A Course Module

on

BASIC ELECTRICAL & ELECTRONICS ENGINEERING (PART-A)

(20A02101T)

Prepared by

Mr.P.RAMANJANEYULU

Assoc.Professor

Department of EEE

SREE RAMA ENGINEERING COLLEGE

Approved by AICTE, New Delhi – Affiliated to JNTUA, Ananthapuramu
Accredited by NAAC with 'A' Grade
An ISO 9001:2015 & ISO 14001:2015 certified Institution
Rami Reddy Nagar, Karakambadi road,Tirupati-517507

UNIT -3

Basics of Power Systems:
Layout & operation of Hydro, Thermal, Nuclear Stations - Solar & wind generating stations – Typical AC Power Supply scheme – Elements of Transmission line – Types of Distribution systems: Primary & Secondary distribution systems.

Learning Outcomes

At the end of this unit, the student will be able to

- Understand working operation of various generating stations
- Explain the types of Transmission and Distribution systems

Text Books:

1. D. P. Kothari and I. J. Nagrath - "Basic Electrical Engineering" - Tata McGraw Hill - 2010.
2. V.K. Mehta & Rohit Mehta, "Principles of Power System" – S.Chand – 2018.

References:

1. L. S. Bobrow - "Fundamentals of Electrical Engineering" - Oxford University Press - 2011.
2. E. Hughes - "Electrical and Electronics Technology" - Pearson - 2010.
3. C.L. Wadhwa – "Generation Distribution and Utilization of Electrical Energy", 3rd Edition, New Age International Publications.

Course Outcomes:

The student should be able to

- Apply concepts of KVL/KCL in solving DC circuits
- Understand and choose correct rating of a transformer for a specific application
- Illustrate working principles of DC Motor
- Identify type of electrical machine based on their operation
- Understand the basics of Power generation, Transmission and Distribution

Part 'B'- Electronics Engineering

COURSE OBJECTIVES

- Understand principles and terminology of electronics.
- Familiar with the theory, construction, and operation of electronic devices.
- Learn about biasing of BJTs and FETs.
- Design and construct amplifiers.
- Understand the concept & principles of logic devices.

Unit-1:

Diodes and Applications: Semiconductor Diode,Diode as a Switch& Rectifier, Half Wave and Full Wave Rectifiers with and without Filters; Operation and Applications ofZener Diode, LED, Photo Diode.

Transistor Characteristics: Bipolar Junction Transistor (BJT) – Construction, Operation, Amplifying Action, Common Base, Common Emitter and Common Collector Configurations, Operating Point, Biasing of Transistor Configuration; Field Effect Transistor (FET) – Construction, Characteristics of Junction FET, Concepts of Small Signal Amplifiers –CE & CC Amplifiers.

Learning outcomes:

At the end of this unit, the student will be able to

- Remember and understand the basic characteristics of semiconductor diode. (L1)
- Understand principle of operation of Zener diode and other special semiconductor diodes. (L1)
- Analyze BJT based biasing circuits. (L3)
- Design an amplifier using BJT based on the given specifications. (L4)

Unit-2:

Operational Amplifiers and Applications: Introduction to Op-Amp, Differential Amplifier Configurations, CMRR, PSRR, Slew Rate; Block Diagram, Pin Configuration of 741 Op-Amp, Characteristics of Ideal Op-Amp, Concept of Virtual Ground; Op-Amp Applications - Inverting, Non-Inverting, Summing and Difference Amplifiers, Voltage Follower, Comparator, Differentiator, Integrator.

Learning outcomes:

At the end of this unit, the student will be able to

- Describe operation of Op-Amp based linear application circuits, converters, amplifiers and non-linear circuits. (L2)
- Analyze Op-Amp based comparator, differentiator and integrator circuits. (L3)

Unit-3:

Digital Electronics: Logic Gates,Simple combinational circuits–Half and Full Adders, BCD Adder.Latches and Flip-Flops (S-R, JK andD), Shift Registers and Counters.Introduction to Microcontrollers and their applications (Block diagram approach only).

Learning outcomes:

At the end of this unit, the student will be able to

- Explain the functionality of logic gates. (L2)
- Apply basic laws and De Morgan’s theorems to simplify Boolean expressions. (L3)
- Analyze standard combinational and sequential circuits. (L4)
- Distinguish between 8085 & 8086 microprocessors also summarize features of a microprocessor. (L5)

Text Books:

1. R.L.Boylestad& Louis Nashlesky, Electronic Devices &Circuit Theory, Pearson Education,2007.
2. Ramakanth A. Gayakwad, Op-Amps & Linear ICs, 4thEdition, Pearson, 2017.

DC circuits

An **electric circuit element** is the most elementary building block of an electric circuit, and the **electric circuit** is an interconnection of different circuit elements connected in a fashion so they form a closed path for current to flow.

We may classify circuit elements in two categories, passive and active elements.

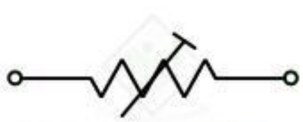
Passive Element: The element which receives energy (or absorbs energy) is called passive element.
Transformer is an example of passive element.

Active Element: The elements that supply energy (give energy) to the circuit is called active element.
Examples of active elements include voltage and current sources, generators, and
Electronic devices that require power supplies.

There are three most basic circuit elements that we use to form different electrical and electronic circuits are **Resistor, Inductor** and **Capacitor**.

Resistance (R): A resistance is the property of a resistor (passive element) that opposes the flow of current through it. Units: ohm (Ω)

Fixed Resistor



Variable Resistor

Resistor

The resistance offered by a conducting material varies as follows:

It is directly proportional to its length.
It is inversely proportional to the conductor's cross-sectional area.
It depends on the nature of the material.
It is also affected by the conductor's temperature.
Thus, the resistance R offered by the conductor is given by,

$R = \rho l/A$

where l is the length of the conductor, A is the cross-sectional area and ρ is a constant of the material, generally known as the specific resistance or resistivity of the material. The resistivity of a material depends on its nature and the temperature of the conductor, but not on its shape and size.

Inductance(L): An inductance is the property of inductor(a passive element) that stores energy in form of the electromagnetic field. Units: Henry (H)

Inductor Symbol

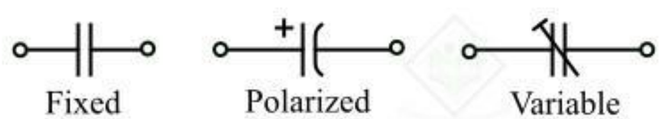
Inductor

The voltage across an inductor is proportional to the rate of change of current flowing through it.

e=L * di/dt

Here, e= voltage, L is the self-inductance. di/dt =rate of change of current

Capacitance(C): A capacitance is the property of capacitor (a passive element) that stores energy in form of the electrostatic field. The voltage across a capacitor is proportional to the charge. Units: Farads (F)



Capacitor Symbols

Capacitor

The current through the capacitor is proportional to the rate of change of voltage applied. Capacitive current, I = C * dV/dt.

Here, I= current, C is the Capacitance. dV/dt =rate of change of voltage

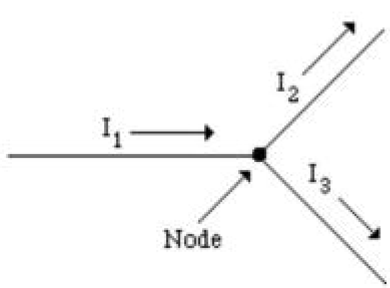
Ohm's law: This law states that the current in a circuit is directly proportional to the potential difference across the circuit and inversely proportional to the resistance in the circuit.

Mathematically, this can be expressed as **I = V / R**

Limitations of Ohm's law:

1. Ohm's law is applicable when the temperature of the conductor is constant. Resistivity changes with temperature.
2. The relation between voltage and current depends on the sign of voltage.
3. It does not apply to semiconductors, which do not have a direct current-voltage relationship.
4. ohm's law is not applicable to unilateral electrical elements like diodes and transistors as they allow the current to flow through in one direction only.
5. Ohm's law is only applicable to metallic conductors.

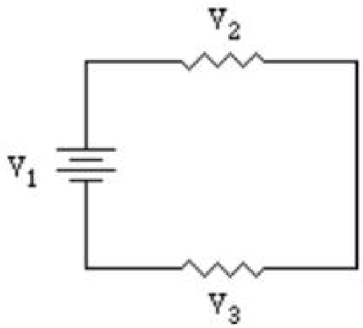
Kirchoff's current law : This law states that the algebraic sum of all currents at a node(junction point) is zero. Currents coming into a node are considered negative and currents leaving a node are considered positive.



For the situation in figure , we have -I1 + I2 + I3 = 0 or I1 = I2 + I3

This is a statement of the law of conservation of charge. Since no charge may be stored at a node and since charge cannot be created or destroyed at the node, the total current entering a node must equal the total current out of the node.

Kirchoff's voltage law: This law states that the algebraic sum of all the changes in potential (voltages) around a loop must equal zero. A potential difference is considered negative if the potential is getting smaller in the direction of the current flow.



For the situation in figure , we have +V1 - V2 - V3 = 0 or V1 = V2 + V3

This is a statement of the law of conservation of energy. Since potential differences correspond to energy changes and since energy cannot be created or destroyed in ordinary electrical interactions, the energy dissipated by the current as it passes through the circuit (V2 + V3) must equal the energy given to it by the power supply (V1)

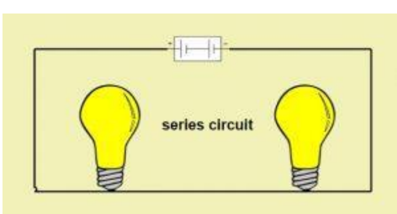
Types of Electrical Circuits

DC Circuits

In DC Circuits, the excitation applied is a constant source. Based on the type of connection of active and passive components with the source, a circuit can be classified into Series and Parallel circuits.

Series Circuits

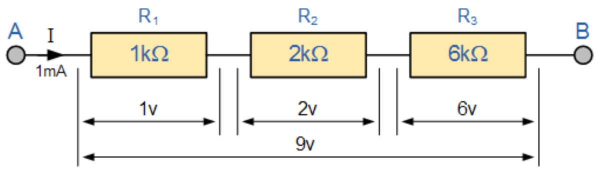
When several passive elements are connected in series with an energy source, such a circuit is known as a series circuit. For a series circuit, same amount of current flows through each element and voltage is divided. In series circuit, as the elements are connected in a line,if there is faulty element among them ,complete circuit acts as open circuit.



For a resistor connected in DC circuits, the voltage across its terminals is directly proportional to the current passing through it, thus maintaining a linear relationship between the voltage and current.

