UNIT X

COMMUNICATION SYSTEMS

Weightage Marks : 05

TOPICS TO BE COVERED

Elements of communication system (block diagram) only, Band width signals (speech, TV and digital data) band width of transmission medium.

Propagation of electromagnetic waves in the atmosphere, sky and space wave propogation, Need f or modulation, production and detection of na amplitude modulated wave.

KEY POINTS

❏ Communication is the faithful transfer of message from one place to another.

❏ A communication system consists of three basic elements.

Channel
Input Information → | Transmitter | === | Receiver | → output Information

❏ **Transmitter :** An equipment which converts the information data into electrical signal.

❏ A transmitter consists of

    (i)   Transducer or Converter   (ii) Modulator

    (iii) Carrier Oscillator   (iv) Transmitting Antenna

❏ **Channel :** It is the medium through which the electrical signals from the transmitter pass to reach the receiver.

❏ **Receiver :** An equipment which receives and retrieves information from the electrical signals.

- A Receiver section consists of

  (i) Receiver Antenna (ii) Transducer/Converter

  (iii) Demodulator

- Two important forms of communication system are **Analog** and **Digital**. In Analog communication, the information is in analog form.

- In Digital communication, the information has only discrete or quantised values.

- Modulation is a process by which any electrical signal (called input, baseband or modulating signal) of low frequency is mounted on to another signal (carrier) of high frequency.

- Need of Modulation :

  (i) To avoid interference between different base band signals.

  (ii) To have a practical size of antenna.

  (iii) To increase power radiated by antenna.

- **Demodulation :** It is a process by which a base band signal is recovered from a modulated wave.

- **Amplitude Modulation :** In this type of modulation, the amplitude of carrier wave is varied in accordance with the information signal, keeping the frequency and phase of carrier wave constant.

- **Bandwidth:** Bandwidth is the range of frequencies over which an equipment operates.

- Space communication uses free space between transmitter and receiver for transfer of data/information.

- **Ground Wave :** These are the waves radiated by antenna that travel at zero or lower angle with respect to earth surface. They are heavily absorbed by earth surface and not suitable for long range communication.

- **Space Wave :** These are the waves that travel directly through space between transmitting and receiving antennas. The space waves are within the troposphere region of atmosphere and have two **Modes of Transmission :**

  (i) Line of sight communication
  (ii) Satellite communication

Physical Quantity	Formulae	SI Unit
Power radiated by an antena	$\alpha \dfrac{1}{\lambda^2}$	W
Sinusoidal carrier wave	$E = E_C \cos(\omega_c t + \phi)$	V
The range of tower	$d = \sqrt{2Rh}$ $R \to$ radius of earth $h \to$ Height of antena	m
The number of channels	$\dfrac{\text{Bandwidth}}{\text{Bandwidth per channel}}$	
The maximum rang of broadcast between transmitting and receiving tower h_t and $h_r \to$ height of transmitting and receiving towers	$d_{max} = \sqrt{2Rh_t} + \sqrt{2Rh_r}$ where $R \to$ Radius of earth	

QUESTIONS

VERY SHORT ANSWER QUESTIONS (I Mark)

1. What are ground waves?

2. What are the two basic modes of communication?

3. On what factors does the maximum coverage range of ground wave communication depend?

4. What is a base band signal?

5. What is the least size of an antenna required to radiate a signal of wavelength λ?

6. Why do we use high frequencies for transmission?

7. Why is ionisation low near the earth and high far away from the earth?

8. Define the modulation index.

9. What should be the length of dipole antenna for a carrier wave of frequency 2×10^6 Hz?

10. Why is the transmission of signals using ground wave communication restricted to a frequency of 1500 kHz?

11. What is meant by tranducer? Give one example of a transducer.

12. A T.V. transmitting antenna is 81m tall. How much service area can it cover if the receiving antenna is at ground level?

13. What is attenuation?

14. Why are repeaters used in communication?

15. What is the significane of modulation index? What is its range?

Ans : Modulation index deter mines the strength and quality of the transmitted signal. High modulation index ensures better quality and better strength. Its range is 0 to 1.

SHORT ANSWER QUESTIONS (2 Marks)

1. Write two differences between point to point communication and broadcast mode of communication. Give one example of each.

2. An audio signal of amplitude one fourth of the carrier wave, is used in amplitude modulation. What is the modulation index?

