UNIT – X

Communication System

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Communication ↦ Communication means the processising a transfer of signal / information from one place to another place either through wires or through opt fibre or through space.

Types of communication ↦

① On the basis of link or medium or transmissi channel used communication can be classified as

(a) Cable communication (wire link)
(b) Ground wave communication (wireless link)
(c) Sky " " (" ")
(d) Satellite Communication (" ")
(e) Optical " (wire link)

(2) On the basis of type of modulation used, the communication can be classified as.

(a) Amplitude modulated communication
(b) frequency " "
(c) Phase " "
(d) Pulse " " etc.

(3) On the basis of type of signal used, the communication can be of following types

(a) Analog communication
(b) Digital "

Elements of communication system ↦

To communicate from one place to other plac at a long distance (say through a telephone) a communication system has to be setup. The block diagr

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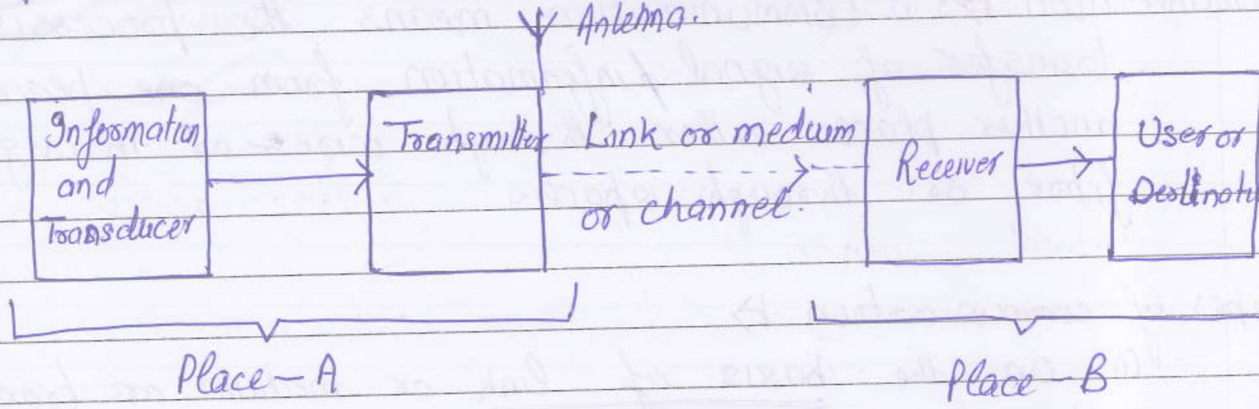
of the basic communication system is as shown



(1) Transmitter ↦ At the transmitting station, information signal (say audio or video) is converted into electrical signal using transducer. This electrical signal is modulated, amplified and fed to the communication channel.

(b) Communication Channel ↦ Depending on the type of communication, signal received from the transmitter is carried from station A to station either through wire links or wireless links.

(c) Receiver ↦ At the receiving station-B, receiver amplifies the received signal and demodulate it to extract the original information.

Basic terminology used in electronic communication system

(1) Information ↦ Information is a useful message in the form of speech, pictures, text, data etc.
For a radio station, it is in the form of speech whereas for a TV " , it is in the form of speech & picture.

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(9) Signal ↦ ~~Information~~. While transmitting the information over a long distance, it has to be converted in electromagnetic form.

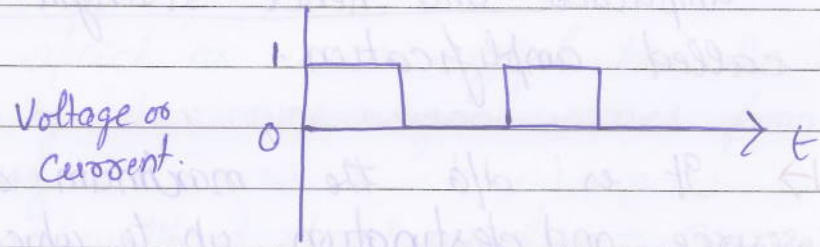
The information in electromagnetic form is called signal

(a) Analog Signal ↦ A signal whose magnitude changes continuously with time is called analog signal.

(b) Digital Signal ↦ A signal which has only two levels/values ie max or min OR high or low OR on or off.

Max or high or on ~~or~~ is represented by binary digit 1

and Min or Low or off is represented by binary digit 0.



13) Encoding ↦ The process of converting an information into signal is called encoding

4. Transducer ↦ A device which converts one form of energy ~~f~~ into another form of energy is called transducer. e.g. microphone, LED etc

microphone converts speech or voice into electrical signal

LED " electrical signal into light signal

5. Attenuation ↦ The strength of signal decreases as it travels ~~fo~~ through the medium or link.

The loss of strength or power of an electrical signal while travelling through a medium or communication channel is called attenuation.

6. Noise ↦ It is d/a the disturbance or unwanted elements which interfere with the desired signal.

7. Modulation ↦ The process of superimposing low frequency signal waves on high frequency carrier waves is called modulation.

