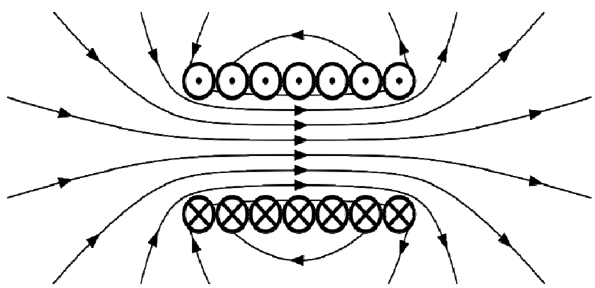
Basic electrical engineering-

UNIT-1

INTRODUCTION-

History of Electricity -Electricity has been a subject of scientific interest since at least the early 17th century.William Gilbert was a prominent early electrical scientist, and was the first to draw a clear distinction between magnetism and static electricity. He is credited with establishing the term "electricity". He also designed the versorium .a device that detects the presence of statically charged objects. In 1762 Swedish professor Johan wilcke invented a device later named electrophorus that produced a static electric charge. By 1800 Alessandro Volta had developed the voltaic pile,a forerunner of the electric battery



LEARNING OBJECTIVE-

- Learning objective in electrical engineering focus on building core technical skills (circuit analysis) power system, electronics, control system)
- Problem solving abilities(design, analysis research)
- Practical application (hand-on building, software tools, experimentation)
- Professional competencies(ethics, teamwork, communication, lifelong learning) to create versatile engineers who can solve complex societal challenges responsibility and ethically

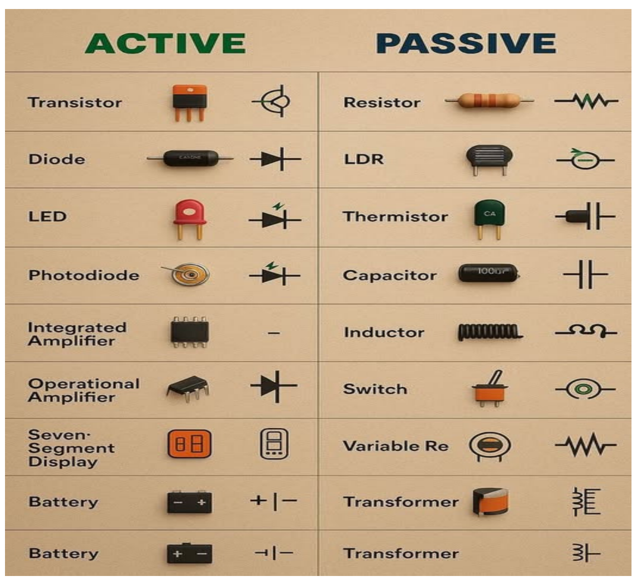
Active and Passive Element-

Active element - Active elements are components that supply energy and control electron flow in circuits, like batteries, transistors, diodes, and operational amplifiers, enabling amplification and signal processing, unlike passive elements (resistors, capacitors) that only absorb or dissipate energy. They generate power, control current, and are essential for circuit function, categorized as independent or dependent sources, or voltage/current-controlled devices.

Types of Active Elements (Sources)-

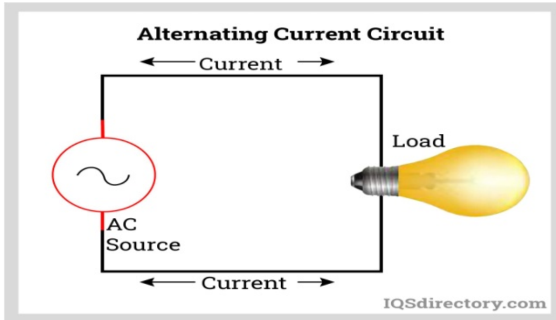
Independent Sources: Provide constant voltage or current (e.g., a battery).
Dependent Sources: Output depends on another circuit variable (voltage or current) (e.g., a transistor).
Voltage-Controlled: Output current is controlled by input voltage (e.g., BJT).
Current-Controlled: Output current is controlled by input current (e.g., a FET).

