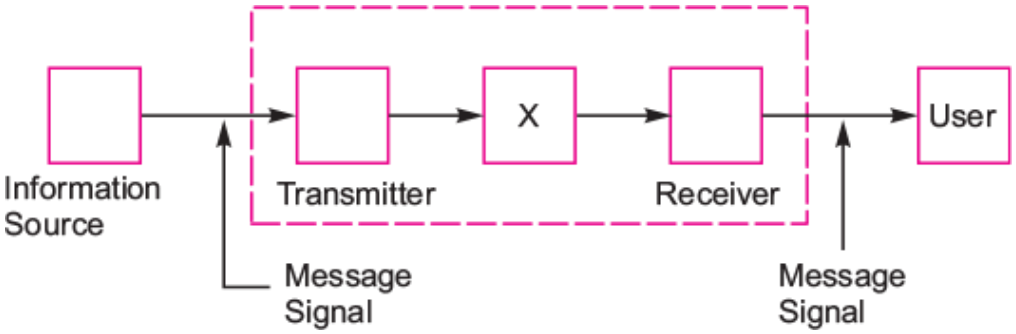
Very Short Answer Questions (PYQ)

Q. 1. Name the essential components of a communication system.
[CBSE Central 2016]

Ans. Transmitter, Medium or Channel and Receiver.

Q. 2. The figure given below shows the block diagram of a generalised communication system. Identify the element labelled 'X' and write its function.
[CBSE Delhi 2014]



Ans. X represents communication channel.

Function: It connects the transmitter to the receiver and carries the modulated wave.

Q. 3. Distinguish between a transducer and a repeater. [CBSE Delhi 2017]

Ans. Transducer: A device which converts one form of energy into some another form is called a transducer.

Repeater: It is a combination of a receiver and a transmitter. It picks up the signal from the transmitter, amplifies and retransmits it to the receiver.

Q. 4. What is sky wave propagation? [CBSE Delhi 2011, 2009]

Ans. Sky wave propagation is a mode of propagation in which communication of radio waves in frequency range 2 MHz–20 MHz takes place due to reflection from the ionosphere.

Q. 5. What is ground wave propagation? [CBSE Delhi 2009]

Ans. Ground wave propagation is a mode of propagation in which electromagnetic waves of low frequencies 500 KHz–1500 KHz travel directly from one point to another following the surface of earth.

Q. 6. What is space wave propagation? [CBSE Delhi 2009]

Ans. Space wave propagation or line of sight propagation is a propagation of electromagnetic waves from transmitting antenna to receiving antenna both installed on the ground.

Q. 7. Give two examples of communication system which use space wave mode. [CBSE Delhi 2010]

Ans. (i) Television Transmission,

(ii) Satellite Communication

Q. 8. What is meant by modulation? [CBSE Delhi 2009]

Ans. The original low frequency information/message signal cannot be transmitted over long distances. Therefore, it is essential to superimpose the information signal on a high frequency radio wave called the carrier wave. The process of superposition of information signal on high frequency radio wave (carrier wave) is called modulation.

Q. 9. Define bandwidth and describe briefly its importance in communicating signals.
[CBSE (F) 2015]

Ans. It is defined as the frequency range over which a given equipment operates.

Importance: To design the equipments used in communication system for distinguishing different message signals.

Q. 10. Why is the amplitude of modulating signal kept less than the amplitude of carrier wave? [CBSE Delhi 2011]

Ans. The amplitude of modulating signal is kept less than the amplitude of carrier wave to avoid distortion.

Q. 11. Why are broadcast frequencies (carrier waves) sufficiently spaced in amplitude modulated wave? [CBSE (F) 2013]

Ans. To avoid mixing up of signals from different transmitters. This can be done by modulating the signals on high frequency carrier waves, e.g., frequency band for satellite communication is 5.925 – 6.425 GHz.

Q. 12. How are side bands produced? [CBSE Delhi 2015]

Ans. Side bands are produced due to the superposition of carrier waves of frequency ω_c over modulating or audio signal of frequency ω_m. The frequency of lower side band is $\omega_c - \omega_m$ and the upper side band is $\omega_c + \omega_m$.

Q. 13. What is the function of a band pass filter used in a modulator for obtaining AM signal? [CBSE Ajmer 2015]

Ans. Band pass filter rejects dc and sinusoid of frequency ω_m, $2\omega_m$ and $2\omega_c$ and retain frequencies $\omega_c \pm \omega_m$. Thus, it allows only the desired frequencies to pass through it.

Q. 14. Which basic mode of communication is used in satellite communication? Which type of wave propagation is used in this mode? Write the expression for the maximum line of sight distance d between two antennas having heights h_1 and h_2.
[CBSE Guwahati 2015]

Ans. Line of sight mode is used in the satellite communication.

Space wave propagation is used

$$d = \sqrt{2Rh} + \sqrt{2Rh_2}, \text{ where } R = \text{radius of the earth.}$$

Q. 15. Which basic mode of communication is used for telephonic communication?
[CBSE Allahabad 2015]

Ans. Point to point communication mode.

Q. 16. State briefly why do the electromagnetic waves with frequency range from a few MHz upto 30 MHz can reflect back to the earth. What happens when the frequency range exceeds this limit? [CBSE Ajmer 2015]

Ans. Ionosphere acts as reflector for the range of frequencies from few MHz to 30 MHz, hence it bends the radio waves back to the Earth. Waves of frequencies greater than 30 MHz penetrate the ionosphere and escape.

Very Short Answer Questions (OIQ)

Q. 1. Identify the parts X and Y in the following block diagram of a generalised communication system.

Ans. Part X is message signal or information source.

Part Y is a transmission channel.

Q. 2. Name the types of modulation in analog communication.

Ans. There are three types of modulations in analog communication:

(i) Amplitude modulation,

(ii) Frequency modulation and

(iii) Phase modulation.

Q. 3. What characteristic of modulated carrier wave vary in amplitude modulation?

Ans. In amplitude modulation, the amplitude of modulated wave varies in accordance with the amplitude of information signal wave.

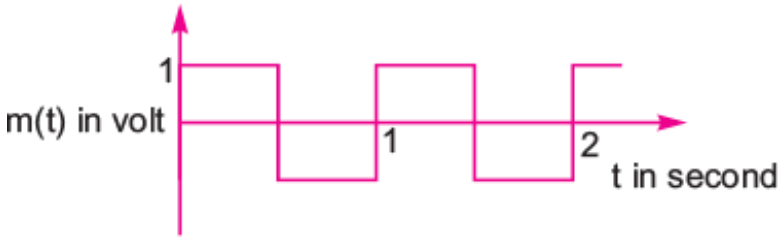
Q. 4. What characteristic of modulated carrier wave vary in frequency modulation?

Ans. In frequency modulation, the frequency of modulated wave varies in accordance with the frequency of information signal wave.

Q. 5. The carrier wave is given by

C(t) = 2 sin (8π t) volt.

The modulating signal is a square wave as shown. Calculate modulation index.



Ans.

$$\text{Modulation index } \mu = \frac{\text{Amplitude of mod ulating signal}}{\text{Amplitude of carrier waves}}$$

$$\frac{A_m}{A_c} = \frac{1\ V}{2\ V} = 0.5$$

Q. 6. What type of modulation is required for radio broadcast?

Ans. Amplitude modulation as well as frequency modulation is required for radio broadcast.

Q. 7. What type of modulation is required for television broadcast?

Ans. Frequency modulation is required for television broadcast.

Q. 8. Why is the frequency modulation preferred over amplitude modulation?

Ans. In frequency modulation (FM) the noise is minimised, hence FM is preferred.

Q. 9. Why is shortwave band used for long distance radio broadcast?

Ans. Shortwaves are not absorbed by earth's atmosphere, hence they are used for long distance radio broadcast.

Q. 10. Name the type of radio wave propagation involved when TV signals, broadcast by a tall antenna, are intercepted directly by the receiver antenna.

Ans. Space wave propagation.

Q. 11. What is meant by modulated wave?

Ans. The resulting wave formed by superposition of information signal over carrier wave is called the modulated wave.

Q. 12. Why high frequency carrier waves are employed for transmission?

Ans. Since low frequency waves are easily absorbed by atmosphere, so high frequency carrier waves are employed for transmission.

