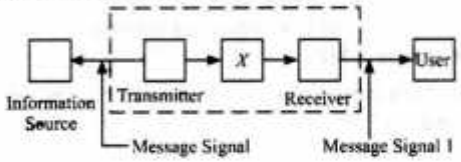
COMMUNICATION SYSTEMS

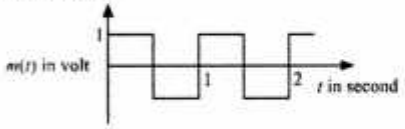
VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)

■ COMMUNICATION SYSTEM AND MODULATION

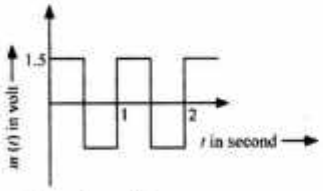
1. What is the purpose of modulation of signal in transmission?
2. What type of modulation is required for television broadcast?
3. What type of modulation is required for commercial broadcast of voice signals?
4. What should be the frequency of carrier wave with reference to message signal for the process of modulation?
5. What is mean by modulation?
6. What is meant by demodulation?
7. What is frequency modulation?
8. What is amplitude modulation?
9. What is phase modulation?
10. A message signal has a band width of 5 MHz. Suggest a possible communication channel for its transmission?
11. What do you mean by term message signal?
12. Define the term bandwidth of a signal.
13. What is bandwidth of (i) Audible frequencies (ii) TV signals (iii) Digital signals?
14. What are the frequencies contained by amplitude modulated signal?
15. Define the term 'base band' of message signal.
16. What is transducer? Give one example.
17. Name an appropriate communication channel, needed to communicate a signal of bandwidth 100 kHz over a distance of 8 km.
18. Name the type of communication corresponding to the case where the signal is
    (i) a continuous signal essentially similar to the message or information.
    (ii) a discrete and binary coded version of the message or information?
19. Name the types of communication systems according to the mode of transmission.
20. What is the meaning of the term 'attenuation' in communication system?
21. Name the type of communication that uses carrier signals having frequencies in the range 10^{12} Hz to 10^{16} Hz.
22. Why is frequency modulation preferred over amplitude modulation for transmission of music?
23. What should be the length of dipole antenna for a carrier wave of frequency 6×10^8 Hz?.
24. Why AM is used for broadcasting radio signals?
25. The figure given below shows the block diagram of a generalized communication system. Identify the element labelled 'X' and write its function.



26. The carrier wave is given by
    $C(t) = 2 \sin(8\pi t)$ volt.
    The modulating signal is a square wave as shown. Find modulation index.



27. The carrier wave of a signal is given by $C(t) = 3 \sin(8\pi t)$ volt.



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

■ SPACE COMMUNICATION

28. Upto which frequencies is the ground wave propagation restricted?
29. What is the frequency range of signals that are reflected back by ionosphere?
30. Why ground wave propagation cannot be used for TV transmission?

31. Why is the transmission of signals using ground waves restricted upto a frequency of 1500 kHz?

32. Transmission of TV signals is not possible using sky waves. Why?

33. Why are short wave used in long distance broadcasts?

34. A T.V. tower has a height of h meter. What is the area of earth's surface over which its signals can be received?

35. Mention the frequency at which T.V. signals are transmitted.

36. How does the effective power radiated by an antenna vary with wavelength?

37. At which of the following frequency the communication will not be reliable for a receiver situated beyond horizon: 100 kHz or 1 MHz?

38. By which means of waves, frequencies in the UHF range normally propagate?

39. An intelligence signal with a band width of 100 kHz, is to be communicated over a distance of 10 km. Suggest an appropriate form of a communication channel.

40. What is a ground wave?

41. What is a sky wave?

42. What is a space wave?

43. Name the type of radiowave propagation involved when TV signals, broadcast by a tall antenna, are intercepted directly by the receiver antenna.

44. A T.V. tower has a height of 71 m. What is the maximum distance upto which T.V. transmission can be received? Given that the radius of earth = 6.4×10^6 m.

45. Suggest a possible communication channel for the transmission of a message signal which has a bandwidth of 5 MHz.

46. How many telephone channels, each alloted a bandwidth of 8 kHz, can be accommodated in a microwave telephone link, operating at the central frequency of 10^{10} Hz.

47. Name the mode of propagation of radio waves which travel in a straight line from the transmitting antenna to the receiving antenna.

48. What is meant by range of transmission in communication?

49. What is sky wave propagation?

50. What is ground wave propagation?

51. What is space wave propagation?

SHORT ANSWER TYPE QUESTIONS (2 OR 3 MARKS)

1. What is an analog signal and a digital signal?

2. What is meant by the term 'modulation' ? Explain with the help of a block diagram, how the process of modulation is carried out in radio broadcasts.

3. How do we make the choice of a communication channel? A message signal has a bandwidth of 5 MHz. Suggest a possible communication channel for its transmission.

4. What is amplitude modulation? Represent the process graphically. Write its two limitation and two advantages.

5. What is a communication system? Describe briefly the major constituents of a communication system.

6. What is an analog signal ? Explain the terms bandwidth and baseband.

7. What is amplification of signal in communication? How does it helps in transmission of signals?

8. Why should transmitters broadcasting programs use different carrier frequencies ?

9. What is a carrier wave? Why high frequency carrier waves are employed for transmission ?

10. What is frequency modulation? Discuss its advantages.

11. What is an antenna? What role does it play in a communication system ? What should be the length of a dipole antenna ?

