UNIT-1

Application and Advantage of electricity

Concept of electricity – According to this theory, every matter (solid, liquid or gaseous) consists of very small divisible particles, called "molecules". A molecule is composed of very small particles called "atom". An atom consists of two parts namely, the central nucleus and orbital electrons. The nucleus of an atom is largely a cluster of two types of particles, called the 'Protons' and 'Neutrons'.
The number of protons or electrons in an atom is called "Atomic Number".
On applying a potential difference between the two ends of a conductor, the movements of electrons gives a steady flow of electrons along the conductor.
The flow of electrons in a conductor or a closed circuit is called electrical current.
Such metals (like Silver, Cu, Al) are called as conductors.
Such materials (like glass, mica, wood and porcelain) are called as non-conductors or insulators.

Various applications of electricity – It has vast applications in our domestic, industrial and field applications. Various applications of electricity in our daily life are-

1. Lighting – It is used for lighting purposes in houses, industries, institutions, offices, workshops and street lights.

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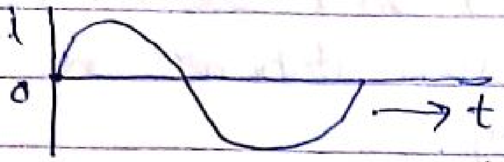
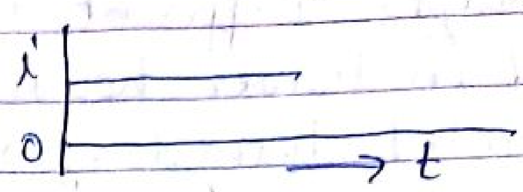
2. Heating – It is used for heaters, hot plates, room heaters, ovens, geysers etc. In industries, electricity is used for heating ovens, boilers, furnaces etc.
3. Running of motors – For domestic purposes, electricity runs the motors of appliances like ceiling fans, table fans, refrigerators, coolers, air conditioners, water coolers etc. In industries, electricity runs the motors of various machines used in that industry, coal conveyors, air conditioning plants etc. In offices it is used in fans, air-conditioners, lifts etc.
4. Welding – Welding of metals is done with the help of electricity by use of welding Transformers and welding generators.
5. Electroplating – Electrolysis process and electroplating of utensils and ornaments etc. are done using electricity.
6. Charging of battery – Secondary batteries are charged by applying electricity. These batteries are commonly used in automobiles, invertors, mobile phones, laptop, U.P.S. etc.
7. In sound system – Electricity finds its application in radios, transistors, tape recorders and record players. Amplifiers also uses electricity.
8. In electronic equipments – Electronic equipments like T.V., laptops, computers etc. also work on electricity.
9. Telephones – Telephones system also operates with electricity.

10. For Theaters - In today's life an important application of electricity is in screening of films.
11. Relays - Different Protections and alarm relays used in power houses and sub-stations are operated ~~being~~ using electricity.
12. Electric Traction - For electric traction (train, hoists etc) electricity is required.

Advantages of electricity over other types of energy -
1. It is clean.
2. It can easily be controlled.
3. It is more flexible.
4. It has high efficiency.
5. It can be easily transmitted over long distances.
6. It is environmental friendly as no smoke or fumes are produced.
7. Its operation is noiseless.
8. It can be easily converted from one form to the other.
9. Electrical energy can be utilized instantaneously just by the press of a button. There is no time gap.
10. Equipments operated on electrical energy are more reliable and safe to use.

Difference between A.C. (Alternating current) and D.C. (Direct current):

A.C.	D.C
1. Magnitude of A.C is variable	1. Magnitude of D.C is constant.
2. A.C. changes its directions regularly in the circuits.	2. D.C. flows in one directions only.
3. Alternating voltages can be "Stepped up" or "Stepped down"	3. D.C supply cannot be Stepped up and stepped

with the help of a transformer	down.
4. Wave shape of A.C. is 	4. Wave shape of D.C. is 
5 A.C. is used for running A.C. motors	5. D.C. is used for running D.C. motors.
6. A.C. power at high voltages can be easily transmitted from one place to another.	6. D.C. power at high voltages cannot be easily transmitted from one place to another.
7. During power transmission the power losses are very small.	7. Power losses are very large.

UNIT-2
Basic Electrical Quantities

Electrical voltage (Electrical Potential) – When a body is charged negatively or positively, work is done in both the cases. This work is done in stored in the body in the form of electric potential or Potential energy. So the charged body has the capacity to do work by moving other charges either by the force of attraction of repulsion. The capacity of the charged body to do work is called electric potential.

$$\text{Electrical Potential, } V \text{ (Potential)} = \frac{\text{Work done}}{\text{Charge}} = \frac{W}{Q}$$

Unit of Potential difference is volt (V).

Electric current - The rate of flow of electric charge is called electric current.

$$i = \frac{Q}{t}$$

or

The flow of electrons in a closed circuit is called electric current. Its unit is ampere.

Potential difference - When two bodies or points are charged at different potential, then their exists a potential difference between them.

The flow of electrons or current between the two ends of a conductor. The difference of electric pressure is necessary for the flow of current between two ends of a conductor. This difference of electric pressure is called as "Potential difference

Greater the potential difference between the two ends of a conductor, greater will be current flow. No potential difference, no current. The unit of potential difference is volt (V).

Electric Power - The rate at which work is done in an electric circuit is called electric power.

$$\text{Electric power} = \frac{\text{Work done in electric circuit}}{\text{Time}}$$

$$\text{Power} = \text{voltage} \times \text{current}$$

$$= V \times I$$

Unit of electric power is watt or kilowatt

$$1 \text{ watt} = 1 \text{ volt} \times 1 \text{ ampere}$$

voltage = 250 $= 250 \times 0.4$

current = 0.4 $= 100$ watt

(one kilowatt) 1 kW = 1000 watts
(one megawatt) 1 MW = 10^6 watts or 10^3 kW

<u>Electric energy</u> – The total amount of work done in an electric circuit. OR
The capacity of doing work is called electric energy.

