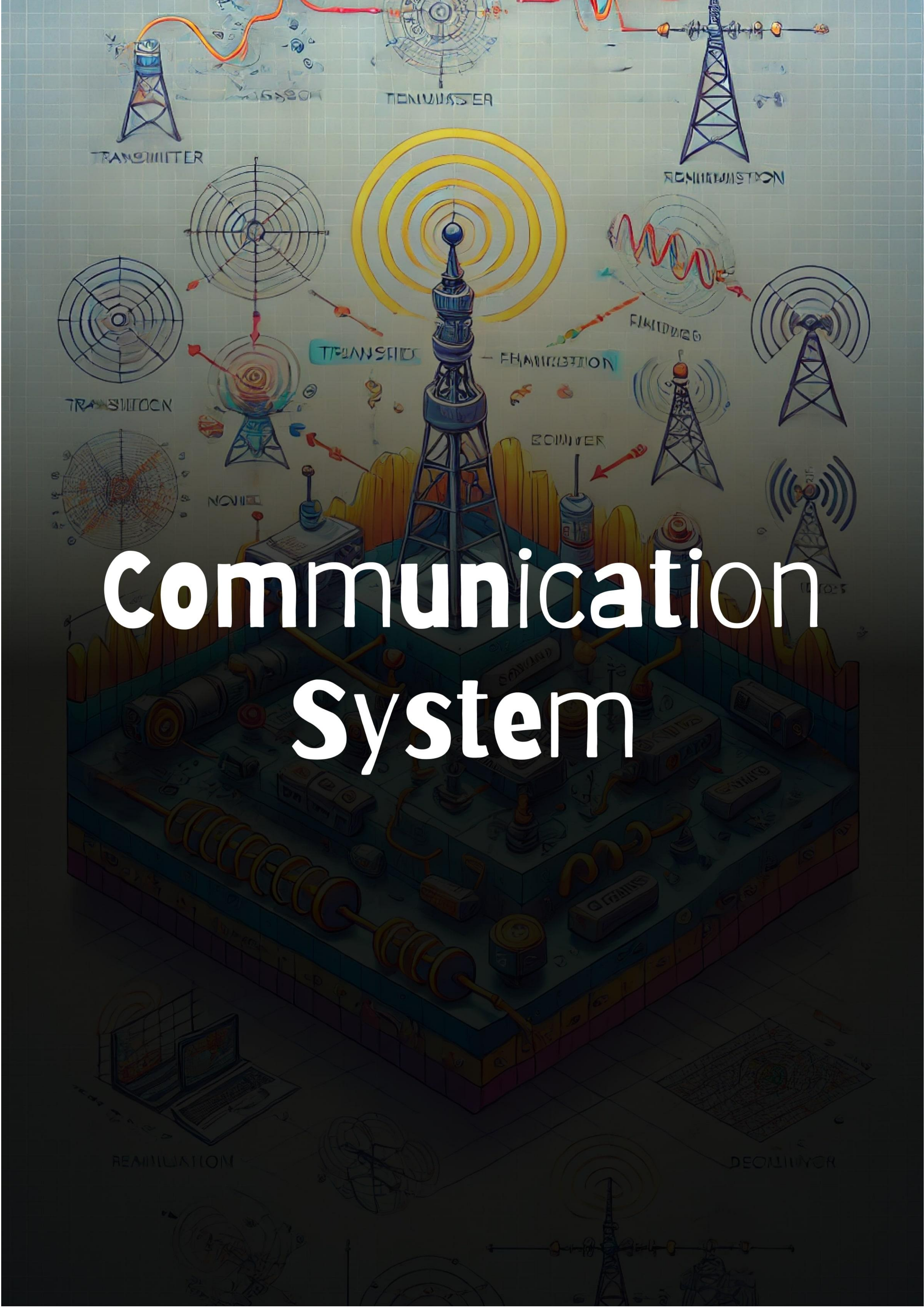


Communication System

Communication System

L-C Oscillations are used to produce high frequency AC v/g.

MICROPHONE

It is an acostic (accoustic) - to - electric transducer OR senser that converts sound into an electrical signal.

- They are used in many applications such as telephones, tap recorders, Karoke system, motion pictures etc.
- Most microphones today use EMI to produce an electrical voltage signal from mechanical vibration.
- Different types of microphone have different ways of converting energy but they are all share one common thing - the diaphragm, which is a thin piece of material (such as paper, plastic or Aluminium) which vibrates when struck by sound waves.
- When diaphragm vibrates, it causes other components in the microphone to vibrate. These vibrations are converted into electric current which become audio signal.

TRANSDUCER

Device which converts one form of energy to another.
Eg - Microphone, Speaker.

ANTENNA (AERIAL)

It is an electrical device which converts electrical power into radio waves & vice-versa.

- Radio wave has frequency b/w 500 KHz to 1000 MHz.
- Antenna is usually used with radio transmitter OR radio receiver.

MODULATION

It is the process of loading OR superimposing low frequency wave (called audio frequency waves having frequency 20 Hz to 20 KHz) on high frequency wave ------

[called radio wave, which acts as carrier wave].

Need for Modulation:

1. Size of Antenna:

- For transmitting a signal, we need an antenna OR aerial.
- The antenna should have a size comparable to the wavelength of the signal i.e. atleast ($\lambda/4$).
- If the message signal (having large wavelength) is directly transmitted, the length of the antenna will be very large.
- Hence, there is a need for modulation.

2.) Effective Power:

- Effective power radiated by the antenna is given by ($P \propto \frac{1}{\lambda^2}$) λ is the wavelength of the signal to be transmitted.
- If the base-band signals are directly transmitted, then power radiated from the antenna would be small.
- Hence these is a need for high frequency ~~modulation~~ transm^n.