12. Explain the term demodulation.

13. What is the difference between noise and attenuation of signal in communication?

14. Draw a plot of the variation of amplitude versus ω for an amplitude modulated wave. Define modulation index. State its importance for effective amplitude modulation.

15. Draw a block diagram of a simple amplitude modulation. Explain briefly how amplitude modulation is achieved.

16. Explain, why high frequency carrier waves are needed for effective transmission of signals.
A message signal of 12 kHz and peak voltage 20 V is used to modulate a carrier wave of frequency 12 MHz and peak voltage 30%. Calculate the (i) modulation index (ii) side band frequencies.

17. What is the role of a band-pass filter in amplitude modulation?

Draw a block diagram of a detector of AM signal and briefly explain how the original signal is obtained from the modulated wave.

18. 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.

19. Explain briefly with the help of diagrams, the terms : (*i*) amplitude modulation, (*ii*) frequency modulation. Which of these (a) gives better quality transmission, (b) has a coverage ?

20. What is a communication channel ? Discuss briefly the various communication channels employed in communication.

21. Distinguish between frequency modulation and amplitude modulation. Why is an FM signal less susceptible to noise than an AM signal?

22. Calculate the length of a half wave dipole at (a) 30 MHz, (b) 300 MHz, and (c) 3000 MHz. What inference do you draw from the results ?

23. A microwave telephone link operating at the central frequency of 10 GHz has been established. If 2 % of this is available for microwave communication channel, then how many telephone signal can be simultaneously granted, if each telephone is allotted a bandwidth of 8 kHz.

24. What is a dipole antenna ? What role does it play in the communication system ? How does the length of dipole antenna vary with frequency of the carrier waves?

25. Define the term modulation. Name three different types of modulation used for a message signal using a sinusoidal continuous carrier wave. Explain the meaning of any one of them.

26. Using the circuit diagram, explain how amplitude modulated signal wave is produced.

27. Using the circuit diagram, explain how amplitude modulated wave is detected and the audio/video signal is demodulate from the AM wave input?

28. In a diode AM detector, the output circuit consists of $R = 1\ k\Omega$ and $C = 10\ pF$. A carrier signal of 100 kHz is to be detected. Is it good ? If yes, then explain why ? If not, what value would you suggest ?

29. (a) Draw the block diagram of a communication system. (b) What is meant by detection of a modulated carrier wave? Describe briefly the essential steps for detection.

30. Define the term modulation index for an AM wave. What would be the modulation index for an AM wave for which the maximum amplitude is *a* while the minimum amplitude is *b*?

31. The amplitude modulated carrier wave of angular frequency ω_c, contains the frequencies 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.

32. Define the term bandwidth of transmission medium in communication. Hence give the frequency bands of
(i) AM broadcast (ii) FM broadcast
(iii) TV broadcast (iv) Cellular Mobile
(v) Satellite communication

33. What is an antenna ? What should be the length of an antenna in comparison to the wavelength of RF signal applied ? A TV tower has a height of 100 m. How population is covered by the TV broadcast if the average population density around the tower is 1000 persons per square km ? (Radius of earth = 6.40×10^6 m)

34. The TV transmission tower at a particular station has a height of 160 m.
(i) What is its coverage range?
(ii) What is the population covered by the transmission, if the average population density around the tower is 1200 km^{-2}?
(iii) By how much should the height of the tower be increased to double its coverage range?
(Radius of earth = 6400 km)

35. Why do we require a satellite for long distance TV transmission? A fax message is to be sent from Delhi to Washington via a geostationary satellite. Calculate the minimum time delay between the dispatch and its getting received. (Take height of geostationary satellite = 36,000 km).

36. Describe briefly, with the help of a diagram the basic principle of satellite communication.

37. What are different modes of propagation of Radio waves?

38. Why ground wave propagation is not suitable for high frequencies ?

39. Derive an expression for the maximum distance upto which signals transmitted by a TV tower can reach.

40. Sky waves are not used in transmitting T.V. signals. Why? State two factors by which the range of transmission of TV signals can be increased.

41. What is ionosphere? Explain its importance in communication.

42. Long distance radio broadcasts use short-wave bands. Why?

43. Is it necessary to use satellites for long distance TV transmission. Why?

44. A radio can tune to any station in the 7.5 MHz to 12 MHz band. What is the corresponding wavelength band?

45. Frequencies higher than 10 MHz can be found not to be reflected by the ionosphere on a particular day at a place. Calculate the maximum electron density of the ionosphere.

46. A ground receiver station is receiving a signal at (a) 5 MHz, and (b) 100 MHz, transmitted from a ground transmitter at a height of 300 m located at a distance of 100 km. Identify whether it is coming via space wave or sky wave propagation or satellite transponder. Radius of earth $= 6.4 \times 10^6$ m, N_{max} = of ionosphere = $10^{12} m^{-3}$

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

48. Explain, with the help of a schematic diagram, the basic principle of satellite communication. Describe briefly what important considerations in the choice of the orbits is taken into account.