Passive element- Passive elements in electronics are components like resistors, capacitors, and inductors that don't generate power but instead absorb, store (in electric/magnetic fields), or dissipate it (as heat), without needing an external power source to function, serving to control current and voltage in circuits. They are crucial for filtering, impedance matching, and creating timing circuits, working alongside active elements (like transistors) that do supply power or amplify signals

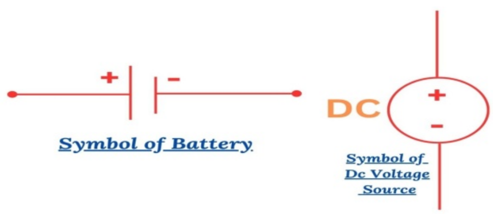


AC source and DC source :-

AC source - An AC (Alternating Current) source provides electrical power where the current periodically reverses direction, unlike DC, and is the standard for power grids, homes, and businesses, generated by sources like generators and delivered through wall outlets as sinusoidal waves at specific frequencies (50/60 Hz) and voltages (e.g., 120V/220V). AC sources can also be specialized lab power supplies that offer stable, controllable voltage, frequency, and waveform simulation for testing electronics

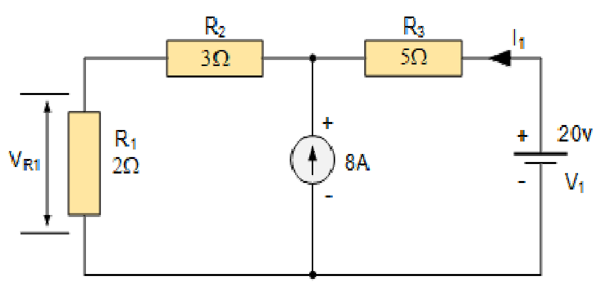


DC source - A DC (Direct Current) source provides a steady, one-directional flow of electrical current, unlike AC (Alternating Current) that periodically reverses direction, with common examples being batteries, solar cells, and DC power supplies (which convert AC to DC). These sources are essential for powering electronics like phones, EVs, and laptops, offering stable voltage for devices that require a constant current

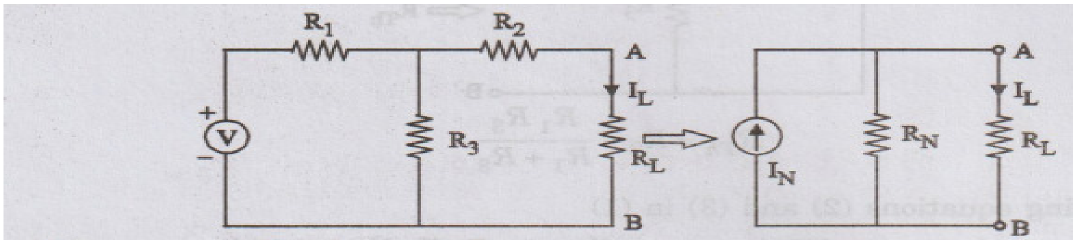


Theorem :-

1) Superposition Theorem -The Superposition Theorem simplifies complex linear circuits with multiple sources by stating that the total current or voltage in any element is the algebraic sum of the effects from each independent source acting alone, with other sources turned off (voltage sources shorted, current sources opened) and replaced by their internal resistance. This fundamental principle allows breaking down complex problems into simpler ones, making circuit analysis easier, but it only applies to linear, bilateral networks and not to power calculations.



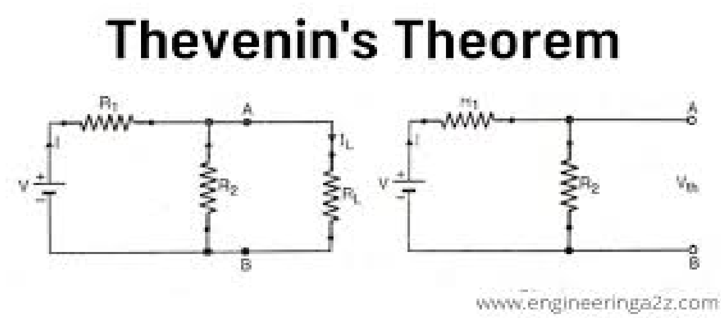
2) Norton's theorem: - Norton's theorem states that any linear circuit can be simplified to an equivalent circuit consisting of a single current source and parallel resistance that is connected to a load.