Electrical energy = Electric power × Time

$= V \cdot I \cdot \times t$

$= I^2 R \cdot t$

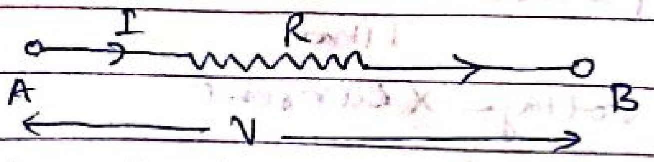
$= \frac{V^2}{R} \cdot t = I^2 R t$

$\left[\begin{array}{l} V = IR \\ I = \frac{V}{R} \end{array} \right]$

one Horse power = 0.7355 kilowatt
= 735.5 watts

Unit of electric energy is joule, watt sec. or watt hour.

<u>Ohm's law</u> – According to ohm's law, the current flowing between the ends of a conductor is directly proportional to the potential difference across the ends provided the physical conditions i.e. temperature etc. do not change.



mathematically, $I \propto V$

$\frac{V}{I} = \text{constant}$

This constant is called Resistance, R of the conductor,

$\frac{V}{I} = R$

For calculations, this can be written in three forms.

1. $I = \frac{V}{R}$, i.e. current = $\frac{\text{Potential difference (voltage)}}{\text{Resistance}}$

11. $V = I \cdot R$. i.e. Pot. difference (voltage) = current X Resistance

111. $R = \frac{V}{I}$ i.e. resistance = $\frac{\text{Potential difference (voltage)}}{\text{current}}$

The unit of charge is coulomb.

1 coulomb = charge on 628×10^{16} electrons

Some practical every day examples of this very basic rule are:

Radiators (electric fires), Electric Frypans, Toasters, Irons and electric light bulbs and ohm's law is used for finding the solution of networks and problems.

ohm's law graphical chart — it can be applied for D.C. as well as A.C circuits.

Voltage	Current	Resistance
E = I X R	I = E/R	R = E/I
12 V = 2A X 6R	2A = 12V / 6R	6R = 12V/2A
$P = E^2 R$	$P = I^2 X R$	P = E X I
24W = [12V X 12V] / 6R	24W = [2A X 2A] X 6R	24W = 12V X 2A

Concept of Ammeters – An Ammeter is used to measure the current in a circuit and it is connected in series with the circuit. In order to avoid the large voltage drop across the ammeter and much consumption of power, the ammeter are manufactured with very low value resistance which has few turns of thick wire. Its unit is ampere (A).

Concept of Voltmeters – A voltmeter is used to measure the voltage across the circuit and is connected in parallel with it. Voltmeters are made of very high resistance of thin wire, so that it takes very little current from the circuit and may
~~instance~~ minimum power. The deflecting torque produced in an ammeter is proportional to the current in the circuit, whereas the deflecting torque produced in the voltmeter is proportional to the voltage across the load. Its unit is Volt (V).

voltmeter:

Induction-type single phase energy meter — Energy meter is an integrating instrument which measures total quantity of an electrical energy supplied to the circuit in a given period. In other words electrical energy is the product of electrical power and time i.e.

mathematically

$$E.E. = Power \times Time$$

Single phase energy meters are mostly used for the measurement of electrical energy in A.C. circuits. The Principle of working is the same as that of induction watt-meters. When a rotating magnetic field links with a metallic disc, an e.m.f. is induced in it causing flow of eddy currents through it. These eddy currents develope a torque, causing movement of the disc.

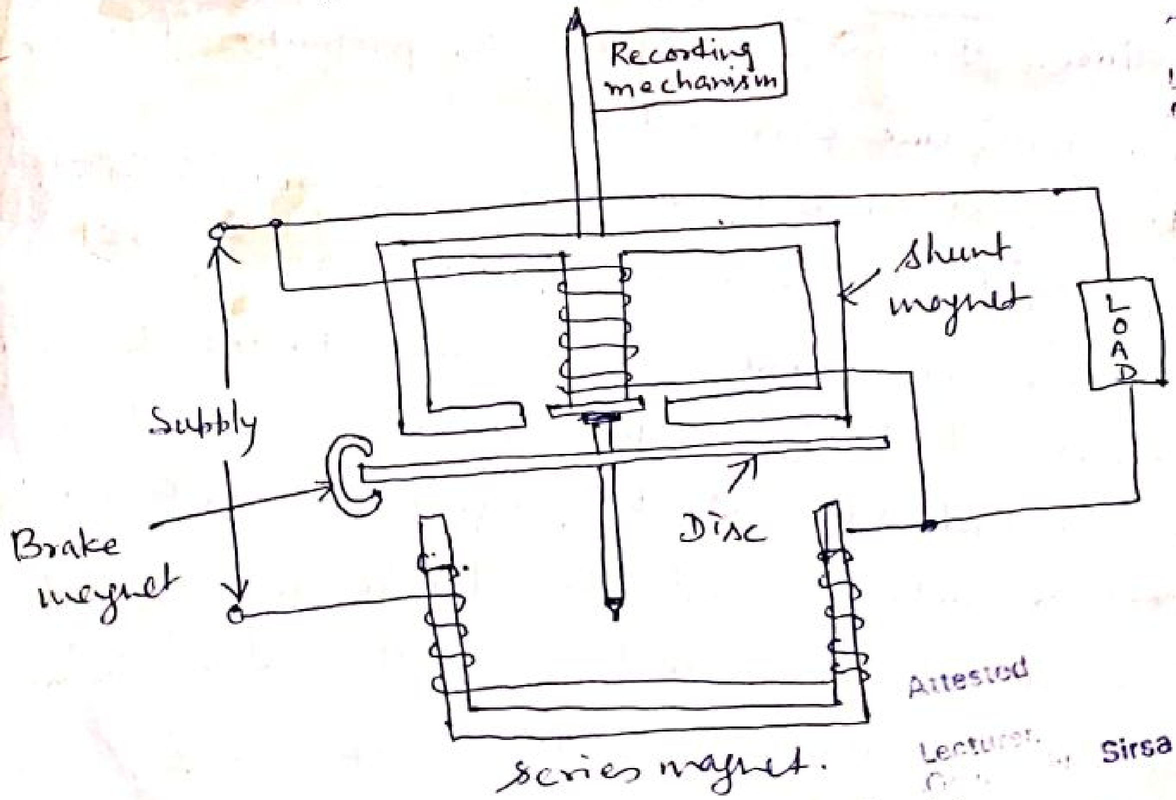
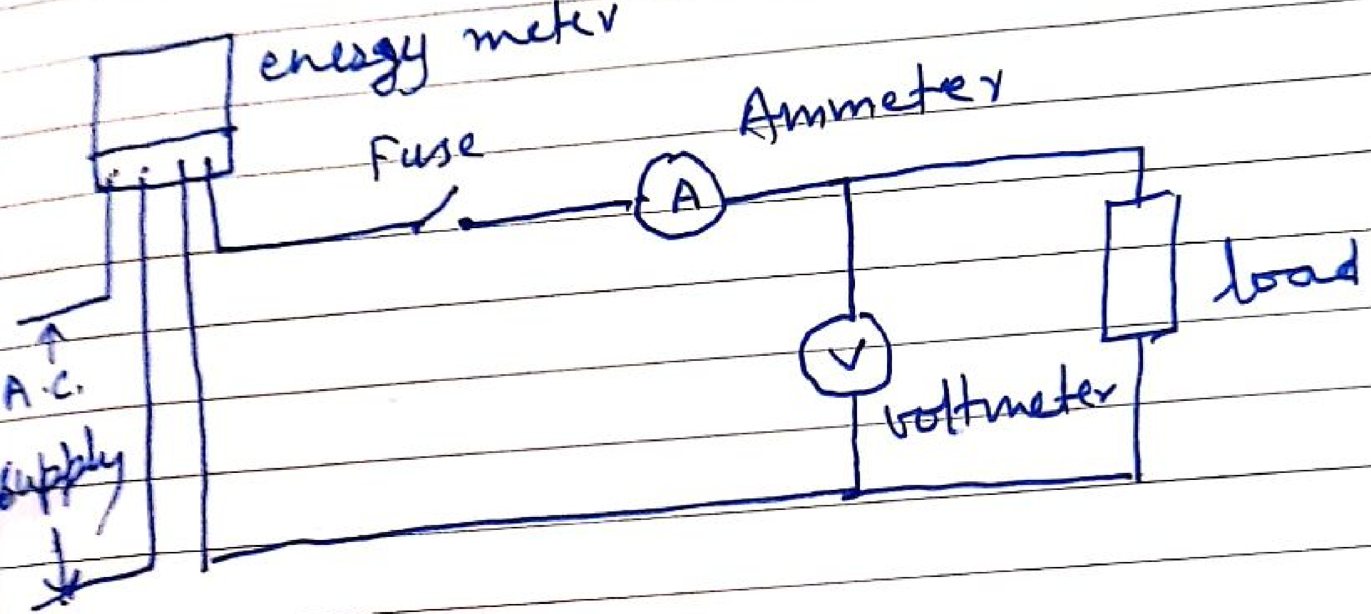