49. A transmitting antenna at the top of a tower has a height of 36 m and the height of the receiving antenna is 49 m. What is the maximum distance between them, for satisfactory communication in the LOS mode? (Radius of earth = 6400 km).

50. A TV transmitting antenna is 125 m tall. How much service area can this transmitting antenna cover, if the receiving antenna is at the ground level? (Radius of earth = 6400 km)

51. Distinguish between 'point to point' and ' broadcast' communication modes. Give one example of each.

52. What is space wave propagation? Which two communication methods make use of this mode of propagation? If the the sum of the heights of transmitting and receiving antenna in line of sight of communication is fixed at h, show that the range is maximum when the two antenna have a height $\frac{h}{2}$ each.

53. What does the term LOS communication mean? Name the types of waves that are used for this communication. Which of the two-height of transmitting antenna or height of receiving antenna can affect the range over which this mode of communication remains effective?

54. Why cannot the (i) ground waves, (ii) space waves and (iii) sky waves be sustained for long distance communication beyond 10 to 20 MHz ?

What is meant by critical frequency for sky wave propagation ? Write an expression for the critical frequency in terms of the maximum electron density of eth ionosphere. What is the range of variation of frequency for this critical frequency?

55. Define the term critical frequency in relation to sky wave propagation of electromagnetic waves. On a particular day, the maximum frequency reflected from the ionosphere is 10 MHz. On another day, it was found to decrease to 8 MHz. Calculate the ratio of the maximum electron densities of the ionosphere on the two days.

56. Distinguish between sky wave and space wave propagation. Give a brief description with the help of suitable diagrams indicating how these waves are propagated.

57. Assume that light of frequency 4.5×10^{14} Hz is used in optical communication system. If 2% of this frequency bandwidth is used, how many T.V channels can be accommodated in this bandwidth? The bandwidth needed for T. V. transmission is 4.5×10^6 Hz/channel.

58. Write the function of (i) Transducer and (ii) Repeater in the context of communication system.

59. Write two factors justifying the need of modulation for transmission of a signal.

60. Distinguish between sky wave and space wave propagation. Give a brief description with the help of suitable diagrams indicating how these waves are propagated.

61. What is meant by term modulation? Draw a block diagram of a simple modulator for obtaining an AM signal.

62. By what percentage will the transmission range of a TV tower be affected when the height of the tower is increased by 21%?

63. Why are high frequency carrier waves used for transmission?

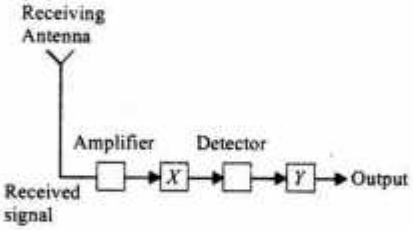
64. Write two factors justifying the need of modulating a signal. A carrier wave of peak voltage 12 V is used to transmit a message signal. What should be the peak voltage of the modulating signal in order to have a modulation index of 75%?

65. Which mode of propagation is used by short wave broadcast services having frequency range from a few MHz upto 30 MHz? Explain diagrammatically how long distance communication can be achieved by this mode. Why is there an upper limit to frequency of waves used in this mode?

66. (i) Define modulation index.
(ii) Why is the amplitude of modulating signal kept less than the amplitude of carrier wave?

67. Draw a schematic diagram showing the (i) ground wave (ii) sky wave and (iii) space wave propagation modes for em waves.
Write the frequency range for each of the following :
(i) Standard AM broadcast
(ii) Television
(iii) Satellite communication

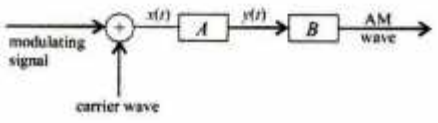
68. In the given block diagram of a receiver, identify the boxes labelled as X and Y and write their functions.



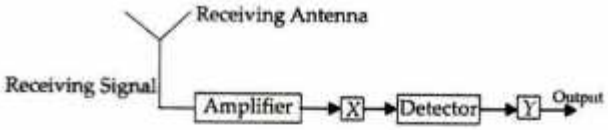
69. Explain briefly the following terms used in communication system :
(i) Transducer (ii) Repeater (iii) Amplification

70. Mention three different modes of propagation used in communication system. Explain with the help of a diagram how long distance communication can be achieved by ionospheric reflection of radio waves.

71. In the block diagram of a simple modulator for obtaining an AM signal shown in the figure, identify the boxes A and B. Write their functions.



72. Block diagram of a receiver is shown in the figure.



(a) Identify X and Y.
(b) Write their functions.

73. 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.

74. Name the type of waves which are used for line of sight (LOS) communication. What is the range of their frequencies? A transmitting antenna at the top of a tower has a height of 20 m and the height of the receiving antenna is 45 m. Calculate the maximum distance between them for satisfactory communication in LOS mode.
(Radius of the Earth = 6.4×10^6 m)

75. A transmitting antenna at the top of a tower has a height of 45 m and the height of the receiving antenna is 80 m. Calculate the maximum distance between them for satisfactory communication in LOS mode.
(Radius of the Earth = 6.4×10^6 m)

76. A transmitting antenna at the top of a tower has a height of 45 m and the receiving antenna is on the ground. Calculate the maximum distance between them for satisfactory communication in LOS mode.
(Radius of the Earth = 6.4×10^6 m)

77. Write the functions of the following in communication system:
(i) Transducer (ii) Repeater

78. Write the functions of the following in communication systems:
(i) Transmitter (ii) Modulator

79. Write the functions of the following in communication systems:
(i) Receiver (ii) Demodulator

80. Write two basic modes of communication. Explain the process of amplitude modulation. Draw a schematic sketch showing how amplitude modulated signal is obtained by superposing a modulating signal over a sinusoidal carrier wave.