Using current division technique

$$I_L = \frac{I_N \times R_N}{R_L + R_N} \quad ...(1)$$

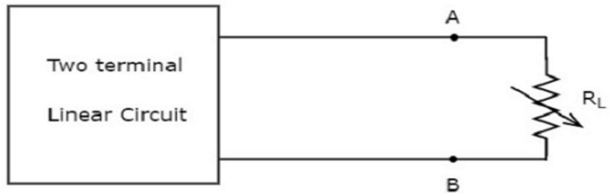
3) Thevenin theorem: - Thevenin's theorem states that any linear circuit, no matter how complex, can be simplified to an equivalent circuit consisting of a single voltage source with a series resistance connected to a load.

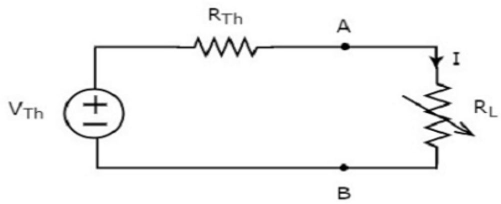


4) Maximum Power Transfer Theorem: - The Maximum Power Transfer Theorem states that maximum power is delivered from a source to a load when the load resistance RL equals the source's internal resistance (Rth) or for AC circuits, when the load impedance is the complex conjugate of the source impedance. This condition, often achieved by setting

$RL=Rth$,

Maximizes power to the load but results in only 50% efficiency, with the other 50% dissipated in the source.





5) Kirchhoff's Law:- Kirchhoff's Laws are two fundamental rules for analyzing electrical circuits

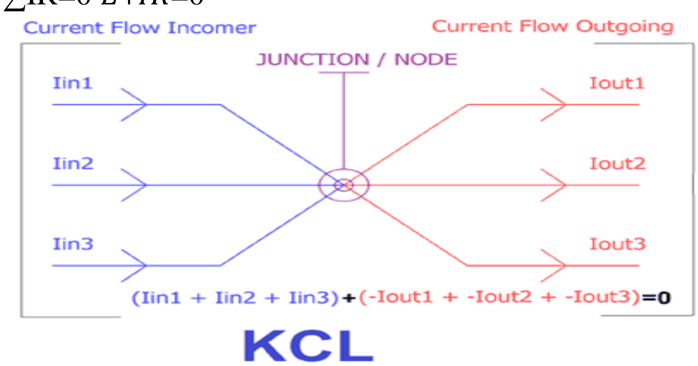
(a) Kirchhoff's current Law

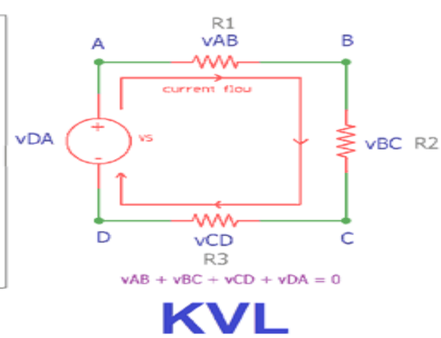
(b) Kirchhoff's voltage Law

(a)Kirchhoff's current Law- the total current entering any junction (node) in an electrical circuit must equal the total current leaving that junction, based on the principle of conservation of charge essentially, current isn't lost at a node, just redirected, meaning the algebraic sum of all currents at a node is zero ($\Sigma I = 0$).

(b) Kirchhoff's voltage Law - Kirchhoff's Voltage Law (KVL), or the loop rule, states that the algebraic sum of all voltage rises and drops around any closed loop in a circuit must equal zero, a principle derived from the conservation of energy. This means the total voltage supplied by sources (like batteries) in a loop must equal the total voltage dropped across components (like resistors) in that same loop, often expressed as $\sum V=0$