Q. 13. Name two uses of optical transmission.

Ans. (i) High bandwidth and

(ii) Security of signal.

Q. 14. Why is the transmission of signals through a co-axial cable not possible for frequencies greater than 20 MHz?

Ans. At high frequency (greater than 20 MHz), the transmission lines start radiating, so transmission becomes very lossy.

Q. 15. What is the purpose of modulating a signal in transmission?

Ans. A signal is modulated to

(i) Reduce size of antenna.

(ii) Reduce larger bandwidth.

(iii) Avoid mixing up of signals.

Q. 16. What is the type of communication in which signal is discrete and binary coded version of the message (or information)?

Ans. Digital communication.

Q. 17. Name the type of communication systems according to the mode of the transmission.

Ans. (i) Analog communication

(ii) Digital communication.

Q. 18. Why are repeaters used in communication system?

Ans. Repeaters are used to increase the range of a communication system.

Q. 19. Which device is used for transmitting TV signals over long distances?

Ans. Communication satellite is used for transmitting TV signals over long distances.

Q. 20. How many minimum number of communication satellites are used for simultaneous world-wide communication?

Ans. For simultaneous world-wide space communication, at least 3-communication satellites are required.

Q. 21. Why do we need carrier waves of very high frequency in the modulation of signals? [HOTS]

Ans. High frequency waves require antenna of reasonable length and can travel long distances without any appreciable power loss; so we need high frequency carrier waves.

Q. 22. What should be the length of dipole antenna for a carrier wave of frequency 6×10^8 Hz? [HOTS]

Ans. $$\text{Length of dipole antenna, } l = \frac{\lambda}{4} = \frac{1}{4}\left(\frac{c}{\nu}\right) = \frac{1}{4} \times \frac{3 \times 10^8}{6 \times 10^8} = 0.125\, m$$

Q. 23. Why are sky waves not used in transmission of TV signals? [HOTS]

Ans. TV signals have high frequency range of 100 to 200 MHz. Ionospheric layers do not reflect back such high frequency signals. Hence, sky waves cannot be used for transmission of TV signals.

Q. 24. An intelligence signal with a bandwidth of 100 kHz is to be communicated over a distance of 10 km. Suggest the form of a communication channel. [HOTS]

Ans. The communication channel is twisted pair.

Q. 25. A message signal has a bandwidth of 5 MHz. Suggest a possible communication channel for its transmission. [HOTS]

Ans. The suitable communication channel is co-axial cables.

Short Answer Questions – I (PYQ)

Q. 1. Write the functions of the following in communication systems:

(i) Modulator,

(ii) Demodulator [CBSE (AI) 2014]

Ans. (i) Modulator: It is a device in which amplitude of a high frequency carrier wave is made to change in accordance with the amplitude of message/information signal during superposition.

(ii) Demodulator: It is a device used to retrieve information/message signals from the carrier wave at the receiver.

Q. 2. Explain the terms (i) Attenuation and (ii) Demodulation used in Communication System. [CBSE Delhi 2016]

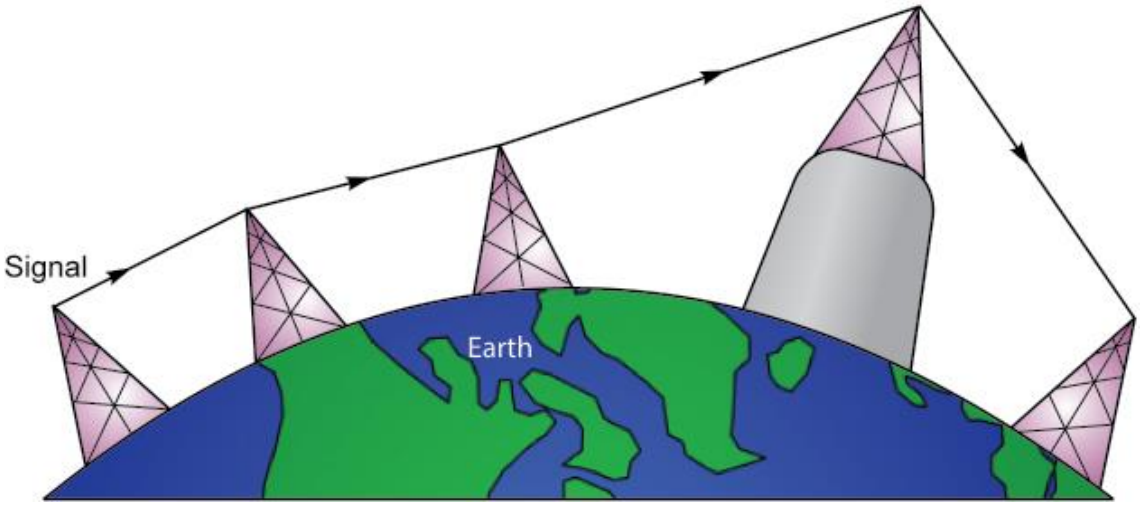
Ans. Attenuation: The loss in strength of a signal while propagating through a medium is known as attenuation.

Demodulation: The process of retrieval of information, from the carrier wave at the receiver end is called demodulation. This is the reverse process of modulation.

Q. 3. Explain the function of a repeater in a communication system. [CBSE (F) 2011, Delhi 2010]

Ans. Functions of a Repeater: A repeater is a device which picks up a signal from the transmitter, amplifies it and transmits it to the receiver. Repeaters are used to increase the range of communication of signals.

A typical example of repeater station is a communication satellite.



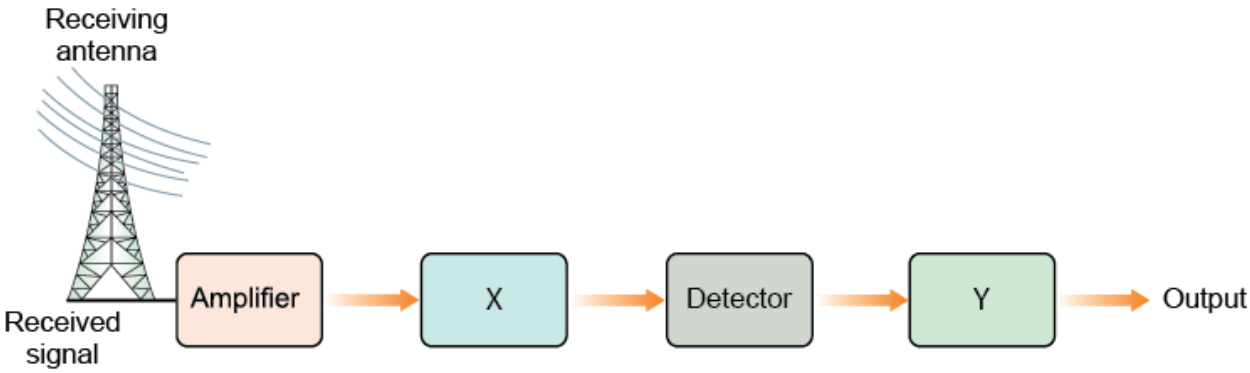
Q. 4. Which basic mode of communication is used in satellite communication? What type of wave propagation is used in this mode? Write, giving reason, the frequency range used in this mode of propagation. [CBSE Delhi 2017]

Ans. The basic mode of communication used in satellite communication is point to point broadcast communication.

Space wave propagation is used in this mode. Frequency range of this mode of propagation is above 40 MHz.

This is because the electromagnetic wave of frequencies above 40 MHz are not reflected back by the ionosphere but penetrate through it and escape.

Q. 5. In the given block diagram of a receiver, identify the boxes labelled as X and Y and write their functions. [CBSE Delhi 2013, (AI) 2012]



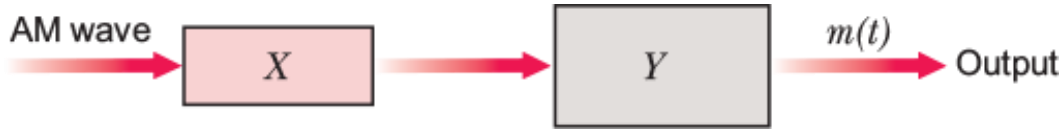
Ans. Here, X→ IF stage (Intermediate Frequency stage)

Its function is to change the carrier frequency to lower frequency.