81. When Sunita, a class XII student, came to know that her parents are planning to rent out the top floor of their house to a mobile company, she protested. She tried hard to convince her parents that this move would be a health hazard.

Ultimately her parents agreed :

(i) In what way can the setting up of transmission tower by a mobile company in a residential colony prove to be injurious to health?

(ii) By objecting to this move of her parents, what value did Sunita display?

(iii) Estimate the range of em waves which can be transmitted by an antenna of height 20 m.

(Given radius of the Earth = 6400 km)

Solutions

VERY SHORT ANSWER TYPE QUESTIONS

2. FM

3. AM

4. In range of kHz to MHz

10. Coaxial cable or AM radio

13. (i) 20 Hz to 20 kHz

(ii) 6 MHz

(iii) Infinite

14. $(\omega_c - \omega_m)$, ω_c, $(\omega_c + \omega_m)$

17. Twisted pair or Ground wave

18. (i) Analog communication

(ii) Digital communication

21. Optical communication

23. $\lambda = \frac{c}{\upsilon} = \frac{3\times10^8}{6\times10^8} = 0.5\text{ m}$

Length of dipole antenna $L = \frac{\lambda}{2} = \frac{0.5}{2} = 0.25\text{ m}$

25. X in given diagram represents the communication channel. It carries the modulated wave from the transmitter to the receiver.

26. Modulation index,

$$\mu = \frac{\text{Amplitude of modulated signal } (A_m)}{\text{Amplitude of carrier wave } (A_c)}$$

Here, $A_m = 1$ V, $A_c = 2$ V

$\therefore \quad \mu = \frac{1}{2} = 0.5$

28. 2 MHz

29. 2 MHz to 30 MHz

34. Area = $2\pi hR_e$

39. Twisted pair

43. Space wave propagation.

49. The radio wave propagation in which radio waves are transmitted to distant places via reflection from ionosphere is called sky wave propagation.

50. In ground wave propagation, radio waves travel close to the surface of earth and due to low frequency they also bend through regular aperture of earth as well as bend with the shape of each. Such propagation of waves takes place when transmitting and receiving antenna are close to the surface of the earth.

51. In space wave propagation, the transmitted radio waves of large frequencies travel in straight lines directly from transmitting antenna to the receiving antenna.

SHORT ANSWER TYPE QUESTIONS

3. Coaxial cable or sky wave propagation

7. It is the process of increasing the amplitude and hence the strength of a signal using an electronic circuit called the amplifier. It helps in increasing the range of transmission of signals.

13. Noise refers to the unwanted signals that tend to disturb the transmission and processing of message signals in communication.

Attenuation is the lose of strength of signal while propagating through the transmission medium.

16. (i) Modulation index = 20/30 = 0.67%

(ii) The side band frequencies are

$\omega_c + \omega_m = (12000 + 12)$ kHz = 12012 kHz

$\omega_c - \omega_m = (12000 - 12)$ kHz = 11988 kHz

22. (a) $\upsilon = 30$ MHz $= 3 \times 10^7$ Hz , $\lambda = \frac{c}{\upsilon} = \frac{3\times10^8}{3\times10^7} = 10\text{ m}$

Length of antenna, $L = \frac{\lambda}{2} = \frac{10}{2} = 5\text{ m}$

(b) $\upsilon = 300$ MHz = 1 m, $L = 0.5$m

Thus, more the frequency of the signal to be transmitted, shorter is the length of antenna required.

23. 2% of 10 GHz $= \frac{2}{100}\times10\times10^9$ Hz $= 2 \times 10^8$ Hz

Number of telephone calls $N = \frac{2\times10^8\text{ Hz}}{8\times10^3\text{ Hz}}$ or $N = 2.5 \times 10^4$

24. $L = \frac{\lambda}{2} = \frac{c}{2\upsilon}$ or $L \propto 1/\upsilon$

28. $\frac{1}{f_c} = \frac{1}{100\times10^3} = 10^{-5}$ s , $RC = 10^3 \times 10 \times 10^{-12} = 10^{-8}$ s

Here $\frac{1}{f_c}$ is not much smaller than RC.

Whereas for demodulation $\frac{1}{f_c} << RC$. So it is not good.