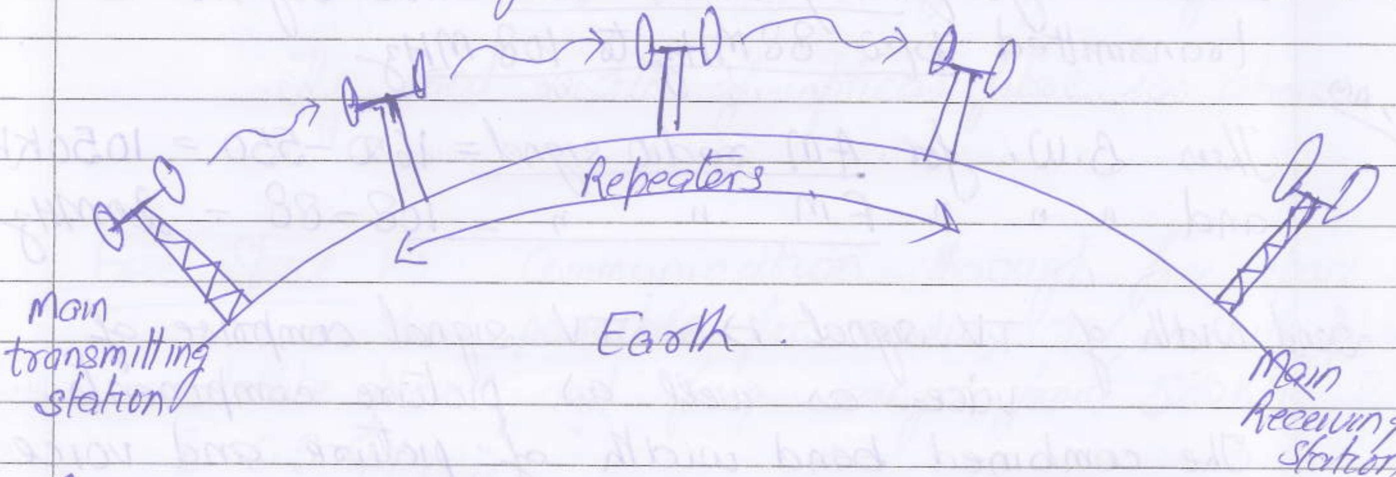
8. Demodulation ↦ The process of extracting signal waves from the modulated wave is called demodulation.

9. Amplification ↦ The process of increasing the amplitude and hence strength of the signal is called amplification.

Range ↦ It is d/a the maximum distance between source and destination up to which desired signal with sufficient amplitude can reach.

Repeaters ↦ In order to increase the range of transmission or to transmit the signal over a long distance, number of receivers and transmitters k/a repeaters are installed between the main transmitting and main receiving stations

Each repeater receives the signal, amplifies and retransmit it to the next repeater. Thus fina[lly] the desired signal reaches the distant destinat[ion].



Band Width of signals ↦ The width of frequency spectrum of a signal is K/a band width of the signal.

If frequency of the signal varies from ν_{min} to ν_{max} then band width of the signal is

$$B.W = \nu_{max} - \nu_{min}.$$

(i) Band width of speech or voice signal ↦ In telephony frequency of the voice signal varies from 300 Hz to 3100 Hz.

Thus bandwidth of speech signal is = 3100 − 300 = 280[0]

(ii) Band width of music or Audio signal ↦ Human ear can hear music of audible range i.e b/w 20 Hz to 20000 Hz.

Thus band width of music signal = (20000 − 20) Hz
= 19980 Hz
≃ 20 KHz

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Bandwidth of radio Signal ↦ Amplitude modulated radio signal is transmitted b/w 550 KHz to 1600 where as frequency modulated radio signal is transmitted b/w 88 MHz to 108 MHz

FM > AM

Thus B.W. for AM radio signal = 1600 − 550 = 1050
and " " " FM " " = 108 − 88 = 20 M

Band width of TV signal ↦ TV signal compose of voice as well as picture components. The combined band width of picture and voi signal is about 6 MHz

T.V. signals are transmitted on the following bands

High frequency (HF) → 54 MHz to 72 MHz
Very " " (VHF) → 174 MHz to 216 MH
Ultra " " (UHF) → 420 MHz to 890 MH

Band width of digital signal ↦ Theoretically infini band width is required for digital signal.

Because rectangular digital signal be considered to be made up due to superposition of infinite sinusoidal signa

Band width of transmission Medium ↦ Depending the frequency range or band width of signal to be transmitted, ~~transmission~~ suitable transmission medium is selec

Band width of co-axial cable ↦ Co-axial c are used for signals below 18

The bandwidth of commonly used

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Band width of optical fibre ↦ Optical fibres are used for the transmission of microwaves & UV waves of frequency range of 1 THz to 1000 T

The band width of optical fibre is above 10^{11} Hz.

Free Space ↦ Communication through free space best possible for radio, TV, mobile ph satellite phone and freq. ranges from 580 KHz to 6.5 GHz

Various frequency ranges of radio and micro

S.No	Name of signal	Frequency range
1	Very low frequency (VLF)	< 30 KHz
2.	Low frequency (LF)	30 KHz to 300 KHz
3	Medium freq. (MF) or Med wave	300 KHz to 3 MHz
4	High freq (H.F) or Short wave	3 MHz to 30 MHz
5	Very High freq. VHF	30 MHz to 300 MHz
6	Ultra " " UHF	300 MHz to 3000 MHz
7	Super " " SHF	3 GHz to 30 GHz
8	Extremely " " EHF.	> 30 GHz

Behaviours of earth's atmosphere towards em waves ↦

The earths atmosphere contains 78% of nitro and 21% of O_2 and remaining 1% of other gas like CO_2, CO or Ar etc.

Earths atmosphere can be divided into

four basic regions. Various regions of earths atmosphere behaves differently towards em waves.