$\sum E+\sum IR=0$ $E+IR=0$





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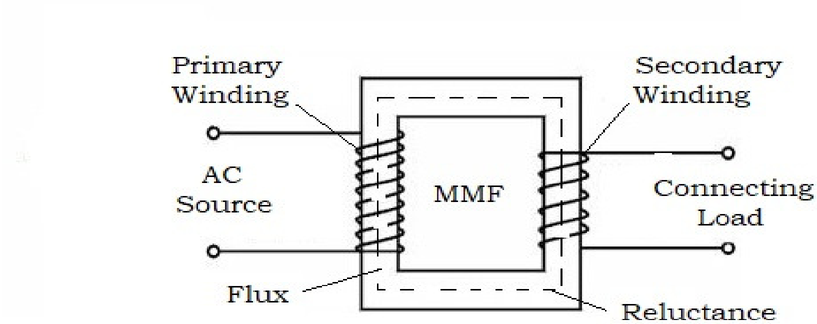
UNIT-2

Magnetic circuit concept:- A magnetic circuit is a closed path for magnetic flux, analogous to an electric circuit for current, using ferromagnetic materials (like iron) to guide the field, with its core components being magneto motive force (MMF, the "voltage" source), magnetic flux (Φ the "current"), and reluctance (the "resistance" to flux). While nothing physically "flows," these circuits efficiently concentrate magnetic fields for devices like motors, transformers, and inductors, where flux is generated by current in coils and guided by a core, often with air gaps



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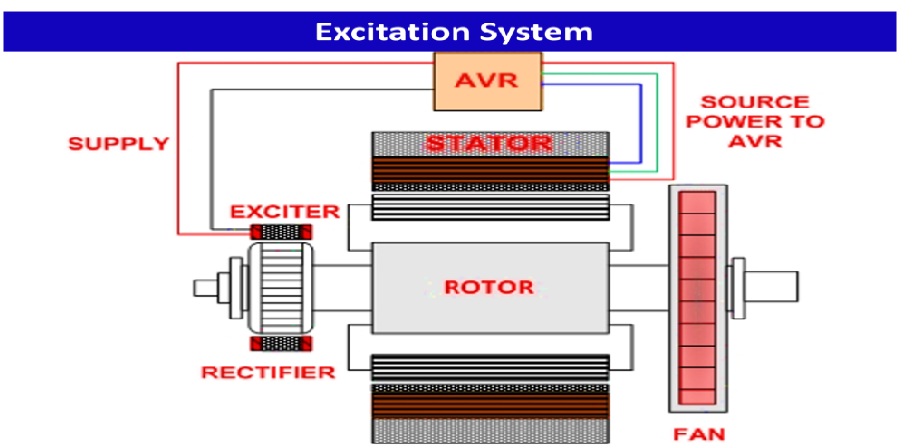
Magnetic Circuit Diagram

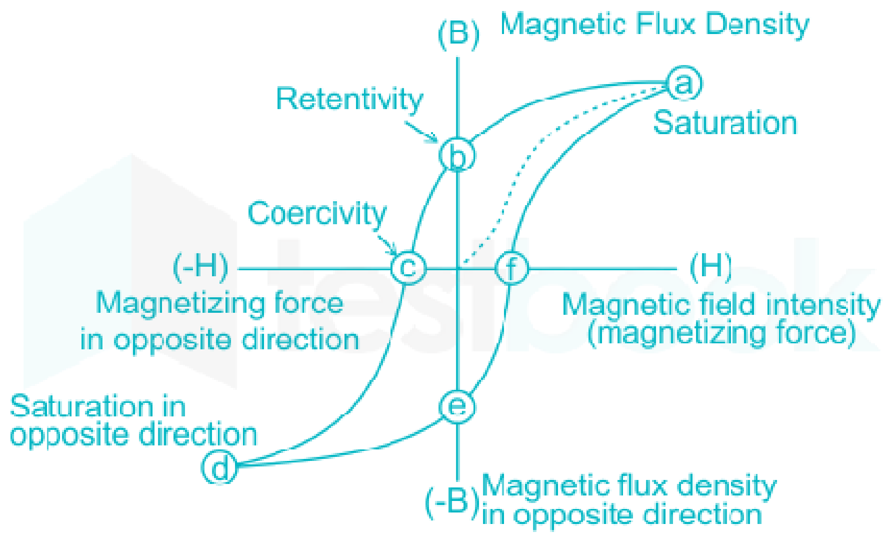
Magnetic circuit with AC and DC excitation :-

DC excitation- A magnetic circuit with DC excitation creates a steady, constant magnetic field, determined by voltage and resistance (V=IR) in steady state, with inductance only significant during transients (switching).