For the circuit to be good.

$$RC >> \frac{1}{f_c}$$

or $10^3 \times C >> 10^{-5}$ or $C >> 10^{-8}$ F

or $C >> 10^{-8}$ F

or $C = 1\ \mu$F

30. (a) In AM, modulation index is the ratio of amplitude of modulating signal to the amplitude of carrier wave $\mu = \frac{A_m}{A_c}$

(b) Since AM wave is given by

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

So, maximum amplitude is $A_c + A_m = a$

and minimum amplitude is $A_c - A_m = b$

Adding them, we get $A_c = \frac{a+b}{2}$

So, modulation index $\mu = \frac{A_m}{A_c} = \frac{a-b}{a+b}$

32. (i) 540-1600 kHz

(ii) 88-108 MHz

(iii) 54-890 MHz

(iv) 840-935 MHz

(v) 3.7 to 6.4 GHz

33. $L = \frac{\lambda}{2}$,

population covered $= 2\pi h R_e = 2 \times 3.14 \times 0.1 \text{ km} \times 6.4 \times 10^3 \text{km} \times 1000 \text{ km}^{-2} = 4.0192 \times 10^6$ person

34. (i) $d = \sqrt{2hR_e} = \sqrt{2 \times 160 \times 6.4 \times 10^6}$

$= 4.5255 \times 10^4 \text{m} = 45.255 \text{ km}$

(ii) Population covered

$= \pi d^2 n = 3.14 \times (45.255 \text{ km})^{-2} \times 1200 \text{ km}^{-2}$

$= 7.72 \times 10^6$ persons

(iii) $\frac{d_2}{d_1} = \sqrt{\frac{h_2}{h_1}}$ or $h_2 = h_1 \left(\frac{d_2}{d_1}\right)^2$ or $h_2 = 160 \times \left(\frac{2d_1}{d_1}\right)^2$

or $h_2 = 640$ m

35. Distance travelled by the signal

$s = 36000 + 36000 = 72000$ km

or $s = 7.2 \times 10^7$ m time taken by signal to travel

$$t = \frac{s}{v} = \frac{7.2 \times 10^7 \text{ m}}{3 \times 10^8} = 2.4 \times 10^{-1} = 0.24 \text{ s}$$

44. $\upsilon_1 = 7.5 \text{ MHz} = 7.5 \times 10^6$ Hz

$$\lambda_1 = \frac{c}{\upsilon_1} = \frac{3 \times 10^8}{7.5 \times 10^6} = 40 \text{ m}$$

$\upsilon_2 = 12 \text{ MHz} = 12 \times 10^6$ Hz

$$\lambda_2 = \frac{c}{\upsilon_2} = \frac{3 \times 10^8}{12 \times 10^6} = 25 \text{ m}$$

So wavelength band is 25 m to 40 m

45. $f_c = 9\sqrt{N_{max}}$

$$N_{max} = \frac{f_c^2}{81} = \frac{(10 \times 10^6)^2}{81} \text{ Hz} = 1.23 \times 10^{12} \text{m}^{-3}$$

46. $h = 300$ m, so coverage range of transmitter is $d = \sqrt{2hR}$

or $d = \sqrt{2 \times 300 \times 6.4 \times 10^6}$

or $d = 61.96 \times 10^3$m

or $d = 61.96$ km

Since receiver station is 100 km away from ground transmitter, so it cannot receive the signal via space wave propagation.

Also, $f_c = 9\sqrt{N_{max}} = 9\sqrt{10^{12}} = 9 \times 10^6$ Hz $= 9$ MHz

(a) Hence signal of 5 MHz, is coming via sky wave propagation, as ionosphere reflects the signals of frequency upto 9 MHz.

(b) Signal of 100 MHz is coming via satellite transponder, as ionosphere is not able to reflect the signals of frequency 100 MHz.

49. $d_m = \sqrt{2Rh_T} + \sqrt{2Rh_R} = \sqrt{2R}\left(\sqrt{h_T} + \sqrt{h_R}\right)$

$= \sqrt{2 \times 6.4 \times 10^6}\left(\sqrt{36} + \sqrt{49}\right)$

$= \sqrt{12.8} \times 10^3 \times (6+7) = 3.58 \times 13 \times 10^3$

$d_m = 46.54 \times 10^3$ m $= 46.54$ km

50. $d = \sqrt{2Rh_T} = \sqrt{2 \times 6.4 \times 10^6 \times 125} = \sqrt{25 \times 64 \times 10^6}$

or $d = 5 \times 8 \times 10^3 = 40 \times 10^3$m $= 40$ km

Area in which signals from TV tower can be received is

$A = \pi d^2 = 3.14 \times 40^2$

or $A = 5024 \text{ km}^2$

52. Distance between the transmitting and receiving antenna in line of sight communication is given by

$d_m = \sqrt{2Rh_T} + \sqrt{2Rh_R}$ (i)

Given that $h_T + h_R = h$ or $h_R = h - h_T$

Using it in equation (i), we get

$d_m = \sqrt{2Rh_T} + \sqrt{2R(h - h_T)}$

Differentiating it w.r.t. h_T, we get

$$\frac{d(d_m)}{dh_T} = \sqrt{2R} \times \frac{1}{2\sqrt{h_T}} - \sqrt{2R} \times \frac{1}{2\sqrt{h - h_T}}$$

For maximum range $\frac{d(d_m)}{dh_T} = 0$

or $\frac{\sqrt{2R}}{2} \frac{1}{\sqrt{h_T}} - \frac{1}{\sqrt{h - h_T}} = 0$

or $\frac{1}{\sqrt{h_T}} - \frac{1}{\sqrt{h - h_T}} = 0$

or $\frac{1}{\sqrt{h_T}} = \frac{1}{\sqrt{h - h_T}}$

or $h - h_T = h_T$

or $h_T = \frac{h}{2} = h_R = h - h_T = h - \frac{h}{2} = \frac{h}{2}$

53. A space wave travels in a straight line from transmitting antenna to the receiving antenna. It is called line of sight (LOS) communication. TV signals of frequencies greater than 50 MHz and micro wave links use this mode of communication.

