CHAPTER

15

Communication System

A Quick Recapitulation of the Chapter

1. Communication is the act of transmission and reception of information.
2. Every communication system has three essential elements which are as transmitter, medium or communication channel and receiver.
3. **Basic terminology used in electronic communication system**
   (i) **Signal** Information converted into electrical form and suitable for transmission is called a signal.
   (ii) **Transducer** Any device/arrangement that converts one form of energy into another is called a transducer, e.g. microphone.
   (iii) **Noise** It refers to the unwanted signals that tend to disturb the transmission and processing of message signals in communication system.
   (iv) **Attenuation** It refers to the loss of strength of a signal during its propagation through the communication channel.
   (v) **Amplification** It is the process by which amplitude of a signal is increased using an electronic circuit called the amplifier.
   (vi) **Range** It is the largest distance between a source and a destination up to which the signal is received with sufficient strength.
   (vii) **Repeater** Repeaters are erected at suitable distances between the transmitter and receiver. Repeaters are used to extend the range of a communication system.
4. **Message signals** A time varying electrical signal generated by a transducer out of original signal is termed as message signal.

   The message signals are of two types as given below.
   (i) **Analog signal** A continuous electrical signal which at any instant lies within the range of a maximum and a minimum value.
   (ii) **Digital signal** (Pulse signal) Digital signals are those which can take only discrete stepwise values, *e.g.,* output of a computer, fax etc.
5. **Bandwidth of communication channel** is the range of frequencies used to pass through channel.
6. **Ground wave propagation** ($f < 2$ MHz) In ground wave propagation, the radio waves (AM) travel along the surface of the earth. These waves are guided along the earth's surface and they follow the curvature of the earth.
7. **Sky wave propagation** ($2\text{ MHz} < f < 30\text{ MHz}$)
   Long distance communication can be achieved by ionospheric reflection of radio waves back towards earth. This mode of propagation is called sky wave propagation and is used by short wave broadcast services.
8. **Space wave propagation** ($f > 30$ MHz)
   A space wave travels in a straight line from transmitting antenna to the receiving antenna. Space waves are used for Line-of-Sight (LOS) communication as well as satellite communication.
   (i) Range of TV transmission, $d = \sqrt{2hR}$
   where, h = height of antenna, R = radius of the earth,
   d = maximum distance/range of transmission
   (ii) Range of line-of-sight distance between two antennas,
   $$d_M = d_T + d_R,\ d_M = \sqrt{2h_TR} + \sqrt{2h_RR}$$

where, h_T and h_R are heights of transmitting and receiving antenna and d_T is the radio horizon of the transmitting antenna.

9. **Satellite communication** Signals which are reflected by ionosphere is reflected back by satellite. In this communication, frequency band 5.9 GHz to 6.4 GHz is used for uplinking and 3.7 GHz to 4.2 GHz is used for downlinking.
10. For transmitting a signal, we need an antenna. This antenna should have a size comparable to the wavelength of the signal (atleast $\lambda/4$ is dimension).
11. The effective power radiated by an antenna is proportional to $(l/\lambda)^2$, where l is the length of linear antenna. For a good transmission, we need high power.
12. **Baseband** Band of frequencies representing the original signal is called baseband.
13. **Modulation** Modulation is the process of variation of some characteristics of a carrier wave in accordance with the instantaneous value of a modulating signal.
14. *Types of pulse modulation*
    (i) PAM (Pulse Amplitude Modulation)
    (ii) PDM (Pulse Duration Modulation)
    (iii) PPM (Pulse Position Modulation)
    (iv) PCM (Pulse Code Modulation)
15. **Amplitude modulation** In amplitude modulation, the amplitude of the carrier is varied in accordance with the information signal.
    (i) AM can be represented by expression
    $$C_m(t) = A_c \sin\omega_c t + \frac{\mu A_c}{2}\cos(\omega_c - \omega_m)t - \frac{\mu A_c}{2}\cos(\omega_c + \omega_m)t$$
    where, A_c = amplitude of a carrier wave,
    A_m = amplitude of modulating wave
    $\mu = A_m/A_c$ is the modulation index ($\mu \le 1$),
    f_c = frequency of carrier wave
    and f_m = modulating wave frequency.
16. **Modulation index**
    $$\mu = \frac{\text{Change in amplitude of carrier wave}}{\text{Amplitude of carrier wave}}$$
    $$= \frac{A_m}{A_c} = \frac{A_{max} - A_{min}}{A_{max} + A_{min}},\ A_{max} = A_c + A_m,\ A_{min} = A_c - A_m$$
    where, A_{max} = maximum amplitude of AM wave
    A_{min} = minimum amplitude of AM wave
17. Upper side band frequency = $f_c + f_m$
    Lower side band frequency = $f_c - f_m$
    where, f_c and f_m are frequencies of carrier wave and modulating wave.
    Bandwidth = USB – LSB = $(f_c + f_m) - (f_c - f_m) = 2f_m$
18. **Demodulation** It is the process of extracting the audio frequency message signal from the modulated wave.

Objective Questions Based on NCERT Text

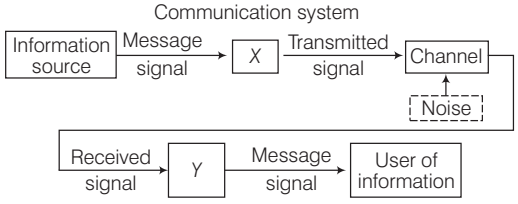
Topic 1
Basic Terminology used in Electronic Communication System

1. A modern communication system acts as a
(a) transmitter (b) receiver
(c) messenger (d) None of these

2. Languages and methods used in communication have kept evolving from prehistoric to modern times, to meet the growing demands in terms of ..... and ..... of information.
(a) receive, sender (b) receiver, sender
(c) speed, complexity (d) language, quality

3. A communication system consists of
(a) transmitter and receiver
(b) receiver and communication channel
(c) transmitter and communication channel
(d) transmitter, communication channel and receiver

4. Identify the parts … X … and … Y … in the block diagram of a generalised communication system.



(a) channel, transmitter (b) transmitter, receiver
(c) receiver, channel (d) receiver, transmitter

5. If the output of the information source is a non-electrical signal like a voice signal, a ..... converts it to ..... form before giving it as an input to the ..... .