figure-shows an induction type single phase energy meter. It consists of the following parts:

connection of these instruments in an electric circuit -

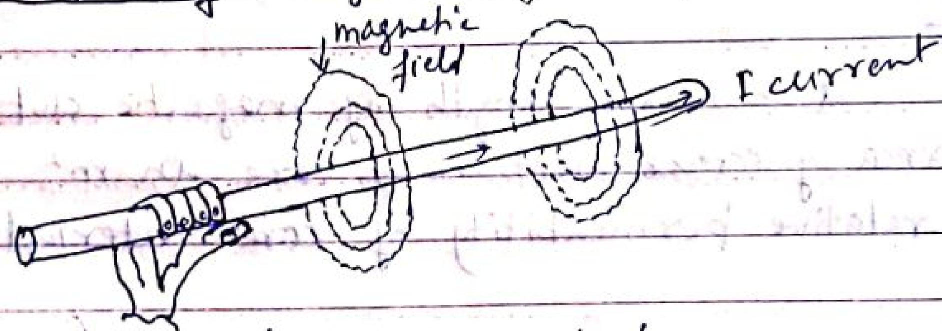


UNIT - 3
AC Fundamentals

Electro-magnetism - The branch of electrical engg. which deals with the magnetic effects of electric current is called electro-magnetism.

An emf can be induced in a conductor by changing the flux linking with the conductor. This phenomenon was called electro-magnetic induction.

Concept of magnetic field produced by flow of current



"When an electric current flows through a conductor, magnetic field is set up all along the length of the conductor." figure shows the magnetic field produced by the current flowing in a straight conductor. The magnetic lines of force are in the form of concentric circles around the conductor.

The following points may be noted about the magnetic effect of electric current -

1. Higher the current flowing through the conductor, stronger is the magnetic field.
2. Magnetic lines of force around the conductor will be either clockwise or anticlockwise, depending upon the direction of current.

Faraday's laws of Electro-magnetic induction

First law – This law states that when the flux linking with the coil or circuit changes an emf is induced in it or whenever the magnetic flux is cut by the conductor an emf is induced in the conductor.

Second law – This law states that the magnitude of emf induced in a coil is directly proportional to the rate of change of flux linkage or to the product of number of turns and rate of change of flux linking the coil.

Rate of change of flux linkages $= \frac{N(\phi_2 - \phi_1)}{t}$ wb-turns/s

Where,

N = No. of turns of the coil

ϕ_1 = Initial flux linkage

ϕ_2 = Final flux linkage

$\phi_2 - \phi_1$ = change of flux in wb

t = time in seconds for the change

According to Faraday's second law of electro-magnetic induction,

$$\text{induced emf, } e \propto \frac{N(\phi_2 - \phi_1)}{t}$$

$$e = \frac{N(\phi_2 - \phi_1)}{t}$$

In differential form, $e = N \frac{d\phi}{dt}$ volts

Using minus sign is given to right hand side which indicates that emf induced is in such a direction which opposes the cause that produces it.