3. What are the essential components of a communication system? Explain with the help of a Block diagram.

4. Explain by a diagram, how space waves are used for Television broadcast.

5. Long distance radio broadcasts use short wave bands. Why?

Ans : The short waves are the waves of wavelength less than $200m$ or frerquency greater than 1.5 MHz. They are absorbed by the earth due to their high frequency. These waves are reflected from ionosphere. These waves after reflection from ionosphere reach the surface of earth only at a large distance from the place of transmission. It means attenuation is less for short waves. It is due to this reason; the short waves are used in long distance broadscasts.

6. What is modulation? Why do we need modulation? Give two reasons.

7. Give two reasons for using satellite for long distance T.V. transmission.

8. Explain the propagation of sky wave in ionospheric layers with the help of a neat, labelled diagram.

9. Derive an expression for maximum range of an antenna of height 'h' for LOS communication.

10. Plot amplitude v/s frequency for an amplitude modulated signal.

11. Draw block diagram of simple modulator to obtain amplitude modulated signal.

12. It is necessary to use satellites for long distance TV transmission. Why?

    Ans : Yes, TV signals being of high frequency are not reflected by the ionosphere. Therefore, to reflect these signals, satellites are needed. That is why; satellities are used for long distance TV transmission.

13. What is the basic difference between an analog communication system and a digital communication system?

    Ans : An analog communication system makes use of analog signals, which vary continuously with time. A digital communication system makes use of a digital signal, which has only two valuse of votage either high or low.

14. What is ground wave? Why short wave communication over long distance is not possible via ground waves?

    Ans : The amplitude modulated radiowaves having frequency 1500 kHz to 40 MHz (or wavelength between 7.5 m to 200 m) which are travelling directly following the surface of earth are known as ground waves. The short wave communication over long distance is not possible via ground because the bending of these waves become severe round the corners of the objects on earth and hence, their intensity falls with distance. Moreover the ground wave transmission becomes weaker as frequency increases.

SHORT ANSWER QUESTIONS (3 MARKS)

1. With the help of Block Diagram show how an amplitude modulated wave can be demodulated.

2. How an amplitude modulated wave can be produced? Give the equation of amplitude modulated wave.

3. What is a mplitude modulation? Derive the equation of an amplitude modulated wave.

4. What are the different ways of propagation of radiowaves? Explain briefly.

5. Draw block diagram for a :

   (a) Transmitter

   (b) Receiver

6. Write the band width of the following :

   (1) Telephonic communication

   (2) Video signal

   (3) TV signal

7. Explain the following terms :

   (1) Ground waves

   (2) Space waves

   (3) Sky waves

   Sol : (i) At low frequencies (v < 2MHz), radio-waves radiated by antenna travel directly following the surface of earth and are known as ground waves. [*(v < 2MHz) (About this frequency, it weakens rapidly)]

   (ii) Frequencies ranging from 100-200 MHz penetrate ionosphere and hence can only be transmitted by using line-of-sight antenna or satellites, are known as space wave propagation.

   (iii) Frequencies between 2-20 MHz are reflected by the ionosphere and known as sky waves (or ionospheric propagation)

8. What does 'LOS communciation[1] mean? Name the types of waves that are used for this communication. Give typical examples, with the help of suitable figure, of communication systems that use space mode propagation.

   Sol : Mode of radiowave propagation by space waves, in which the wave travells in a straight line from transmitting antenna to the receiving antenna, is called *line-of-sight* (LOS) communication. Two types of waves that are used for LOS communication are : Space wave and Ground wave. At frequencies above 40 MHz, LOS communication is essentially limited to line-of-sight paths.

Various propagation modes for EMW
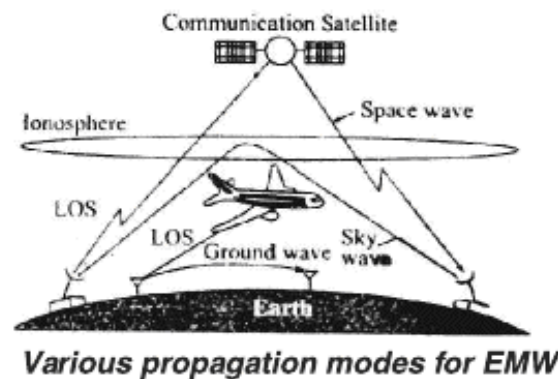
NUMERICALS

1. A sinusoidal carrier wave of frequency 1.5 MHz and amplitude 50 volt is amplitude modulated by sinusoidal wave of frequency 10 kHz producing 50% modulation. Calculate the frequency

   (*i*) amplitude; (ii) frequencies of lower and upper side bands.