3.) Mixing up of signals from different transmitter:

- Another imp. agreement against transmitting modulation signal directly is more practical in nature.
- Suppose many people are talking at the same time OR many transmitters are transmitting base-band signals simultaneously. All these signals will get mixed-up & there is no way to distinguish b/w them.
- In order to separate various base-band signals, it is necessary to convert them all to different portions of the FM spectrum.
- FM Channel spectrum: 88 MHz ———— 108 MHz

There are three types of modulation -

1.) Amplitude Modulation

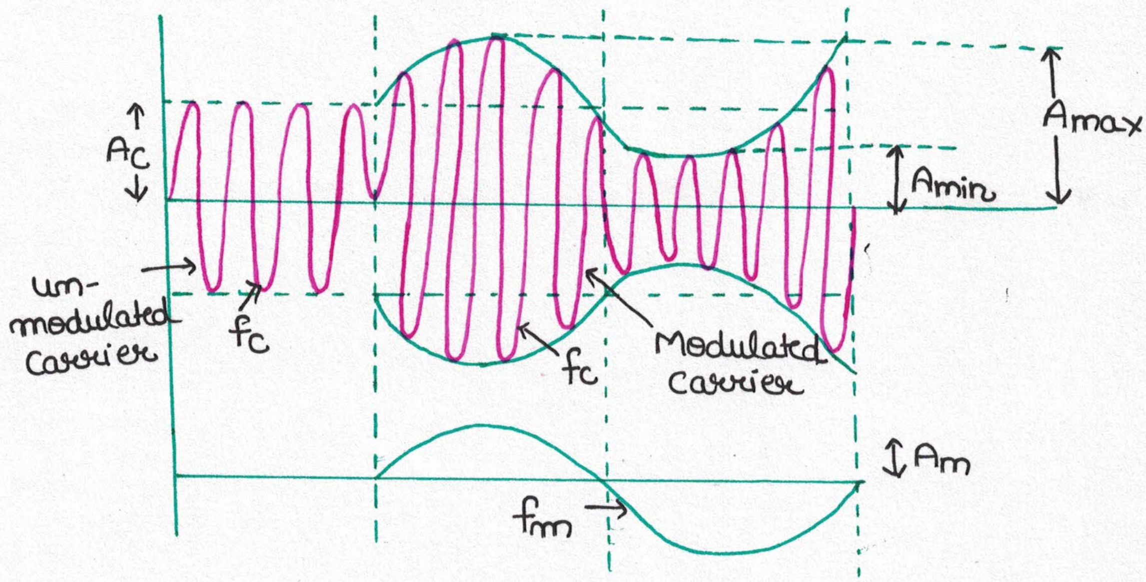
2.) Frequency Modulation

3.) Phase Modulation

Modulation is always of the carrier.

AMPLITUDE MODULATION

It is that type of modulation of the carrier wave in which amplitude of carrier wave changes in accordance with modulating signal keeping the frequency and phase of the carrier wave constant, i.e. if the amplitude of modulating signal increases, amplitude of carrier wave also increases & if the amplitude of modulating signal decreases, amplitude of carrier wave also decreases.



A_c = amplitude of unmodulated carrier wave.

A_m = amplitude of modulating signal

A_{max} = Max. amplitude of modulated signal

A_{min} = Min. amplitude of modulated signal

- $A_m < A_c$ but is comparable in value, ie if A_c is 10V, then A_m should be $\geq$ 3-4 volt.

Modulation Index (μ)

$$\mu = \frac{A_m}{A_c}$$

$$A_c + A_m = A_{max} \quad -①$$

$$A_c - A_m = A_{min} \quad -②$$

$$\therefore \quad \mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} \qquad [\text{from } ① \ \& \ ②]$$

Importance of Modulation Index:

- It plays an imp. role in determining the strength & quality of signal to be transmitted.
- If $A_m <<< A_c$ ($\mu << 1$) [Eg- $A_c = 10V$, $A_m = 0.01V$] i.e. carrier is modulated to a very small extent, then strength & quality of the signal to be transmitted is weak & poor.
- As the value of μ increases, the strength & quality of the signal improve. But if ($A_m > A_c$) ($\mu > 1$) [The condition is called over modulation], the signal becomes distorted.
- Hence, for all practical purposes, μ lies b/w 0 & 1 OR μ should be close to 1 (but less than 1)

ANALYTICAL TREATMENT OF AMPLITUDE MODULATION

Carrier wave $c(t) = A_c \sin(\omega_c t)$ —(1) ; $\omega_0 = 2\pi f_c$

Modulating signal $m(t) = A_m \sin(\omega_m t)$ —(2) ; $\omega_m = 2\pi f_m$

Modulated wave $C_m(t) = A \sin(\omega_c t)$ —(3) $f_m << f_c$

A = amplitude of modulated wave

$$A = A_c + m(t)$$
$$= A_c + A_m \sin(\omega_m t)$$
$$= A_c + \mu A_c \sin(\omega_m t) \quad \text{—(4)}$$

from (3) & (4)

$$C_m(t) = (A_c + \mu A_c \sin(\omega_m t)) \sin(\omega_c t)$$

$$C_m(t) = A_c \sin(\omega_c t) + \frac{\mu A_c}{2} \cos(\omega_c - \omega_m) - \frac{\mu A_c}{2} \cos(\omega_c + \omega_m) \quad \text{—(5)}$$