$$e = -N \frac{d\phi}{dt} \text{ volts}$$

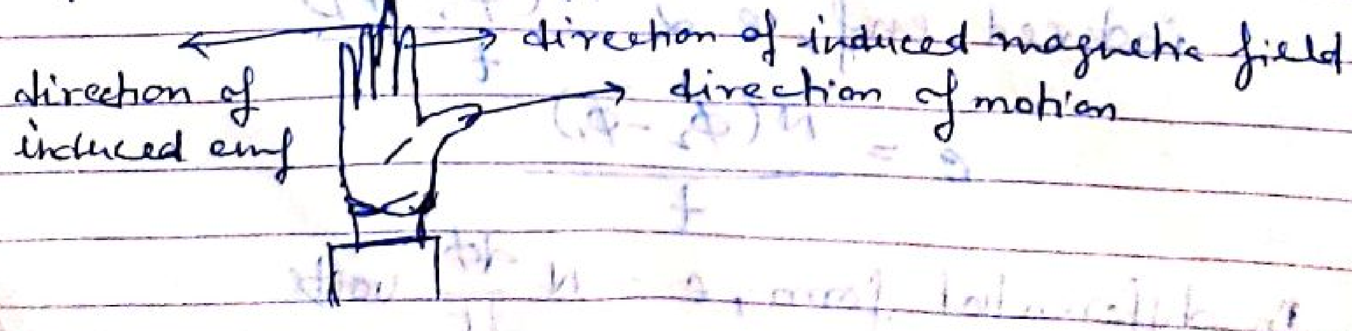
<u>Lenz's law</u> – 'Lenz's law' states that the direction of the induced emf and hence of the current flow is always such that it opposes the cause producing it.

$$e = -N \frac{d\phi}{dt} \text{ volts}$$

<u>Fleming's Right hand rule</u> –

Stretch out the first finger, second figure and thumb of the right hand in such a way that these are in mutually perpendicular directions.

If the first finger points in the direction of the magnetic field, thumb points in the direction of motion of the conductor relative to the magnetic field, then the second finger (also called as middle finger) represents the direction of the induced emf or current.

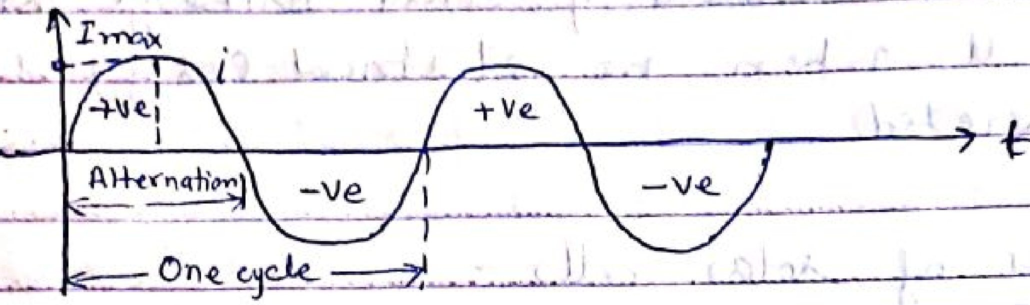


Fleming's left hand rule - To find direction of the force on a current carrying conductor, the following rule, called the Fleming's left hand rule.

Keep the first and second fingers and the thumb of the left hand at right angles to one another; Points the first finger in the direction of the flux, the second finger in the direction of the current, then, the thumb will point in the direction of the force acting on the conductor.

first finger - field
Second finger - current
Thumb - Motion

Concept of alternating voltage and current, Difference between a.c. and d.c. already explained in unit no. 1.



1. <u>Cycle</u> – When an AC quantity goes through a complete set of +ve and -ve values it is said to have complete one cycle.

2. <u>Time Period (T)</u> – The time taken in seconds by an AC quantity to complete one cycle is called Time period. It is denoted by T.

3. <u>Frequency (f)</u> – The number of cycles made per second by an AC quantity is called frequency. It is denoted by f and measured in cycles per second (c/s) or hertz (Hz). In India frequency of AC used is 50 Hz.

4. <u>Amplitude</u> (Imax or Vmax): The maximum value, positive or negative, which an AC quantity attains during one complete cycle is called amplitude or peak value or maximum value. The amplitude of AC current and voltage is represented by Imax

and Emax or Vmax.

5. Instantaneous value - The value of an AC quantity at some particular instant of time is called instantaneous value. The instant value of alternating current is represented by i and that of AC voltage by e or v.

6. Alternation - One half cycle i.e. complete set of +ve or -ve values is called an alternation.

7. Waveform - The graph between an AC quantity (voltage or current) and time is called waveform.

8. Phase - Phase of an AC quantity at any particular instant of time is defined as the fraction of the time period or cycle through which the quantity has advanced from selected origin or zero value.

9. Peak value - The Peak value is maximum value attained by an alternating quantity during a cycle. It is also known as crest value or amplitude. A sinusoidal alternating quantity obtained its maximum value at 90°. The max. value of alternating voltage and current is represented by V_m and I_m.

10. Average value - The arithmatic average of all the instantaneous values of an alternating

quantity at various instants of time over one cycle is called it's average value.

11. Effective value or R.M.S. value – A steady current (d.c.) which when flows through a resistor of known resistance for a given time produces the same amount of heat as produced by the alternating current when it flows through the same resistor for the same time is called effective value or r.m.s. value of the alternating current.

12. Form factor = $\frac{E_{r.m.s}}{E_{av}}$ or $\frac{I_{r.m.s}}{I_{av}}$

for the sinusoidal current.

$$\text{Form factor} = \frac{I_{rms}}{I_{av}} = \frac{I_m/\sqrt{2}}{2I_m/\pi} = \frac{\pi I_m}{2\sqrt{2}\, I_m}$$

$$\text{Form factor} = \frac{0.707 \text{ maximum value}}{0.637 \text{ maximum value}} = 1.11$$

13. Peak factor – The ratio of maximum value to r.m.s. value of alternating quantity is called Peak factor.

$$\text{Peak factor} = \frac{I_m}{I_{rms}} \text{ or } \frac{E_m}{E_{rms}}$$

$$\text{Peak factor} = \frac{I_m}{I_{rms}} = \frac{I_m}{I_m/\sqrt{2}} = \sqrt{2} = 1.4142$$

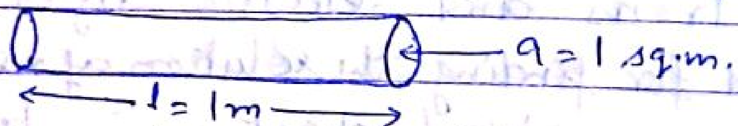
Resistance – The property of a conductor which opposes the flow of electric current through it is known as resistance. It is denoted by R and its unit is ohm (Ω) The Instrument that measures resistance is known as ohmmeter.