(1) Troposphere ↦ extends from 0 to 12km
temp falls from 280K to 220K
Low energy infrared radiations can't penetrate through it.

(2) Stratosphere ↦ extends from 12 km to 50 km
temp rises from 220 K to 280K.
It contains ozone layer, which protects us from the harmfull U.V radiations coming from the sun.

3. Meso sphere ↦ extends from 50km to 80km
temp falls from 280K to 180km

This layer absorbs a part of high frequency em waves and allows the rest of em waves to pass through it.

4. Ionosphere ↦ extends from 80km to 400 km
temp rises with height in this region.
The density of this region goes on decreasing with height.

Ionosphere plays a vital role in the radio-communication.
Ionosphere helps in transmitting the radio-messages round the curve of the earth.

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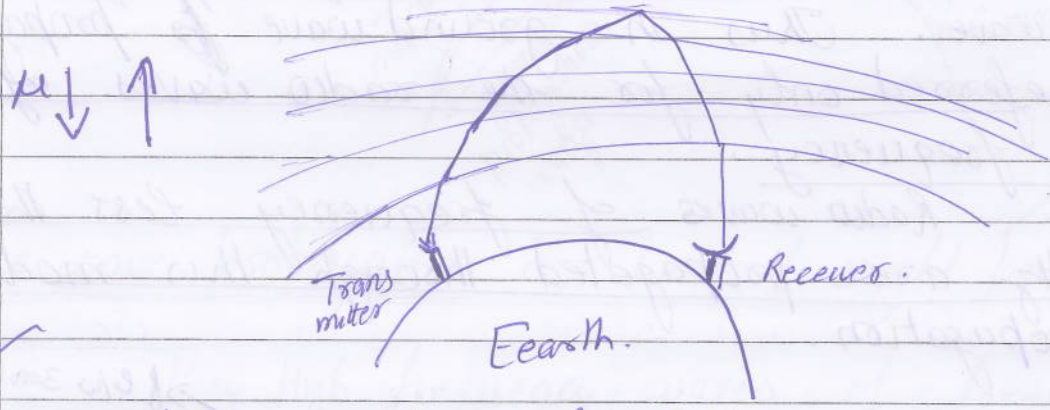
Radio-message is transmitted towards the ionosphere, As densities of the different layers of the ionosphere goes on decreasing with height, thus transmitted message bends continuosly away from normal. And finally when angle of incidence becomes more than critical angle, total internal reflection takes place and thus message get reflected back to earth and can be received even round the curve of earth.



Modes of propagation of electromagnetic waves ↦

Since behaviour of earth and its atmosphere is different for different frequency range. Thus depending on the frequency of the radio wave or microwave, it can be transmitted from one place on earth to other part of earth

(1) Ground Wave propagation
(2) Sky wave propagation or ionosphere propagation.
3. Space wave propagation or Line of Sight propagation.

(A)

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① Ground wave propagation ↦ → ① Signal's transmitted … → ⑤ Reason why (low freq … less … → f < 1500 KHz

In ground wave or s… wave propagation, radio waves travel from transmitting antenna to receiving antenna … the surface of earth. Due to conducti… and permitivity of earth, energy of th… transmitted wave goes on decreasing … distance.

Since loss of energy (ie attenua… increases with increase in frequency of … radio wave. Thus in ground wave ~~p~~ p… is preferred only for the radio waves … lower frequency.

Radio waves of frequency less … 1500 KHz are propagated through this m… of propagation.

2. Sky wave ~~of~~ or ionospheric propagation ↦ → f 6/… → along … → use …

~~In this mode o~~

In sky wave propagation, wav… frequency more than 3000 KHz (= 3 MHz) … directed towards the ionosphere.

While travelling through the ionos… it goes on bending due to refraction … finally total internal reflection takes … and ~~the~~ waves are received back … surface of earth.

With the help of sky wave … tion, waves can be transmitted over th… curved surface of earth.

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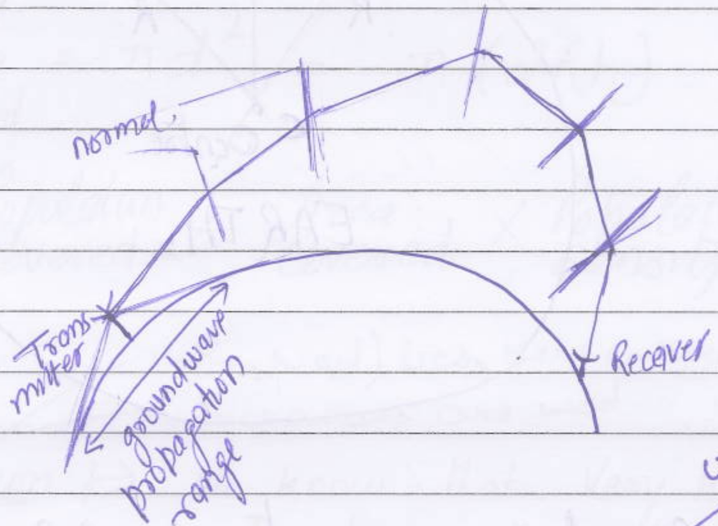
Sky wave propagation is useful for frequency between 3 MHz to 30 MHz. Because waves of frequency more than 30 MHz, penetrates through the ionosphere and are not reflected back.



$\upsilon > 80$ MHz

→ No obstruction b/w transmitter & receiver

(3) Space wave propagation or Line of sight propagation ↦

→ Line of sight

Very High frequency waves of frequency more than 80 MHz (also known as space waves) can be propagated from transmitting antenna to receiving antenna through space wave propagation.