In eq^n (5), the first term has amplitude $= A_c$
and frequency $= f_c$

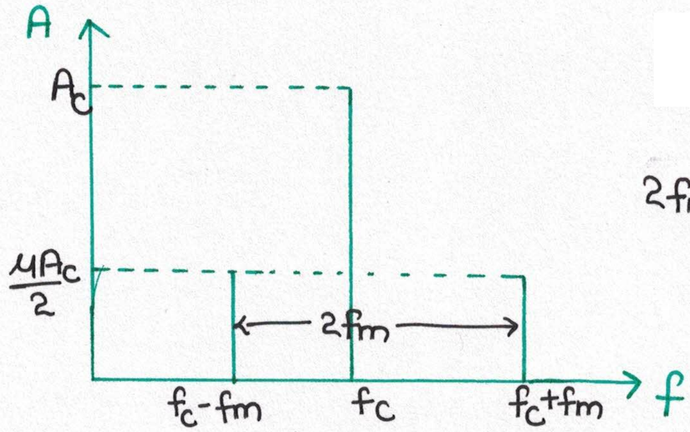
2nd term has, amplitude $= \frac{\mu A_c}{2}$
and frequency $= f_c - f_m$

3rd term has, amplitude $= \frac{\mu A_c}{2}$
and frequency $= f_c + f_m$

Hence, the process of modulation does not change the original carrier frequency (f_c) but produces two new frequencies $(f_c - f_m)$ & $(f_c + f_m)$.

★ $(f_c - f_m)$ is called LSB (lower side band frequency)

★ $(f_c + f_m)$ is called USB (upper side band frequency)



$2f_m$ = band width

Que.) A message signal of f = 10KHz & peak V = 10V is used to modulate a carrier of f = 1MHz & peak V = 20V. Determine modulation index and the side bands produced.

$f_m = 10^4 Hz$, $A_m = 10V$

$f_c = 10^6 Hz$, $A_c = 20V$

$\mu = \frac{A_m}{A_c} = \frac{10}{20} = \frac{1}{2} = 0.5$ (50% modulation)

→ LSB = $f_c - f_m$ = 990 KHz.

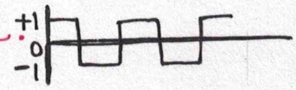
→ USB = $f_c + f_m$ = 1010 KHz.

Que.1.) A carrier wave of peak V = 12V is used to transmit a message signal. What should be the peak voltage of the modulating signal in order to have modulation index of 75%.

Que.2.) A modulating signal is a square wave as shown in fig. The carrier wave is given by $e(t) = 2\sin(8\pi t)$ V.

(i) Sketch amplitude modulated carrier wave.

(ii) What is the modulation index?



Que.3.) For an amplitude modulated wave A_{max} = 10V & A_{min} = 2V. Determine μ = 2/3.

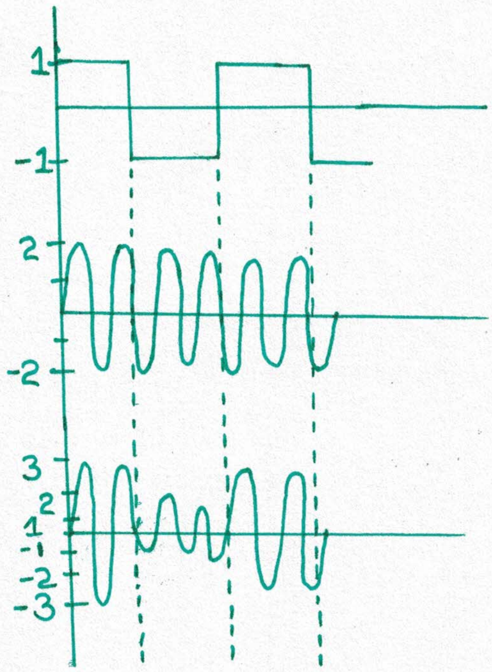
Que.4.) Due to economic reasons, only upper side band of Am wave is transmitted, but at receiving station, there is a facility for generating the carrier. Show that if a device is available which can multiply two signals then it is possible to recover the modulating signal at receiver station.

1.) $A_c = 12V$

$\mu = \frac{3}{4}$

$A_m = \frac{3}{4}(12) = 9V$

2.)



4.) $\left[\frac{\mu A_c}{2} \cos(\omega_c + \omega_m)t\right] \times \left[A_c \sin(\omega_c t)\right]$

$= \frac{\mu A_c^2}{4}\left[\sin(2\omega_c + \omega_m)t - \sin(\omega_m t)\right]$

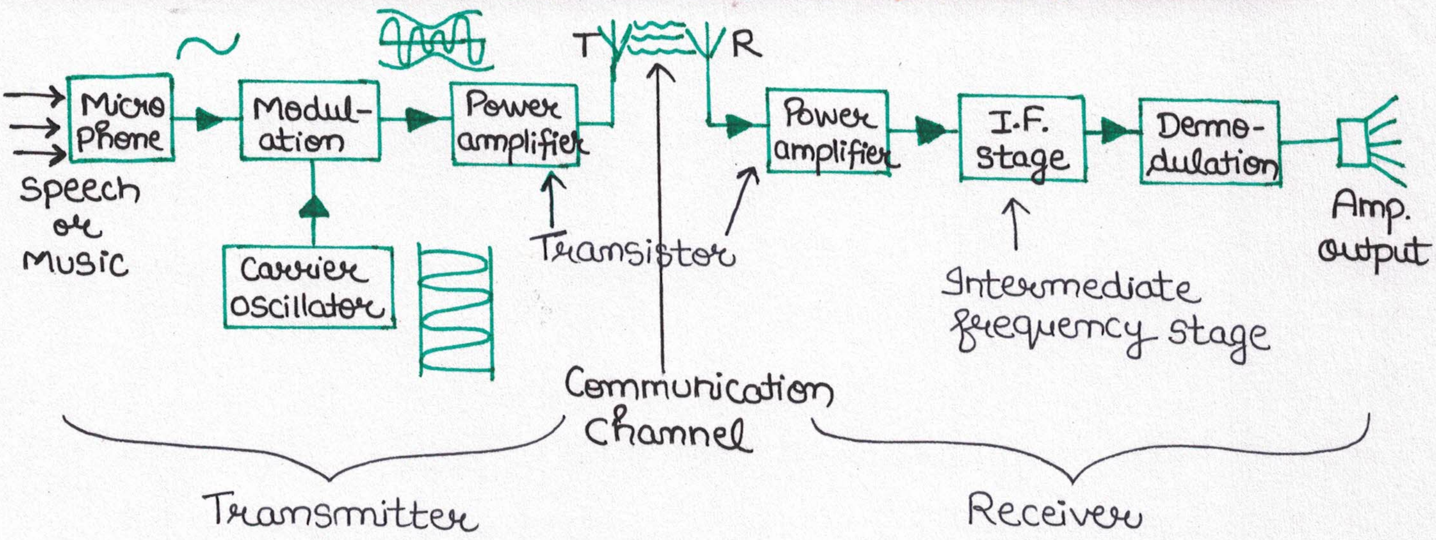
Attenuation:

Weaking of strength of a signal during transmission.

Detection/Demodulation:

It is the process of recovering the message signal from the modulated wave.

BLOCK DIAGRAM OF MODERN COMMUNICATION SYSTEM



COMMUNICATION CHANNEL

It is a physical medium which establishes a link b/w transmitter and receiver.

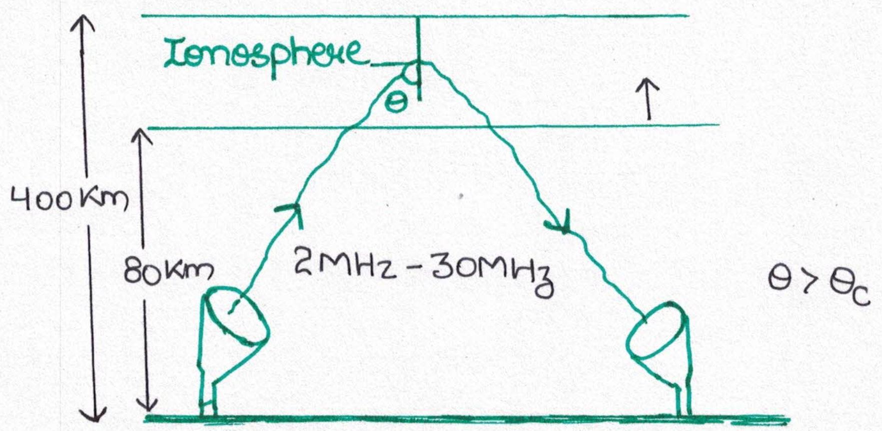
C.C.

- **Line Communication** (Point-to-Point connection b/w transmitter & receiver)
- **Space Communication** (Broadcasting) or Wireless communication
  - **Ground wave propagation**
    - frequency of carrier used = 500 KHz to 1500 KHz
    - used when distance b/w transmitter & receiver is small
    - High frequency carrier waves are absorbed by the ground.
  - **Sky waves propagation**
    - → Ionesphere acts as reflector
    - → only frequencies b/w 2MHz & 30MHz are reflected by ionesphere
  - **Space wave Propagation**

GROUND WAVE PROPAGATION

- This type of propagation is used when transmitting & receiving antenna are close to the surface of the earth.
- As the ground wave glides over the surface of the Earth, its electric field vectors are vertically polarised & charges are induced on the surface of the earth.
- The induced charge on the earth travel with the wave & constitute a current.
- The energy of the wave is dissipated due to the flow of current through the Earth's surface. Therefore the wave is attenuated.
- The attenuation of surface wave increases very rapidly with increase in frequency.
- Hence, GWP can be sustained only at low frequencies (500 KHz - 1500 KHz).
- Also, GWP is used when distance b/w T & R is not very large.

SKY WAVE PROPAGATION

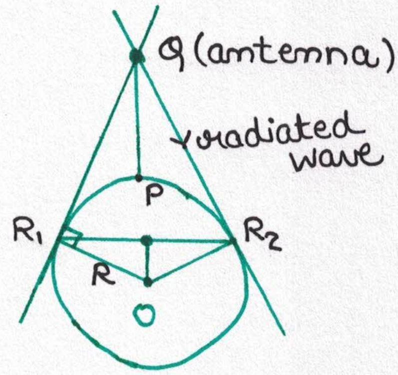


- In the frequency range from a few MHz upto 30-40 MHz, long distance communication can be achieved by ionospheric reflection of radio waves back towards the Earth.
- Used by short wave broadcast services.
- The ionosphere is so called because of the presence of a large no. of ions or charged particles.
- It extends from 65 Km to 400 Km.
- The ionosphere layer acts as a reflector for a certain range of frequencies (2MHz - 30MHz).

- EM waves of frequencies higher than 30MHz penetrate the ionosphere & escape.
- The max. frequency of the EM wave that can be reflected by a particular layer of ionosphere is called critical frequency.

SPACE WAVE PROPAGATION

- The SWP commences with very high frequency band i.e. 30MHz to 300 MHz.
- FM & TV signals are transmitted in this way.
  (TV → high frequency)
  80 - 200 MHz
- The transmitted waves travelling in straight line directly reach the receiver & are then picked up by the receiving antenna.



P is very near to surface of earth

- It can be shown that due to finite curvature of the earth, such waves cannot be seen beyond the tangent points R_1 & R_2.
- Hence, sometimes this mode of communication is termed as line-of-sight communication.