Lowersideband	=	1490kHz
Uppersideband	=	1510kHz
Amplitude	=	125volt

2. An amplitude modulator consist of L–C circuit having a coil of inductance 8mH and capacitance of 5pF. If an audio signal of frequency 10kHz is modulated by the carrier wave generated by the L–C circuit, find the frequency of upper and lower side bands.

   [**Ans.** $f_c = 7.96 \times 10^5$ Hz; Lower side band = 786 kHz;
   Upper side band = 806 kHz]

3. A T.V. Tower has height of 70m.

   (i) How much population is covered by the T.V. broadcast if the average population density around the tower is 1000km^{-2}? Radius of earth is 6.4×10^6 m.

   (ii) By How much should the height of the tower be increased to double the coverage area?
   [**Ans. :** Population covered = 28.16 lacs; Change in height = 70m]

4. A communication system is operating at wavelength λ = 750 nm. If only 1% of the frequency is used as channel bandwidth for optical communication then find the number of channels that can be accommodated for transmission of

    (i)   an Audio signal requiring a bandwidth of 8 kHz.

    (ii)   an Video T.V. signal requiring a bandwidth of 4.5 KHz.

5. Calculate the percentage increase in the range of signal reception, if the height of TV tower is increased by 44%.   [**Ans.** : 20% increase]

6. A transmitting antenna at the top of a tower has a height 32m and the hight of the receiving antenna is 50m. What is the maximum distance between them for satisfactory communication in LOS mode? Given radius of earth 6.4 X 10^6m.

$$d_m = \sqrt{2 + 64 \times 10^5 \times 322} \cdot \sqrt{\times 64 \times 10^5 \, 50\,m}$$

Sol :
$$= 64 \times 10^2 \times \sqrt{10} + 8 \times 10^3 \times \sqrt{10}\,m$$
$$= 144 \times 10^2 \times \sqrt{10}\,m = 45.5\,km$$

7. A message singnal of frequency 10 kHz and peak voltage of 10 volts is used to modulate a carrier of frequency 1 MHz and peak voltage of 20 volts. Determine (a) modululation index, (b) the side bands produced.

Sol :   (a) Modulation index = 10/20 = 0.5 $= \dfrac{A_m}{A_c}$

    (b) The side bands are at (1000 + 10) kHz = 1010 kHz and (1000 − 10) kHz = 990 kHz.

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

Sol : $\mu = 0.75 = \dfrac{A_m}{A_c}$
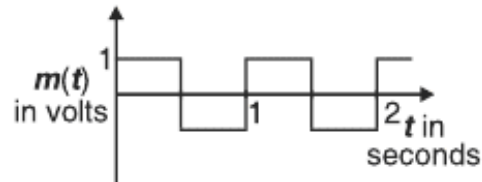
    Hence, A_m = 0.75 Ac = 0.75 x 12 V = 9 V

9. A modulating signal is a square wave, as shown in figure.

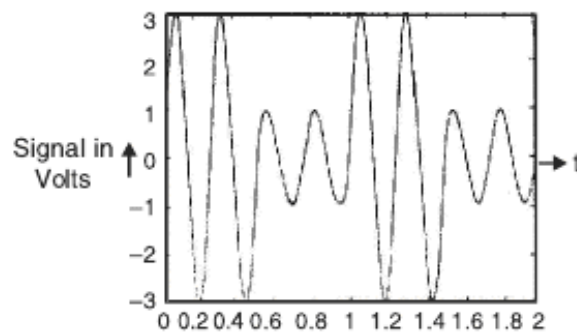The carrier wave is given by c(t) = 2 sin (8 πt) volts.

(i) Sketch the amplitude modulated waveform

(ii) What is the modulation index?

Sol : (i)

(ii) $\mu = 0.5$

10. For an amplitude modulated wave, the maximum amplitude is found to be 10 V while the minimum amplitude is found to be 2 V. Determine the modulation index, μ.

What would be the value of μ if the minimum amplitude is zero volt?

Sol : The AM wave is given by $(A_c + A_m + \text{Sin } \omega_m t) \cos \omega_c t$,

The maximum amplitude is $M_1 = A_c + A_m$ while the minimum amplitude is

$M_2 = A_c - A_m$

Hence the modulation index is

$$\mu = \frac{A_m}{A_c} = \frac{M_1 - M_2}{M_1 - M_2} = \frac{8}{12} = \frac{2}{3}$$