In space wave propagation, signals can be received only if receiving antenna directly intercepts the signal from the transmitting antenna. i.e if there is no obstruction b/w transmitting and receiving antennas. Thus this propagation is also known as line of sight propagation.

Thus in this mode of propagation, distance covered or area covered depends upon the height of the antennas.

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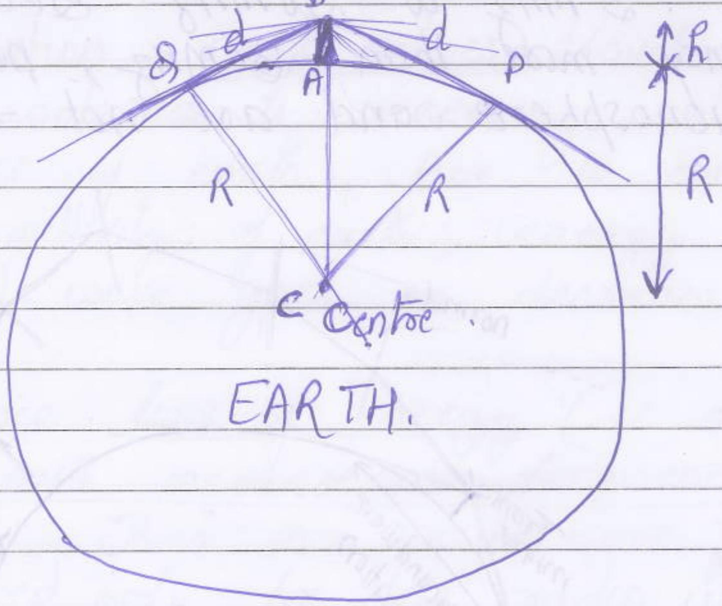
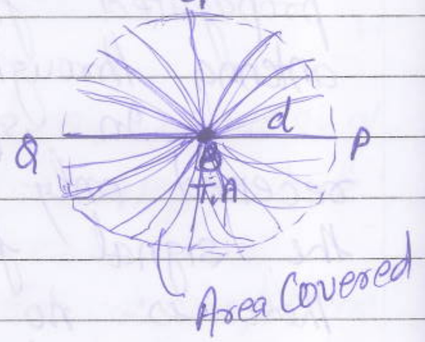
Height of the antenna and area covered ↦



Consider an antenna AB of height h is installed on the surface of earth. The transmitted from point B of the antenna will be received by the people living in circle of radius BP or BQ.



In right angle triangle $\triangle BCP$

$$BC^2 = BP^2 + PC^2$$

$$(AB + AC)^2 = BP^2 + PC^2$$

$$(h + R)^2 = BP^2 + R^2$$

$$R^2 + h^2 + 2Rh = BP^2 + R^2$$

$$BP^2 = h^2 + 2Rh$$

since $h << R$ $\therefore$ h^2 can be neglected

$$\therefore BP^2 = 2Rh$$

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or $d^2 = 2Rh$

$\Rightarrow$ $\boxed{d = \sqrt{2Rh}}$

Thus area covered by the signal is

$$\text{Area covered} = \pi d^2 = \pi(2Rh) = 2\pi Rh.$$

or Population covered = Area covered × Population density

~~Sattel~~

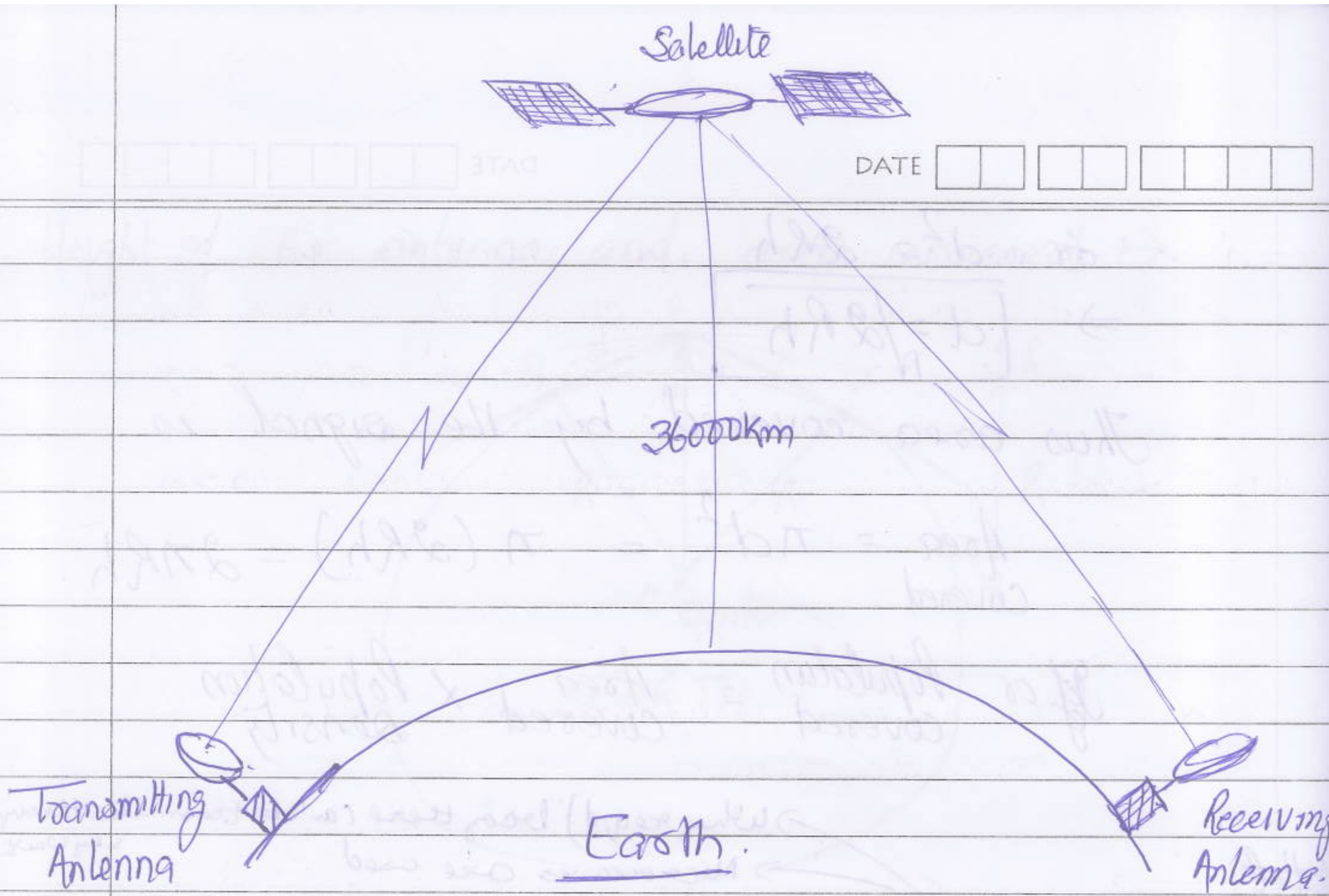
→ Why reqd) bcoz there can't be transmitted through sky wave
→ Microwaves are used