(a) receiver, electrical, channel
(b) channel, magnetic, transducer
(c) transducer, electrical, channel
(d) transducer, electrical, transmitter

6. When noise adds to the transmitted signal, which part of the generalised communication system receives a corrupted version of the transmitted signal?
(a) Channel (b) Receiver
(c) Transducer (d) Transmitter

7. ..... reconstructs a recognisable form of the original message signal for delivering it to the user information.
(a) channel (b) transducer
(c) receiver (d) transmitter

8. In a point to point communication mode, communication takes place over a link between
(a) transmitter and channel (b) channel and transmitter
(c) transmitter and receiver (d) channel and receiver

9. Which of the following is an example of point to point communication mode?
(a) Radio (b) Television
(c) Telephone (d) Microwave

10. The transmission media can be
(a) only guided (b) only unguided
(c) Both (a) and (b) (d) None of these

11. Point to point communication requires the use of
(a) only a guided medium (b) only unguided medium
(c) any medium (d) None of these

12. Quality of transmission depends upon
(a) nature of the medium only
(b) nature of signal only
(c) Both (a) and (b)
(d) Neither (a) nor (b)

13. Which of the following project was undertaken by US defence department?
(a) ETHERNET (b) ARPANET
(c) INTERNET (d) INTRANET

14. ARPANET allowed
(a) file transfer from one computer to another connected to the network
(b) a message signal representing the original signal delivered by the source of information
(c) communicating without using wires
(d) message signals and make it suitable for transmission

15. Which of the following optical systems are superior and more economical as compared to traditional communication system?
(a) Ray optical (b) Fibre optical
(c) Wave optical (d) Light optical

16. With the advancement of technology, a communication system is based on
(a) electrical (b) electronic
(c) optical (d) All of these

17. Which type of communication system is used in FAX machine?
(a) Binary (b) Analog (c) Hybrid (d) All of these

18. Tremendous growth of message transmission through post offices is due to
(a) E-mail (b) FAX (c) television (d) telegraph

19. Which of the following is not a transducer?
(a) Loudspeaker (b) Amplifier
(c) Microphone (d) All of these

20. A device that converts some physical variable (pressure, displacement, force, temperature, etc.) into the corresponding variation in the electrical signal at its output is that
(a) transducer (b) receiver
(c) noise (d) transmitter

21. Audio signal cannot be transmitted directly upto large distance
(a) the signal has more noise
(b) the signal cannot be amplified for distance communication
(c) the transmitting antenna length is very small to design
(d) the transmitting antenna length is very large and cannot be achieved practically

22. In electronic communication systems, we usually come across devices that have either their inputs and outputs in the form of
(a) magnetic (b) electrical
(c) Both (a) and (b) (d) None of these

23. Signals are essentially single-valued function of
(a) distance (b) displacement
(c) speed (d) time

24. Which of the following is the fundamental analog signal?
(a) cos wave (b) cosec wave
(c) sine wave (d) tan wave

25. Which of the following statement is incorrect?
(a) All analog signals can be fully understood in terms of their sine wave components
(b) Sound and picture signals in TV are analog in nature
(c) Digital signals are those which cannot take only discrete stepwise values
(d) Binary system that is extensively used in electronics employs just two level of a signal

26. Fading in the variation in the strength of a signal at a receiver is due to
(a) interference of waves (b) diffraction of waves
(c) polarisation of waves (d) None of these

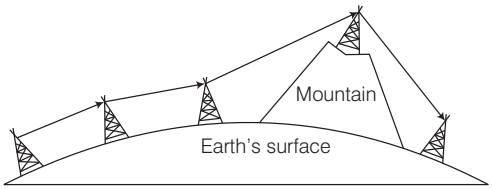
27. The loss of strength of a signal while propagating through a medium is known as
(a) amplification (b) receiver
(c) attenuation (d) noise

28. Why is the amplification necessary in the communication system?
(a) To compensate for the attenuation of the signal
(b) To compensate for the range of the signal
(c) To compensate for the receiver of the signal
(d) To compensate for the transmitter of the signal

29. The energy needed for additional signal strength is obtained from
(a) AC power source (b) DC power source
(c) generator (d) sunlight

30. Which is the largest distance between a source and a destination upto which the signal is received with sufficient strength?
(a) Bandwidth (b) Demodulation
(c) Repeater (d) Range

31. Consider the transmission of singal as shown in figure.



Why are repeaters used?
(a) To discrete the range of a communication system
(b) To extend the range of a communication system
(c) Both (a) and (b)
(d) None of the above

32. Which one of the following is essentially repeater station in space?
(a) Artificial satellite
(b) Natural satellite
(c) Communication satellite
(d) All of the above

Topic 2
Bandwidth of Signals & Transmission Medium

33. In a communication system, message signal can be
(a) voice (b) music
(c) picture or computer data (d) All of these

34. The type of communication system needed for a given signal depends on the ..... which is considered essential for the communication process.
(a) range of wavelength
(b) band of frequencies
(c) Either (a) or (b)
(d) None of the above

35. Rectangular wave can be decomposed into a superposition of sinusoidal waves of frequencies are
(a) $\nu_0, 3\nu_0, 6\nu_0, 9\nu_0, \cdots, n\nu_0$
(b) $4\nu_0, 8\nu_0, 12\nu_0, 16\nu_0, \cdots, n\nu_0$
(c) $\nu_0, 2\nu_0, 3\nu_0, 4\nu_0, \cdots, n\nu_0$
(d) $2\nu_0, 4\nu_0, 6\nu_0, 8\nu_0, \cdots, n\nu_0$

36. What happen if the bandwidth is large enough to accommodate a few harmonics?
(a) The information is not lost
(b) The rectangular signal is more or less recovered
(c) Both (a) and (b)
(d) Only (b)

37. Large bandwidth for higher data rate is achieved by using
(a) high frequency carrier wave
(b) low frequency carrier wave
(c) high frequency audio wave
(d) low frequency audio wave

38. A laser is a coherent source because it contains
(a) many wavelengths
(b) in ordinate wave of particular wavelength
(c) coordinate waves of many wavelength
(d) coordinate waves of particular wavelength

39. Message signals are also called
(a) band signals (b) electronic signals
(c) electromagnetic signals (d) baseband signals

40. How many signals, is a single frequency sinusoid?
(a) Two bandwidth (b) No signal
(c) One signal (d) Three signals

41. A singal spreads over a range of frequencies called
(a) signal bandwidth
(b) signal baseband
(c) signal audio frequency
(d) signal video frequency

42. The effective power radiated by a long wavelength baseband signal would be
(a) large
(b) small
(c) either small or large
(d) neither small nor large

43. The radio waves frequency 80 MHz of 300 MHz belong to
(a) high frequency band
(b) very high frequency band
(c) ultra frequency band
(d) super high frequency band