To find the height of transmitting antenna:

Let $PQ = h =$ Height of antenna

$PR_1 = d =$ Range of antenna

$OR_1 = OR_2 = R =$ radius of Earth

In right ΔOR_1Q,

$$OQ^2 = OX_1^2 + OR_1^2$$

$$(R_{Th})^2 = 2R^2 + R^2 \quad —(1)$$

In right ΔPR_1Q,

$$QR_1^2 = PQ^2 + PR_1^2$$

$$QR_1^2 = h^2 + d^2 \quad —(2)$$

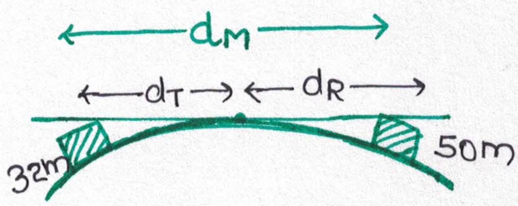
adding (1) & (2)

$$\cancel{R^2} + \cancel{h^2} + 2Rh = \cancel{R^2} + \cancel{h^2} + d^2$$

$$d^2 = 2Rh$$
$$d = \sqrt{2Rh}$$

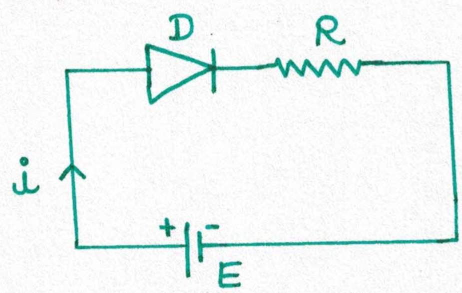
Que.) A transmitting antenna at the top of a tower has a height of 32m. & height of receiving antenna is 50m, what is the max. distance b/w them for satisfactory communication in L-O-S mode?

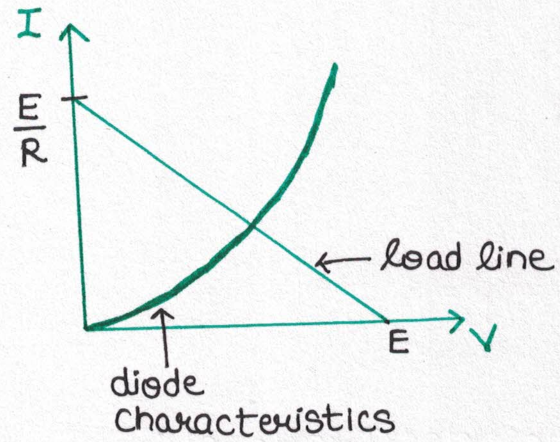
$$d_{max} = \sqrt{2R(32)} + \sqrt{2R(50)}$$