Satellite Communication ↦ We know that Very High frequency waves can be transmitted through line of sight communication. Thus in order to transmit these waves over the whole globe large no. of repeaters are required ~~~~ which is not possible due to geographic condition of the earth.

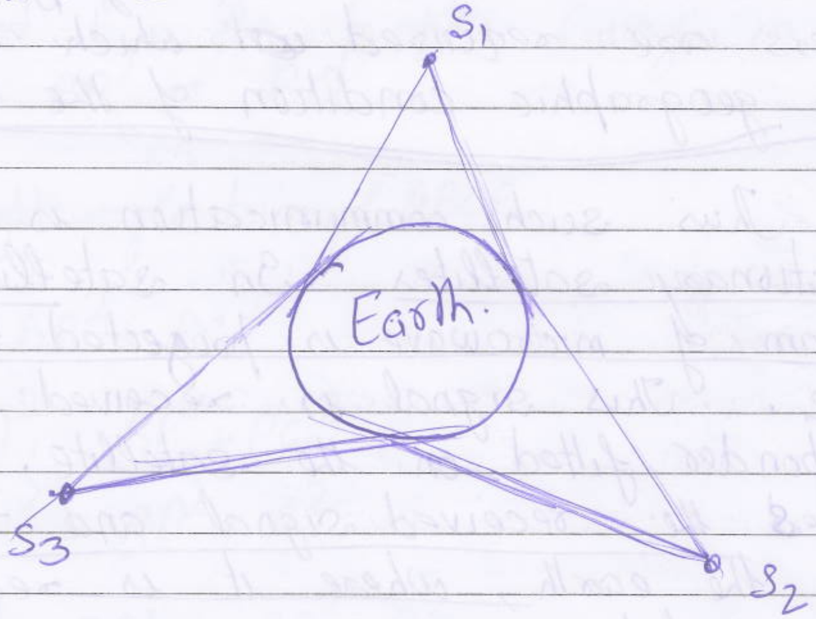
Thus such communication is made through geo-stationary satellites. In satellite communication a beam of microwave is projected towards the satellite. This signal is received by the transponder fitted on the satellite. Transponder amplifies the received signal and retransmit it towards the earth, where it is received by the receiving station.

Thus we can say that satellite acts as a big microwave repeater in the sky.

~~Thre~~



Three geo-stationary stellite separated by an angular separation of 120° each can cover the entire earth



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Need of Modulation ↦ Audio signal / music having very low frequency of range b/w 20Hz to 20KHz, cannot be transmitted as such over a long dista[nce] because of the following factors.

① Height of the transmitting antenna required ↦

We know that height of the transmitting antenna required to transmit a signal must be of height equal to $\frac{1}{4}$ th of the wave length of the signal.

Thus for a audible signal wave of freq. 15 KHz, the wave length of the wave is

$$\lambda = \frac{c}{\nu} = \frac{3\times10^8 ms^{-1}}{15\times100 Hz} = 2\times10^4 m$$

$$\Rightarrow \lambda = 20 km$$

Thus height of the transmitting antenna required is

$$h = \frac{\lambda}{4} = \frac{20}{4} = 5 km$$

To erect / instal such a tall antenna is almost impossible. Thus low frequency ~~audio~~ audio signal is superimposed on high freq. carrier waves (ie modulation) for long distance transmission.