Series Resistor Circuit:

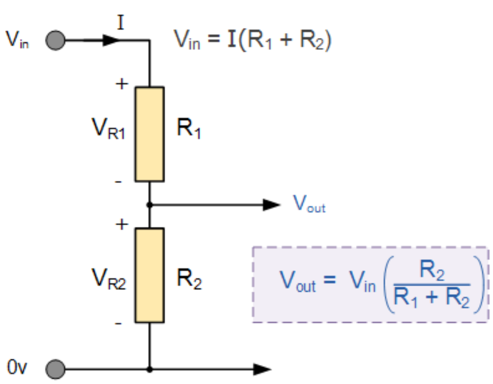
For resistors connected in series, the total resistance is equal to the sum of all resistance values.



$$R_T = R_1 + R_2 + R_3$$

Req = R1 + R2 + R3 = 1kΩ + 2kΩ + 6kΩ = 9kΩ

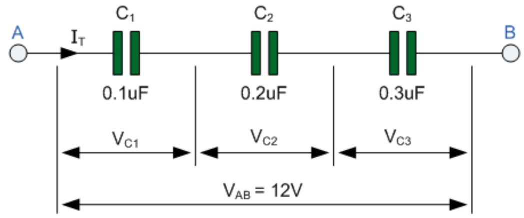
Voltage Divider Network:



The voltage across a resistor in series circuit is given by total voltage times the ratio of that resistance value to sum of resistance values.

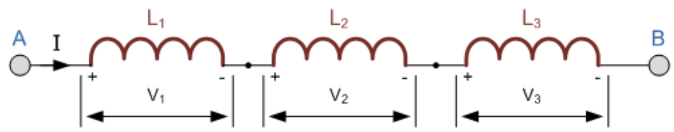
Similarly for other elements in series circuits,

For capacitors connected in series, the total capacitance is equal to the sum of reciprocals of all capacitance values.



$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots \text{etc}$$

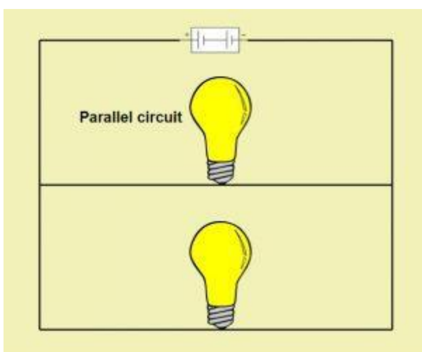
For inductors connected in series, total inductance is equal to the sum of all inductance values.



Ltotal = L1 + L2 + L3 + ….. + Ln etc

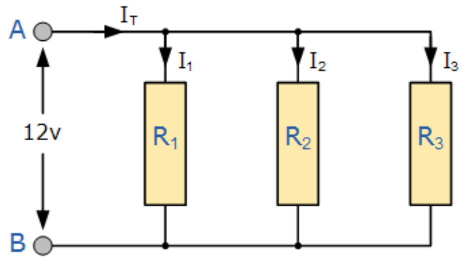
Parallel Circuits

In a parallel circuit, one terminal of all the elements is connected to the one terminal of the source and the other terminal of all elements is connected to the other terminal of the source.



In parallel circuits, the voltage remains the same in the parallel elements while the current changes. If there is any faulty element among parallel elements there is no effect on the circuit.

Resistors in Parallel:

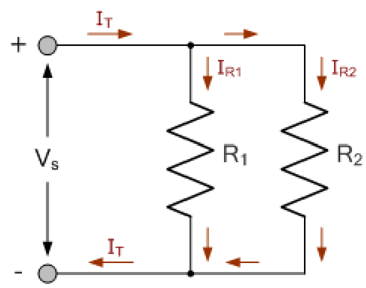


$$V_{R1} = V_{R2} = V_{R3} = V_{AB} = 12V$$

Parallel Resistor Equation $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots\ldots + \frac{1}{R_n}$ etc

For resistors connected in parallel, the total resistance is equal to the sum of reciprocals of all resistance values.

Currents in a Parallel Resistor Circuit (current division rule):

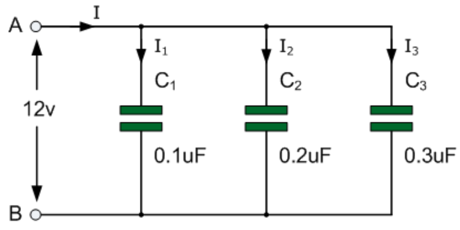


The current in a resistor in parallel circuit is given by total current times the ratio of opposite resistance value to sum of resistance values.

$$\therefore I_{R1} = I_T\left(\frac{R_2}{R_1 + R_2}\right) \qquad \therefore I_{R2} = I_T\left(\frac{R_1}{R_1 + R_2}\right)$$

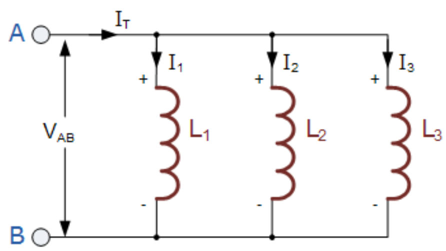
Similarly for other elements in parallel circuits,

For capacitors connected in parallel, the total capacitance is equal to the sum of all capacitance values.



$$C_T = C_1 + C_2 + C_3 + \ldots.etc$$

For inductors connected in parallel, total inductance is equal to the sum of all reciprocals of inductance values.



$$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} \ldots\ldots + \frac{1}{L_N}$$

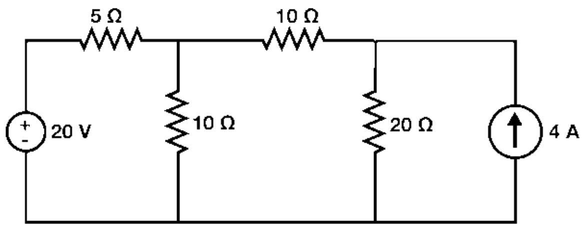
Superposition theorem:

"In any linear and bilateral network or circuit having multiple independent sources, the response of an element will be equal to the algebraic sum of the responses of that element by considering one source at a time."

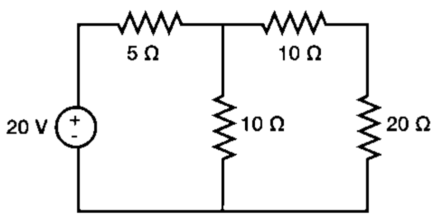
Procedure to Apply Superposition Theorem:

1. The first step is to select one among the multiple sources present in the bilateral network.
2. Except for the selected source, all the sources must be replaced by their internal impedance.
3. Using a network simplification approach, evaluate the current flowing through or the voltage drop across a particular element in the network.
4. The same considering a single source is repeated for all the other sources in the circuit.
5. Upon obtaining the respective response for individual source, perform the summation of all responses to get the overall voltage drop or current through the circuit element.

Pb1. Find the current flowing through 20 Ω using the superposition theorem?

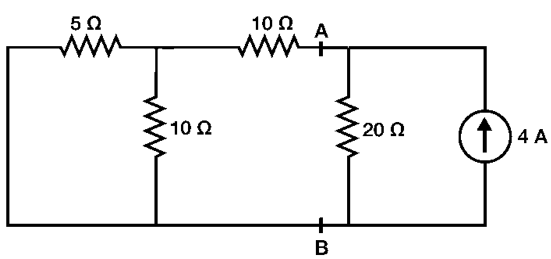


Step 1: First, let us find the current flowing through a circuit by considering only the 20 V voltage source. The current source can be open-circuited, hence, the modified circuit diagram is shown in the following figure.

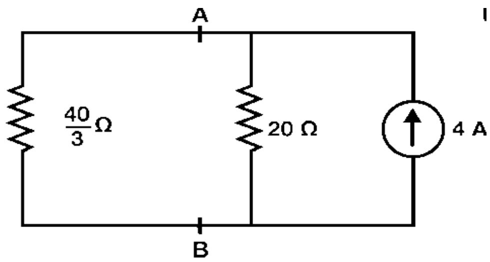


Step2: finding current (I1) through 20 ohm resistor using network reduction techniques. Therefore, the current flowing through the 20 Ω resistor to due 20 V voltage source is 0.4 A.

Step 3: Now let us find out the current (I2) flowing through the 20 Ω resistor considering only the 4 A current source. We eliminate the 20 V voltage source by short-circuiting it. The modified circuit, therefore, is given as follows:



the simplified circuit is shown as follows:



The current flowing through the 20 Ω resistor can be determined using the current division principle. Therefore, the current flowing through the circuit when only 4 A current source is 1.6 A.

Step 4: The summation of currents I1 and I2 will give us the current flowing through the 20 Ω resistor. Mathematically, this is represented as follows:

I = I1 + I2

Substituting the values of I1 and I2 in the above equation, we get

I = 0.4+1.6 = 2 A

Therefore, the current flowing through the resistor is 2 A.

Annexure-I

1. **Differences between Series and Parallel Circuit**

Sl no	Series Circuit	Parallel Circuit
1.	A circuit is called a series circuit when the flow of current remains the same in all components .A circuit is called a series circuit when the flow of current remains the same in all components	Parallel circuit refers to the circuit having two or more than two paths.
2.	In this circuit all the components are arranged in a single line	In this circuit, components are arranged parallel to each other

3.	In a series circuit, R=R1+R2+R3R=R1+R2+R3	In a parallel circuit, R=1/R1+1/R2+1/
4.	In the case of this circuit, if V is total voltage then the equation will be V1+V2+V3V1+V2+V3.	In a parallel circuit, if V is total voltage then the equation will be V1=V2=V3V1=V2=V3.
5.	The fault at a point of the circuit can break the total circuit.	It does not affect the total circuit.

2. What is the difference between mesh and nodal analysis?

The difference between mesh and nodal analysis is that nodal analysis is an application of Kirchhoff's current law, which is used for calculating the voltages at each node in an equation. While mesh analysis is an application of Kirchhoff's voltage law which is used for calculating the current.

Mesh Analysis	Nodal Analysis
This method is used to determine the current circulating a mesh or loop in a closed path of any electrical circuit.	This method is used to determine the unknown voltage drop around the circuit between two or more nodes.
It is also known as Mesh Current analysis or mesh loop analysis	It is also known as node voltage method or node voltage analysis or supernode analysis
It is based on Kirchhoff's Voltage Law(KVL)	It is based on Kirchhoff's current law(KCL)
It is applicable for planar circuits.	It is applicable for parallel circuits with a ground terminal.

AC CIRCUITS

Equation of AC voltage & current:

An alternating voltage is any voltage that varies in both magnitude and polarity with respect to time. At any instant, the instantaneous value of the sine wave equals the product of the maximum value of the sine wave and the sine of the angle corresponding to time.