44. Coaxial cables are normally operated below
(a) 18 GHz (b) 18 kHz
(c) 18 MHz (d) 18 THz

45. Communication through free space using ..... waves takes place over a very wide range of frequencies : from a few hundreds of kHz to a GHz.
(a) gamma waves (b) microwaves
(c) radio waves (d) None of these

46. For mobile communication to base station, the required frequency band is
(a) 896-901 MHz (b) 896-901 kHz
(c) 840-935 MHz (d) 840-935 kHz

47. Optical communication is performed in the frequency range of
(a) 100 GHz (b) 1 THz to 1000 THz
(c) 1 THz to 100 Tz (d) Only 1000 THz

48. How much bandwidth, is required by an optical fibre for data transmission?
(a) 100 GHz (b) 1000 GHz
(c) 100 kHz (d) 1000 kHz

49. The range of frequency allotted for UHF TV broadband is
(a) 470 - 960 kHz (b) 47 - 960 MHz
(c) 470 - 960 MHz (d) 174 - 216 MHz

50. The Cellular Mobile Radio wave of frequency 840 - 935 MHz belongs to
(a) base station to mobile (b) mobile to base station
(c) ultra high frequency (d) very high frequency

51. Which type of communication uses carrier signals having frequencies in the range of 10^{12} Hz to 10^{16} Hz?
(a) Optical communication (b) Analog communication
(c) Digital communication (d) None of these

52. A communication between a fixed base station and several mobile units, located on ships or aircraft utilising two way radio communication in the VHF and UHF is of frequency band
(a) 3 to 30 MHz (b) 30 to 300 MHz
(c) 30 to 470 MHz (d) 30 to 600 MHz

53. Optical fibre communication is generally preferred over general communication system because
(a) it is more efficient
(b) it has signal security
(c) it cannot be jammed as easily as radio waves
(d) All of the above

Topic 3
Propagation of Electromagnetic Waves

54. As the electromagnetic waves travel away from the transmitter, the strength of the wave keeps on
(a) increasing
(b) decreasing
(c) Either increasing or decreasing
(d) Both (a) and (b)

55. Which size of the antenna should have comparable to the wavelength λ of the signal, to radiate signals with high frequency?
(a) Atleast ~ $\lambda/2$ (b) Atleast ~ $\lambda/4$
(c) At maximum ~ $\lambda/2$ (d) At maximum ~ $\lambda/4$

56. A ground receiver in line-of-sight communication cannot receive direct waves due to
(a) its low frequency (b) curvature of earth
(c) its high intensity (d) smaller antenna

57. Sky wave is used by
(a) long wave broadcast services
(b) short wave broadcast services
(c) Both (a) and (b)
(d) middle wave broadcast services

58. The ionosphere is acting as reflector due to
(a) Presence of a short number of ions
(b) Presence of a large number of ions or charged particles
(c) Presence of neither short nor large number of ions
(d) Both (a) and (b)

59. From which height does the ionosphere extends above the earth's surface?
(a) 65 to 75 km (b) 170 to 190 km
(c) ~ 65 km to 400 km (d) ~ 65 to ~ 75 km

60. Ionisation occurs due to
(a) absorption of the gamma rays
(b) absorption of the infrared rays
(c) absorption of the X-rays
(d) absorption of the ultraviolet rays

61. The degree of ionisation depends on
(a) height (b) intensity
(c) thickness (d) All of these

62. Which of the following is the correct statement?
(a) Electromagnetic wave of frequencies higher than 30 MHz penetrates the ionosphere and escape
(b) Electromagnetic wave of frequencies higher than 30 kHz, penetrates the ionosphere and escape
(c) Electromagnetic wave of frequencies lower than 30 MHz penetrates the ionosphere and escape
(d) Electromagnetic wave of frequencies lower than 30 kHz penetrates the ionosphere and escape

63. Radio waves are propagated through
(a) ground wave (b) sky wave
(c) space wave (d) All of these

64. Which of the following statements is incorrect?
(a) Ground wave propagation can be sustained at frequencies 500 kHz to 1500 kHz
(b) Satellite communication is useful for the frequencies above 30 MHz
(c) Sky wave propagation is useful in the 50 to 80 MHz
(d) Space wave propagation takes place through tropospheric space
(e) The phenomenon involved in sky wave propagation is total internal reflection

65. The part of the ionosphere which exists during day and night time is
(a) D-layer (b) E-layer
(c) F_1-layer (d) F_2-layer

66. On which path, a space wave travels from transmitting antenna to the receiving antenna?
(a) Parabola (b) Straight line
(c) Circular path (d) Rectangular path

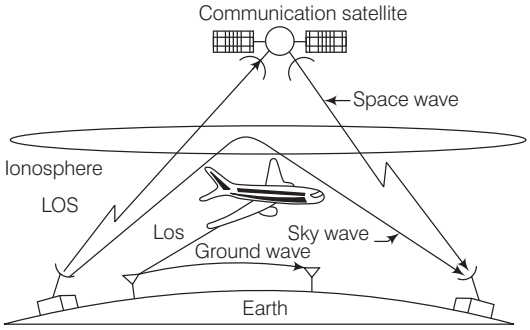
67. Space waves are used for
(a) Line-of-Sight (LOS) communication
(b) satellite communication
(c) Both (a) and (b)
(d) None of the above

68. Line-of-Sight (LOS) communication is only possible when the frequency is
(a) above 40 MHz (b) above 40 kHz
(c) equal to 40 MHz (d) below 40 MHz

69. Where the receiving antenna must be stand so that the signal is to be received beyond the horizon?
(a) At lowest (b) At highest possible
(c) In the middle (d) Neither low or high

70. Which of the following are the examples of communication system using space wave mode of propagation?
(a) Telephonic communication, microwave links and television broadcast
(b) Telephonic communication, satellite communication, and microwave links
(c) Radio broadcast, television broadcast and telephonic communication
(d) Microwave link, satellite communication and television broadcast

71. What does the given figure depict?



(a) various propagation modes for electromagnetic waves
(b) various propagation modes for magnetic waves
(c) sight communication by space waves
(d) sky wave propagation

72. A transmitting antenna at the top of tower has a height 32 m and the height of the receiving antenna is 50 m. What is the maximum distance between them for satisfactory communication is LOS mode? (given, radius of earth $= 6.4 \times 10^6$ m)
(a) 45.5 km (b) 4.55 m
(c) 45.5 m (d) 45.5 cm

73. Frequencies in the UHF range, normally propagate by means of
(a) ground waves (b) sky waves
(c) surface waves (d) space waves