AC excitation- In contrast, AC excitation produces a time-varying, alternating magnetic field, where inductance is crucial even at steady-state, governed by voltage, frequency, and the B-H curve, as seen in transformers, requiring analysis of hysteresis and core losses.

B-H CURVE:- A B-H curve (Magnetic Hysteresis Loop) shows the relationship between Magnetic Flux Density(B) (vertical axis) and Magnetic Field Strength (H) (horizontal axis) in a magnetic material, illustrating how the material magnetizes and demagnetizes, forming a characteristic loop with points like saturation, retentivity, residual magnetism , and coercivity . The area within the loop represents energy lost as heat (hysteresis loop) during magnetization cycles, crucial for designing transformers and motors.

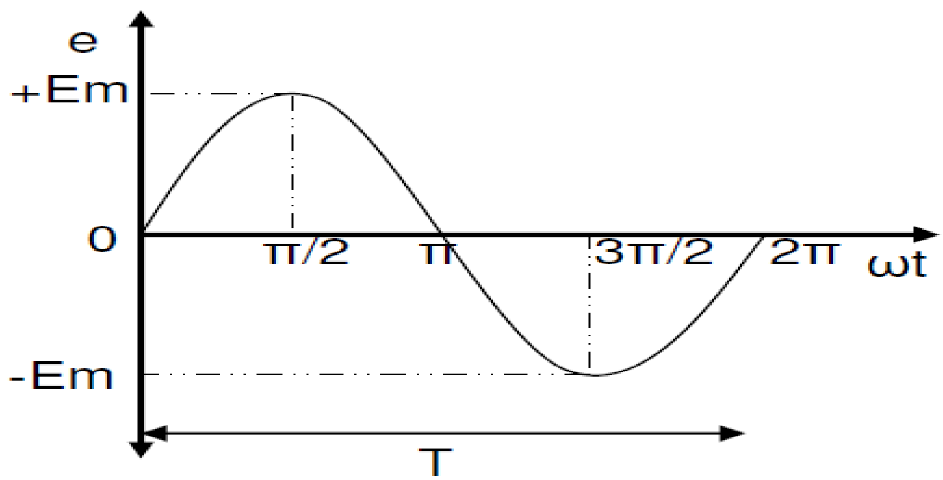


Hysteresis and Eddy current loss:- Hysteresis loss and eddy current loss are key power losses in magnetic cores, converting energy to heat hysteresis loss comes from the magnetic domains lagging behind the changing magnetic field (reduced by soft materials like silicon steel), while eddy current loss is from induced circulating currents within the core (reduced by thin, insulated laminations). Both impact efficiency in transformers, motors, and generators, necessitating material and design choices to minimize them.