The maximum line of-sight distance i.e. range between the transmitting and receiving antenna is given by

$$d_m = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

So, the range of LOS communication depends both on the height of transmitting antenna (h_T) and the height of receiving antenna h_R.

55. The critical frequency for reflection from ionosphere is

$$f_c = 9\sqrt{N_{max}}$$

(i) When f_c = 10 MHz = 10×10^6 Hz = 10^7 Hz

$$10^7 = 9\sqrt{N_{max}} \quad \text{or} \quad 10^{14} = 81 \times N_{max}$$

or $N_{max} = \frac{1}{81} \times 10^{14} = 1.23 \times 10^{12} m^{-3}$

(ii) When f_c = 8MHz = 8×10^6 Hz

$$8 \times 10^6 = 9\sqrt{N_{max}}$$

or $N_{max} = \frac{64}{81} \times 10^{12} = 7.9 \times 10^{11} m^{-3}$

57. Frequency bandwidth = 2% of $4.5 \times 10^{14} = 9 \times 10^{12}$ Hz

Number of TV channels = $\frac{9 \times 10^{12} \text{ Hz}}{4.5 \times 10^6 \text{ Hz}} = 2 \times 10^6$

58. (i) Transducer : Any device that converts one form of energy into another is called transducer. Like phone converts electrical signal into sound and hence is transducer.

(ii) Repeater : A repeater, picks up the signal from the transmitter, amplifier and re-transmits it to the receiver sometimes with a change in carrier frequency. Thus, repeater compensates the loss in energy during transmission of signals.

59. Two factors justifying the need of modulation for transmission of a signal are :

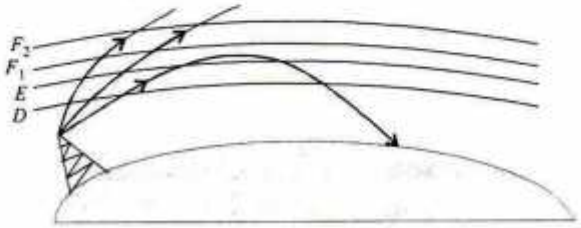
(a) Managable size of the antenna : Audio signals when converted into em waves have low frequency and large wavelength λ, so an antenna of large length $L = \frac{\lambda}{4} \approx 3.75$ km is required, which is unpractical. However for modulating audio signals with carrier waves of large frequencies, antenna of small managable size is required.

(b) More effective power radiated by antenna : Power radiated by antenna is $P \propto \frac{l^2}{\lambda^2}$

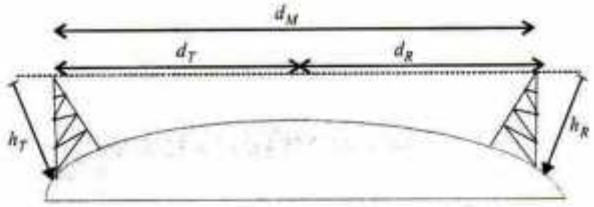
This shows that there is a need of higher frequency conversion for effective power transmission by the antenna.

60. In sky wave propagation, the transmitted radio waves reach the receiving antenna after reflection from the ionosphere. Whereas, in space wave propagation or line of sight propagation, radio waves travel in straight line from transmitting to receiving antenna.

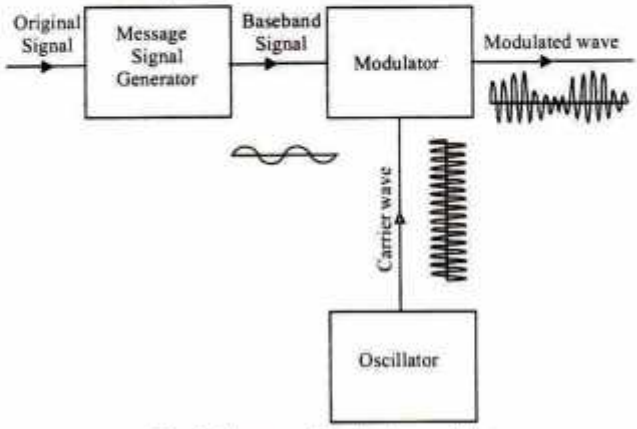
(i) Sky wave propagation : Here the radio waves reach the receiving antenna from transmitting antenna after reflection from ionosphere.



(ii) Space wave propagation : Here the transmitted radio waves reach the receiver through a line of sight straight propagation. The range of such a transmission is limited by the curvature of the earth.



61. The process of variation of some characteristic of high frequency carrier wave in accordance with the instantaneous value of a signal is called modulation.