74. A radar has a power of 1 kW and is operating at a frequency of 10 GHz. It is located on a mountain top of height 500 m. The maximum distance upto which it can detect object located on the surface of the earth (Radius of earth $= 6.4 \times 10^6$ m) is **[AIEEE 2012]**
(a) 80 km (b) 16 km
(c) 40 km (d) 64 km

75. The highest frequency of radio waves which when sent at some angle towards the ionosphere, gets reflected from that and returns to the Earth is called
(a) critical frequency (b) maximum usable frequency
(c) polarisation of waves (d) None of the above

76. Through which mode of propagation, the radio waves can be sent from one place to another
(a) ground wave propagation
(b) sky wave propagation
(c) space wave propagation
(d) All of the above

77. A transmitting antenna of height 20 m and the receiving antenna of height h are separated by a distance of 40 km for satisfactory communication in line of sight mode. Then, the value of h is (Given radius of the earth is 6400 km)
(a) 40 m (b) 45 m (c) 30 m (d) 25 m

78. What should be the height of a transmitting antenna, if the TV telecast is to cover a radius of 128 km?
(a) 1280 m (b) 1280 km (c) 1540 m (d) 1140 km

79. The maximum distance upto which TV transmission from a TV tower of height h can be received is proportional to
(a) $h^{1/2}$ (b) h (c) $h^{3/2}$ (d) h^2

80. A TV transmission tower antenna is at a height of 20 m. The percentage increase in area covered in case if the receiving antenna is at ground level to that at a height of 25 m is (Radius of earth $= 6.4 \times 10^6$ m)
(a) 248% (b) 348.9% (c) 150% (d) 360.2%

81. 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 LOS mode?
(a) 46.5 km (b) 45.5 km (c) 42.75 km (d) 35.77 km

82. The area of the region covered by the TV broadcast by a TV tower of 100 m height is (radius of the earth $= 6.4 \times 10^6$ m)
(a) 12.8×10^8 km^2 (b) $1.28\pi \times 10^3$ km^2
(c) $0.64\pi \times 10^3$ km^2 (d) $1.28\pi \times 10^4$ km^2

83. For transmitting a signal, we need an
(a) signal (b) modulation
(c) receiver (d) antenna or aerial

84. Antenna should have a size comparable to the
(a) bandwidth of the signal
(b) baseband of the signal
(c) wavelength of baseband
(d) wavelength of the signal

85. For an electromagnetic wave of frequency 20 kHz, the wavelength λ is that
(a) 20 km (b) 20 m (c) 15 km (d) 15 m

86. To transmit a signal of 3 kHz frequency, the minimum length of antenna is …… km.
(a) 20 (b) 25 (c) 50 (d) 75

87. What should be the length of the dipole antenna for a carrier wave of frequency 3×10^8 Hz?
(a) 1 m (b) 1 cm (c) 0.5 m (d) 5 cm

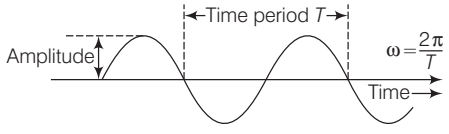
88. A theoretical study of radiation from a linear antenna (length l) shows that the power radiated is
(a) proportional to $(\lambda / l)^2$
(b) inversely proportional to $(l/\lambda)^2$
(c) proportional to $(l/\lambda)^2$
(d) inversely proportional to $(l/\lambda)^2$

89. For a good transmission, we need
(a) high power
(b) low power
(c) never low power
(d) neither low power nor high power

90. The fundamental radio antenna is a metal rod which has a length equal to
(a) λ in free space at the frequency of operation
(b) $\lambda/2$ in free space at the frequency of operation
(c) $\lambda/4$ in free space at the frequency of operation
(d) $3\lambda/4$ in free space at the frequency of operation

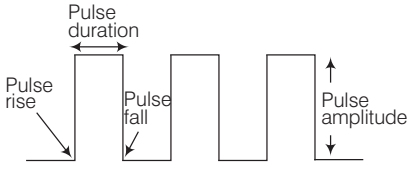
Topic 4
Modulation

91. A figure shows the nature of wave is



(a) pulse (b) sinusoidal
(c) Both (a) and (b) (d) None of these

92. A figure shows the nature of wave is



(a) sinusoidal (b) pulses
(c) Both (a) and (b) (d) None of these

93. A process which attaches information to the carrier wave, known as
(a) modulation (b) demodulation
(c) amplification (d) transmission

94. During the process of modulation, any of the three parameters, *viz.*, A_c, ω_c and ϕ, of the carrier wave can be controlled by
(a) baseband
(b) bandwidth
(c) message or information signal
(d) Both (a) and (b)

95. Choose the correct statements. **[JEE Main 2016]**
(a) In amplitude modulation, the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.
(b) In amplitude modulation, the frequency of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.
(c) In frequency modulation, the amplitude of the high frequency carrier wave is made to vary in proportion to the frequency of the audio signal.
(d) In frequency modulation, the amplitude of the high frequency carrier wave is made to vary in proportion to the frequency of the audio signal.

96. The significant characteristics of a pulse are
(a) pulse amplitude, pulse duration, pulse receiver
(b) pulse amplitude, pulse repeater, pulse width
(c) pulse amplitude, pulse duration or pulse width, pulse repeater
(d) pulse amplitude, pulse duration or pulse width, pulse position

97. Various types of pulse modulation are
(a) pulse amplitude modulation, pulse position modulation, pulse frequency modulation
(b) pulse frequency modulation, pulse phase modulation, pulse position modulation
(c) pulse amplitude modulation, pulse phase modulation, pulse position modulation
(d) pulse amplitude modulation, pulse duration or pulse width modulation, pulse position modulation

98. In an amplitude modulation with modulation index 0.5, the ratio of the amplitude of the carrier wave to that of the sideband in the modulated wave is
(a) 4 : 1 (b) 1 : 4
(c) 1 : 2 (d) 2 : 1

99. The modulation techniques used for transforming digital data into analog signals are
(a) only Amplitude Shift Keying (ASK)
(b) only Frequency Shift Keying (FSK)
(c) only Phase Shift Keying (PSR)
(d) All of the above

100. In amplitude modulation, the amplitude of the carrier is varied in accordance with the
(a) message signal (b) baseband
(c) bandwidth (d) information signal