Y→ Amplifier

Its function is to amplify the signal because the detected signal may not be strong enough to use by the user.

Q. 6. Figure shows a block diagram of a detector for amplitude modulated signal. Identify the boxes 'X' and 'Y' and write their functions. [CBSE (F) 2012]



Ans. Here X → Rectifier

Y → Envelope detector

Rectifier: It allows only the positive half of the AM input wave to go onwards.

Envelope Detector: It separates the message signal from the carrier wave.

Q. 7. (i) Which mode of propagation is used by shortwave broadcast services having frequency range from a few MHz upto 30 MHz? Explain diagrammatically how long distance communication can be achieved by this mode.

(ii) Why is there an upper limit to frequency of waves used in this mode? [CBSE Central 2016]

Ans. (i) Sky wave propagation is used by short wave broadcast services.

Long distance communication can be achieved by reflection of radio waves by the ionosphere, back towards the Earth. This ionosphere layer acts as a reflector only for a certain range of frequencies. (3 MHz to 30 MHz)

(ii) Electromagnetic waves of frequencies higher than 30 MHz, penetrate the ionosphere and escape whereas the waves less than 30 MHz are reflected back to the earth by the ionosphere.

For Fig. refer to Basic Concepts 6.

Q. 8. What is the range of frequencies used for T.V. transmission? What is common between these waves and light waves? [CBSE Delhi 2010]

Ans. Range of frequencies used in TV transmission is 76 MHz–88 MHz and 420 MHz–890 MHz.

Similarity: Speed of waves is same for both TV waves and light waves.

Q. 9. Distinguish between 'point to point' and 'broadcast' communication modes. Give one example of each. [CBSE (F) 2016, 2017]

Ans. Point to Point Communication: The communication which takes place over a link between a single transmitter and receiver is called point to point communication mode. Telephone is an example of such a system.

Broadcast Mode: In such a mode, large number of receivers is linked to a single transmitter. Example: Radio, Television.

Q. 10. Answer the following questions:

(i) What is the line of sight communication?

(ii) Why is it not possible to use sky waves for transmission of TV signals? Upto what distance can a signal be transmitted using an antenna of height 'h'? [CBSE Delhi 2017]

Ans. (i) Communication using waves which travel in straight line from transmitting antenna to receiving antenna is line of sight communication.

(ii) This is because TV signal waves are not reflected back by the ionosphere.

Coverage range of an antenna, d = $\sqrt{2hR}$.

Q. 11. Why is communication using line of sight mode limited to frequencies above 40 Mhz? [CBSE Delhi 2010]

Ans. The line of sight (LOS) mode is limited to frequencies above 40 MHz, because at these frequencies antennas are relatively smaller and can be placed at heights of many wavelengths above the ground.

The direct waves can get blocked by curvature of earth. If the signal is to be received beyond horizon, then the receiving antenna must be high enough to intercept the line of sight waves.

Q. 12. Distinguish between 'sky wave' and 'space wave' modes of propagation. Why is the sky wave mode of propagation restricted to frequencies upto 40 MHz? [CBSE Bhubaneshwar 2015]

Ans.

S.No.	Sky Wave	Space Wave
(i)	In this mode, the waves are achieved by the ionospheric reflection.	In this mode, the waves travels in straight line from transmitting antenna to the receiving antenna.
(ii)	Frequency range from few MHz upto 30 to 40 MHz.	The same frequency (or any frequency) are used for LOS communication.
(iii)	Electromagnetic waves of frequencies higher than 30 MHz penetrate the ionosphere and escape.	Electromagnetic waves above 40 MHz are used in satellite communication.
(iv)	Electromagnetic waves follow total internal reflection at any layer of ionosphere.	In satellite communication the em waves do not follow total internal reflection at any stage in the space.

The electromagnetic waves of frequency greater than 40 MHz penetrate the ionosphere and escape. So sky wave mode is restricted upto 40 MHz.

Q. 13. A transmitting antenna at the top of a tower has a height of 32 m and the height of the receiving antenna is 50 m. What is the maximum distance between them, for satisfactory communication in LOS mode? (Radius of earth = 6400 km). [CBSE Delhi 2010]

Ans. Given h_T = 32 m, h_R = 50 m, and R_e = 6400 km = 6.4×10^6 m.

Maximum LOS distance, $d_m = \sqrt{2R_e h_T} + \sqrt{2R_e h_R}$

$$\sqrt{2R_e}(\sqrt{h_T} + \sqrt{h_R})$$

$$= 3.578 \times 10^3 \ (5.66 + 7.07)$$

$$= 3.578 \times 10^3 \times 12.73 \text{ m}$$

$$= 45.5 \times 10^3 \text{ m} = \mathbf{45.5 \text{ km}}$$

Q. 14. For an amplitude modulated wave, the maximum amplitude is found to be 10V while the minimum amplitude is 2V. Calculate the modulation index. Why is modulation index generally kept less than one? [CBSE (F) 2011]

Ans. A_{max} = 10V, A_{min} = 2 V

$$\text{Modulation index} = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} = \frac{10 - 2}{10 + 2} = \frac{8}{12} = 0.67$$

Generally, the modulation index is kept less than one to avoid distortion.

Short Answer Questions – I (OIQ)

Q. 1. Give the frequency ranges of the following:

(i) High frequency band (HF)

(ii) Very high frequency band (VHF)

(iii) Ultra-high frequency band (UHF)

(iv) Super-high frequency band (SHF)

Ans. (i) High frequency band : Range is 3 MHz to 30 MHz.

(ii) Very high frequency band : Range is 30 MHz to 300 MHz.

(iii) Ultra-high frequency band : Range is 300 MHz to 3000 MHz.

(iv) Super-high frequency band : Range is 3000 MHz to 30,000 MHz.

Q. 2. The maximum amplitude of an A.M. wave is found to be 15V while its minimum amplitude is found to be 3V. What is the modulation index? [NCERT Exemplar]

Ans. $A_c + A_m = 15$ and $A_c - A_m = 3$

$2A_c = 18$, $2A_m = 12$

$$m = \frac{A_m}{A_c} = \frac{6}{9} = \frac{2}{3}$$

Q. 3. Which of the following would produce analog signals and which would produce digital signals?

(i) A vibrating tuning fork.
(ii) Musical sound due to a vibrating sitar string.
(iii) Light pulse
(iv) Output of NAND gate. [HOTS] [NCERT Exemplar]

Ans. (i) Analog,

(ii) Analog,

(iii) Digital,

(iv) Digital

Q. 4. Would sky waves be suitable for transmission of TV signals of 60 MHz frequency?
[HOTS] [NCERT Exemplar]

Ans. No, signals of frequency greater than 30 MHz will not be reflected by the ionosphere, but will penetrate through the ionosphere.

Q. 5. Two waves A and B of frequencies 2 MHz and 3 MHz respectively are beamed in the same direction for communication via sky wave. Which one of these is likely to travel longer distance in the ionosphere before suffering total internal reflection?
[HOTS] [NCERT Exemplar]

Ans. The refractive index increases with increase in frequency which implies that for higher frequency waves, angle of refraction is less, i.e., bending is less. Hence, the condition of total internal reflection is attained after travelling larger distance (by 3MHz wave).

Short Answer Questions – II (PYQ)

Q. 1. Mention the function of any two of the following used in communication system:

(i) Transducer,

(ii) Repeater

(iii) Bandpass Filter [CBSE Delhi 2014, 2012, South 2016]

Ans. (i) Transducer: A device which converts one form of energy into another.

(ii) Repeater: It picks up a signal from the transmitter, amplifies it and retransmits it to the receiver.

(iii) Bandpass filter: A bandpass filter rejects low and high frequencies and allows a band of frequencies to pass through.