The equation for a sine wave of voltage is

$$v = V_m \sin \theta$$

v = Instantaneous value of alternating voltage
Vm= Max. value of alternating voltage θ is any angle.

An alternating current is any current that varies in both magnitude and direction with respect to time. At any instant, the instantaneous value of the sine wave equals the product of the maximum value of the sine wave and the sine of the angle corresponding to time. The equation for a sine wave of current is $i = I_m \sin \theta$

i = Instantaneous value of alternating current
Im= Max. value of alternating current,
θ is any angle.

WAVEFORM

The path traced by a quantity (such as voltage or current) plotted as a function of some variable (such as time, degree, radians etc.) is called waveform.

CYCLE

1. One complete set of positive and negative values of alternating quality (such as voltage and current) is known as cycle.
2. The portion of a waveform contained in one period of time is called cycle.

PERIOD

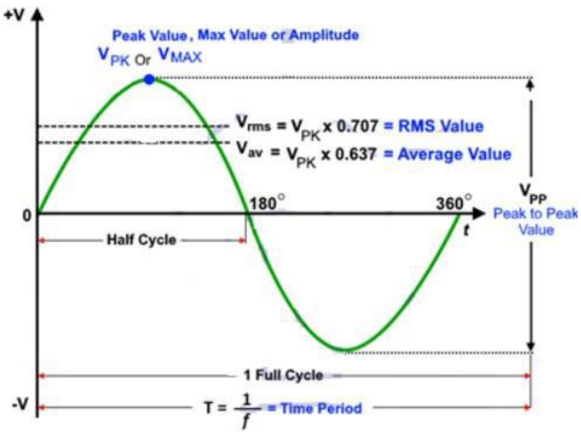
The time taken by an alternating quantity (such as current or voltage) to complete one cycle is called its time period "T".
It is inversely proportional to the Frequency "f" and denoted by "T" where the unit of time period is Second.
Mathematically; T = 1/f

FREQUENCY

Frequency is the number of cycles passed through per second. It is denoted by "f" and has the unit cycle per second i.e. Hz (Herts).
The number of completed cycles in 1 second is called frequency. f = 1/T

AMPLITUDE

The maximum value, positive or negative, of an alternating quantity such as voltage or current is known as its amplitude. Its denoted by V_P, I_P or E_{MAX} and I_{MAX}.



AVERAGE VALUE:

The arithmetical average of all the instantaneous values of an alternating quantity over one cycle is known as the "Average Value of Alternating Quantity".

$$\textit{Average value} = \frac{\textit{sum of all instantaneous values over one cycle}}{\textit{Number of instants}}$$

RMS VALUE:

The value of an AC which will produce the same amount of heat while passing through in a heating element (such as resistor) as DC produces through the element is called R.M.S Value.

For a sinusoidal wave

$$I_{RMS} = \frac{I_M}{\sqrt{2}} , \quad V_{RMS} = \frac{V_M}{\sqrt{2}}$$

$$I = 0.707 \times I_M , V = 0.707 \times V_M$$

PEAK FACTOR:

Peak Factor is also known as Crest Factor or Amplitude Factor.

It is the ratio between maximum value and RMS value of an alternating wave.

$$\textbf{Peak Factor} = \frac{\text{Maximum Value}}{\text{R.M.S Value}}$$

For a sinusoidal alternating voltage:

$$\frac{E_M}{0.707\,E_M} = 1.414$$

For a sinusoidal alternating current:

$$\frac{I_M}{0.707\,I_M} = 1.414$$

FORM FACTOR:

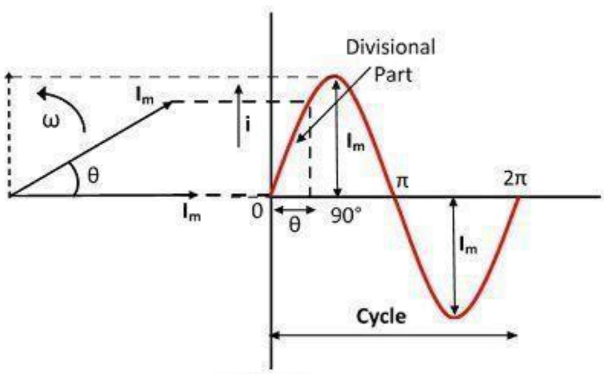
The ratio between RMS value and Average value of an alternating quantity (Current or Voltage) is known as Form Factor.

$$\text{Form Factor} = \frac{\text{RMS Value}}{\text{Average Value}}$$

$$= \frac{0.707\,E_M}{0.637\,E_M} \text{ Or } \frac{0.707\,I_M}{0.637\,I_M} = 1.11$$

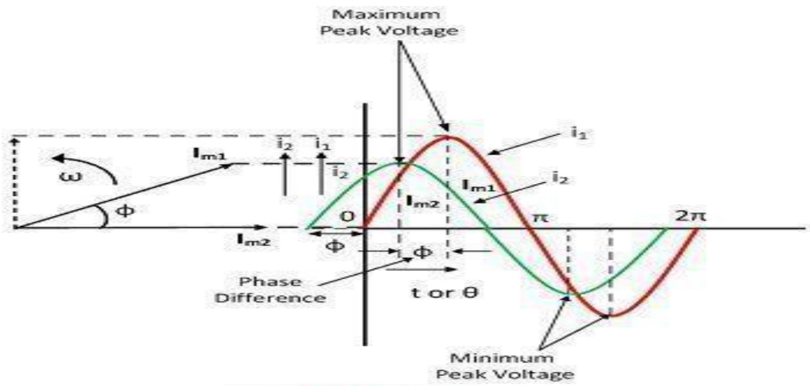
PHASE

The phase of an alternating quantity is defined as the divisional part of a cycle through which the quantity moves forward from a selected origin.



PHASE DIFFERENCE

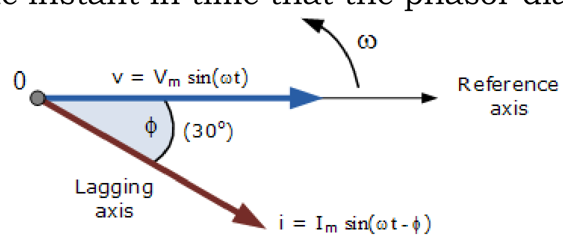
The phase difference between the two electrical quantities is defined as the angular phase difference between the maximum possible value of the two alternating quantities having the same frequency.



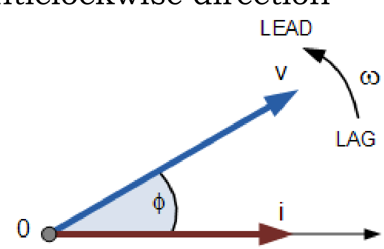
The quantity which attains its +ve maximum value before the other is called a leading quantity, whereas the quantity which reaches its maximum positive value after the other, is known as a lagging quantity.

Relationship between voltage and current for R, L, C

Phasor Diagrams are a graphical way of representing the magnitude and directional relationship between two or more alternating quantities. The lengths of the phasors are proportional to the values of the voltage, (V) and the current, (I) at the instant in time that the phasor diagram is drawn.



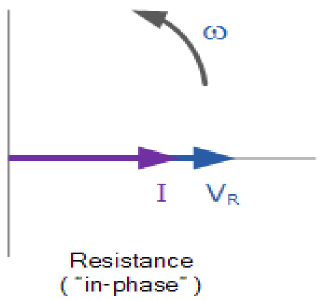
The current phasor lags the voltage phasor by the angle, Φ, as the two phasors rotate in an anticlockwise direction



The voltage phasor is “leading” the current phasor by angle, Φ.

Resistor

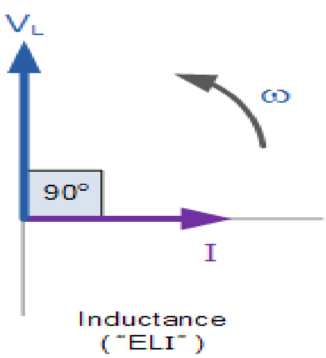
In case of resistor, the voltage and the current are in same phase or we can say that the phase angle difference between voltage and current is zero. The vector diagrams will therefore have the current vector as their reference with the resistive voltage vectors being plotted with respect to this reference as shown below.



$$i(t) = \frac{v(t)}{R} = \frac{V}{R} \sin \omega t$$

Inductor:

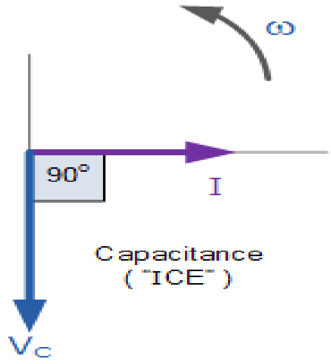
In inductor, the voltage and the current are not in phase. The voltage leads that of current by 90° or in the other words, voltage attains its maximum and zero value 90° before the current attains it. The vector diagrams will therefore have the current vector as their reference with the inductive voltage vectors being plotted with respect to this reference as shown below.



$$i(t) = \frac{1}{L} \int v(t)\, dt = \frac{1}{\omega L} \int V \sin \omega t \; d(\omega t)$$
$$= \frac{V}{\omega L}(-\cos \omega t) = -\frac{V}{\omega L} \sin(90^\circ - \omega t)$$
$$= \frac{V}{\omega L} \sin(\omega t - 90^\circ)$$

Capacitor:

In case of capacitor, the current leads the voltage by 90° or in the other words, voltage attains its maximum and zero value 0° after the current attains it i.e the phasor diagram of capacitor is exactly opposite of inductor. The vector diagrams will therefore have the current vector as their reference with the capacitive voltage vectors being plotted with respect to this reference as shown below.



$$i(t) = C\frac{dv(t)}{dt} = C\frac{d(V\sin\omega t)}{dt}$$
$$= \omega CV\cos\omega t = \omega CV\sin(90^\circ - \omega t)$$

CONCEPT OF IMPEDANCE:

Impedance

Impedance(Z) is a measure of the opposition to electrical flow including both resistance and reactance. It is measured in ohms.

In AC systems, the "reactance" enters the equation due to the frequency-dependent contributions of capacitance and inductance.

The value of impedance is represented as

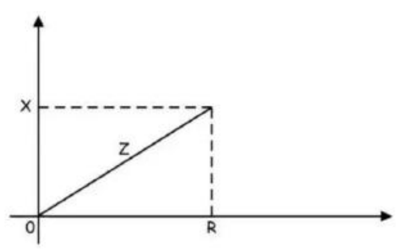
$$Z = \sqrt{R^2 + X^2}$$

Where R is the value of circuit resistance and X is the value of circuit reactance.