101. To avoid distortion modulation index μ is kept.
(a) < 1 (b) > 1 (c) $= 1$ (d) ≤ 1

102. Using trigonometric relation $\sin A \sin B = 1/2\,[\cos(A-B)] - \cos(A+B)$, we can write $c_m(t) = A_c \sin \omega_c t + \mu A_c \sin \omega_m t \sin \omega_c t$ as follows
(a) $c_m(t) = A_c \sin \omega_m t + \frac{\mu A_c}{2} \cos(\omega_c - \omega_m) t - \frac{\mu A_c}{2} \cos(\omega_c + \omega_m) t$
(b) $c_m(t) = A_c \sin \omega_c t + \frac{\mu A_m}{2} \cos(\omega_c - \omega_m) t - \frac{\mu A_m}{2} \cos(\omega_c + \omega_m) t$
(c) $c_m(t) = A_c \sin \omega_c t + \frac{\mu A_c}{2} \cos(\omega_c - \omega_m) t - \frac{\mu A_c}{2} \cos(\omega_c + \omega_m) t$
(d) $c_m(t) = A_c \sin \omega_c t + \frac{\mu A_c}{2} \cos(\omega_c + \omega_m) t - \frac{\mu A_c}{2} (\omega_c - \omega_m) t$

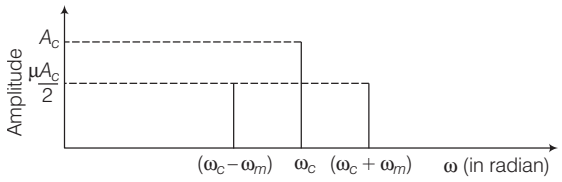
103. A signal of 5 kHz frequency is amplitude modulated on a carrier wave of frequency 2MHz. The frequencies of the resultant signal is/are
(a) 2 MHz only **[JEE Main 2015]**
(b) 2005 kHz and 1995 kHz
(c) 2005 kHz, 2000 kHz and 1995 kHz
(d) 2000 kHz and 1995 kHz

104. A signal wave of frequency 12 kHz is modulated with a carrier wave of frequency 2.51 MHz. The upper and lower sideband of frequencies are respectively,
(a) 2512 kHz and 2508 kHz (b) 2522 kHz and 2488 kHz
(c) 2502 kHz and 2498 kHz (d) 2522 kHz and 2498 kHz

105. As carrier wave,
$c_m(t) = A_c \sin \omega_c t + \frac{\mu A_c}{2} \cos(\omega_c - \omega_m) t - \mu A_c/2 \cos(\omega_c + \omega_m) t$
In the given equation, $(\omega_c - \omega_m)$ and $(\omega_c + \omega_m)$ are
(a) upper side frequency, lower side frequency
(b) lower side frequency, lower side frequency
(c) upper side frequency, lower side frequency
(d) lower side frequency, upper side frequency

106. The modulated signal consists of the carrier wave of frequency ω_c plus two sinusoidal waves each with a frequency slightly different, known as
(a) sidebands (b) baseband
(c) width band (d) All of these

107.



Which one of the following graphs is shown in figure?

(a) Modulation of carrier wave
(b) Modulation of sky wave
(c) Frequency spectrum of the amplitude modulated signal
(d) Pulse modulation of carrier wave

108. A message signal of frequency 10 kHz and peak voltage of 10 V is used to modulate a carrier of frequency 1 MHz and peak voltage of 20 V. Determine the modulation index.

(a) 0.5 (b) 0.2 (c) 2 (d) 5

109. In the above question, sidebands produced are

(a) 1010 kHz and 990 kHz (b) 1010 MHz and 990 MHz
(c) 1010 Hz and 990 Hz (d) 1010 THz and 990 THz

110. A sinusoidal carrier voltage of amplitude 100 V is amplitude modulated by a sinusoidal voltage to give as amplitude modulation wave to minimum voltage amplitude of 70 V. Find the modulation index.

(a) 0.03 (b) 30 (c) 0.3 (d) 0.003

111. A carrier wave of peak voltage 10 V is used to transmit a message signal. What would be the peak voltage of the modulating signal in order to have a modulation index of 50%?

(a) 5 V (b) 3 V (c) 9 V (d) 10 V

112. If the minimum voltage in an AM wave was found to be 2V and maximum voltage 10 V. Find per cent modulation index.

(a) 80% (b) 66.67% (c) 64.25% (d) 76.25%

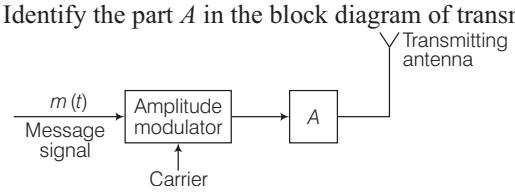
113. A carrier is simultaneously modulated by two sine waves having modulation index of 0.3 and 0.4. The total modulation index will be

(a) 0.1 (b) 0.5 (c) 0.7 (d) 0.35

114. The modulator is to be followed by a

(a) baseband (b) bandwidth
(c) signal (d) power amplifier

115. Identify the part *A* in the block diagram of transmitter.

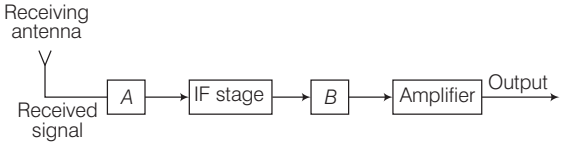


(a) square law device (b) band pass filter centred
(c) power amplifier (d) modulating signal

116. In the communication system, AM is used for broadcasting because

(a) it avoids receiver complexity
(b) it is more noise immune than other modulation system
(c) it requires less transmitting power
(d) no other modulation system can give the necessary bandwidth for faithful transmission

117. Identify the parts *A* and *B* of a diagram of a receiver.

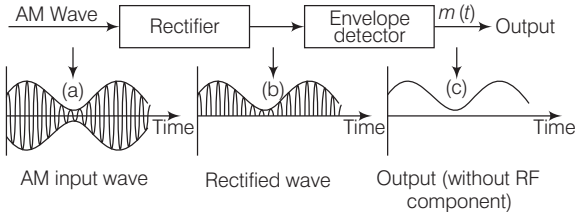


(a) detector, amplifier
(b) signal, carrier wave
(c) amplifier, detector
(d) carrier wave, signal

118. Which of the following is the process of recovering the modulating signal from the modulated carrier wave?

(a) Amplification
(b) Detection
(c) Rectifier
(d) Demodulation

119. The method shown in the block diagram is used to obtain.



(a) the original message signal $m(t)$ of angular frequency ω_m
(b) the original information signal $c(t)$ of a simpler modular
(c) an AM signal
(d) modulation of carrier wave

120. In a modulated signal, an envelope of rectified wave is

(a) message signal
(b) informal signal
(c) Both (a) and (b)
(d) None of these

121. In order to retrieve $m(t)$, the signal is passed through

(a) rectifier
(b) amplifier
(c) envelope detector
(d) Both (a) and (c)

Special Format Questions

I. Assertion and Reason

■ **Directions** (Q. Nos. 122-125) *In the following questions, a statement of assertion is followed by a corresponding statement of reason. Of the following statements, choose the correct one.*

(a) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.
(c) Assertion is correct but Reason is incorrect.
(d) Assertion is incorrect but Reason is correct.