Q. 2. Draw a block diagram of a generalised communication system. Write the functions of each of the following: [CBSE (AI) 2017]

(a) Transmitter

(b) Channel

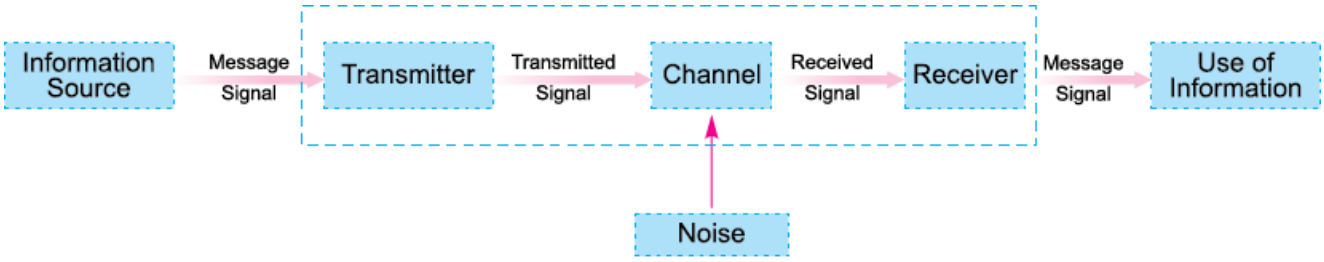
(c) Receiver

Ans. A communication system consists of three components

(i) Transmitter

(ii) Transmission channel and

(iii) Receiver.



(a) Transmitter: A transmitter is an arrangement which processes the incoming message signal so as to make it suitable for transmission through a channel and subsequent reception.

(b) Channel: It carries the message signal from a transmitter to a receiver.

(c) Receiver: A receiver extracts the desired message signals from the received signals at the channel output.

Q. 3. Define the term modulation. Draw a block diagram of a simple modulator for obtaining AM signal. [CBSE (F) 2014]

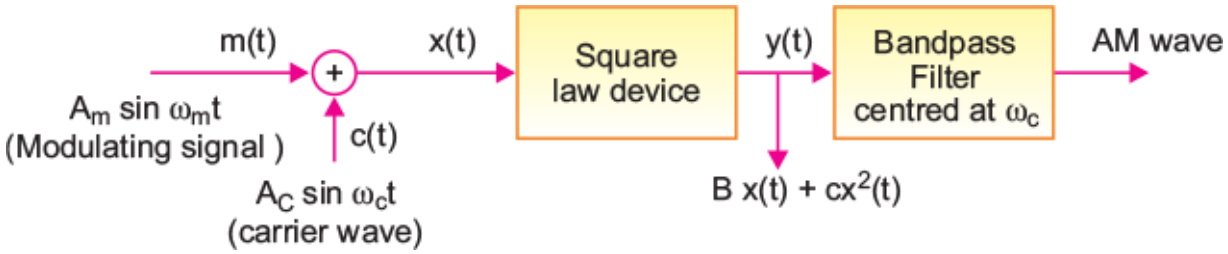
OR

Draw a block diagram of a simple modulator to explain how the AM wave is produced. Can the modulated signal be transmitted as such? Explain. [CBSE Guwahati 2015, Sample Paper 2016]

Ans. Modulation is the process of super imposition of low frequency message signal over a high frequency carrier wave.

Amplitude Modulation:

The block diagram is shown in fig.



Explanation:

The AM wave has to be fed to power amplifier to provide the necessary power. It is then fed to the antenna for transmission.

Q. 4. Answer the following questions:

(i) How is amplitude modulation achieved?

(ii) The frequencies of two side bands in an AM wave are 640 kHz and 660 kHz respectively. Find the frequencies of carrier and modulating signal. What is the bandwidth required for amplitude modulation? [CBSE (AI) 2017]

Ans. (i) In amplitude modulation, the amplitude of the carrier varies in accordance with the information signal. At the input of the transistor as CE, the low frequency modulating signals are superimposed on high frequency carrier wave. The output signal is carrier signal varying in amplitude in accordance with biasing modulation voltage. Thus, AM wave is produced.

For diagram refer to above question.

(ii) Frequencies of side bands are:

$$f_c + f_m \text{ and } f_c - f_m$$

$$\therefore \quad f_c + f_m = 660 \text{ kHz} \qquad \ldots (i)$$

$$f_c - f_m = 640 \text{ kHz} \qquad \ldots (ii)$$

Adding equations (i) and (ii), we get

$$2f_c = 660 \text{ kHz} + 640 \text{ kHz}$$

$$\therefore \quad f_c = 650 \text{ kHz}$$

Now, $f_c + f_m = 660 \text{ kHz}$

$$\therefore \quad f_m = 660 \text{ kHz} - 650 \text{ kHz}$$

$$\therefore \quad f_m = 10 \text{ kHz}$$

Band width required for amplitude modulation = Upper side band – Lower side band

$$= (f_c + f_m) - (f_c - f_m) = 2f_m$$

$$= 2 \times 10 \text{ kHz} = 20 \text{ kHz}$$

Q. 5. Write three important factors which justify the need of modulating a message signal. Show diagrammatically how an amplitude modulated wave is obtained when a modulating signal is superimposed on a carrier wave.

Three factors for the need of modulating a message signal:

[CBSE Delhi 2013, 2016; Panchkula 2015]

Ans. (i) If λ is the wavelength of the signal then the antenna should have a length at least $\frac{\lambda}{4}$. For an electromagnetic wave of frequency 20 kHz, the wavelength λ is 15 km. Such a long antenna is not possible to construct and operate. So, there is need to modulate the wave in order to reduce the height of antenna to a reasonable height.

(ii) The power radiated by a linear antenna (length l) is proportional to $\left(\frac{l}{\lambda}\right)^2$. This shows that power radiated increases with decreasing λ. So, for effective power radiation by antenna, there is need to modulate the wave.

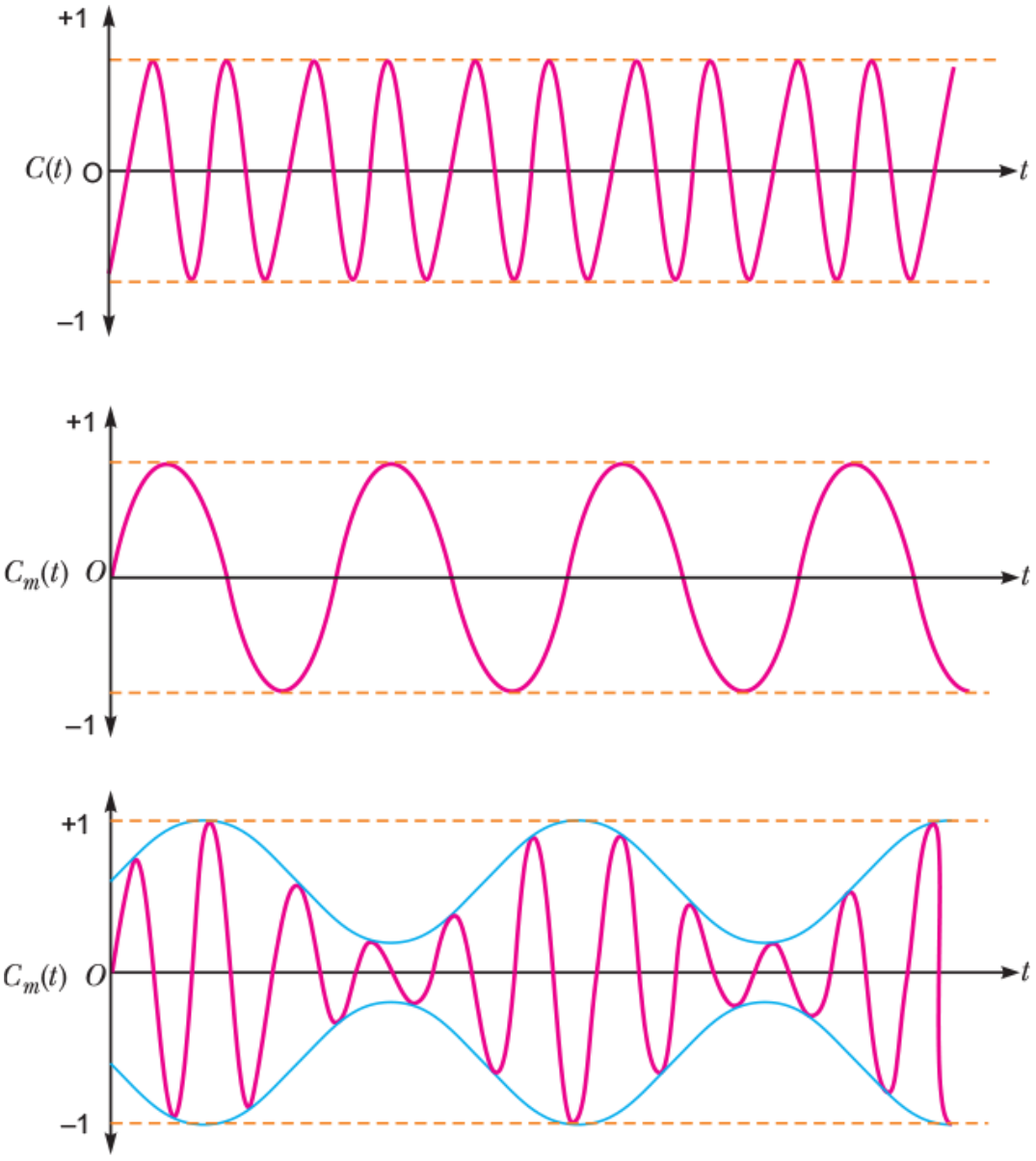
(iii) To avoid mixing up of signals from different transmitters.