$$d_m = d_T + d_R$$
$$d_m \simeq 45.5 \text{ Km}$$

LOAD LINE



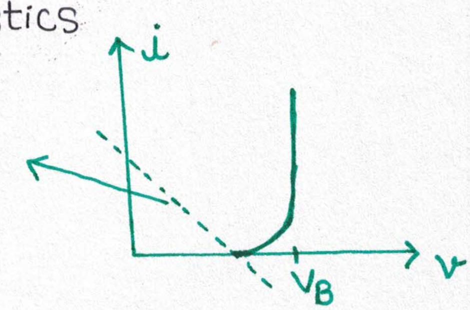


$$V_d + iR = E$$
$$i = \frac{E}{R} - \frac{V_d}{R}$$

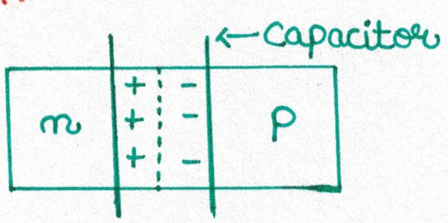
Simplification of VI-characteristics

$V_B = 0.6\text{V}$ for I

no solution ⇒ no current



- In pn-junction

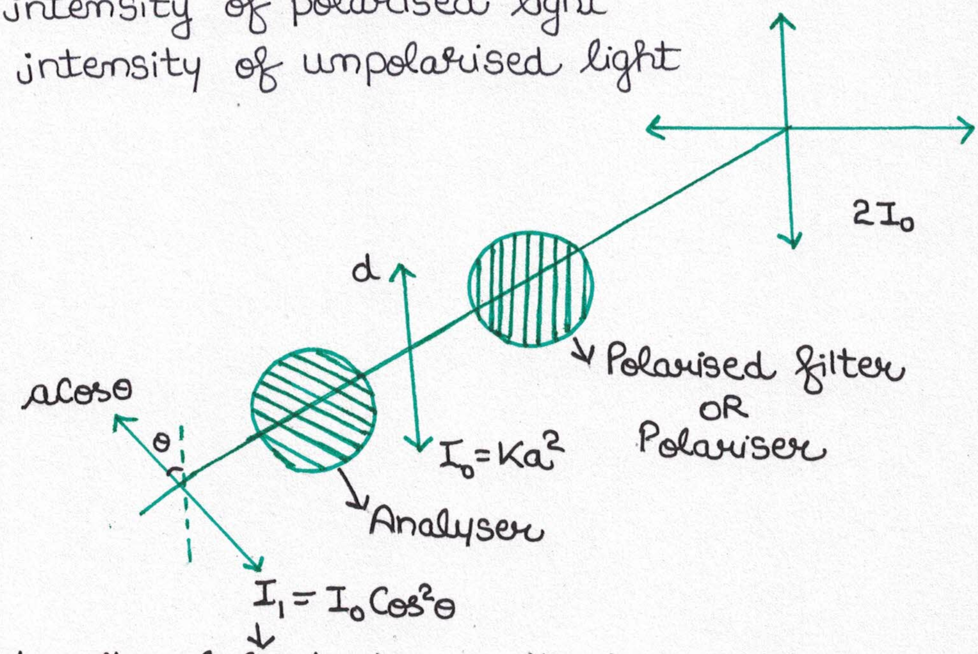


(inter atomic level size)
less spacing
∴ high capacitance

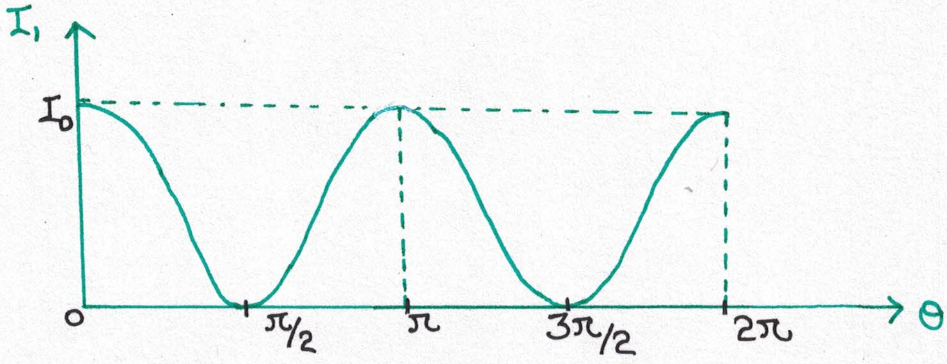
★Reverse biased pn junction → capacitor with very high capacitance

Battery also has high capacitance.

I_0 = intensity of polarised light
$2I_0$ = intensity of unpolarised light



Intensity of light transmitted through the analyser



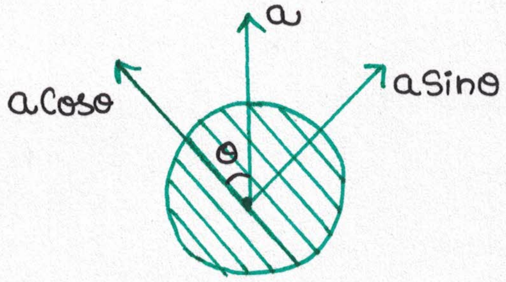
Analyser is used to check if polarisation has taken place or not.

Que.) What happens to the intensity of light transmitted through the polariser, if polariser is continuously rotated?

The intensity of light transmitted through the polariser will remain unchanged.

Que.) What happens to the intensity of light transmitted through the analyser if it is continuously rotated?

The I of light through analyser will decrease from max. to zero, again increase from zero to max. and so on. This is clearly visible from graph.



θ = angle b/w pass axis of polariser & pass axis of analyser.

Que.) What happens to the intensity of light if a polariod is roatated between two crossed polaroid?

$$I_1 = \frac{I_0}{4} (\sin^2 2\theta)$$

Que.) Figure shows a system of three polarising sheets in the path of initially unpolarised light. The pass axis OR polarising direction of 1st sheet is parallel to y-axis & that of 2nd sheet is 60° counterclockwise from y-axis & that of 3rd sheet is parallel to x-axis. What fraction of initial intensity of light emerges.

$$\frac{I_1}{2I_0} = \frac{1}{2}\left(\frac{1}{4}\left(\frac{\sqrt{3}}{2}\right)^2\right)$$

$$= \frac{3}{32} = 0.094$$

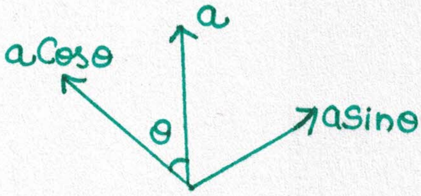
LAW OF MALUS

Intensity of light transmitted through the analyser is directly proportional to the square of the cosine of the angle between the pass-axis of analyser & the pass axis of polariser.

Let OA = 'a' = amplitude of polarised light

Now, we resdue this amplitude along and ⊥r to the pass-axis of analyser as 'a Cosθ' & 'a Sinθ'.

'a Sinθ' component will be absorbed by the analyser & 'a Cosθ' component will be transmitted by the analyser.



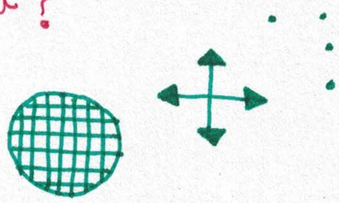
Hence, intensity of light transmitted through analyser is given by

$$I = K (a\cos\theta)^2$$

$$I \propto \cos^2\theta$$

Que. What happens to intensity of unpolarised light, when it passes through a crossed polaroid?

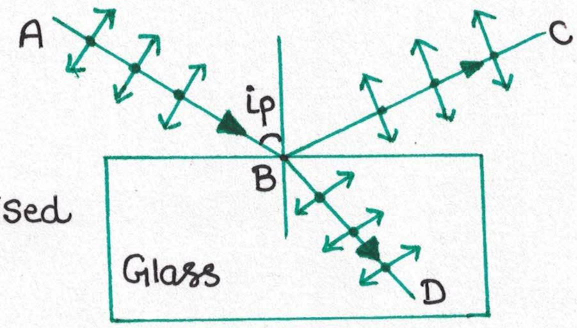
No light is transmitted.



★ unpolarised light can also be represented as 

POLARISATION BY REFLECTION (BREWSTER LAW)

Brewster in 1808 experimentally observed that



ip = angle of polarisation

When an unpolarised light is incident on a transparent surface (like glass, water) at a particular angle of incidence (called angle of polarisation), then after reflection the light becomes completely polarised.