122. Assertion Digital signals are preferred over analog signals for transmission of information.
Reason Analog signals require amplification and correction at suitable intervals.

123. Assertion In real life, an approximate bandwidth of 20 kHz is required to transmit the music.
Reason High frequencies are produced by the musical instruments.

124. Assertion A TV signal requires the bandwidth of 76-88 MHz for transmission.
Reason A TV signal contains both voice and picture.

125. Assertion Antenna should have a size comparable to the wavelength of the signal (atleast $\lambda/4$ in dimension).
Reason The antenna properly senses the time variation of the signal.

II. Statement Based Questions

126. Digital signals
I. do not provide a continuous set of a values.
II. represent values as discrete values.
III. can utilise binary system and.
IV. can utilise decimal as well as binary systems.
Which of the above statements are correct?
(a) I and II (b) II and III
(c) I, II and III (d) All of these

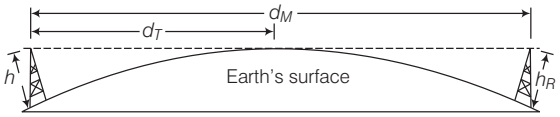
127. Read the following statements and select the correct option from the options given below.
I. To reproduce the rectangular wave shape exactly we need to superimpose all the harmonics $v_0, 2v_0, 3v_0, 4v_0 \cdots$, which implies an infinite bandwidth.
II. For practical purposes, the contribution from higher harmonics cannot be neglected, thus limiting the bandwidth.
III. Received waves are distorted version of the transmitted one.
(a) I and III (b) I and II (c) Only III (d) All of these

128. Which of the following statement(s) is/are correct?
I. Similar to message signals, different types of transmission media offer different bandwidths.
II. The commonly used transmission media are wire, free space and optical fibre.
III. Coaxial cable is widely used wire media, which offers a bandwidth of approximately 750 MHz.
(a) I and II (b) II and III
(c) I, II and III (d) Only I

129. Which of the following statement(s) is/are correct?
I. The frequency used in satellite communication lies between 5MHz and 1MHz.
II. The uplink and downlink frequencies are different.
III. The orbit of geostationary satellite lies in the equatorial plane at inclination of 0°.
(a) I and II (b) I and III
(c) II and III (d) I, II and III

130. Which of the following statement(s) is/are correct regarding ground wave propagation?
I. A wave induces current in the ground over which it passes and surrounding particle.
II. It is attenuated as a result of absorption of energy by the Earth and surrounding particle.
III. The attenuation of surface waves decreases very rapidly with increase in frequency.
IV. The maximum range of coverage depends on the transmitted power and frequency (less than a few MHz).
(a) I and II (b) I and III
(c) I, II and IV (d) All of these

131. Consider the following figure



Line of sight communication by space waver

Which statement of the following is/are correct?
I. Because of line of sight nature of propagation, direct waves get blocked at some point by the curvature of the Earth.
II. Because of sky wave nature of propagation, direct waves get blocked at some point by the curvature of the Earth.
III. Because of surface wave nature of propagation, direct waves not blocked at some point by the curvature of the Earth.
(a) Only I (b) II and III (c) I and III (d) I and II

132. High frequency carrier waves are needed for effective transmission of signals.

I. To reduce the length (l) of the transmitting antenna as $l = \lambda/4$.

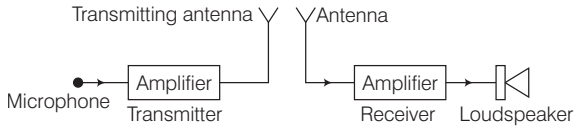
II. To increase the power (P) radiated by the antenna (as $P \propto 1/\lambda^2$) so as to increase the range of transmission.

III. To transmit a large number of signals simultaneously.

(a) I and II (b) Only I

(c) I and III (d) All of these

133. A schematic arrangement for transmitting a message signal (20 Hz to 20 kHz) is given in figure



Which of the following statement(s) is/are correct?

I. The message signal is in the AM range and cannot be transmitted beyond some distances as it possess small energy.

II. An Amplitude Modulation (AM) signal does not possess enough energy to travel an appreciable distance from the antenna.

III. The heights of the antennas required are so large that is impossible to build them.

(a) Only I

(b) I and II

(c) I and III

(d) All of the above

III. Matching Type

134. Match the following Column I with names given in Column II and choose the correct option from the codes given below.

	Column I		Column II
A.	0	1.	Binary coded decimal.
B.	Combinations of number system.	2.	High level of voltage/current.
C.	Universally popular digital code.	3.	Low level of voltage/ current.
D.	'1'	4.	(ASCII) American Standard Code for Information Interchange.

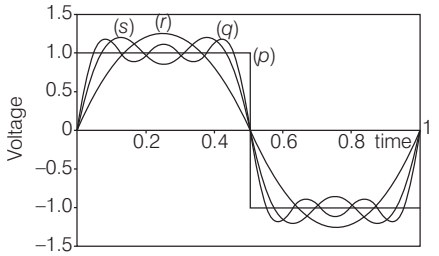
	A	B	C	D		A	B	C	D
(a)	3	2	1	4	(b)	3	1	4	2
(c)	4	1	3	2	(d)	2	4	1	3

135. Match the following Column I with names given in Column II and choose the correct option from the codes given below. **[HOTS]**

	Column I		Column II
A.	Speech signals	1.	Bandwidth of 20 kHZ
B.	Speech signals for commercial telephonic communication	2.	Frequencies extends from 20 Hz to 20 kHz
C.	Music transmission	3.	Frequency range 300 Hz to 3100 Hz.
D.	Audible range of frequencies	4.	6 MHz of bandwidth
E.	Video signals for transmission of picture	5.	Bandwidth of 2800 Hz (3100 Hz - 300 Hz)
F.	TV signal	6.	4.2 MHz of bandwidth

	A	B	C	D	E	F
(a)	6	4	3	2	1	5
(b)	5	3	2	1	4	6
(c)	3	5	1	2	6	4
(d)	4	2	1	6	5	3

136. Consider the following figure.



Match the following columns.