Block diagram of a simple modulator

62. Transmission range of TV tower is $d = \sqrt{2hR}$

Given, $\frac{h_2 - h_1}{h_1} \times 100 = 21\%$ or $\frac{h_2}{h_1} = 1.21$.

$$\frac{d_2}{d_1} = \sqrt{\frac{2h_2R}{2h_1R}} = \sqrt{\frac{h_2}{h_1}} = \sqrt{1.21} = 1.1$$

$$\frac{d_2}{d_1} - 1 = 1.1 - 1 = 0.1$$

or $\frac{d_2 - d_1}{d_1} \times 100 = 0.1 \times 100 = 10\%$

i.e., transmission range then increases by 10%.

63. High frequency carrier waves are used for transmission because

(i) Audio/video signals when converted into em waves, do not have sufficiently high energy to travel upto long distances, because of their lower frequency. So, these signals are modulated with high frequency carrier waves, before being transmitted.

(ii) For effective transmission by an antenna, the size of antenna should be at least of the size $\lambda/4$, where λ is wavelength of signal to be send. As wavelength λ of audio/video signals is large, so impractical large antenna is required to transmit audio/video signals directly.

However, on modulating there signals with high frequency carrier waves, length of antenna required for transmission of signals become small.

64. Need of modulation :

(i) Audio/video signals do not have sufficiently high energy to travel upto long distances, because of their lower frequency.

(ii) For effective transmission, the size of the antenna should be at least of the size $\frac{\lambda}{4}$, where λ is wavelength of signal to be sent.

For an em wave of the frequency of the order of audio signal, we need an antenna of size 3.75 km, which is practically impossible.

Hence these low frequency base band signals are first converted into high frequencies, through modulation.

Modulation index, $\mu = \frac{A_m}{A_c}$

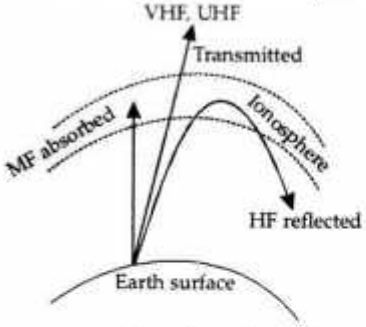
So peak voltage of modulating signal, $A_m = \mu A_c$

$\Rightarrow \quad A_m = 0.75 \times 12 = 9$ V

65. Sky wave propagation is used by short wave broadcast services having frequency range from a few MHz upto 30 MHz.

Sky waves are used for long distance radio communication.

The successive reflection of these radiowaves at the earth's surface and the ionosphere make it possible to transmit these waves from one part to another part of the earth.



These waves are reflected by ionosphere by means of total internal reflection, which arises due to change in refractive indices of different layers of ionosphere. Critical frequency of reflection for a particular layer is given by $f_c = 9\sqrt{N_{max}}$ where N_{max} = maximum electron density in the given layer.

For any frequency greater than f_c ionosphere is not able to reflect the radiowave. Hence there exists an upper limits to frequency of waves used in this mode.

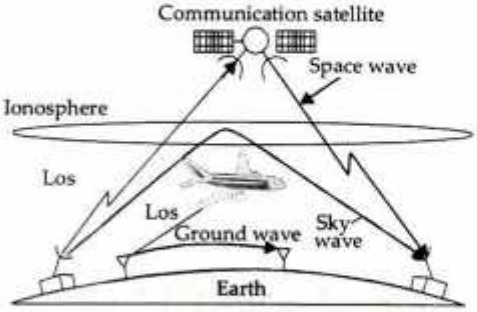
66. (i) Modulation index : The modulation index of an amplitude modulated wave is defined as the ratio of the amplitude of modulating signal (A_m) to the amplitude of carrier wave (A_c).

i.e., Amplitude modulation index,

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

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

67. The diagram given is showing various propagation modes for em waves.



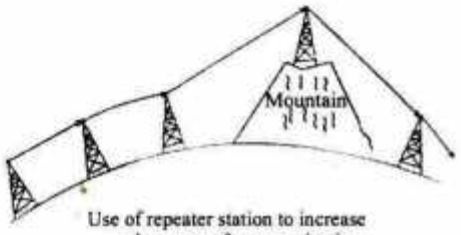
(i) 540-1600 kHz

(ii) 54-72 MHz
76-88 MHz
174-216 MHz
420-890 MHz

(iii) 5.925-6.425 GHz
3.7-4.2 GHz

68. X = Intermediate frequency (IF) stage
Y = Amplifier/Power Amplifier
IF Stage : IF stage changes the carrier frequency to a lower frequency.
Amplifier: Increases the strength of signals.

69. (i) Transducer : Any device that convert one form of energy into another can be termed as a transducer. In electronic communication systems, devices that have either their inputs or outputs in the electrical form. An electrical transducer is a device that converts some physical variable (pressure, displacement, force, temperature, etc) into corresponding variations into the electrical signal at its output.
(ii) Repeater: A repeater is a combination of a receiver and a transmitter. A repeater, picks up the signal from the transmitter, amplifies and retransmits it to the receiver sometimes with a change in carrier frequency. A communication satellite is essentially a repeater station in space.



Use of repeater station to increase the range of communication

(iii) Amplification: It is the process of increasing the amplitude of a signal using an electronic circuit called the amplifier. Amplification is necessary to compensate for the attenuation of the signal in communication systems. The energy needed for additional signal strength is obtained from a DC power source.

71. Identification:
A is the square law device.
B is the bandpass filter.
Functions:
Square law device is a non linear device and produces the output.
Bandpass filter rejects dc and sinusoidal frequencies ω_m, $2\omega_m$, $2\omega_c$ and gives the AM wave as its output.