It was also observed that when light is completely polarised, then reflected and refracted rays become ⊥r.

$$\frac{\sin(i_p)}{\sin(r)} = \mu_g \quad —①$$

also, $r + i_p = 90^\circ$

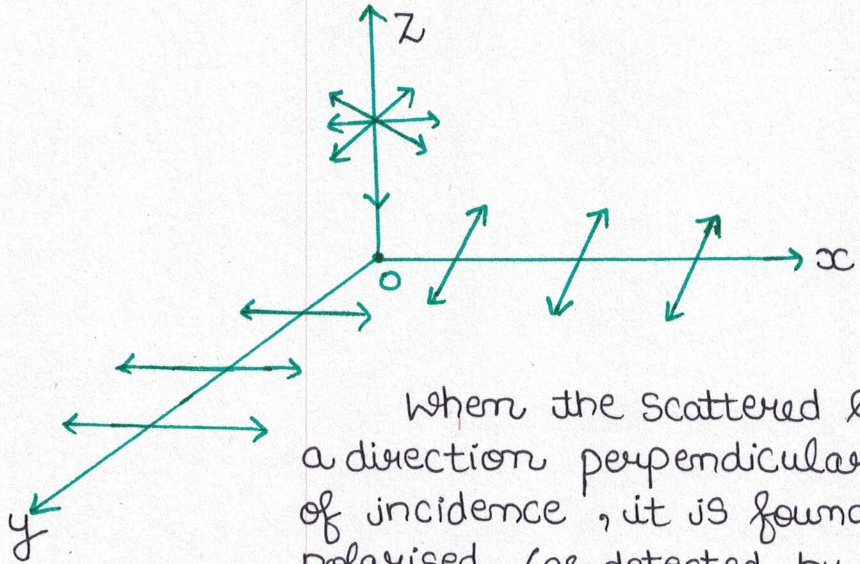
$\sin r = \cos i_p \quad —②$

from ① & ②

$$(\tan(i_p) = \mu)$$

POLARISATION BY SCATTERING

When a beam of white light is passed through a medium containing particles whose size is of the order of wavelength of light, then the beam gets scattered.



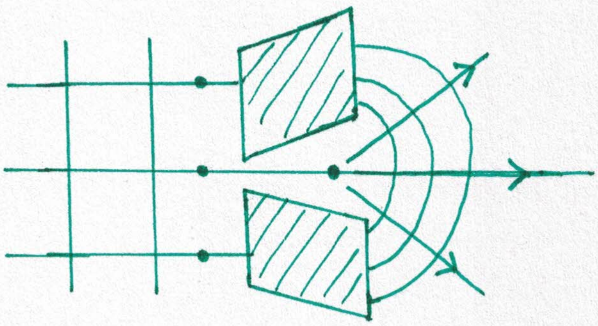
When the scattered light is seen in a direction perpendicular to the direction of incidence, it is found to be plane-polarised (as detected by the analyser).
The phenomenon is called polarisation by scattering.

DIFFRACTION OF LIGHT

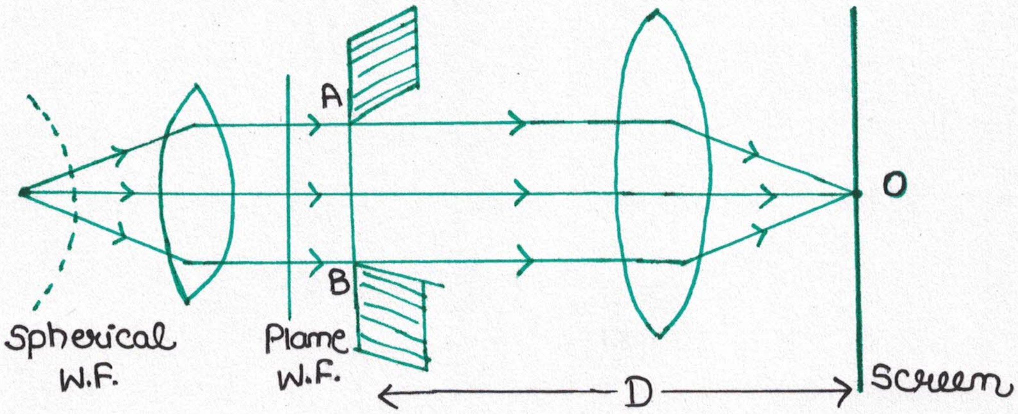
Phenomena of bending of light at a small aperture OR around the corner of an object.

★ Narrower/smaller the size of slit, more is the bending.

Size of slit comparable to wavelength of light ⇒



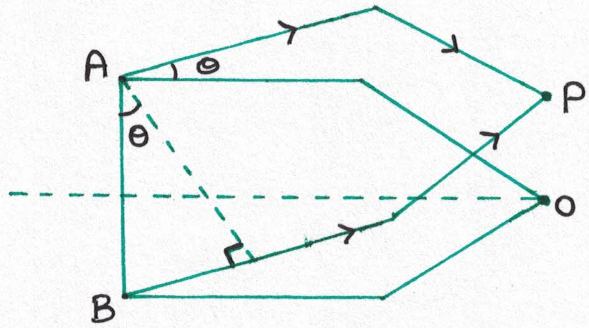
DIFFRACTION BY A SINGLE SLIT



AB = a = Size of slit

Imp. Que: Difference b/w Interference & Diffraction

	Interference	Diffraction
(1.) No. of slits	= 2	
(2) Intensity of fringes	= same for all	different (Central-most bright)
(3) Contrast b/w bright and dark	= Good	Poor
(4) Fringe width	= May / May not be same	(Always different)

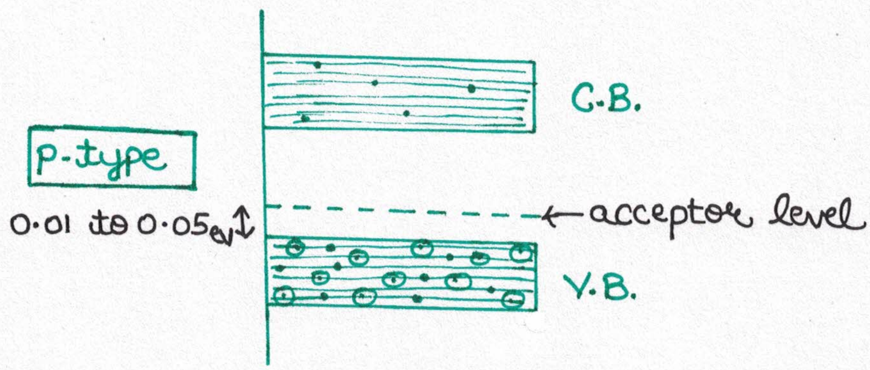


BN = path difference

In right ΔABN

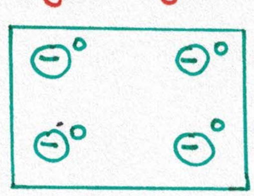
$$\sin\theta = \frac{BN}{AB}$$

$$BN = a\sin\theta = \Delta x$$

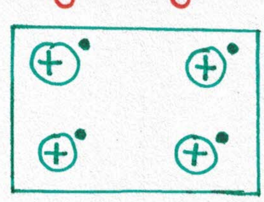


Generally, N-type semiconductors are a bit more Conductive than P-type semiconductors.