	Column I		Column II
A.	(p)	1.	Fundamental wave (ν_0)
B.	(q)	2.	Fundamental (ν_0) + second harmonics ($2\nu_0$) + third harmonics ($3\nu_0$)
C.	(r)	3.	Rectangular wave
D.	(s)	4.	Fundamental wave (ν_0) + second harmonics ($2\nu_0$)

	A	B	C	D
(a)	2	4	3	1
(b)	1	3	4	2
(c)	3	2	1	4
(d)	4	1	2	3

137. Match the following Column I with names given in Column II and choose the correct option from the codes given below.

	Column I		Column II
A.	Standard AM broadcast	1.	54 - 72 MHz
B.	FM broadcast	2.	5.925 - 6.425 GHz
C.	Satellite communication (uplink)	3.	540 - 1600 kHz
D.	Television (VHF)	4.	88 - 108 MHz

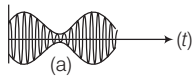
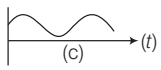
	A	B	C	D		A	B	C	D
(a)	4	2	3	1	(b)	2	1	4	3
(c)	1	3	4	2	(d)	3	4	2	1

138. Match the following Column I with names given in Column II and choose the correct option from the codes given below.

	Column I		Column II
A.	F_2 (Thermosphere) 300 km at night, 250-400 km during day time.	1.	Partially absorbs HF waves yet allowing them to reach F_2.
B.	E (part of stratosphere) (100 km).	2.	Efficiently reflects HF waves, particularly at night.
C.	F_1 (Part of mesosphere) 170 – 190 km.	3.	VHF (upto several GHz)
D.	D (Part of stratosphere) (65-75 km).	4.	Helps surface waves, reflects HF.
E.	Troposphere (10 km).	5.	Reflects LF, absorbs MF and HF to some degree.

	A	B	C	D	E		A	B	C	D	E
(a)	2	4	1	5	3	(b)	1	4	5	2	3
(c)	4	2	5	3	1	(d)	5	1	4	3	2

139. Match the following Column I with names given in Column II and choose the correct option from the codes given below.

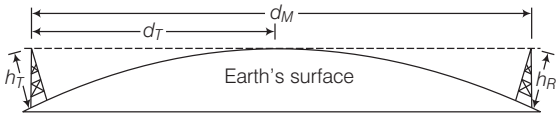
Column I	Column II
A. 	1. Output
B. 	2. AM input wave
C. 	3. Rectified wave

	A	B	C		A	B	C
(a)	3	2	1	(b)	2	3	1
(c)	2	1	3	(d)	1	3	2

IV. Passage Based Questions

■ **Directions** (Q. Nos. 140-142) *These questions are based on the following situation. Choose the correct options from those given below.*

Space waves are used for line-of-sight (LOS) communication as well as satellite communication. Because of line-of-sight nature of propagation, direct waves gets blocked at some point by the curvature of the earth as illustrated in figure. If the signal is to be received beyond the horizon then the receiving antenna must be high enough to intercept the line-of-sight waves.



140. If the transmitting antenna is at a height h_T, the distance to the horizon d_T is given as

(a) $d_T = \sqrt{2hR_T}$ (b) $d_T = \sqrt{2Rh_T}$

(c) $d_T = 2Rh_T$ (d) $d_T = 2Rh_T\left(1+\frac{hr}{2R}\right)$

141. In the above question, d_T is also called the radio

(a) horizon of the transmitting antenna
(b) horizon of the transmitter
(c) horizon of the modulation
(d) horizon of the signal

142. The maximum line of sight distance d_M between the two antennas having heights h_T and h_R above the Earth is

(a) $d_M = 1+\sqrt{2Rh_T}$ (b) $d_M = 1+\sqrt{2Rh_R}$

(c) $d_M = \sqrt{2Rh_T}+\sqrt{2Rh_R}$ (d) $d_M = 2Rh_T\,(1+\sqrt{2Rh_R})$

■ **Directions** (Q. Nos. 143-145) *These questions are based on the following situation. Choose the correct options from those given below.*

The modulated signal $c_m(t)$ can be written as

$$c_m(t) = (A_c + A_m \sin\omega_m t)\sin\omega_c t$$
$$= A_c\left(1+\frac{A_m}{A_c}\sin\omega_m t\right)\sin\omega_c t \quad \ldots(i)$$

Here, $\mu = \frac{A_m}{A_c}$ is the modulation index; in practice μ is kept ≤ 1 to avoid distortion.

Now, $c_m(t) = A_c \sin\omega_c t + \frac{\mu A_c}{2}\cos(\omega_c - \omega_m)t$
$$- \frac{\mu A_c}{2}\cos(\omega_c + \omega_m)t \quad \ldots(ii)$$

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

143. An amplitude modulation wave is represented as $c_m(t) = 10(1 + 0.4 \sin 3140\, t) \sin(2.2 \times 10^6\ t)$ V. The minimum and maximum voltage applied amplitude of the wave are
(a) 10 V, 2 V (b) 8 V, 10 V
(c) 14 V, 6 V (d) 8 V, 14 V

144. The frequency components contained in the wave are
(a) 350 kHz, 349.5 kHz, 350.5 kHz
(b) 350 MHz, 349.5 MHz, 350.5 MHz
(c) 250 kHz, 249.5 kHz, 250.5 kHz
(d) 250 MHz, 249.5 MHz, 250.5 MHz

145. Amplitudes of frequency components are
(a) 10 V, 6 V, 8 V (b) 10 V, 2 V and 2 V
(c) 8 V, 4 V and 2 V (d) 8 V, 6 V, 2 V

V. More than One Option Correct

146. A TV transmission tower has a height of 240 m. Signals broadcast from this tower will be received by LOS communication at a distance of (assume the radius of earth is to be 6.4×10^6 m)
(a) 100 km (b) 24 km (c) 55 km (d) 50 km

147. An audio signal of 15 kHz frequency cannot be transmitted over long distances without modulation, because
(a) the size of the required antenna would be atleast 5 km which is not convenient
(b) the audio signal cannot be transmitted through sky waves.
(c) the size of the required antenna would be 5m
(d) effective power transmitted would be very low, if the size of the antenna is less than 5 km

148. Audio sine waves of 3 kHz frequency are used to amplitude modulate a carrier signal of 1.5 MHz. Which of the following statements are true?
(a) The sideband frequencies are 1506 kHz and 1494 kHz.
(b) The bandwidth required for amplitude modulation is 6 kHz.
(c) The bandwidth required for amplitude modulation is 3 MHz.
(d) The sideband frequencies are 1503 kHz and 1497 kHz.