Impedance can be represented in complex form.

This is

$$Z = R + jX$$



The real part of complex impedance is resistance and the imaginary part is reactance of the circuit.

ACTIVE POWER

The power which is actually consumed or utilised in an AC Circuit is called True power or Active power or Real power.

It is measured in kilowatt (kW) or MW.

Active power P = V x I cosϕ = V I cosϕ

REACTIVE POWER

The power which flows back and forth that means it moves in both the directions in the circuit is called Reactive Power.

The reactive power is measured in kilo volt-ampere reactive (kVAR) or MVAR.

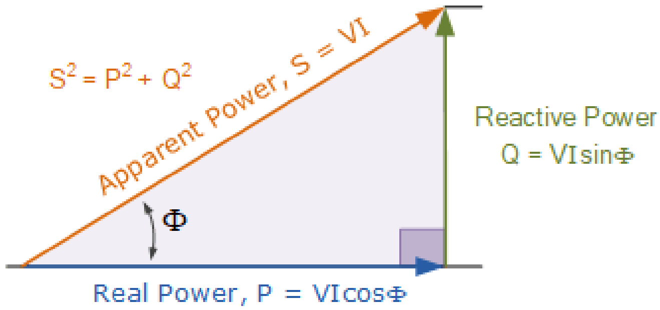
Reactive power Q = V x I sinϕ = V I sinϕ

APPARENT POWER

The product of root mean square (RMS) value of voltage and current is known as Apparent Power.

This power is measured in kVA or MVA.

Apparent power S = V x I = VI



POWER FACTOR

Power factor is defined as the ratio of real power (P) to apparent power (S)

Also, Power factor defines the phase angle between the current and voltage waveforms, where I and V are the magnitudes of RMS values of the current and voltage respectively.

$$\text{Power Factor}(pf) = \frac{\text{Real Power}(P)\text{ in Watts}}{\text{Apparant Power}(S)\text{ in volt-amps}}$$

$$= \frac{P}{S} = \frac{VI\cos\phi}{VI} = \cos\phi$$

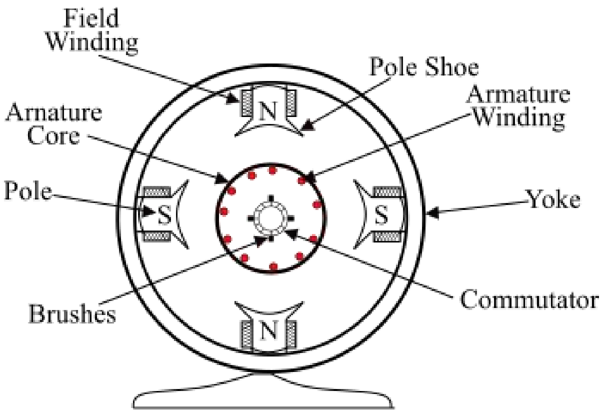
Unit-2: Machines and Measuring Instruments

Machines: Construction, principle and operation of (i) DC Motor, (ii) DC Generator, (iii) Single Phase Transformer, (iv) Three Phase Induction Motor and (v) Alternator, Applications of electrical machines.

Measuring Instruments: Construction and working principle of Permanent Magnet Moving Coil (PMMC), Moving Iron (MI) Instruments and Wheat Stone bridge.

DC machine Construction:

Based on the working principal DC motor & generator, requirement for the both machines are magnetic fields, conductor & mechanical movement. So, construction wise both motor & generator are same. Depends upon the types of input (electrical or mechanical) given to the machines it should be differentiated by either motor or generator.



A DC machine consists of six main parts, which are as follows

Yoke

The outer frame of a DC machine is a hollow cylinder made up of cast steel or rolled steel is known as yoke. The yoke serves following two purposes

- It supports the field pole core and acts as a protecting cover to the machine.
- It provides a path for the magnetic flux produced by the field winding.
-

Magnetic Field System

The magnetic field system of a DC machine is the stationary part of the machine. It produces the main magnetic flux in the generator. It consists of an even number of pole cores bolted to the yoke and field winding wound around the pole core. The field system of DC machine has salient poles i.e. the poles project inwards and each pole core has a pole shoe having a curved surface. The pole shoe serves two purposes

- It provides support to the field coils.
- It reduces the reluctance of magnetic circuit by increasing the cross-sectional area of it.

The pole cores are made of thin laminations of sheet steel which are insulated from each other to reduce the eddy current loss. The field coils are connected in series with one another such that when the current flows through the coils, alternate north and south poles are produced in the direction of rotation.

Armature Core

The armature core of DC machine is mounted on the shaft and rotates between the field poles. It has slots on its outer surface and the armature conductors are put in these slots. The armature core is a made up of soft iron laminations which are insulated from each other and tightly clamped together. In small machines, the laminations are keyed directly to the shaft, whereas in large machines, they are mounted on a spider. The laminated armature core is used to reduce the eddy current loss.

Armature Winding

The insulated conductors are put into the slots of the armature core. The conductors are suitably connected. This connected arrangement of conductors is known as armature winding. There are two types of armature windings are used – wave winding and lap winding.

Commutator

A commutator is a mechanical rectifier which converts the alternating emf generated in the armature winding into the direct voltage across the load terminals. The commutator is made of wedge-shaped copper segments insulated from each other and from the shaft by mica sheets. Each segment of commutator is connected to the ends of the armature coils.

Brushes

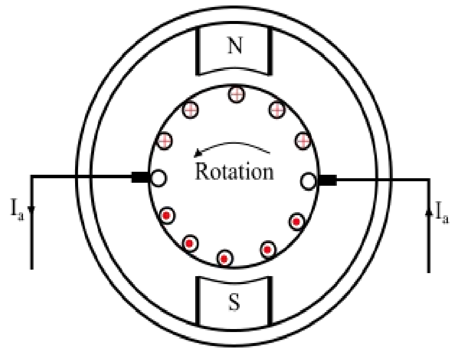
The brushes are mounted on the commutator and are used to collect the current from the armature winding. The brushes are made of carbon and is supported by a metal box called brush holder. The pressure exerted by the brushes on the commutator is adjusted and maintained at constant value by means of springs. The current flows from the armature winding to the external circuit through the commutator and carbon brushes.

DC Motor:

DC motor is an electrical machine that converts electrical energy into mechanical energy. DC motor working is based on the principle that when a current carrying conductor is placed in a magnetic field, it experiences a mechanical force. The direction of the mechanical force is given by Fleming's Left-hand Rule and its magnitude is given by F = BIL Newton.

Working of DC Motor

Consider a two pole DC motor as shown in the figure. When the DC motor is connected to an external source of DC supply, the field coils are excited developing alternate N and S poles and a current flow through the armature windings.



All the armature conductors under N pole carry current in one direction (say into the plane of the paper), whereas all the conductors under S pole carry current in the opposite direction (say out of the plane of the paper). As each conductor carrying a current and is placed in a magnetic field, hence a mechanical force acts on it.

By applying Fleming's left hand rule, it can be seen that the force on each conductor is tending to move the armature in anticlockwise direction. The force on all the conductors add together to exert a torque which make the armature rotating. When the conductor moves from one side of a brush to the other, the current in the conductor is reversed and at the same time it comes under the influence of next pole of opposite polarity. As a result of this, the direction of force on the conductor remains the same. Therefore, the motor being rotating in the same direction.

Significance of back EMF:

This induced emf in the armature always acts in the opposite direction of the supply voltage. This is according to the Lenz's law which states that the direction of the induced emf is always so as to oppose the cause producing it. So as this emf always oppose the supply voltage, it is called back emf. And denoted as Eb.

Voltage Equation of a DC motor:

V = Eb +IaRa+ Brush drop
Neglecting brush drop, then V = Eb +IaRa

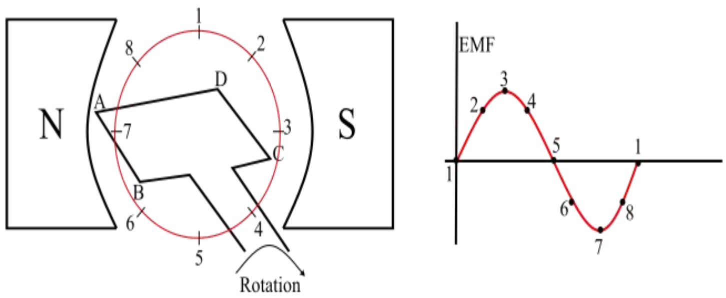
DC Generator

A DC generator is an electromechanical energy conversion device that converts mechanical power into DC electrical power through the process of electromagnetic induction.

A DC generator operates on the principle of electromagnetic induction i.e. when the magnetic flux linking a conductor changes, an EMF is induced in the conductor. Direction of the induced e.m.f can be determined using Fleming's right hand rule.

Working of a DC Generator

Consider a single loop DC generator (as shown in the figure), in this a single turn loop 'ABCD' is rotating clockwise in a uniform magnetic field with a constant speed. When the loop rotates, the magnetic flux linking the coil sides 'AB' and 'CD' changes continuously. This change in flux linkage induces an EMF in coil sides and the induced EMF in one coil side adds the induced EMF in the other.



The EMF induced in a DC generator can be explained as follows

- When the loop is in position-1, the generated EMF is zero because, the movement of coil sides is parallel to the magnetic flux.
- When the loop is in position-2, the coil sides are moving at an angle to the magnetic flux and hence, a small EMF is generated.
- When the loop is in position-3, the coil sides are moving at right angle to the magnetic flux, therefore the generated EMF is maximum.
- When the loop is in position-4, the coil sides are cutting the magnetic flux at an angle, thus a reduced EMF is generated in the coil sides.
- When the loop is in position-5, no flux linkage with the coil side and are moving parallel to the magnetic flux. Therefore, no EMF is generated in the coil.
- At the position-6, the coil sides move under a pole of opposite polarity and hence the polarity of generated EMF is reversed. The maximum EMF will generate in this direction at position-7 and zero when at position-1. This cycle repeats with revolution of the coil.

It is clear that the generated EMF in the loop is alternating one. It is because any coil side (say AB) has EMF in one direction when under the influence of N-pole and in the other direction when under the influence of S-pole. Hence, when a load is connected across the terminals of the generator, an alternating current will flow through it. Now, by using a commutator, this alternating emf generated in the loop can be converted into direct voltage.