② Power radiated by an Antenna ↦ Power radiated by an antenna is more for shorter wave length or for high freq. signal. For covering larger area power radiation should be more, ~~thus high frequency~~ which is possible for high frequency waves. Thus modulation is don[e]

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Power radiated by dish antenna of diam[eter]
D is

$$P_{da} = 6\left(\frac{D}{\lambda}\right)^2$$

and Power radiated by linear antenna

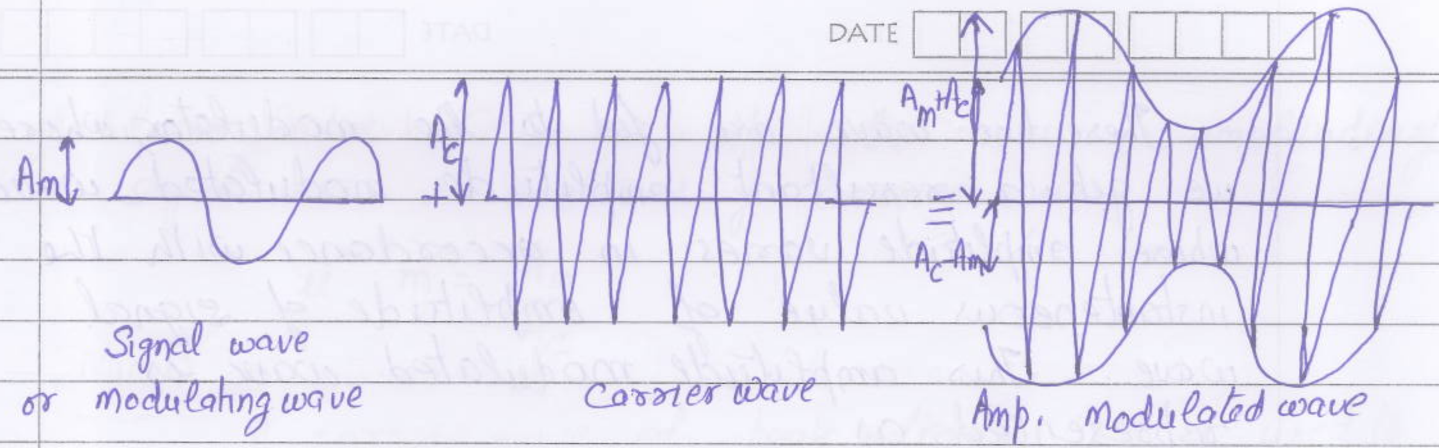
$$P \propto \frac{1}{\lambda^2}.$$

[Noise factor] 3. Mixing up of signal ↦ If voice of a[ll] signals are transmitted as such (without modulation) from different tran[smitting] antenna then these signals will get [mixed] up to produce nothing desirable.

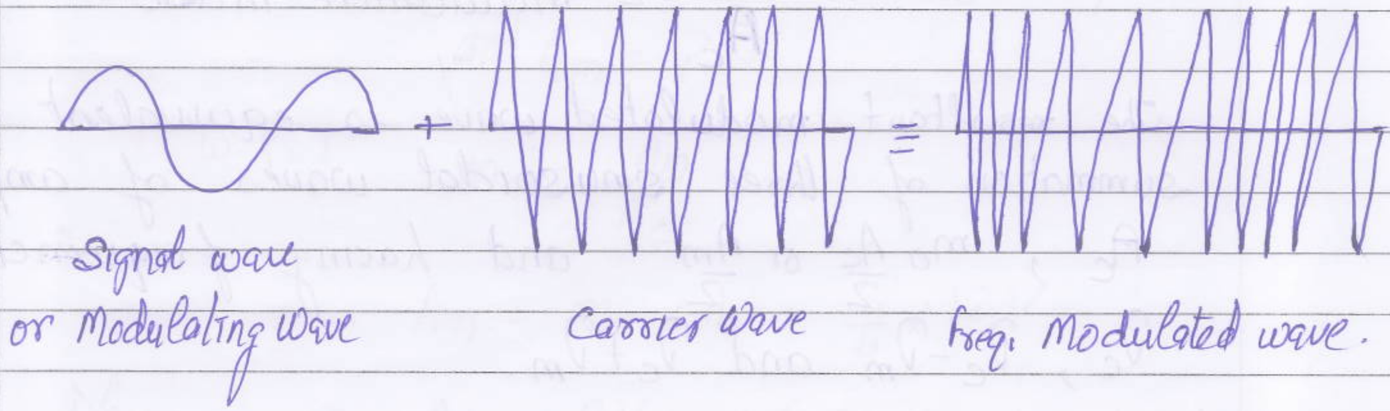
Modulation ↦ The process of mounting or superimpos[ing] low frequency signal wave over a high freq[uency] carrier wave is called modulation.

Types of Modulation ↦

(I) AMPLITUDE MODULATION ↦ In amplitude mo[dulation] (AM) low frequency signal waves (or modula[ting] waves) are superimposed on high freq. ca[rrier] waves to get a resultant modulated wave [in] such a manner that frequency of resul[tant] modulated wave remains same as that of carrier waves where as its amplitude varies [in] accordance with the amplitude of signal



② **Frequency Modulation ↦** In frequency modulation (FM) low freq. signal wave (or modulating wave) is superimposed on high frequency carrier wave to get resultant modulated wave in such a manner that the amplitude of the resultant modulated wave remains same as that of carrier wave where as its frequency varies in accordance with the amplitude of signal wave.



Ques ↦ Derive an expression for amplitude modulated wave. Define modulation index. what are the advantages and disadvantages of AM.