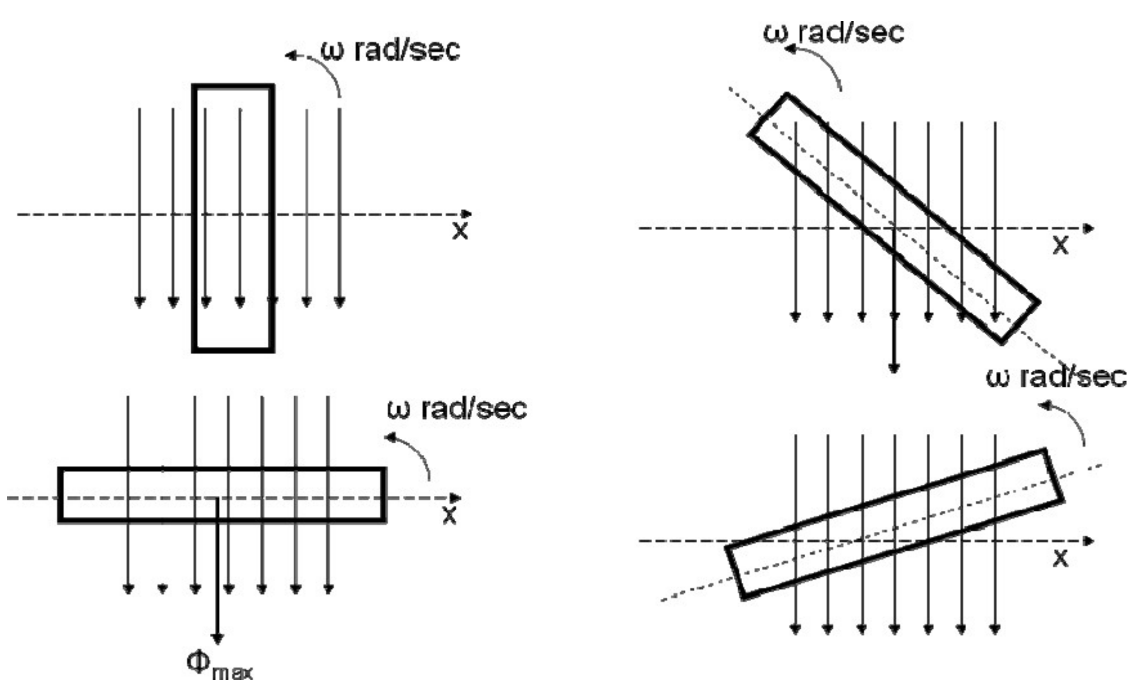
UNIT-3

Steady state Analysis of single phase Ac circuit

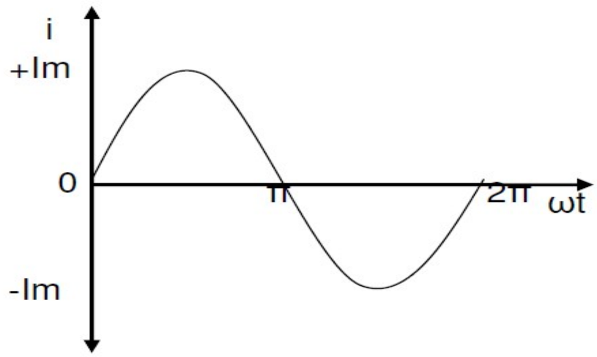
Definition of Alternating Quantity: - An alternating quantity changes continuously in magnitude and alternates in direction at regular intervals of time. Important terms associated with an alternating quantity are defined below.



Generation of sinusoidal AC voltage: - Consider a rectangular coil of N turns placed in a uniform magnetic field as shown in the figure. The coil is rotating in the anticlockwise direction at an uniform angular velocity of ω rad/sec



RMS value of a sinusoidal current



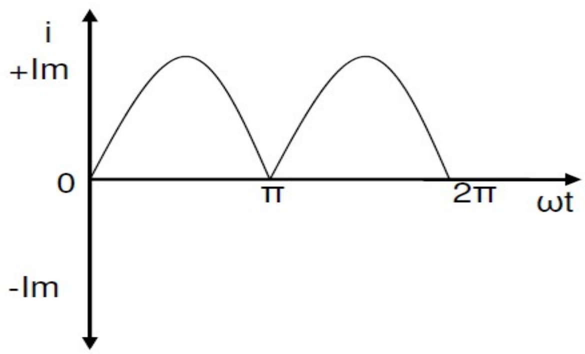
$$i = I_m \sin \omega t$$

$$I_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} i^2 d(\omega t)}$$

$$I_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} I_m^2 \sin^2 \omega t d(\omega t)}$$

$$I_{rms} = \frac{I_m}{\sqrt{2}} = 0.707 I_m$$

RMS value of a full wave rectifier output



$$i = I_m \sin \omega t$$

$$I_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} i^2 d(\omega t)}$$

$$I_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} I_m^2 \sin^2 \omega t d(\omega t)}$$

$$I_{rms} = \frac{I_m}{\sqrt{2}} = 0.707 I_m$$

Form Factor

The ratio of RMS value to the average value of an alternating quantity is known as Form Factor

$$FF = \frac{RMS Value}{Average Value}$$

Peak Factor or Crest Factor

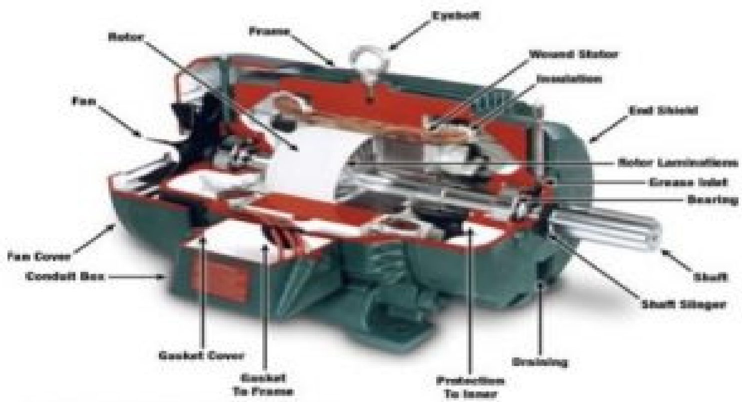
The ratio of maximum value to the RMS value of an alternating quantity is known as the peak factor