Induced E.M.F equation

Let

P = Number of poles in the filed systems
Φ = flux per pole (webers)
N = Speed of the armature(revolution per minute –rpm)
Z = Total number of conductors
= Number conductors X slot per conductor
A = parallel paths
For Lap winding, A=P Wave winding A=2

$$Einduced = \frac{ZN\emptyset}{60}\frac{P}{A}$$

Single Phase Transformers:

A transformer is “a static device which is used to transfer power from one electric circuit to other electric circuit at constant frequency and power”. Transformer operates on mutual inductance principle. During the power transfer, the voltages are either increase or decrease simultaneously the currents are decrease or increase to maintain constant power.

Construction Of a Transformer:

There are two basic parts of a transformer:

1. Magnetic core 2. Winding or coils

Magnetic Core: The core of a transformer is either square or rectangular in size. It is further divided in two parts. The vertical portion on which the coils are bound is called limb, while the top and bottom horizontal portion is called yoke of the core. Core is made up of laminations. Because of laminated type of construction, eddy current losses get minimized. Generally high-grade silicon steel laminations (0.3 to 0.5 mm thick) are used. These laminations are insulated from each other by using insulation like varnish. For this generally ‘L‘ shaped or ‘I‘ shaped laminations are used which are shown in the fig.

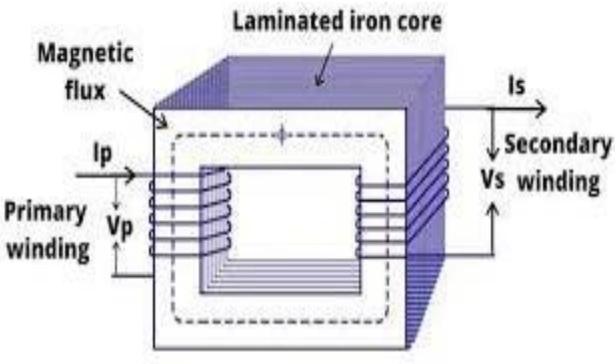
Transformer Core 'E-I' Lamination   Transformer Core 'L' Lamination

Winding:

There are two windings, which are wound on the two limbs of the core, which are insulated from each other and from the limbs as shown in fig. 4. The windings are made up of copper, so that, they possess a very small resistance. The winding which is connected to the load is called secondary winding and the winding which is connected to the supply is called primary winding. The primary winding has N1 number of turns and the secondary windings have N2 number of turns.

Principle of operation of a transformer:

A single-phase transformer works on the principle of mutual induction between two magnetically coupled coils. When the primary winding is connected to an alternating voltage of r.m.s value, V1 volts, an alternating current flow through the primary winding and setup an alternating flux in the material of the core. This alternating flux ϕ, links not only the primary windings but also the secondary windings. Therefore, an e.m.f e1 is induced in the primary winding and an e.m.f e2 is induced in the secondary winding.



Primary Winding

RMS value of induced EMF = $E_1 = 4.44\ f\Phi m * N_1$

Secondary Winding

RMS value of induced EMF = $E_2 = 4.44\ f\Phi m * N_2$

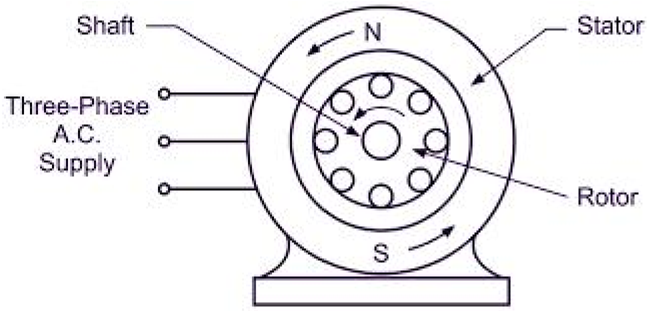
Three phase Induction motor:

A 3-phase induction motor has two main parts

Stator: The stator consists of a steel frame that encloses a hollow, cylindrical core made up of thin laminations of silicon steel

Rotor: The rotor, mounted on a shaft, is a hollow laminated core having slots on its outer periphery. The winding placed in these slots (called rotor winding) may be one of the following two types:

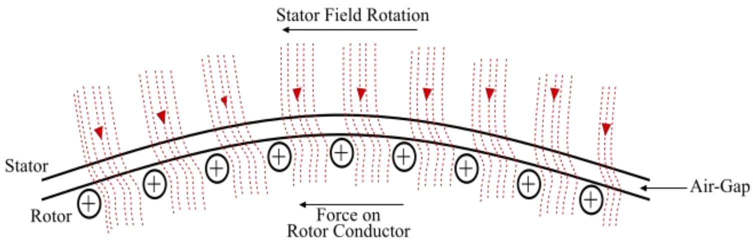
Squirrel Cage Type
Wound Rotor Type



The stator carries a 3-phase winding (called stator winding) while the rotor carries a short-circuited winding (called rotor winding).

Working Principle of a 3-Phase Induction Motor

The working principle of a 3-phase induction motor can be explained by considering a portion of it as follows



When the 3-phase stator winding is fed from a balanced 3-phase supply, a rotating magnetic field (RMF) is produced in the motor. This RMF rotates around the stator at synchronous speed which is given by,

Synchronous Speed, NS $= \frac{120f}{p}$

where N_S = Synchronous speed, f = frequency, P = Number of poles

The RMF passes through the air gap and cuts the rotor conductors, which as yet are stationary. Due to the relative motion between the RMF and the stationary rotor conductors, EMFs are induced in the rotor conductors. As the rotor circuit is closed with short-circuit so currents start flowing in the rotor conductors.

Since the current carrying rotor conductors are placed in the magnetic field produced by the stator winding. As a result, the rotor conductors experience mechanical force. The sum of the mechanical forces on all the rotor conductors produces a torque which moves the rotor in the same direction as the rotating magnetic field. Hence, in such a way the three-phase input electric power is converted into output mechanical power in a 3-phase induction motor.

Also, according to Lenz's law, the rotor should move in the direction of the stator field, i.e., the direction of rotor currents would be such that they tend to oppose the cause producing them. Here, the cause producing the rotor currents is the relative speed between the RMF and the rotor conductors. Thus, to reduce this relative speed, the rotor starts running in the same direction as that of the RMF.

Alternator (or) Synchronous Generator:

A synchronous generator is a synchronous machine which converts mechanical power into AC electric power through the process of electromagnetic induction. It is called synchronous generator because it must be driven at synchronous speed to produce AC power of the desired frequency.

Construction of Synchronous Generator or Alternator

As alternator consists of two main parts viz.

Stator – The stator is the stationary part of the alternator. It carries the armature winding in which the voltage is generated. The output of the alternator is taken form the stator.

Rotor – The rotor is the rotating part of the alternator. The rotor produces the main field flux.

For the alternator, there are two types of rotor constructions are used viz. the salient-pole type and the cylindrical rotor type.

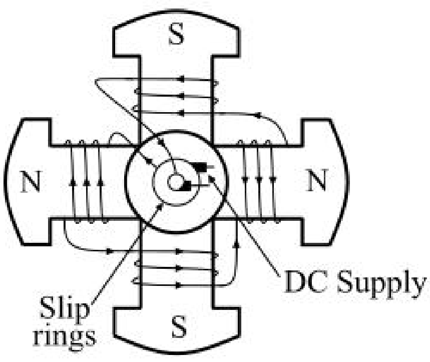


Fig. - Salient Pole Rotor

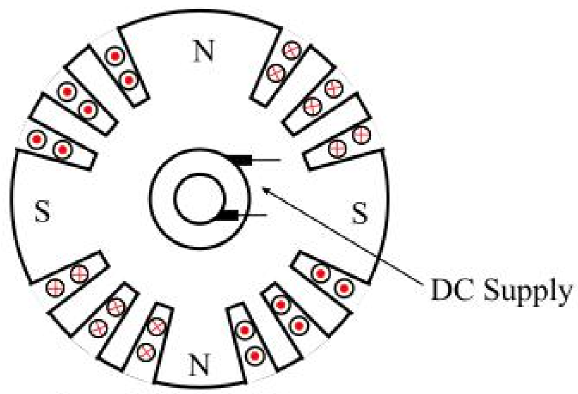


Fig. - Cylindrical Rotor

Working Principle and Operation of Alternator

principle of electromagnetic induction, i.e., when the flux linking a conductor change, an EMF is induced in the conductor. When the armature winding of alternator subjected to the rotating magnetic field, the voltage will be generated in the armature winding.

When the rotor field winding of the alternator is energised from the DC exciter, the alternate N and S poles are developed on the rotor. When the rotor is rotated in the anticlockwise direction by a prime mover, the armature conductors placed on the stator are cut by the magnetic field of the rotor poles. As a result, the EMF is induced in the armature conductors due to electromagnetic induction. This induced EMF is alternating one because the N and S poles of the rotor pass the armature conductors alternatively.

The direction of the generated EMF can be determined by the Fleming's right rule and the frequency of it is given by,

$f = N_s * P/120$

Where, N_s is the synchronous speed in RPM, P is the number of rotor poles.

The magnitude of the generated voltage depends upon the speed of rotation of the rotor and the DC field excitation current. For the balanced condition, the generated voltage in each phase of the winding is the same but differ in phase by 120° electrical.

Applications of electrical machines.

1. Motors: Electric motors are found in applications as diverse as industrial fans, blowers and pumps, machine tools, household appliances, power tools, and disk drives.

2. Generators: Generators are gadgets that are used as an alternative to the current supply. They are also used to meet power demands in industries like road construction, mining, offshore drilling, outdoor filming, event management, etc.

3. Transformers: Transformers are used in a variety of applications, including power generation, transmission and distribution, lighting, audio systems, and electronic equipment. Power generation: Transformers are used in power plants to increase the voltage of the electricity generated by the plant before it is sent to the grid.

In local areas, including residential homes, a transformer that steps down the high voltages to lower voltages is contained. This stepping down of voltage fits the voltage use of some of the household appliances including stoves, air conditioners, laptops, heaters, and televisions.

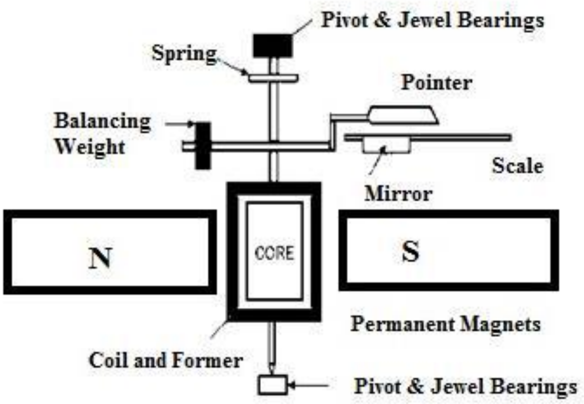
Measuring Instruments

PMMC Instrument

Definition: The instruments which use the permanent magnet for creating the stationary magnetic field between which the coil moves is known as the permanent magnet moving coil or PMMC instrument. It operates on the principle that the torque is exerted on the moving coil placed in the field of the permanent magnet. The PMMC instrument gives the accurate result for DC measurement.