Factors affecting resistance -

The resistance of a conductor depends on four factors:

1. Material - for ex:, silver is a better conductor than copper.
2. Length - The longer the wire, higher is the resistance. ($L \propto R$)
3. Cross-sectional area - The thicker the wire, the smaller is the resistance ($R \propto \frac{1}{a}$)
4. Temperature - Most of the materials have high resistances at higher temperature. ($R \propto T$)

Resistivity - The resistance of a wire is given by the relation, $R = \rho \frac{l}{a}$



The resistance offered by one metre length of a conductor having an area of cross-section of one square metre is called resistivity of the material

$$R = \rho \frac{l}{a} \quad \text{or} \quad \rho = \frac{Ra}{l}$$

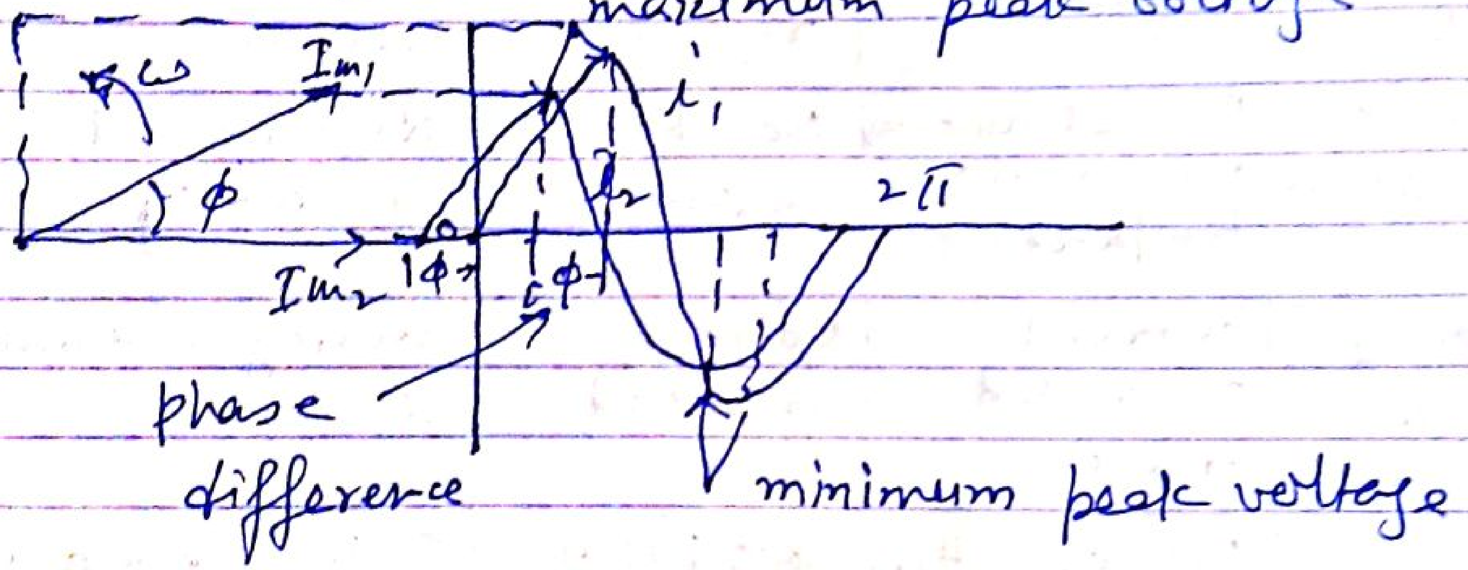
$$\rho = \frac{ohm \times m^2}{m} = ohm\text{-}m$$

unit of resistivity is ohm-m

inductance - inductors store their energy in the form of a magnetic field that is created when a voltage is applied across the terminals of an inductor. However, in an alternating current circuit which contains an AC inductance, the flow of current through an inductor behaves very differently to that of a steady state DC voltage. Inductance is the link between electric circuits and magnetic fields.

capacitance - Capacitors store energy on their conductive plates in the form of an electrical charge. However, in a sinusoidal voltage circuit which contains "AC capacitance", the capacitor will alternately charge and discharge at a rate determined by the frequency of the supply.

Phase difference — Phase difference is used to describe the difference in degrees or radians when two or more alternating quantities reach their maximum or zero values having the same frequency.

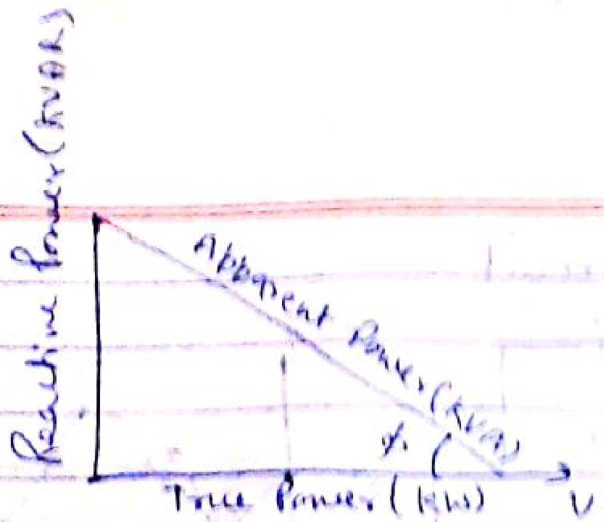


Power factor ($\cos\phi$) of a circuit can be defined is one of the following ways:

(i) Power factor = $\cos\phi$ = cosine of angle between E and I

(2) Power factor = $\frac{R}{Z} = \frac{\text{Resistance}}{\text{Impedance}}$

(3) Power factor = $\frac{EI\cos\phi}{EI} = \frac{\text{True Power}}{\text{Apparent Power}}$