Ans ↦ Consider an audio signal wave of frequency ν_m and angular freq. ω_m. If A_m is it amplitude then instanteneous voltage of signal wave is given as

$$e_m = A_m \sin \omega_m t \quad \text{—— (1)}$$

Similarly instanteneous voltage of high freq. carrier wave is given as

$$e_c = A_c \sin \omega_c t \quad \text{—— (2)}$$

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These two wave are fed to the modulator, whe we get a resultant amplitude modulated wa whose amplitude varies in accordance with the instanteneous value of amplitude of signal wave. This amplitude modulated wave is represented as

$$e = (A_c + e_m) \sin \omega_c t$$

on solving it we get

$$e = A_c \sin \omega_c t + \frac{m_a A_c}{2} \cos(\omega_c - \omega_m)t - \frac{m_a A_c}{2} c$$

where $m_a = \frac{A_m}{A_c}$ = modulation index

The resultant modulated wave is equivalent summation of three sinusoidal waves of a A_c, $m_a \frac{A_c}{2}$ or $\frac{A_m}{2}$ and having frequen ν_c, $\nu_c - \nu_m$ and $\nu_c + \nu_m$.

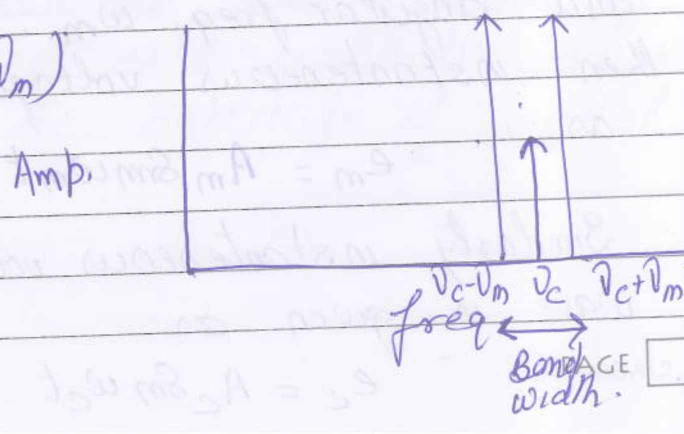
where ν_c = freq. of carrier wave as well as resultant modulate

$\nu_c + \nu_m$ = Upper Side Band (USB) freq.

$\nu_c - \nu_m$ = Lower Side Band (LSB) freq.

Band Width $= \nu_c + \nu_m - (\nu_c - \nu_m)$

$= 2\nu_m$.



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Modulation Index ↦ It is d/a the ratio of amplitude of signal wave to amplitude of carrier wave.

ie $m = \frac{A_m}{A_c}$

Num ↦

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

Ans

Given $A_c = 12V$

$m_a = 75\% = \frac{75}{100} = \frac{3}{4}$

and $A_m = ?$

w.k.T $m_a = \frac{A_m}{A_c}$

$\therefore A_m = m_a \times A_c = \frac{3}{4} \times 12V$

$\Rightarrow A_m = 9V$ Ans.

Advantages of A.M. ↦

① It is an easier method of transmission and receiving.

(2) It is cheaper / inexpensive.

Disadvantages ↦

① Amp. modulation is noise sensitive.

(2) It is limited to short distance point to point transmission.

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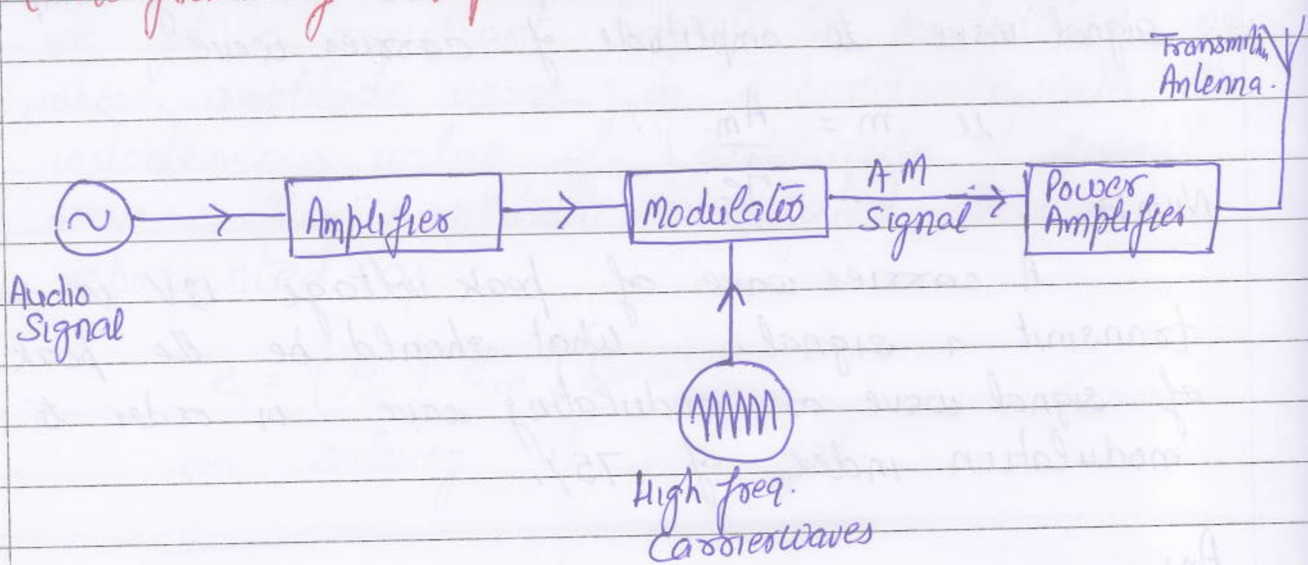
Block diagram of Amplitude modulated transmission ↦