Construction of PMMC Instrument

PMMC instrument diagram :



Moving Coil:

PMMC instruments consist of a light rectangular shape coil having many turns of fine wire that wound on an aluminium former inside which an iron core placed.

The coil is placed upon a jewel bearing and mounted between the pole of the permanent magnet.

Magnet system:

Two permanent magnets made of the soft iron cylinder are used.

Control Spring:

The current led into and out of the moving coil using two control springs which are mounted one above and one below the coil these control springs provide the controlling torque.

Damping Torque:

The damping torque in PMMC instruments is provided by eddy current induced in aluminium former. the aluminium former is responsible for producing damping torque.

Pointer and Scale arrangement:

When the PMMC instrument is connected in circuit to measure current or voltage, the operating current start flowing through the coil, since the coil is carrying current and is kept in the magnetic field of the perma nent magnet. It experiences force and starts moving.

Hence the pointer attached to the moving system moves clockwise direction over the scale to indicate the value of current or voltage to be measured.

Working of permanent magnet moving coil (PMMC) instrument

The working principle of the PMMC instrument is based on Faraday's law of electromagnetic induction. When the current carrying conductor is kept in the magnetic field it experiences force hence the force exerted on the moving coil due to the magnetic field is directly proportional to the current flowing through the conductor or coil.

PMMC instruments are used only for DC measurements and are more accurate and reliable.

The magnetic field in the air gap is radial due to the soft iron core. when measuring current flows through the coil, a constant defecting torque Td act on the coil.

Td=BINA N/m

Where,

B= Flux density in wb/m2
I= Current through the coil
N= number of turns in coil
A= Area of coil

Moving Iron or MI Instrument:

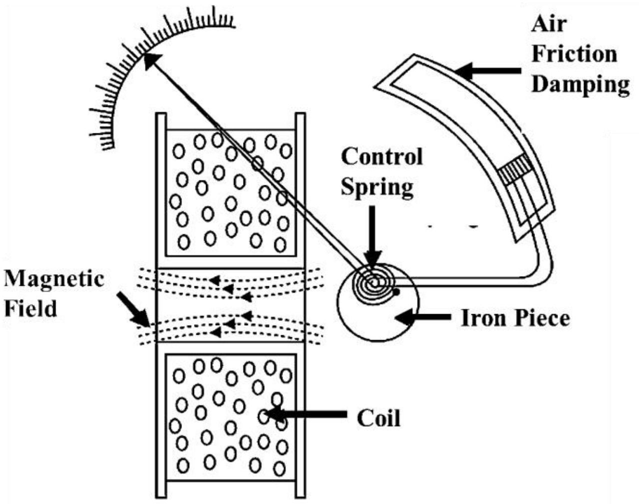
Definition: The moving iron type instruments are one of the types of measuring instruments used for measuring voltage or current. These instruments use a movable piece of iron placed in the magnetic field that deflects the pointer over the scale and hence named moving iron instrument.

There are two types of moving iron (MI) instruments. They are, attraction type and repulsion type moving iron instruments. In this article let us learn about attraction type moving iron instrument.

Attraction type M.I. instrument

Construction: The moving iron fixed to the spindle is kept near the hollow fixed coil (Fig.). The pointer and balance weight are attached to the spindle, which is supported with jewelled bearing. Here air friction damping is used.

In this instrument there is only one piece of iron under the influence of magnetic field of the coil. The iron piece, which is movable may be of any shape, but usually OVAL shape is preferred, as it gives uniform scale to the instrument. To the iron piece, a pointer is attached, which can move on a calibrated scale. See Fig.

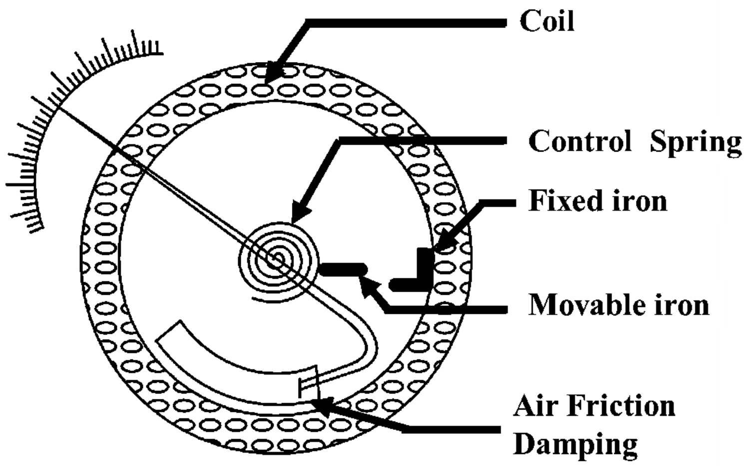


When the current flows through the coil, a magnetic field is developed and the iron piece experiences an attractive force and moves into the coil: as a result the pointer also moves on the scale. When the instrument is removed from the circuit, no current flows through the coil no magnetic field and the iron piece comes out of the coil to its original position. The controlling torque may be provided by spring or by gravity weight. The damping is provided through pneumatic (air friction) method.

Repulsion type moving iron instrument

Construction: The repulsion type instrument has a hollow fixed iron attached to it . The moving iron is connected to the spindle. The pointer is also attached to the spindle in supported with jewelled bearing.

In this instrument, there are two pieces of iron placed in the magnetic field of a coil. One of the pieces is fixed while the other is movable with which a light aluminium pointer is attached (see Figure).



When there is no current in the coil, the two iron pieces are almost touching each other and the pointer rests at the zero position of the scale. When the current (or a current proportional to the voltage) to be measured is passed through the coil, a magnetic field is produced and the two iron pieces are magnetized in the same direction. The free piece experiences a repulsive force from the fixed piece and moves with the result, that the pointer attached with the moving piece shows deflection on the scale. The pointer comes to rest when repulsive torque (deflecting force) and the controlling torque provided by spring become equal. The damping is provided by air friction (pneumatic) method. Eddy current dumping is not possible as it will need a permanent magnet which will affect the magnetic field of the coil.

Wheatstone Bridge

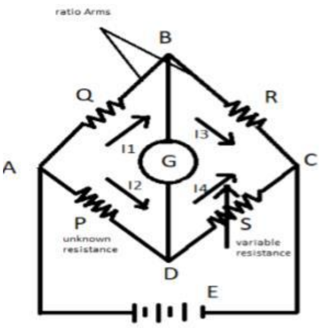
Definition: Wheatstone bridge is a type of dc bridge that is used for the measurement of unknown resistance. It is a series-parallel combination of 4 resistances that provides zero difference voltage at the balanced condition. The principle of null indication is the basis of working of Wheatstone bridge and thus provides high accuracy in measurements.

It consists of four resistances, out of which 2 are known resistances, one is variable resistance that is used to balance the bridge and another one is unknown resistance whose value is to be measured.

Under the balanced condition, the ratio of the values of two known resistances becomes equivalent to the ratio of the variable resistance and the unknown resistance value. Thus, allows us to calculate the unknown value of the resistance employed in the electrical circuit.

Circuit construction and theory of Wheatstone bridge

The figure below shows the general circuit of the Wheatstone bridge. It consists of 4 arms namely AC, AD, BC and BD each containing resistance R1, R2, R3 and R4. Here, R2 is the variable resistance and R4 is the unknown resistance.
A galvanometer is placed at one arm which detects the flow of current through the circuit on providing the supply voltage at another arm of the circuit.



The mechanism of the Wheatstone bridge

A potential difference is applied across AC when the Wheatstone bridge is unbalanced and current flows through the galvanometer. The resistance Q, R and S must be varied to achieve a balanced state. The potential difference across AB should equal the potential difference across AD. Then no current will pass, and the galvanometer will show zero deflection. The flow of current is marked in the diagram. Let us find the unknown current P.

Underbalanced conditions, the potential difference across AB is equal to that of AD.

as V=IR ------------- equation (i).

Now when the Wheatstone bridge is balanced, we can also write:

$I1 = I3 = E/Q+R$ and,

$I2 = I4 = E/P+S$

Now, equating the value of I1 and I2 in equation (i).

$E/(Q+R)x\ Q = E/(P+S)\ x\ P$

Or, $Q/Q+R = 1/(P+S/P)$

Or, $S/P = (Q+R-Q)/Q$

Or, $S/P = R/Q$

Or, $P = QS/R$

Here,

P= unknown resistance

Q and R= known resistance

S= variable resistance

Unit-3

Energy Resources: Conventional and non-conventional energy resources; Layout and operation of various Power Generation systems: Hydel, Nuclear, Solar & Wind power generation.

Electricity bill: Power rating of household appliances including air conditioners, PCs, Laptops, Printers, etc. Definition of “unit” used for consumption of electrical energy, two-part electricity tariff, calculation of electricity bill for domestic consumers.

Equipment Safety Measures: Working principle of Fuse and Miniature circuit breaker (MCB), merits and demerits. Personal safety measures: Electric Shock, Earthing and its types, Safety Precautions to avoid shock

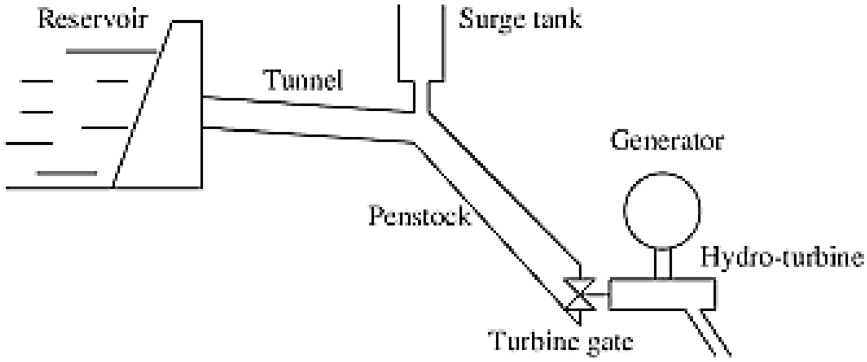
---

Conventional and non-conventional energy resources:

Conventional sources of energy	Non-conventional sources of energy
Fossil fuel, CNG, coal, oil, natural gas are the examples of the conventional sources of energy.	Solar Energy, Wind Energy, Bio Energy, Tidal Energy, Ocean Energy are the examples of non-conventional energy resources.
The conventional sources of energy are non-renewable by any natural process.	Non-conventional energy resources are renewable.
Conventional sources of energy available in limited quantity in nature.	Since non-conventional sources are renewable, hence they available in abundance in nature.
Most of the conventional energy sources pollute the environment and cause global warming.	Non-conventional energy sources are environment friendly and do not cause pollution.