(1) Apparent Power - The product of r.m.s. value of current and voltage, EI is called the apparent power and, is measured in volt-ampere or kilo-volt amperes (KVA)

$$A.P. = EI \text{ volt-amperes or } \frac{EI}{1000} \text{ KVA}$$

(2) True Power (real power) - The true power in an a.c. circuit is obtained by multiplying the apparent power by the power factor and is expressed in watts or kilo-watts (KW). It is equal to $EI \cos\phi$

$$T.P. = EI\cos\phi \text{ watts or } \frac{EI\cos\phi}{1000} \text{ KW}$$

(3) Reactive power - The product of apparent power, EI and the sine of the angle between voltage and current, $\sin\phi$ is called the reactive power. This is also known as wattless power.

$$R.P. = EI\sin\phi \text{ var or } \frac{EI\sin\phi}{1000} \text{ KVAR}$$

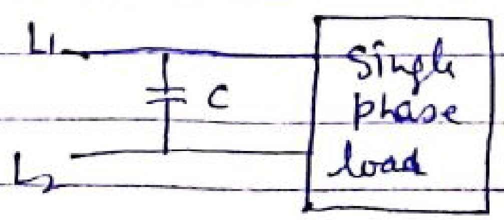
$$KVA = \sqrt{(KW)^2 + (KVAR)^2}$$

Disadvantages of low power factor -

1. Greater conductor size - To transmit or distribute a fixed amount of power at a fixed ~~currents~~ voltage at low power factor, the conductor will have to carry large amount of current which will necessitate a large conductor size.
2. large copper losses - Due to more currents carried by the conductors, I^2R losses are increased.
3. Poor Voltage regulations - Due to low power factor, and increased currents, the voltage in transformers, distribution lines drops more which again results in poor voltage regulation.
4. Large KVA rating of the equipment - The output power of electrical machine e.g. alternators and transformers is always rated in apparent power i.e. KVA

because $KVA = \frac{KW}{\cos\theta}$

Power factor improvement - The low power factor is generally due to inductive loads in nature and also take the current at lagging power factor. In order to improve (to raise) the power factor, a static capacitor is connected in parallel with the load. The static capacitor draws a current which leads the voltage.



Conversion of circuits from star to Delta and Delta to star —

Delta / Star transformation—

Consider three resistors R_{AB}, R_{BC}, R_{CA} connected in delta to three terminals A, B and C as shown in figure. let the equivalent star-connected network have resistances R_A, R_B and R_C.

let us consider the terminals A and B of the network.

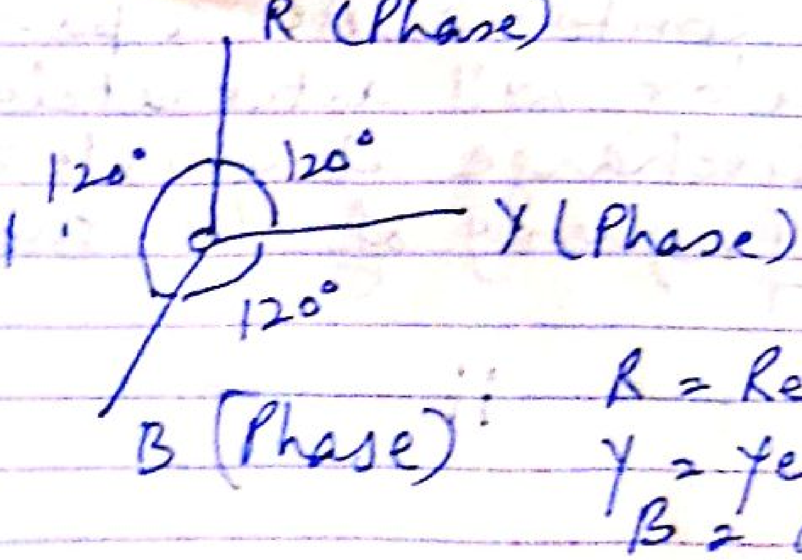
R_{AB}, R_{BC} and R_{CA} are connected in delta.

Equivalent star connected network has resistances R_A, R_B and R_C.

Resistance between A and B for star = Resistance between A and B for delta.

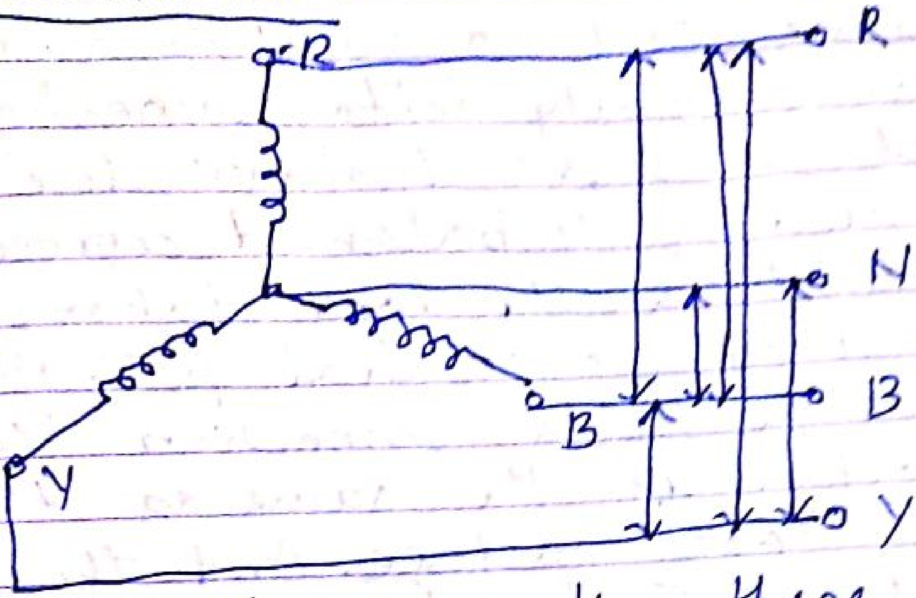
Concept of three phase system: star and delta connection: voltage and current relationship (no derivation) — There are two types of system available in electric current, single phase and three phase system. In single phase circuit, there will be only one phase, i.e the current will flow through only one wire and there will be one return path called neutral line to complete the circuit.

In three phase circuit, there will be three phases, where three phases are send together from the generator to the load. Each phase are having a phase difference of 120°, i.e. 120° angle electrically. So from the total of 360°, three phases are equally divided into 120° each.