$$PF = \frac{Maximum Value}{RMS Value}$$

Unit-5

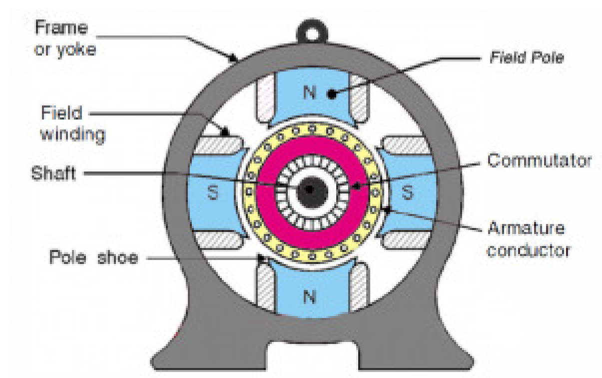
Introduction of DC motor -

A DC machine is an electromechanical energy alteration device. The working principle of a DC machine is when electric current flows through a coil within a magnetic field, and then the magnetic force generates a torque that rotates the dc motor. The DC machines are classified into two types such as DC generator as well as DC motor.



Construction of DC Machine -

The construction of the DC machine can be done using some of the essential parts like Yoke, Pole core & pole shoes, Pole coil & field coil, Armature core, Armature winding otherwise conductor, commutator, brushes & bearings. Some of the parts of the DC machine is discussed below.



Yoke -Another name of a yoke is the frame. The main function of the yoke in the machine is to offer mechanical support intended for poles and protects the entire machine from moisture, dust, etc. The materials used in the yoke are designed with cast iron, cast steel otherwise rolled steel.

Pole and Pole Core -The pole of the DC machine is an electromagnet and the field winding is winding among pole. Whenever field winding is energized then the pole gives magnetic flux. The materials used for this are cast steel, cast iron otherwise pole core. It can be built with the annealed steel laminations for reducing the power drop because of the eddy currents.

Pole Shoe -Pole shoe in the DC machine is an extensive part as well as to enlarge the region of the pole. Because of this region, flux can be spread out within the air-gap as well as extra flux can be passed through the air space toward armature. The materials used to build pole shoe is cast iron otherwise cast steed, and also used annealed steel lamination to reduce the loss of power because of eddy currents.

Field Windings - In this, the windings are wounded in the region of pole core & named as field coil. Whenever current is supplied through field winding than it electromagnetics the poles which generate required flux. The material used for field windings is copper**.**

Armature Core- Armature core includes a huge number of slots within its edge. The armature conductor is located in these slots. It provides the low-reluctance path toward the flux generated with field winding. The materials used in this core are permeability low-reluctance materials like iron otherwise cast. The lamination is used to decrease the loss because of the eddy current.

Unit-6

Soldering and Desoldering:-

Soldering joins components with molten solder for a strong electrical/mechanical bond, requiring a clean iron, flux, and solder, while desoldering removes it using solder wick (braid) or solder (pumps/electric) by melting and wicking/sucking away liquid solder, essential for rework; both demand safety, good ventilation, and clean tips for successful application on electronic circuits

Technique of Soldering-

1. **Preparation:** Clean and "tin" (coat) your iron tip with fresh solder; ensure parts are clean and secured, and work in a ventilated area.
2. **Heat the Joint:** Touch the iron tip to *both* the component lead and the pad simultaneously for a second or two to heat them evenly.
3. **Apply Solder:** Feed solder onto the heated joint (not the iron tip) until it flows smoothly, creating a shiny, volcano-like shape.
4. **Remove Solder & Iron:** Remove the solder, then the iron, holding parts still until cool.