Layout & working of Hydel power plant

Hydroelectric power plant (Hydel plant) utilizes the potential energy of water stored in a dam built across the river. The potential energy of the stored water is converted into kinetic energy by first passing it through the penstock pipe. The kinetic energy of the water is then converted into mechanical energy in a water turbine. The turbine is coupled to the electric generator. The mechanical energy available at the shaft of the turbine is converted into electrical energy by means of the generator.



Dam/Reservoir:

The purpose of the dam is to store the water and to regulate the outgoing flow of water. It also helps to increase the head of the water.

Penstock:

A penstock is a huge steel pipe which carries water from the reservoir to the turbine. Potential energy of the water is converted into kinetic energy as it flows down through the penstock due to gravity.

Surge tank:

A surge tank is a small tank in which the water level rises or falls due to sudden changes in pressure. This sudden rise of pressure in the penstock pipe is known as water hammer.

Water Turbine:

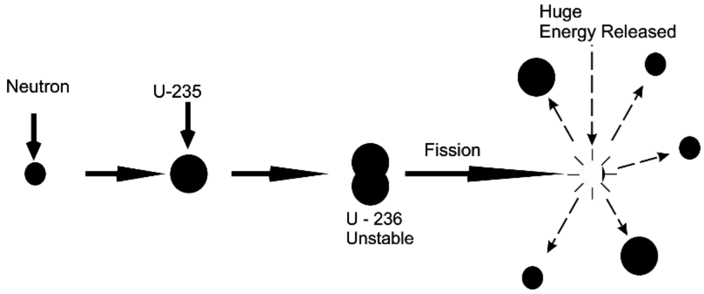
The water turbine receives water from the penstock. The kinetic energy of the water powers the turbine.

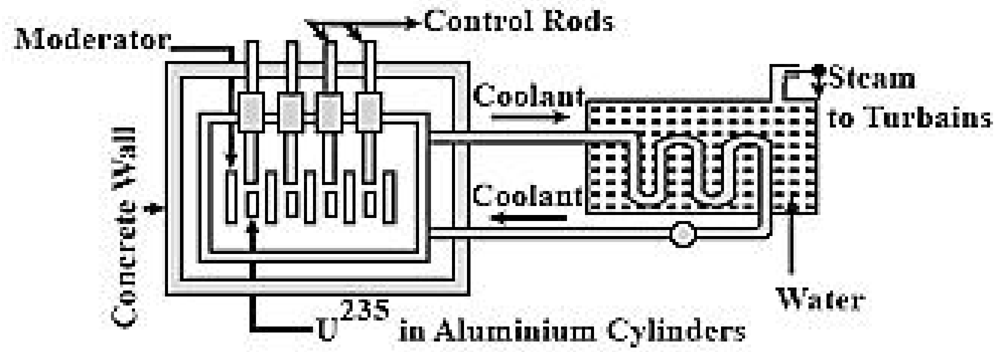
Generator:

A generator is mechanically coupled to the turbine shaft. When the turbine blades are rotated, it drives the generator and electricity is generated.

Layout & working of Nuclear power plant

Nuclear power can be harnessed through Nuclear Fission, and chain reaction. The splitting of a heavy nucleus into two or smaller nuclei is called Nuclear Fission. A fission reaction in which the neutrons from a previous step continue to propagate and repeat the reaction.





1. Nuclear reactor

(a) Core: This contains the nuclear fuel and space for coolant. The fuels used are U233, U235, Pu239

(b) Moderator: The moderator is used to reduce the speed of the fast-moving neutrons. The moderators used are graphite, heavy water or beryllium or the ordinary water.

(c) Control rods: The control rods are used to maintain the chain reaction at required level and to shut down during emergency. The control rods are made of cadmium, boron and hafnium.

(d) Coolant: Coolant is used to transfer the heat which is produced in the reactor to steam generator for rising the steam. The generally used coolants are ordinary & heavy water, air, carbon dioxide, helium and hydrogen.

2. Steam generator:

In this, the steam is generated from the feed water by absorbing heat from the hot coolant from the reactor.

3. Turbine:

The generated steam is given to the turbine blades and turbine rotates that produces work. This work is converted into electricity by generator which is coupled with turbines.

4. Generator:

The generator is used to convert the mechanical energy into electrical energy. The generator is directly coupled to the turbine.

Layout & working of solar thermal polar plant

The operation of solar thermal power plants is based on obtaining heat from solar radiation and transferring it to a heat carrier medium, which is generally water.

To raise the water temperature to the desired high levels, maximum solar radiation must be concentrated which will be used to generate steam.

The produce steam drives the steam turbines. With the movement of the turbines, mechanical energy is transferred to the electrical generators to generate electricity.

1. Solar collectors

Solar collector is a device that collects solar radiation and transfers this solar energy to the fluid passing in contact with it. These are made of Copper, Aluminum (or) steel and coated with black coke powder to have high absorption and low emission. The different types of solar collectors like Flat plate Solar collector, concentrating collectors, Paraboloidal dish collector & Fresnel lens concentrating Solar collector.

2. Heat exchanger

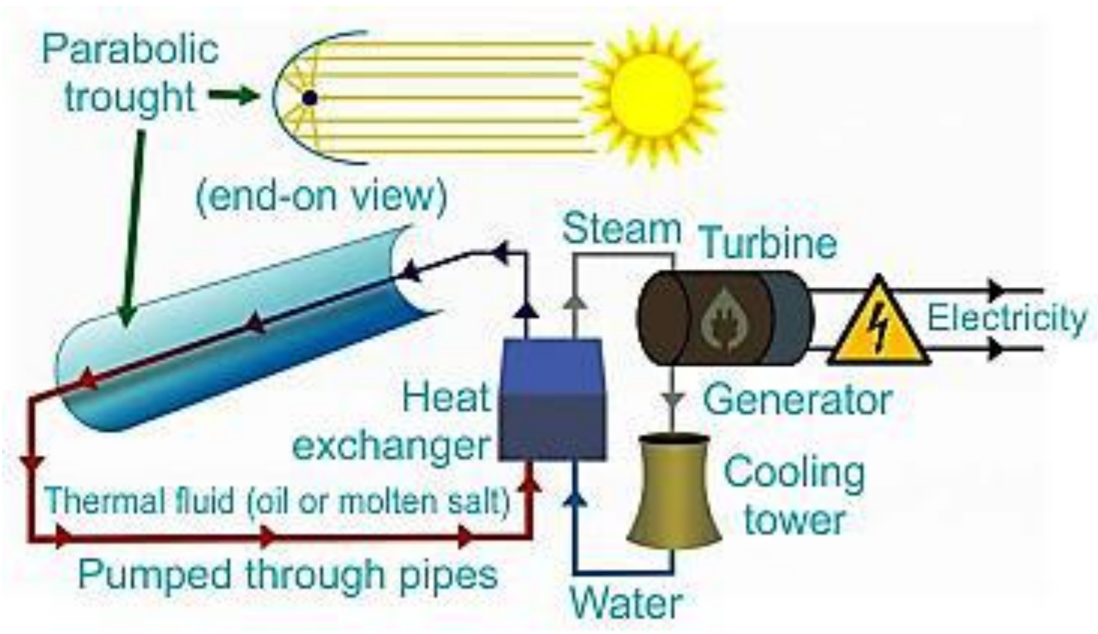
In this, the heat is exchanged to the water that is running in the pipes. The heated water turns its state from liquid to gaseous and produces steam.

3. Turbine

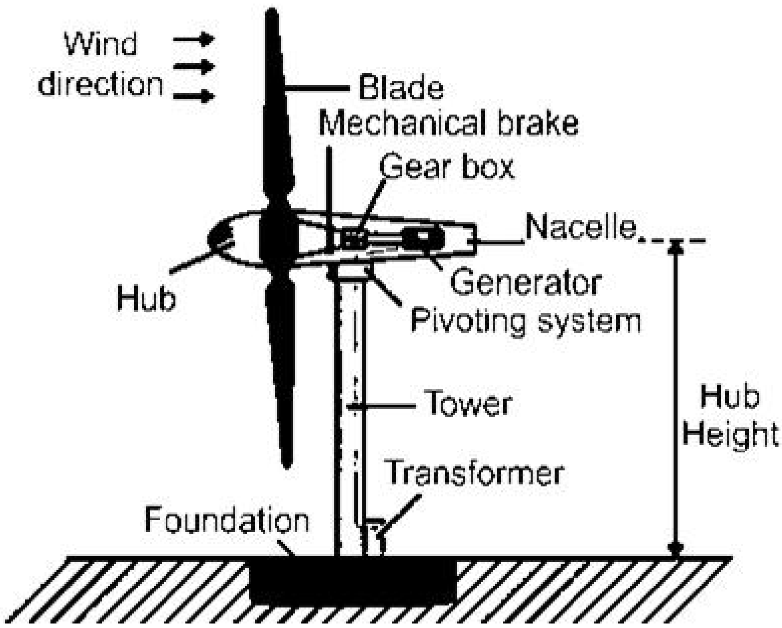
The generated steam is given to the turbine blades and turbine rotates that produces work. This work is converted into electricity by generator which is coupled with turbines.

4. Generator

The generator is used to convert the mechanical energy into electrical energy. The generator is directly coupled to the turbine.



Layout & working of wind power plant



The wind possesses kinetic energy which can be converted into electrical energy. For converting the kinetic energy of wind into electricity, wind turbines are employed. The wind rotates the turbine blades, the shaft of which is mechanically coupled to an electric generator.

Mast/ Tower

The tower is usually cylindrical structure with the heights ranging from 25 meters up to 90 meters. It supports the nacelle and lifts entire setup to higher elevation where blades can safely clear the ground.

Blades

When the wind touches the blades, the air pressure is higher on one side of the blade and lower on the other. Hence, uneven pressure causes the blades to spin or rotate. Usually three-bladed wind turbines are used in wind farms

Nacelle:

Nacelle is mounted at the top of the tower and it houses a gear box, turbine and a generator. The turbine rotor is connected to a high-speed gearbox. Gearbox transforms the rotor rotation from low speed to high speed. The high-speed shaft from the gearbox is coupled with the rotor of the generator.

Generator:

The rotor assembly is coupled to the generator through the gearbox. Thus, when the rotor rotates it drives the generator and, hence, electricity is generated.

Define the unit of electrical energy consumed?

The unit of electrical energy consumed is 1 kWh.

