUM BATTERIES:

The active components of a rechargeable NiCd battery in the charged state consists of nickel hydroxide (NiOOH) in the positive electrode and cadmium (Cd) in the negative electrode. For the electrolyte, potassium hydroxide (KOH) is normally used. Due to their low internal resistance and the very good current conducting properties, NiCd batteries can supply extremely high currents and can be recharged rapidly. These cells are capable of sustaining temperatures down to -20°C. The selection of the separator (nylon or polypropylene) and the electrolyte (KOH, LiOH, NaOH) influence the voltage conditions in the case of a high current discharge, the service life and the overcharging capability. In the case of misuse, a very high-pressure may arise quickly. For this reason, cells require a safety valve. NiCd cells generally offer a long service life thereby ensuring a high degree of economy.

NICKEL METAL HYDRIDE BATTERIES

The active components of a rechargeable NiMH battery in the charged state consist of nickel hydroxide in the positive electrode and a hydrogen storing metal alloy (MH) in the negative electrode as well as a potassium hydroxide (KOH) electrolyte. Compared to rechargeable NiCd batteries, NiMH batteries have a higher energy density per volume and weight.

LITHIUM ION BATTERIES

The term lithium ion battery refers to a rechargeable battery where the negative electrode (anode) and positive electrode (cathode) materials serve as a host for the lithium ion (Li+). Lithium ions move from the anode to the cathode during discharge and are intercalated into the cathode. The ions reverse direction during charging. Since lithium ions are intercalated into host materials during charge or discharge, there is no free lithium metal within a lithium-ion cell. In a lithium ion cell, alternating layers of anode and cathode are separated by a porous film (separator). An electrolyte composed of an organic solvent and dissolved lithium salt provides the media for lithium ion transport.

LITHIUM – ION BATTERY

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Lithium –Ion batteries are now popular in majority of electronic portable devices like Mobile phone, Laptop, Digital Camera, etc due to their long lasting power efficiency. These are the most popular rechargeable batteries with advantages like best energy density, negligible charge loss and no memory effect.

ADVANTAGES OF LITHIUM – ION BATTERY

(i)Light weight compared to other batteries of similar size.
(ii)Very low self-discharge rate of 5-10% per month.

DISADVANTAGES OF LI-ION BATTERY

- The deposits inside the electrolyte over time will inhibit the flow of charge. This increases the internal resistance of the battery and the cell's capacity to deliver current gradually decreases.
- High charging and high temperature may lead to capacity loss.

BATTERY BACKUP:

A backup battery provides power to a system when the primary source of power is unavailable. Backup batteries range from small single cells to retain clock time and date in computers, up to large battery room facilities that power uninterruptible power supply systems for large data centers. Small backup batteries may be primary cells; rechargeable backup batteries are kept charged by the prime power supply.

Hardware device used to supply power to computers and peripherals for a short time if the power happens to be low or removed. A battery backup allows the computer to shut down safely or keep the computer running if the power is off for less than a few minutes. Businesses often use large battery backups to safely shutdown servers if the power goes out or keeps the servers powered if the power is out for a few seconds. These backups are essential if your server is running critical software such as a customer database.

OTHER NAMES FOR BATTERY BACKUP

Battery backup goes by many names. Uninterruptible power supply, uninterruptible power source, on-line UPS, standby UPS, and UPS are the different ways to refer to a battery backup.

AIRCRAFT EMERGENCY BATTERIES

Backup batteries in aircraft keep essential instruments and devices running in the event of an engine power failure. Each aircraft has enough power in the backup batteries to facilitate a safe landing. The batteries keeping navigation, ELUs (emergency lighting units), emergency pressure or oxygen systems running at altitude, and radio equipment operational. Larger aircraft have control surfaces that run on these backups as well. Aircraft batteries are either nickel-cadmium or valve- regulated lead acid type. The battery keeps all necessary items running for between 30 minutes and 3 hours.

COMPUTER

Modern personal computer motherboards have a backup battery to run the real-time clock circuit and retain configuration memory while the system is turned off. Used a relatively large primary battery. Backup batteries are used in uninterruptible power supplies (UPS), and provide power to the computers they supply for a variable period after a power failure, usually long enough to at least allow the computer to be shut down gracefully. UPS backup batteries may be lead-acid or cadmium batteries, with lithium ion cells available in some ratings.

TELEPHONY

A local backup battery unit is necessary in some telephony and combined telephony/data applications. In such networks there are active units on telephone exchange side and on the user side, but nodes between them are all passive in the meaning of electrical power usage. So, if a building loses power, the network continues to function. The user side must have standby power since operating power isn't transferred over data optical line.

HOSPITALS

Power failure in a hospital would result in life-threatening conditions for patients. Patients undergoing surgery or on life support are reliant on a consistent power supply. Backup generators or batteries supply power to critical equipment until main power can be restored.

POWER STATIONS

Power failure in a power station that produces electricity would result in a blackout situation that would cause irreparable damage to equipment such as the turbine-generator. The safety of power station employees is a major concern during an unscheduled power outage at a power plant. A bank of large station backup batteries are used to power uninterruptible power supplies as well as directly power emergency oil pumps for up to 8 hours while normal power is being restored to the power station.