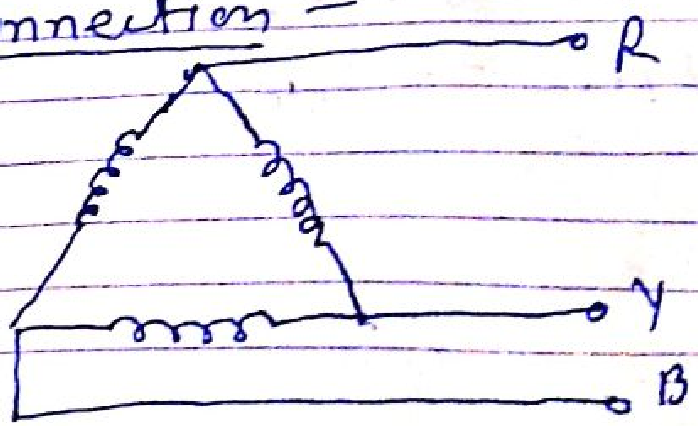
R = Red
Y = yellow
B = Black

Star connection –



In star connection, there is four wire, three wires are phase wire and fourth is neutral which is taken from the star point. Star connection is perferred for long distance power transmission because it is having the neutral point. In this we need to come to the concept of balanced and unbalanced current in power system. When equal current will flow through all the three phases, then it is called balanced current. And when the current will not be equal in any of the phase, then it is called unbalanced current.

Delta connection –



In delta connection, there is three wires alone, and no neutral terminal is taken. Normally delta connection is preferred for short distance due to the problem of unbalanced current in the circuit. In the load station, ground can be used as neutral path if required. In delta connection, the line voltage is the same as that of the phase voltage. And the line current is $\sqrt{3}$ times of phase current.

$$E_{Line} = E_{Phase}$$

$$I_{Line} = \sqrt{3} I_{Phase}$$

In star connection the line voltage is $\sqrt{3}$ times of phase voltage. Line voltage is the voltage between two phases in three phase circuit and phase voltage is the voltage between one phase to the neutral line. And the current is same for both line and phase.

$$E_{Line} = \sqrt{3} E_{Phase}$$

$$I_{Line} = I_{Phase}$$

UNIT-4

Transformer

Transformer is a static machine which transfer electrical energy from one a.c circuit to another a.c circuit without chang in frequency.

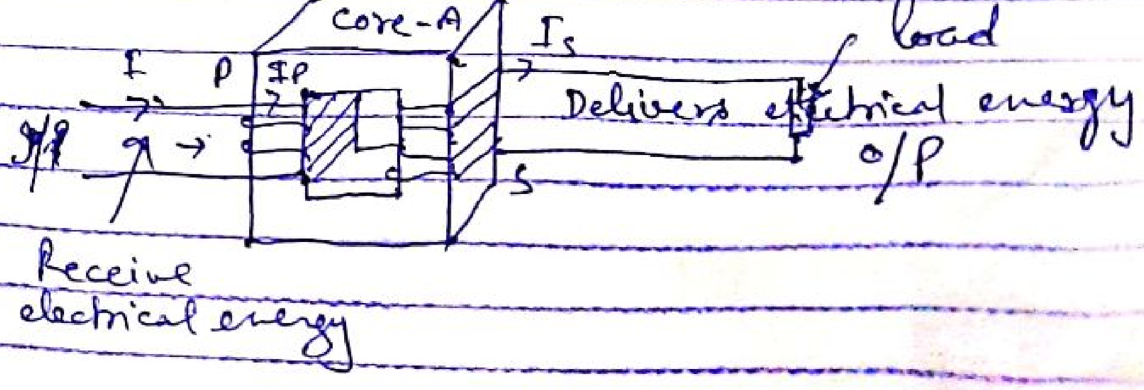
Generally, a transformer receives electrical energy of one voltage and delivers another voltage higher or lower with a corresponding decrease or increase in current.

When the transformer raises the voltage i.e. output voltage is higher than input voltage, it is called step-up transformer. On the other hand,

when a transformer lowers the voltage i.e output voltage is lower than input voltage, it is called step-down transformer.

Construction – A transformer essentially consists of –

1. Core (A)
2. Primary winding (P)
3. Secondary winding (S)



1. Core A – The core consists of laminated sheets of special alloys such as silicon steel etc. These laminations are insulated from each other with varnish enamel. This helps in decreasing eddy current losses.

2. Primary winding, P – This winding is wound on the core as shown in figure. and receives electrical energy from the supply.

3. Secondary winding, S – This winding is also wound on the core and delivers electrical energy to the load

Principle and working → When a.c. supply flow through the primary winding magnetic flux set-up in the coil. Since this flux links the secondary winding, Therefor an alternating voltage of the same frequency is induced in the secondary winding according to Faraday's laws of electro-magnetic induction.

When load is connected to the secondary winding, secondary current I_s flows through as shown in figure. Thus electrical energy is transferred from primary winding to secondary winding through electro-magnetic induction. It should be noted that there is no electrical connection between the two windings; the energy transfer being through fluxes.

<u>Transformer ratio</u> – A transformer with a primary winding of 1000 turns and a secondary winding of 100 turns has a turns ratio of 1000:100 or 10:1.

$$\frac{N_2}{N_1} = \frac{\text{No. of turns of the coil secondary winding}}{\text{No. of turns of the coil Primary winding}}$$

$$\text{T.R. (Transformer ratio)} = \frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{I_2}{I_1}$$

<u>Transformer efficiency</u> – It is denoted by η

$$\eta = \frac{\text{output Power}}{\text{output Power + losses}} \times 100\%$$

Transformer losses are similar to losses of DC machine.