One kilowatt-hour is the electrical energy consumed by an electrical appliance of power 1 kW when it is used for one hour.

Thus,1 kWh = 1 kilowatt x 1 hour

= 10^3watt x 3600 s

= 10^3 J/s × 3600 s

=3.6×106J

Thus, 1 kWh = 3.6x 106 J

Power rating of household appliances

Desktop Computer	100W- 450W
Laptop Computer	40W-120W
Home Air Conditioner	1000W- 4000W
Inkjet Printer	20W-30W
Refrigerator	200W - 400W
Ceiling Fan	70W- 80W
Tube light	22W-30W
LED bulb	9W – 18 W

Problem:

calculation of electricity bill for domestic consumers using simple tariff

A household uses the following electric appliance

a. Refrigerator of rating 400w for 10hrs.

b. Two electric fans of rating 80w each for 12hrs each day.

c. 6 electric bulbs of rating 18w each for 6hrs each day.

Calculate the electric bill of the house for the month of June if the cost of per unit electrical energy is₹3.0

Solution:

Energy consumed by the fridge in a day = 400*10 = 4000 Wh = 4 kWh

Energy consumed by the two fans in a day = 2(80*12) = 1920 Wh = 1.92 kWh

Energy consumed by the six bulbs in a day = 6(18*6) = 648 Wh = 0.648 kWh

Total energy consumed in one day = 4 + 1.92 + 0.648 = 6.568 kWh

Total energy consumed in the month of June = 30 days * 6.568 kWh = 197.04 kWh

Electricity bill (cost) = Rs.3 *197.04 = Rs.591.12

Two-Part Tariff:

When the rate of electrical energy is charged based on maximum demand of the consumer and the units consumed, it is called a two-part tariff

In this method, the total charge is divided into two components: fixed charges and running charges

The fixed charges depend upon the number of units consumed by the consumer.

The consumer is charged at a certain amount per kW of maximum demand plus a certain amount per kWh of energy consumed.

This type of tariff is mostly applicable to industrial consumers who have appreciable maximum demand

Total charges = Rs (b x kW + c x kWh)

b = charge per kW of maximum demand

c = charge per kWh of energy consumed

Problem:

A consumer has a maximum demand of 300 kW with annual units consumed as 919800 kwh. If the tariff is Rs. 125 per kW of maximum demand plus 15 paise per kWh, calculate the overall cost per kWh.

Solution:

Units Consumed/annum = 919800 kWh

Annual energy charges = (Units Consumed/annum) × (Rs./kWh)

⇒ Annual energy charges = 919800 × .15 = Rs.137970

Annual max. demand charges = maximum demand x (Rs./kW)

⇒ Annual max demand charges =300 x 125 =37500

Total annual charges = Annual max. demand charges + Annual energy charges

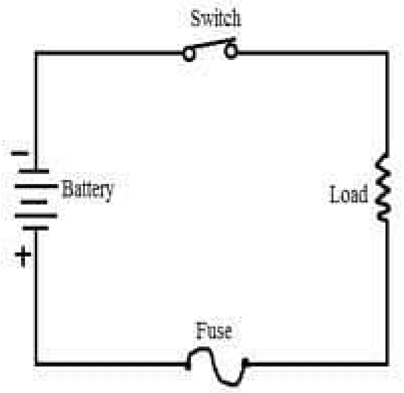
⇒ Total annual charges = 37500 + 137970 = Rs. 175470

Therefore, Overall cost per kWh = Rs. 175470/919800 = Re. 0.1907

= 19.07 paise

Definition of Electric Fuse?

An electric fuse is made up of elements like zinc, copper, aluminum, and silver. This acts as a circuit breaker and breaks the circuit if there is any fault in the circuit because of excessive current flow.



The electric fuse is made from a material that has high resistivity and a very low melting point and hence when there is more current flow it gets overheated and melts down.

Working of Electric Fuse

The electric fuse is a non-combustible material that is made from a thin metallic wire. It is always connected at both the ends of the terminal in the series connection with the circuit.

In a circuit, because the current flows excessively, heat will be generated melting the fuse as the melting point of the fuse is low. This also opens the circuit in addition to melting the fuse. This excessive current flow will cause breakdown and even stop the flow of the current. If such a case happens, the fuse has to be replaced or changed with a new one.

Whenever continuous overcurrent flows through MCB, the bimetallic strip is heated and deflects by bending. This deflection of the bi-metallic strip releases a mechanical latch.

What Is An MCB?

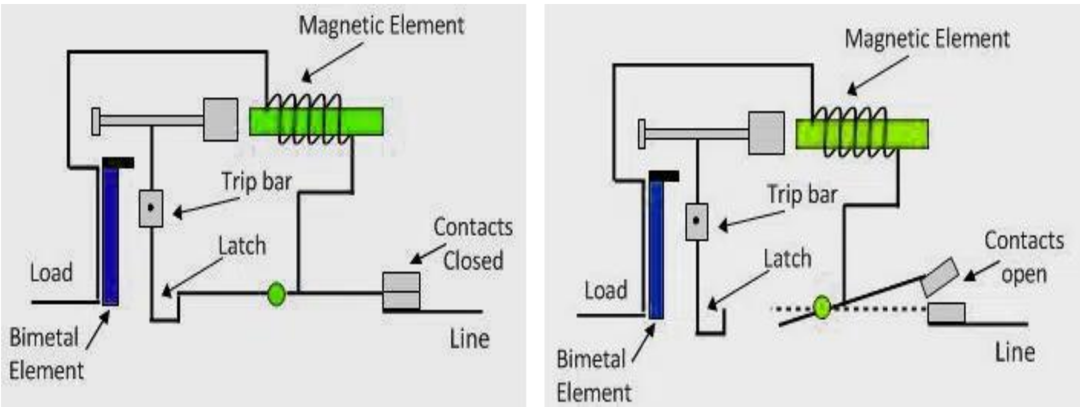
A miniature circuit breaker (MCB) is an Electrical Switch that automatically switches off the electrical circuit during an abnormal condition of the network means an overload condition as well as a faulty condition.

Working Principle of MCB

As this mechanical latch is attached to the operating mechanism, it causes to open the miniature circuit breaker contacts, and the MCB turns off thereby stopping the current to flow in the circuit. To restart the flow of current the MCB must be manually turned ON.

This mechanism protects from faults arising due to overcurrent or overload and short circuits.

But during short circuit conditions, the current rises suddenly, causing electromechanical displacement of the plunger associated with a tripping coil or solenoid. The plunger strikes the trip lever causing the immediate release of the latch mechanism consequently opening the circuit breaker contacts.



Advantages & Disadvantages of MCB

Advantages	Disadvantages
Safety	Limited current protection
Reliability	Limited overcurrent rating
Easy to install and use	Nuisance tripping
Cost-effective	Replacement and maintenance
Space-saving	Limited protection for high power appliances

Advantages & Disadvantages of fuse?

Merits:

(i) Negligible replacement cost.

(ii) Easy removal for replacement without any damage of coming into contact with a live part.

Demerits:

(i) The fuse wire deteriorates over a period, due to oxidation through the continuous heating up of the element.

(ii) There is a possibility of renewal by the fuse wire of wrong size.

(iii) Breaking capacity is low.

(iv) Accurate calibration of fuse wire is impossible, as a longer fuse operates earlier than one of shorter length.

What is Electrical Shock?

When a person comes into direct contact with an electrical energy source, he or she receives an electric shock. When electrical energy flows through a portion of the body, it causes a shock.

Personal safety Measures:

What are some safety precautions that we can follow to avoid electric shocks?

1. Make sure the appliance or the socket is properly earthed.
2. Don't overload a socket by plugging in more appliances into the same socket.
3. Make sure the plastic cover on the wires is intact.
4. Don't touch current carrying equipment with wet hands.
5. Use proper safety equipment like gloves and right tools to do electric repairs.

Earthing:

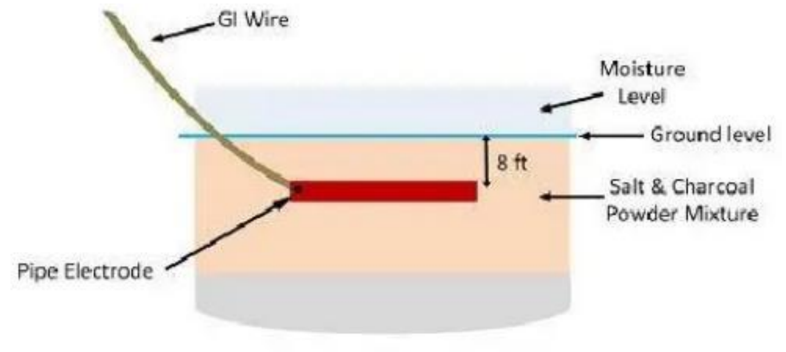
Earthing is defined as “the process in which the instantaneous discharge of the electrical energy takes place by transferring charges directly to the earth through low resistance wire.”

Types of Earthing

There are three types of earthing, they are:

- Pipe earthing
- Plate earthing
- Strip earthing

Pipe earthing is the best and most efficient way of earthing and is also easily affordable. Pipe earthing uses 38mm diametre and 2 metres length pipe vertically embedded in the ground to work as earth electrodes.



Pipe Earth Electrode

In plate earthing, an earthing plate made of copper or G.I. is buried into the ground at a depth more than 3 metres from the ground level. This earthing plate is embedded in an alternative layer of coke and salts.

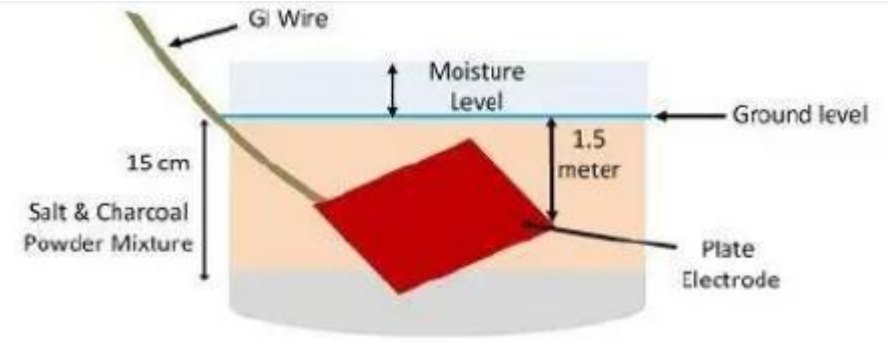


Plate Earth Electrode

Strip earthing is used in transmission processes. Strip electrodes of cross section not less than 25mm X 1.6mm of copper or 25 mm X 4mm of G.I. or steel are buried in horizontal trenches of a minimum depth of 0.5m.