(a) High frequency

(b) Less noise

(c) Maximum use of transmitted power

Diagrammatic representation:



Q. 6. (a) Define the term 'modulation index,' used in communication system. Why is its value kept less than or equal to one?

(b) A message signal of frequency 10 kHz and peak voltage of 10 V is used to modulate a carrier frequency of 1 MHz and peak voltage of 10V. Determine the (i) modulation index, and (ii) side bands produced. [CBSE (F) 2017]

OR

Define modulation index. Give its physical significance. [CBSE (F) 2012]

Ans. Modulation index: It is the ratio of peak value of modulating signal to the peak value of carrier wave.

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

It is kept less than or equal to 1 to avoid distortion.

Physical significance: It signifies the level of distortion or noise. A lower value of modulation index indicates a lower distortion in the transmitted signal.

Here, $A_m = 10\ V$, $A_c = 10\ V$

$f_m = 10\,\text{kHz}$, $f_c = 1\ \text{MHz} = 1000\ \text{kHz}$

i. Modulation index, $\mu = \frac{A_m}{A_c} = \frac{10\ V}{10\ V} = 1$

ii. $\text{USB} = f_c + f_m = 1000 + 10 = 1010\ \text{kHz}$

$\text{LSB} = f_c - f_m = 1000 - 10 = 990\ \text{kHz}$

Q. 7. Name the three different modes of propagation of electromagnetic waves. Explain, using a proper diagram the mode of propagation used in the frequency range above 40 MHz. [CBSE Delhi 2012]

Ans. Three mode of propagation of electromagnetic waves are:

(i) Ground waves

(ii) Sky waves

(iii) Space waves

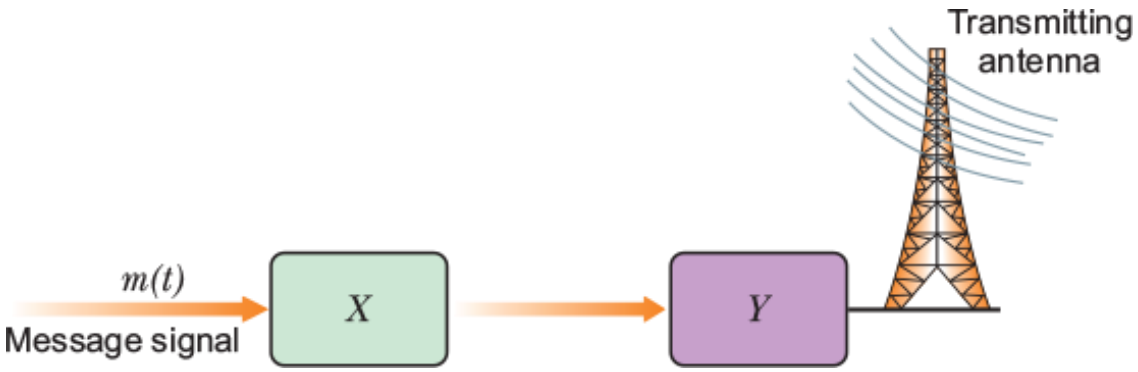
a. LOS (Line of Sight) communication

b. Satellite communication

For figure refer to Basic Concepts Point 6.

Above 40 MHz, the mode of propagation used is via space waves, a space wave travels in a straight line from the transmitting antenna to the receiving antenna. Space waves are used for the line of sight (LOS) communication as well as satellite communication.

Q. 8. Figure shows a block diagram of a transmitter. Identify the boxes 'X' and 'Y' and write their functions. [CBSE (F) 2012]



Ans. *X* → Amplitude Modulator

Y → Power Amplifier

Function of *X*: The original message signal has very small energy and dies out very soon if transmitted directly as such. Hence, these signals are modulated by mixing with very high frequency waves (carrier wave) by modulator power.

Function of *Y*: The signal cannot be transmitted as such because they get weaken after travelling long distance. Hence, use of power amplifier provides them necessary power before feeding the signal to the transmitting antenna.

Q. 9. What is ground wave communication? On what factors does the maximum range of propagation in this mode depend? [CBSE (AI) 2011]

OR

What is ground wave communication? Explain why this mode cannot be used for long distance communication using high frequencies. [CBSE Patna 2015]

Ans. The mode of wave propagation in which wave glides over the surface of the earth is called ground wave communication.

The maximum range of propagation in this mode depends on

(i) Transmitted power and

(ii) Frequency (less than a few MHz)

At high frequencies, the rate of energy dissipation of the signal increases and the signal gets attenuated over a short distance.

Q. 10. What is sky wave propagation? Which frequency range is suitable for sky wave propagation and why? Over which range of frequencies can communication through free space using radio waves takes place? [CBSE (F) 2017]

Ans. A radio wave directed towards the sky and reflected by the ionosphere towards the desired location of the earth is called a sky wave.

The radio waves of frequency range 3 MHz to 30 MHz are suitable for sky wave propagation.

This range of frequencies are reflected by the ionosphere towards the earth. The electromagnetic wave of frequencies higher than 30 MHz penetrates the ionosphere and are not reflected back.

Q. 11. What is space wave communication? Write the range of frequencies suitable for space wave communication. State the factors which limit its range of propagation. Give two examples of space wave mode of propagation is used. [CBSE Delhi 2013, (AI) 2011, (F) 2014, 2017; North 2016]

Ans. Space Wave Propagation: The mode of propagation in which radio waves travel, along a straight line, from the transmitting to the receiving antenna.

Frequency Range: Above 40 Mhz

Space wave propagation is used in:

(i) Television broadcast

(ii) Microwave link

(iii) Satellite communication

Limiting Factors

(i) Curvature of the earth

(ii) Insufficient height of the receiving antenna

(iii) LOS distance (> 40 MHz) travel in straight line

Q. 12. What does the process of detection of amplitude modulated wave mean?

The amplitude modulated carrier wave of angular frequency ω_c, $(\omega_c + \omega_m)$ and $(\omega_c - \omega_m)$, where ω_m is the angular frequency of the modulating signal. Discuss, in brief, with the help of a block diagram the essential details of a simple method used for 'detecting' the modulating signal from this modulated carrier wave.

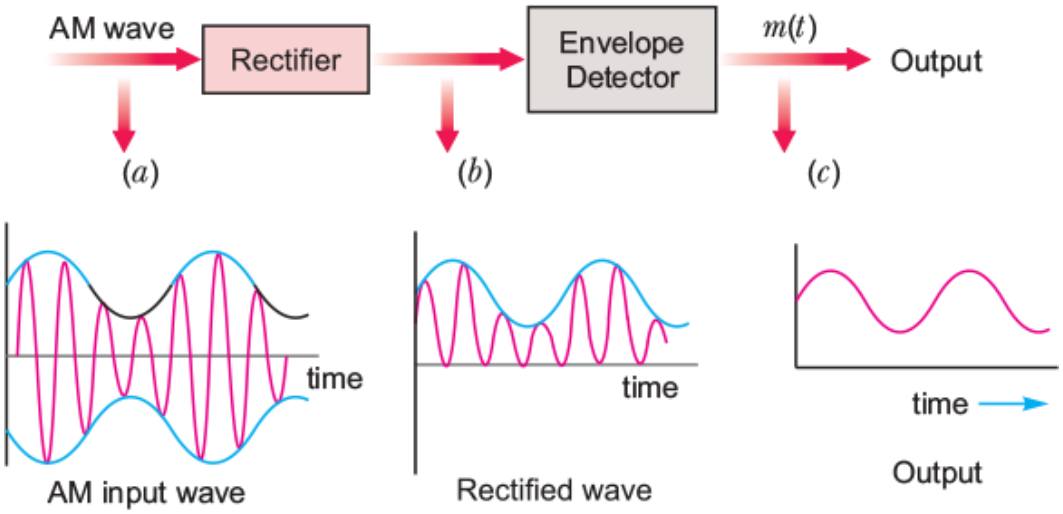
OR

Draw a block diagram of a detector for AM signal and show, using necessary processes and the waveforms, how the original message signal is detected from the input AM wave. [CBSE Delhi 2015]

Ans. Detection is the process of recovery of the modulating signal from the modulated carrier wave.