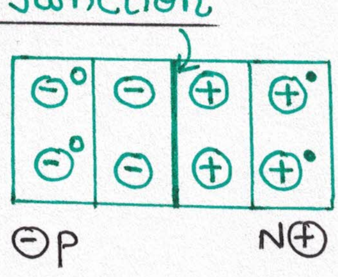
- Profile of P-type

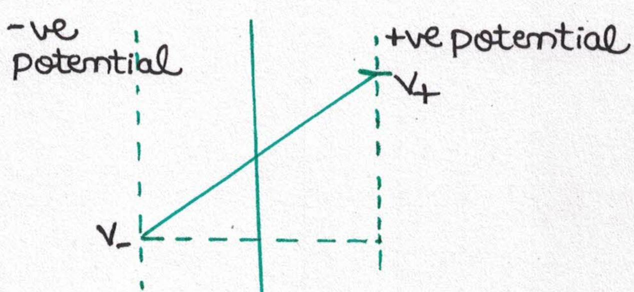


- Profile of n-type



- PN - Junction





$V_+ - V_- =$ potential barrier

Main Use - To convert AC into DC

★ Hole cannot climb this potential hill.

★ e^- cannot come down this potential hill.

Depletion layer:

It is a thin layer near the PN junction, which is devoid of (free electrons and holes) charge carriers.

Potential Barrier:

For Silicon, $V_+ - V_- = 0.7$ volts

For Ge, $V_+ - V_- = 0.2$ volts

Definition - A potential difference built up across the P-N junction which restricts further movement of charge carriers across the junction is known as potential barrier.

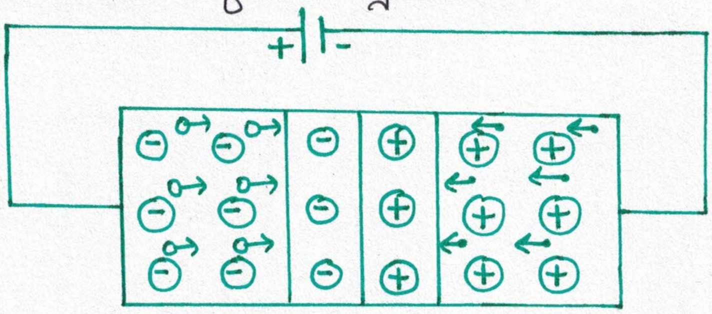
BIASING

- Forward Biasing
- Reverse OR Backward Biasing

When a PN-junction is connected across an electric supply (potential difference), the junction is said to be under biasing.

FORWARD BIASING

1.) When the positive terminal of a DC source (or battery) is connected to p-type & negative terminal is connected to N-type semiconductor of a PN junction.

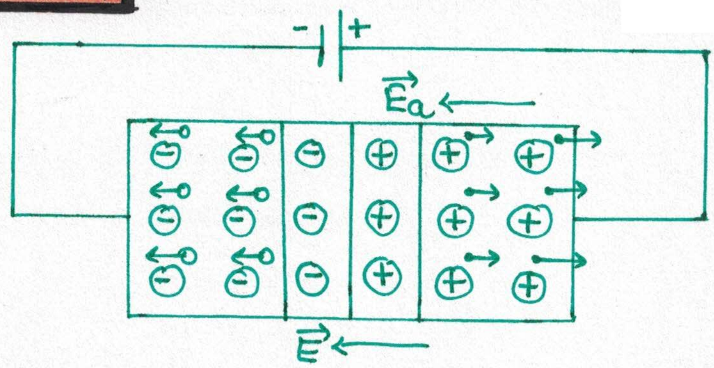


2.) During forward biasing, the majority charge carrier move towards the PN-junction.

3.) Here, the applied forward potential acts in such a way that it establishes an electric field which reduces the field due to potential barrier.
Hence, the potential barrier at the junction is reduced.
As the potential of the external DC source is gradually increased, the thickness of depletion layer gradually decreases, and a time comes when the potential barrier is completely eliminating & there will be free movement of charge carriers across the PN-junction.

4.) During forward biasing, the resistance of the P-N junction becomes negligible i.e. it becomes a good conductor.

REVERSE BIASING



1.) When the positive terminal of a DC source or battery is connected to N-type & negative terminal is connected to P-type semi-conductor of a P-N junction.

2.) Here, the majority charge carrier will move away from the PN junction.
However, minority charge carrier in P & N-side will move towards the P-N junction.

3.) Here, the applied reverse potential acts in such a way that it establishes an electric field which increases the field due to potential barrier. Hence, the thickness of depletion layer will increase.

4.) The resistance in reverse biasing becomes infinitely large i.e. it becomes a bad conductor.

Hence, we can say that in P-N junction, only unidirectional flow of current is possible i.e. from P to N and not from N to P.

- ▷ is a symbol for P.
- | is a symbol for N.

★ P-N junction is also called 'DIODE'.

Forward biasing   Reverse biasing

CHARACTERISTICS

Characteristics represents a graph between the voltage applied across the terminals of a P-N junction diode and the current that flows in the diode.

FORWARD CHARACTERISTICS