1. core losses or Iron losses
2. Hysteresis losses
3. Eddy current losses
4. Copper losses

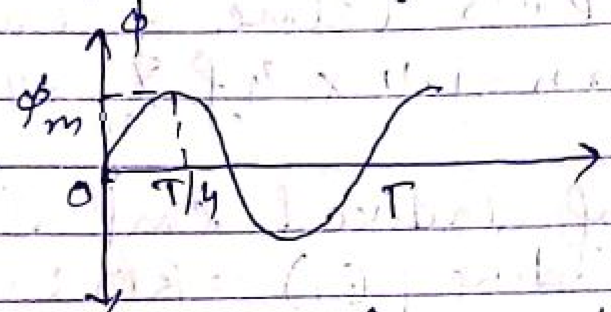
Isolation transformer — Isolation transformer is a tranformer used to transfer electrical power from a source of alternating current (AC) power to some equipment or device while isolating the powered device from the power source, usually the safety reasons. Isolation transformer block transmission of the DC component in signals from one circuit to the other, but allow AC components in signals to pass.

Application of T/F — Electronics testing, supply of equipment at elevated potentials, AC supply transfer one place to another, supply setup and s stepup and stepdown.

EMF Equation of the Transformer –

Let

N_1 = No. of turns in primary winding
N_2 = " " " secondary "
ϕ_m = Maximum flux in the core (in Wb) = ($B_m \times A$)
f = frequency of the AC supply (in Hz)



As shown in the figure, the flux rises sinusoidally to its maximum value ϕ_m from 0. It reaches to the maximum value in one quarter of the cycle i.e in T/4 sec. (where, T is time period of the sin wave of the supply = 1/f).

Therefore,

average rate of change of flux = $\frac{\phi_m}{(T/4)}$

$\phi_m / (1/4f)$

Therefore,

average rate of change of flux = $4 f \phi_m$ ——— (wb/s)

Now,

induced emf per turn = rate of change of flux per turn

Therefore, average emf per turn = $4 f \phi_m$ volts

Now, we know, form factor = RMS value / average value

Therefore, RMS value of emf per turn = form factor × average emf per turn.

As, the flux ϕ varies sinusoidally, form factor of a sine wave is 1.11

Therefore, RMS value of emf per turn = $1.11 \times 4 f \phi_m = 4.44 f \phi_m$

RMS value of induced emf in whole primary winding (E_1) = RMS value of emf per turn × Number of turns in primary winding

$$E_1 = 4.44 f N_1 \phi_m \text{ — eq. (1)}$$

Similarly, RMS induced emf in secondary winding (E_2) can be given as

$$E_2 = 4.44 f N_2 \phi_m \text{ — eq. (2)}$$

from the above equations (1) and (2),

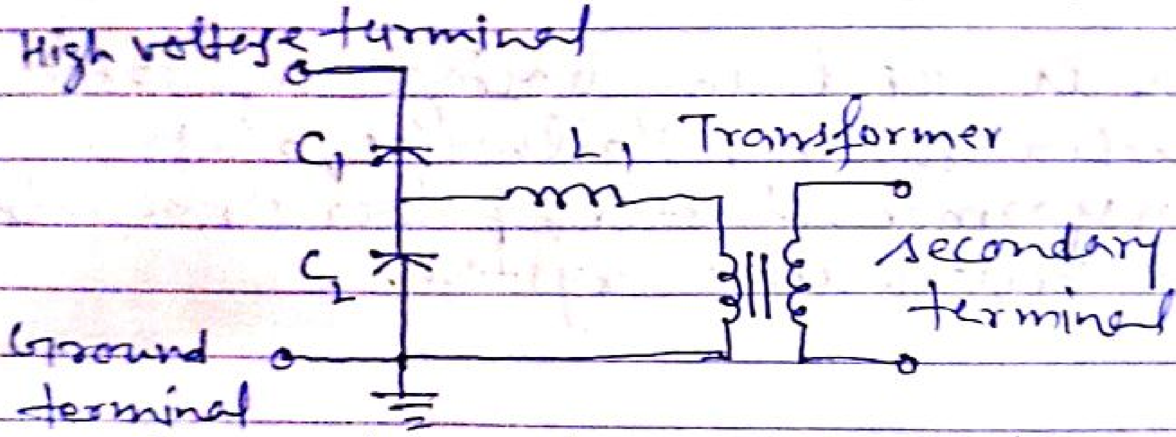
$$\frac{E_1}{N_1} = \frac{E_2}{N_2} = 4.44 f \phi_m$$

This is called the emf equation of transformer, which shows emf / number of turns is same for both primary and secondary winding.

for an ideal transformer on no load, $E_1 = V_1$ and $E_2 = V_2$

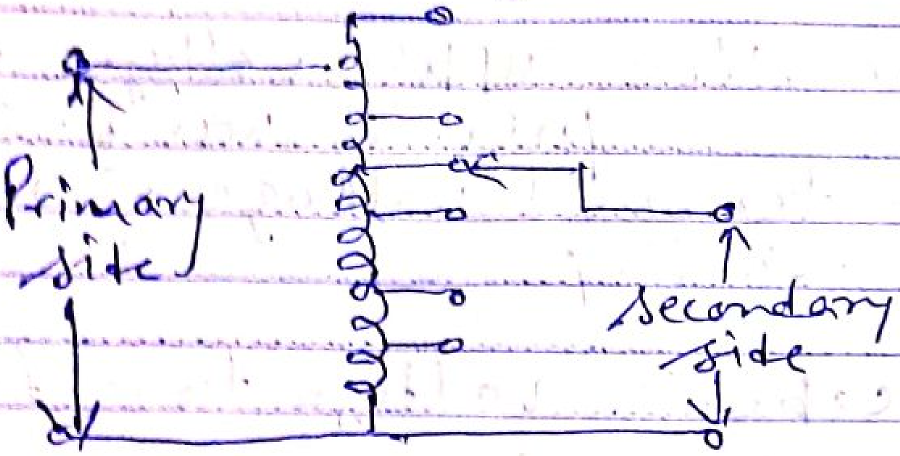
where, V_1 = supply voltage of primary winding
V_2 = terminal voltage of secondary winding

CVT (capacitor voltage transformer)



CVT is a transformer used in power systems to step down extra high voltage signals and provide a low voltage signal, for metering or operating a protective relay. The CVT is useful in communication system. The CVT is installed at a point after Lighting Arrester and before wave trap.

Auto transformer – An auto transformer is an electrical transformer with only one winding. In an autotransformer, portions of the same winding act as both the primary winding and secondary winding sides of the transformer.



This is used in voltage regulator, audio system, Railways, auto-transformer starter, power transmission and distribution system.