The amplitude modulated carrier wave contains waves of frequencies ω_c, $\omega_c + \omega_m$ and $\omega_c - \omega_m$.

The block diagram of a simple method is shown below:



In order to obtain the original message signal $m(t)$ of angular frequency ω_m.

The modulated signal [form (*a*)] is passed through a rectifier to produce the output shown in fig. (*b*). The envelope of signal (*b*) is the message signal. This is separated by passing it through envelope detector (which may consist of simple R.C. circuit).

Q. 13. Answer the following questions:

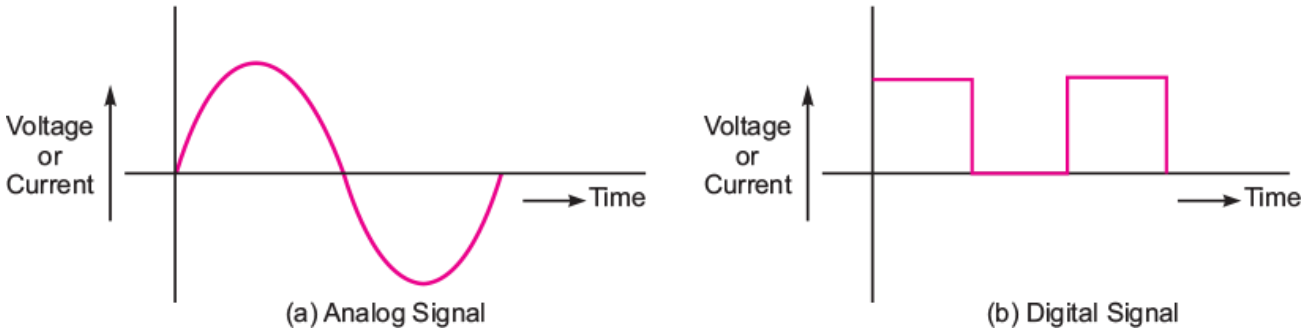
(i) Distinguish between 'Analog and Digital signals'. [CBSE Delhi 2012, Panchkula 2015]

(ii) Explain briefly two commonly used applications of the internet.

Ans. (i) A signal that varies continuously with time (e.g., sine wave form) is called an analog signal.

A signal that is discrete is called a digital signal. The presence of signal is denoted by digit 1 and absence is denoted by digit 0.

These are represented by



(ii) Uses of Internet: email, e-banking, e-shopping, e-ticketing, chatting, surfing, file transfer, etc

Q. 14. By what percentage will the transmission range of a TV tower be affected when the height of the tower is increased by 21%? [CBSE Delhi 2009]

Ans. Transmission range of TV tower

$$d = \sqrt{2hR}$$

If height is increased by 21%, new height

$$h' = h + \frac{21}{100}h = 1.21\,h$$

If d' is the new average range, then $\frac{d'}{d} = \sqrt{\frac{h'}{h}} = 1.1$

$$\% \text{ increase in range } \frac{\Delta d}{d} \times 100\% = \left(\frac{d' - d}{d}\right) \times 100\%$$

$$= \left(\frac{d'}{d} - 1\right) \times 100\%$$

$$= (1.1 - 1) \times 100\% = \mathbf{10\%}$$

Q. 15. Give reasons for the following:

(i) For ground wave transmission, size of antenna should be comparable to the wavelength of the signal, e.g., ~λ/4. [CBSE (F) 2013]

(ii) Audio signals converted into electromagnetic waves are not transmitted as such directly.

(iii) The amplitude of modulating signal is kept less than that of the carrier wave.

Ans. (i) Ground wave propagation is possible for radio waves of frequency band 540kHz – 1600 kHz (or max. 2 MHz)

If a base band signal of frequency 20 kHz, wavelength of the wave must be λ = 15 km, obviously antenna of size l = 3.75 km is not possible to construct and operate.

If base band signals are translated into high frequency radio wave of frequency v > 1MHz, then antenna of few metre can be constructed and can be used in sending the information along the ground.

Low size of the antenna is required for waves of short wavelength and hence comparable.

(ii) Audio signals of large wavelength cannot be sent directly, because large size antenna is required.

(iii) Modulation index, μ = $\frac{V_m}{V_C}$, and its value should be less than 1, otherwise distortion will be produced in the wave.

Q. 16. A carrier wave of frequency 1.5 MHz and amplitude 50 V is modulated by a sinusoidal wave of frequency 10 kHz producing 50% amplitude modulation. Calculate the amplitude of the AM wave and frequencies of the side bands produced.
[CBSE Allahabad 2015]

Ans.

$\mu = 50\% = \frac{1}{2}$

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

$\frac{1}{2} = \frac{A_m}{50V}$

$A_m = \mathbf{25\ V}$

Frequency of LSB = $\mu_c - \mu_m$

= 1.5 MHz – 10 KHz = 1.5 MHz – 0.01 MHz

= **1.49 MHz**

Frequency of USB = $D_c + v_m$

= 1.5 MHz – 0.01 Mhz = **1.51 MHz**

Q. 17. A signal of 5 kHz frequency is amplitude modulated on a carrier wave of frequency 2 MHz. What are the frequencies of the side bands produced? [CBSE North 2016]

Ans. $\nu_{sidebands} = \nu_c \pm \nu_m$

Maximum frequency = 5kHz + 2 MHz = $5 \times 10^3 + 2 \times 10^6 = (5 + 2000) \times 10^3$

= 2005×10^3 Hz = 2005 kHz

Minimum frequency = 2MHz – 5kHz = $2 \times 10^6 - 10^3 = (200 - 5) \times 10^3$

= 1995×10^3 Hz = 1995 kHz

Short Answer Questions – II (OIQ)

Q. 1. What is amplitude modulation? Write its two limitations and two advantages.

Ans. Amplitude modulation is the process in which amplitude of modulated wave (carrier & information signal) varies in accordance with the amplitude of information signal wave.

Limitations:

(i) Amplitude modulation is noisy.
(ii) It cannot be used for high frequency carrier waves *e.g.*, TV broadcasting.

Advantages:

(i) Production and reception of AM waves is convenient.
(ii) It is cheaper.

Q. 2. We do not choose to transmit an audio signal by just directly converting it to an e.m. wave of the same frequency. Give two reasons for the same.

Ans. (i) Size of Antenna: For efficient transmission and reception of a signal, the height of the antenna must be $\frac{\lambda}{4}$. For example, the height of the antenna of an audio signal of frequency 15 kHz,

$$h = \frac{\lambda}{4} = \frac{1}{4} \times \frac{c}{\nu} = \frac{1}{4} \times \frac{3 \times 10^8}{15 \times 10^3} = 5000\ m$$

Which is impossible.

(ii) Simultaneous transmission of signals by different transmitters can overlap, thus causing the disturbance at the receiver end.

Q. 3. Explain briefly the principle of transmitting signals using a satellite. State two main advantages of using a satellite for transmitting signals.

Ans. Principle of transmitting signals using a satellite: The radio or TV signals are directed to the communication satellite from a point on earth. The transponder receives the signal and reflects it towards the earth which is caught by receiving antenna. Thus, the signal gets transmitted from one place to the other.

(For diagram, refer to Point 6 of Basic Concepts)

Main advantages of satellite communication

(i) The high frequency signals which are not reflected by ionosphere may be transmitted by satellite.

(ii) Satellite communication has a very wide coverage range.