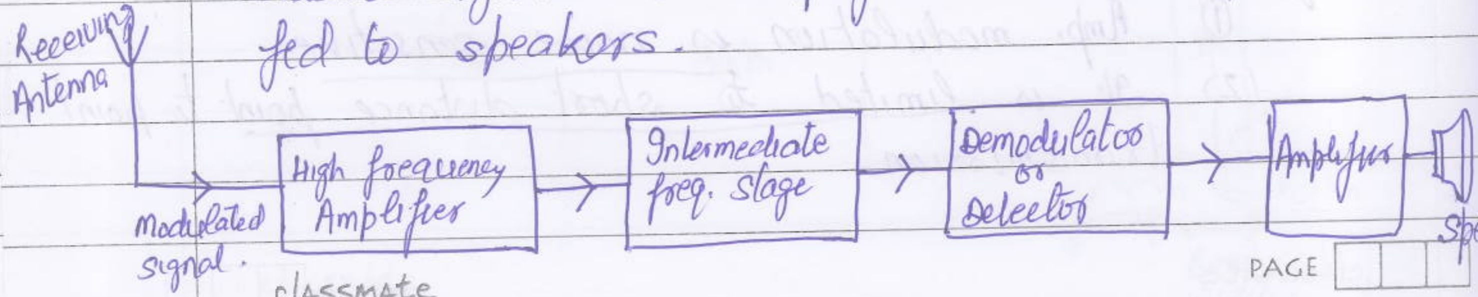


Detection of Amplitude modulated wave or Demodulation ↦

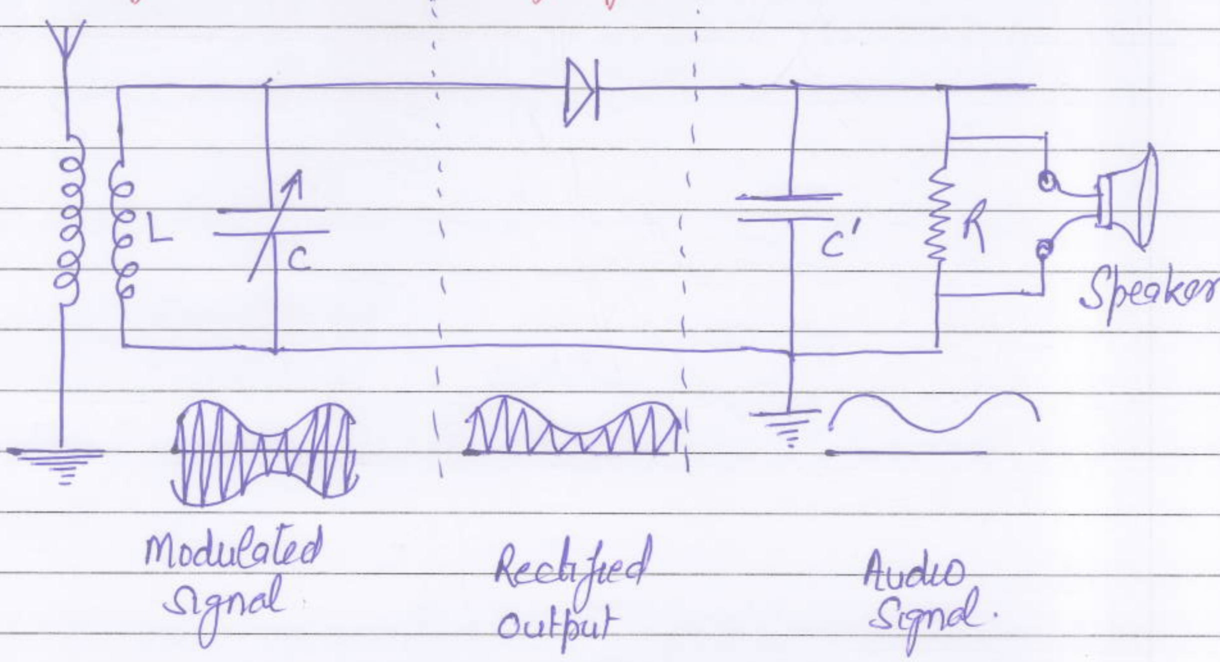
The process of extracting audio signal from the modulated wave is called demodulation

Block diagram of demodulation ↦

A receiving antenna receives the ~~des~~ amplitude modulated signal transmitted by the transmitting antenna. This attenuated signal is first amplified by using high freq. amplifier. Now this signal is fed to intermediate freq. (IF) stage to change it to comparatively low freq. signal. Now demodulator extracts the audio signal from the carrier wave. This audio signal is amplified and output is fed to speakers.



Circuit diagram and working of demodulator ↦



Tuned circuit consisting of a || combination inductor L and variable capacitor C, selects the desired signal among the various signal received the receiving antenna.

This modulated signal is ~~fed to~~ half wave rectified by the PN junction. Out of this rectified signal, high freq. carrier waves ~~are~~ pa easily through the capacitor C' because of it very low capacitive reactance to high frequency ca waves $\left(X_C = \frac{1}{2\pi \nu C} \right)$. Where as low freq. signal waves can't pass through C' and obtained across load ~~res~~ resistor and hence through speaker. Where original speach or music is reproduced.