72. From the given block diagram of demodulation of a typical receiver, we can conclude the following
(a) X represents demodulator while Y represents an amplifier.
(b) In a demodulator, the modulated signal is detected and separated from carrier frequency. While the function of an amplifier is to amplify the detected modulated signal which may not be strong enough to be used.

74. Space waves/radio wave/ micro wave
Frequency range above 40 MHz
Maximum distance, $d_m = \sqrt{2h_T R} + \sqrt{2h_R R}$

$$d_m = \sqrt{2\times6400\times10^3\times45} + \sqrt{2\times6400\times10^3\times20}$$
$$= (24+16)\times10^3 \text{ m} = 40\times10^3 \text{ m}$$

75. Maximum distance $d_m = \sqrt{2h_T R} + \sqrt{2h_R R}$

$$d_m = \sqrt{2\times6400\times10^3\times80} + \sqrt{2\times6400\times10^3\times45}$$
$$= (32+24)\times10^3 \text{ m} = 56\times10^3 \text{ m}$$

76. Maximum distance $d_m = \sqrt{2h_T R} + \sqrt{2h_R R}$
$h_R = 0$
$\therefore \quad d_m = 24\times10^3$ m

77. Transducer : Transducer converts one form of energy to another.
Repeater : A repeater accepts the signal from the transmitter, amplifies and retransmits it to the receiver.

78. Transmitter : A transmitter processes the incoming message signal so as to make it suitable for transmission through a channel and subsequent reception.
Modulator : It is a device in which the amplitude/ frequency/phase of a high frequency carrier wave is made to change in accordance with the message signal through (appropriate) superposition.

79. Receiver : It extracts the desired message signals from the received signals at the channel output.
Demodulator : It is a device to retrieve information (or) the message signal from the carrier wave at the receiver.

80. The two basic modes of communication are
(i) point-to-point communication
(ii) broadcast communication
Amplitude modulation : Amplitude modulation is produced by varying the amplitude of the carrier waves in accordance with the amplitude of the modulating wave.
Let the carrier wave be $C(t) = A_c \sin\omega_c t$
and the modulating signal be $m(t) = A_m \sin\omega_m t$,
where $\omega_m = 2\pi f_m$ is the angular frequency of the message signal.
Modulated signal $C_m(t)$ is

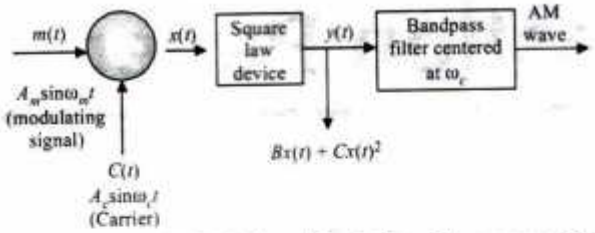
$$C_m(t) = (A_c + A_m \sin\omega_m t)\sin\omega_c t = A_c\left(1+\frac{A_m}{A_c}\sin\omega_m t\right)\sin\omega_c t$$

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

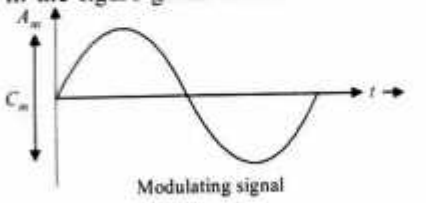
where $\mu = \frac{A_m}{A_c}$ is the modulation index.

$\omega_c - \omega_m$ and $\omega_c + \omega_m$ are the lower side and upper side frequencies, respectively.

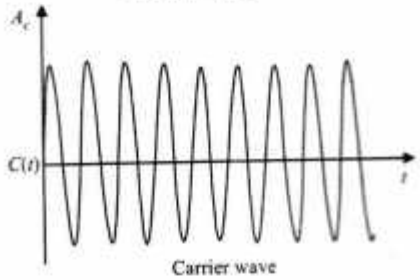
Production of amplitude modulated wave



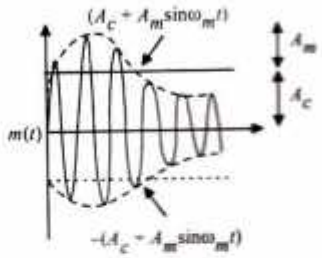
Amplitude modulated signal is obtained by superposing a modulating signal over a sinusoidal carrrier wave is shown in the figure given below.



Modulating signal



Carrier wave



Amplitude-modulated wave

81. (i) A transmission tower transmits electromagnetic waves such as microwaves. Exposure to these waves can cause severe health hazards like cancer and tumour. Also transmission tower (antenna) works on a very high power, so the risk of someone severely gets burnt increases in residential area.

(ii) Sunita has displayed awareness towards the health and environment of society by objecting to this move of her parents.

(iii) Here, $R = 6400 \text{ km} = 64 \times 10^5 \text{ m}$, $h = 20 \text{ m}$, $d = ?$

Range of the transmitting antenna,

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

$$= \sqrt{2 \times (20) \times (64 \times 10^5)} = \sqrt{4 \times 64 \times 10^6}$$

$$\Rightarrow \quad d = 16000 \text{ m}$$