Q. 4. Answer the following questions:

(i) A TV transmitter has a range of 50 km. What is the height of the TV transmission tower? Radius of earth $R_e = 6.4 \times 10^6$ m

(ii) A TV tower has a height of 500 m at a given place. If radius of earth is 6400 km, what is it coverage range?

Ans. (i) Here d = 50 km = 50 × 10^3m

$$\therefore \text{ Height of TV transmission tower } h = \frac{d^2}{2R_e} = \frac{(50\times10^3)^2}{2\times6.4\times10^6} = \mathbf{195.3\ m}$$

(ii) Coverage range of TV tower

$$d = \sqrt{2R_e h} = \sqrt{2 \times 6400 \times 10^3 \times 500}$$

$$= \sqrt{2 \times 6.4 \times 10^6}\,(\sqrt{32} + \sqrt{50})$$

$$= 80 \times 10^3\text{m} = \mathbf{80km}$$

Q. 5. An optical communication system is operating at wavelength 800 nm. If only 1% of the optical source frequency is used as channel band width for optical communication; then find the number of channels that can be accommodated for transmitting (i) audio signals requiring a band width of 8 kHz and (ii) Video TV signals requiring a band width of 4.5 MHz.

Support your answer with suitable calculations.

Ans.

Optical source frequency, $\nu = \frac{c}{\lambda} = \frac{3\times10^{8}}{800\times10^{-9}} = 3.75 \times 10^{14}\,\text{Hz}$

Bandwidth of channel = 1% of 3.75×10^{14} Hz

$$= \frac{1}{100} \times 3.75 \times 10^{14} = 3.75 \times 10^{14} = 3.75 \times 10^{12}\,\text{Hz}$$

i. Number of channels for audio signal $= \frac{3.75\times10^{12}}{8\times10^{3}} = 4.7 \times 10^{8}$

ii. Number of channels for video TV signal $= \frac{3.75\times10^{12}}{4.5\times10^{6}} = 8.3 \times 10^{5}$

Thus, optical communication may transmit a very large number of channels simultaneously.

Q. 6. What would be the modulation index for an amplitude modulated wave for which the maximum amplitude is 'a' while the minimum amplitude is 'b'? [HOTS]

Ans.

Modulation index, is given by

$$a_m = \frac{E_m}{E_c} \qquad \ldots(i)$$

Maximum amplitude of modulated wave

$$a = E_c + E_m \qquad \ldots(ii)$$

Minimum amplitude of modulated wave

$$b = E_c - E_m \qquad \ldots(iii)$$

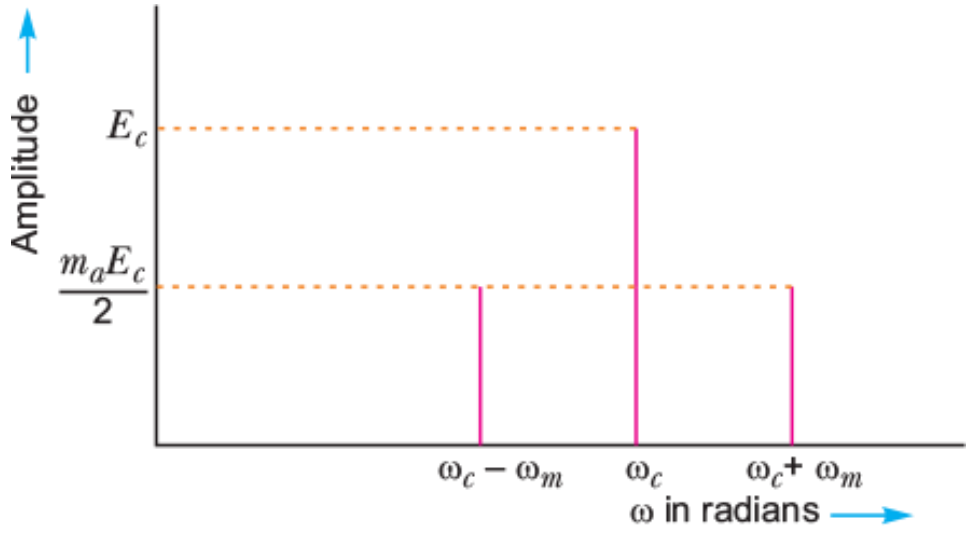
From (ii) and (iii), $E_c = \frac{a+b}{2}$, $E_m = \frac{a-b}{2}$

$\therefore$ From (i), modulation index,

$$a_m = \frac{E_m}{E_c} = \frac{(a-b)/2}{(a+b)/2} = \frac{a-b}{a+b}$$

Q. 7. Draw a plot of variation of amplitude versus ω for an amplitude modulated wave. Define modulation index. State its importance for effective amplitude modulation.
[HOTS]

Ans. Plot of variation of amplitude versus ω for amplitude modulated wave is shown in figure.



Modulation Index: The ratio of amplitude of modulating signal to the amplitude of carrier wave is called modulation index, i.e., ma = $\frac{E_m}{E_c}$

For effective amplitude modulation, the modulation index determines the distortions, so its value is kept ≤ 1 for avoiding distortions.

Q. 8. A ground receiver station is receiving signals at (i) 5 MHz and (ii) 100 MHz, transmitted from a ground transmitter at a height of 300 m located at a distance of 100 km. Identify whether the signals are coming via space wave or sky wave propagation or satellite transponder. Radius of earth = 6400 km; maximum electron density in ionosphere, $N_{max} = 10^{12} m^{-3}$. [HOTS]

Ans.

Maximum coverage range of transmitting antenna, $d = \sqrt{2R_e h}$

Given, R_e = 6400 km = 6400 $\times 10^3$m, h = 300m

$$\therefore \quad d = \sqrt{2 \times 6400 \times 10^3 \times 300} = 6.2 \times 10^4 m = 62\,\text{km}$$

The receiving station (situated at 100 km) is out of coverage range of transmitting antenna, so space wave communication is not possible, in both cases (i) and (ii) The critical frequency (or maximum frequency) of ionospheric propagation is $f_c = 9\sqrt{N_{\max}} = 9 \times \sqrt{10^{12}} = 9 \times 10^6\,\text{Hz} = 9\,\text{MHZ}$

Signal (i) of 5 MHz (< 9 MHz) is coming via ionosphere mode or sky wave propagation, while signal (ii) of 100 MHz is coming via satellite mode.

Q. 9. A (sinusoidal) carrier wave

$C(t) = A_C \sin \omega_c t$

Is amplitude modulated by a (sinusoidal) message signal

$m(t) = A_m \sin \omega m t$

Write the equation of the (amplitude) modulated signal.

Use this equation to obtain the values of the frequencies of all the sinusoidal waves present in the modulated signal.

Ans. The equation of the (amplitude) modulated signal is

$C_m(t) = [(A_c + A_m \sin \omega_m t)] \sin \omega_c t$

This can be rewritten as

$C_m(t) = [A_c (1 + \mu \sin \omega_m t)] \sin \omega_c t$

Where $\mu = \frac{A_m}{A_c}$ = modulation index

$$\therefore \quad C_m(t) = A_c \sin \omega_m t + \frac{\mu A_c}{2} 2 \sin \omega_m t \,.\, \sin \omega_c t$$

$$= A_c \sin \omega_c t + \frac{\mu A_c}{2} [\cos (\omega_c - \omega_m) t - \cos (\omega_c + \omega_m) t]$$

These are the three sinusoidal waves present in the amplitude modulated signal.

The frequencies of these three waves are

$$f_1 = \frac{\omega_c}{2\pi}, \quad f_2 = \frac{\omega_c - \omega_m}{2\pi} \text{ and } f_3 = \frac{\omega_c + \omega_m}{2\pi}$$

Long Answer Questions

Q. 1. What does the term LOS communication mean? Name the types of waves that are used for this communication. What is the range of their frequencies? Give typical examples, with the help of suitable figure of communication systems that use space wave mode propagation. [CBSE (AI) 2013]

Ans. LOS Communication: It means "Line of sight communication".

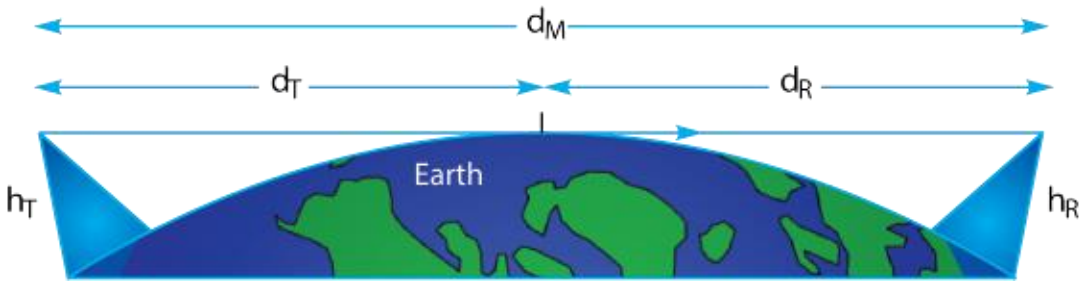
Space waves are used for LOS communication.

In this communication, the space waves (radio or microwaves) travel directly from transmitting antenna to receiving antenna.

Frequency for LOS communication must be more than 40 MHz.

Communication System using Space wave mode propagation are:

LOS communication and fig. shows LOS communication system.



If transmitting antenna and receiving antenna have heights h_T and h_R respectively, then Radio horizon of transmitting antenna,

$$d_T = \sqrt{2R_e h_T}$$

where R_e is radius of earth and radio horizon of receiving antenna.

$$d_R = \sqrt{2R_e h_R}$$

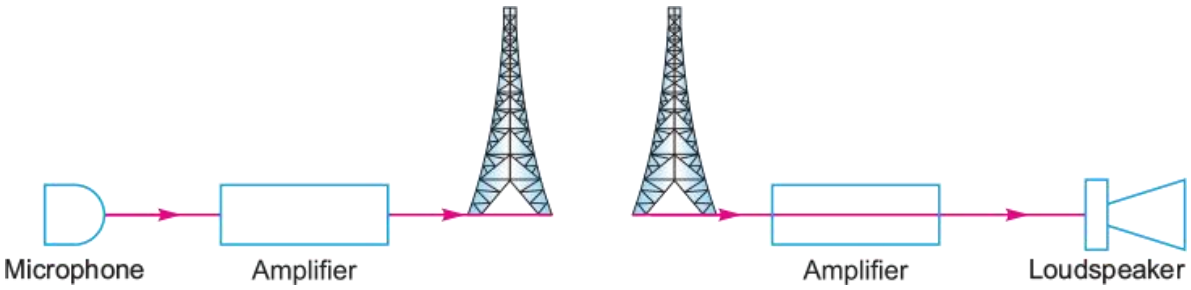
$\therefore$ Maximum line of sight distance,

$$d_M = d_T + d_R = \sqrt{2R_e h_T} + \sqrt{2R_e h_R}$$

(ii) Television, broadcast, microwave links and satellite communication

For diagram of satellite communication refer to the Basic Concepts point 6. The space wave used is microwave.

Q. 2. Schematic arrangement for transmitting a message signal (20 Hz to 20 kHz) is given below:



Give two drawbacks from which this arrangement suffers. Describe briefly with the help of a block diagram the alternative arrangement for the transmission and reception of message signal.

Ans. Drawbacks:

(i) Audio signals cannot be effectively radiated and are absorbed by atmosphere.

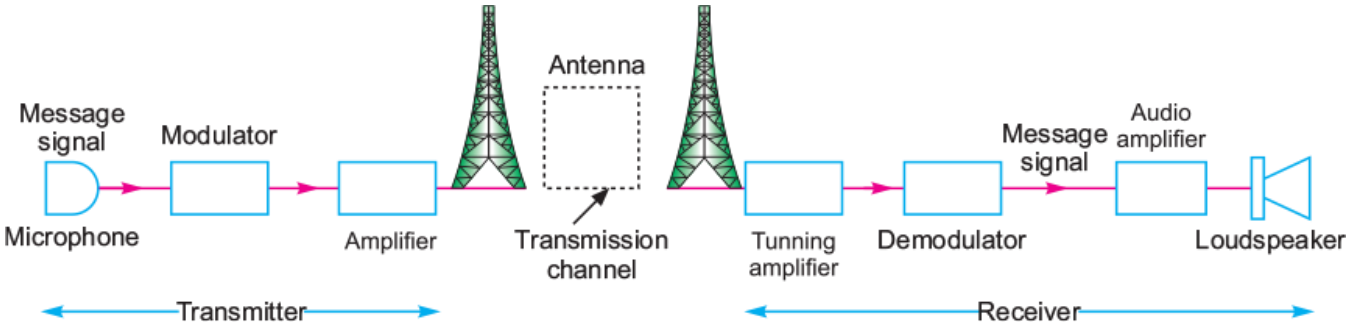
(ii) Simultaneous transmission of signals by different transmitters can overlap; thus causing a disturbance at receiver end.

These difficulties can be overcome by

(iii) Modulating the information on high frequency carrier waves. The modulated high frequency wave can propagate without appreciable attenuation.

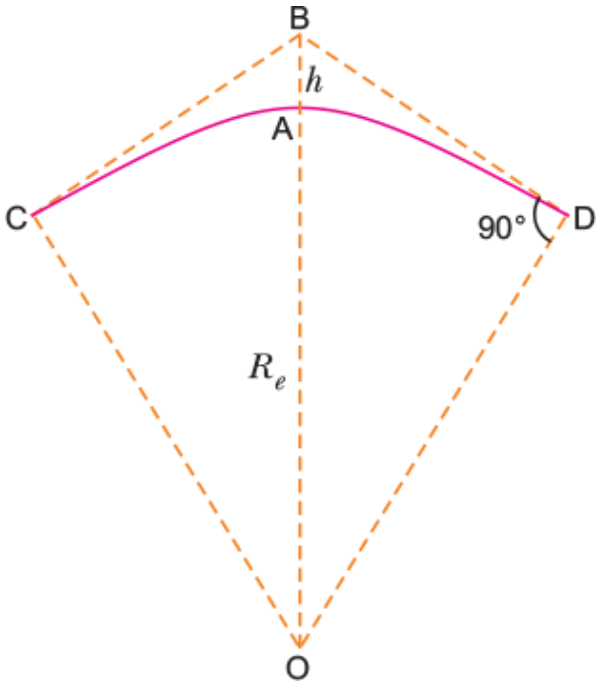
(iv) Different transmitting stations can be allotted different frequency bands and the receiver can be tuned to receive the desired frequency band.

The modified circuit is shown in figure.



Q. 3. Derive an expression for covering range of TV transmission tower.

Ans. TV signals are high frequency signals. They are not reflected back by atmosphere. These signals can be received only if the receiver antenna directly intercepts them. Therefore the range of TV depends on the height of TV antenna.



Let *AB* be a tower of height *h* and R_e, radius of earth. If broadcast is made from the top *B* of tower (*AB*), no reception of direct signals is possible beyond points *C* and *D* in figure. The distance upto which signals can be received (*i.e.*, *AC* = *AD*) is limited due to curvature of earth and is called the range of transmitter. The signals may be intercepted in the region *CAD*.

In right angled triangle *BOD*, $\angle BDO = 90°$

$$\therefore \qquad BO^2 = (OD)^2 + (BD)^2$$

$$i.e., \qquad (R_e + h)^2 = R_e^2 + (\mathrm{BD})^2 \qquad \ldots(i)$$

As height *h* of the tower is very small as compared to radius (R_e) of earth, the point *B* will be very close to *A*, so that

$BD \approx AD = d$ (say)

$\therefore$ Equation (*i*) gives $(R_e + h)^2 = R_e^2 + d^2$

Or $d^2 = (R^e + h)^2 - R_e^2$

$$= R_e^2 + 2\,\mathrm{hR}_e + h^2 - R_e^{\,2} = 2R_e\,h + h^2$$

Again $h << R_e \Rightarrow h_2 << 2R_e\,h$

$\therefore$ $d^2 \approx 2R_e\,h \;\Rightarrow\; d = \sqrt{2\,R_e h}$

or height of transmitting antenna, $h = \frac{d^2}{2R_e}$

or covering range of TV transmitting tower is $d = \sqrt{2R_e h}$

Thus covering range of TV signal can be increased by increasing the height of transmission antenna.