149. In amplitude modulation, the modulation index m, is kept less than or equal to 1 because
(a) $m > 1$, will result in interference between carrier frequency and message frequency, resulting into distortion
(b) $m > 1$, will result in overlapping of both sidebands resulting into loss of information
(c) $m > 1$, will result in change in phase between carrier signal and message signal
(d) $m > 1$, indicate amplitude of message signal greater than amplitude of carrier signal resulting into distortion

NCERT & NCERT Exemplar Questions

NCERT

150. Frequencies in the UHF range normally propagate by means of
(a) ground waves (b) sky waves
(c) surface waves (d) space waves

151. Is it necessary for a transmitting antenna to be at the same height as that of the receiving antenna for line of sight communication? A TV transmitting antenna is 81 m tall. How much service area can it cover, it the receiving antenna is at the ground level?
(a) 3258.5 km^2 (b) 2200.5 km^2
(c) 4512 km^2 (d) 1212 km^2

152. 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 0 V?
(a) 3/2, 1.5 (b) 2/3, 1 (c) 2/3, 0.5 (d) 3/2, 1.33

NCERT Exemplar

153. Three waves such as *A, B* and *C* of frequencies 1600 kHz, 5 MHz and 60 MHz, respectively are to be transmitted from one place to another. Which of the following is the most appropriate mode of communication?
(a) *A* is transmitted *via* space wave while *B* and *C* are transmitted *via* sky wave
(b) *A* is transmitted *via* ground wave, *B* is sky wave and *C* is space wave
(c) *B* and *C* are transmitted *via* ground wave while *A* is transmitted *via* sky wave
(d) *B* is transmitted *via* ground wave while *A* and *C* are transmitted *via* space wave

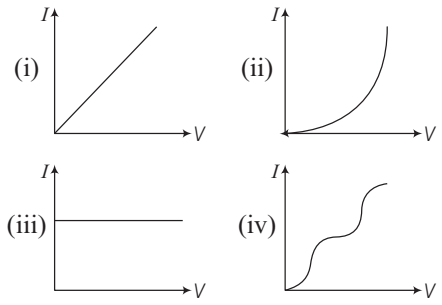
154. A 100 m long antenna is mounted on a 500 m tall building. The building can become a transmission tower for waves with λ is
(a) ~400 m (b) ~25 m
(c) ~150 m (d) ~2400 m

155. A 1 kW signal is transmitted using a communication channel which provides attenuation at the rate of −2 dB per km. If the communication channel has a total length of 5 km, the power of signal received is
(a) 900 W (b) 100 W (c) 990 W (d) 1010 W

156. A speech signal of 3 kHz is used to modulate a carrier signal of frequency 1 MHz using amplitude modulation. The frequencies of the sidebands will be
(a) 1.003 MHz and 0.997 MHz
(b) 3001 kHz and 2997 kHz
(c) 1003 kHz and 1000 kHz
(d) 1 MHz and 0.997 MHz

157. A message signal of frequency ω_m is superposed on a carrier wave of frequency ω_c to get an Amplitude Modulated (AM) wave. The frequency of the AM will be
(a) ω_m (b) ω_c (c) $\frac{\omega_c + \omega_m}{2}$ (d) $\frac{\omega_c - \omega_m}{2}$

158. *I-V* characteristics of four devices are shown in figure



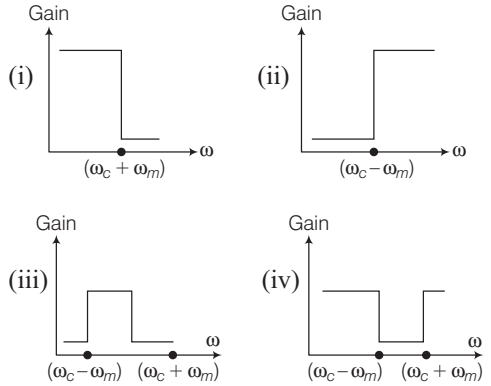
Identify devices that can be used for modulation.
(a) (i) and (iii) (b) Only (iii)
(c) (ii) and some regions of (iv) (d) All devices can be used

159. A basic communication system consists of
(A) transmitter (B) information source
(C) user of information (D) channel
(E) receiver
Choose the correct sequence in which these are arranged in basic communication system.
(a) ABCDE (b) BADEC
(c) BDACE (d) BEADC

160. Which of the following would produce analog signals?
(a) A vibrating tuning fork (b) Light pulse
(c) Output of NAND gate (d) All of the above

161. Which of the following would produce digit signals?
(a) Musical sound
(b) A vibrating tuning fork
(c) Sound and picture signals in TV
(d) Light pulse

162. The frequency response curve for the filter circuit used for production of AM wave should be



(a) (i) followed by (ii) (b) (ii) followed by (i)
(c) (iii) (d) (iv)

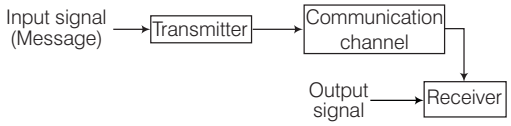
163. Would sky waves be suitable for transmission of TV signals of 60 MHz frequency?
(a) Yes (b) No
(c) May be (d) Never yes

Answers

1.	(c)	2.	(c)	3.	(d)	4.	(b)	5.	(d)	6.	(b)	7.	(c)	8.	(c)	9.	(c)	10.	(c)	11.	(a)	12.	(c)	13.	(b)	14.	(a)	15.	(b)
16.	(d)	17.	(a)	18.	(d)	19.	(b)	20.	(a)	21.	(d)	22.	(b)	23.	(d)	24	(c)	25.	(c)	26.	(a)	27.	(c)	28.	(a)	29.	(b)	30.	(d)
31.	(b)	32.	(c)	33.	(d)	34.	(b)	35.	(c)	36.	(c)	37.	(a)	38.	(d)	39.	(d)	40.	(b)	41.	(a)	42.	(b)	43.	(a)	44.	(a)	45.	(c)
46.	(a)	47.	(b)	48.	(a)	49.	(d)	50.	(a)	51.	(a)	52.	(c)	53.	(d)	54.	(b)	55.	(b)	56.	(b)	57.	(b)	58.	(b)	59.	(c)	60.	(d)
61.	(a)	62.	(a)	63.	(d)	64.	(c)	65.	(d)	66.	(b)	67.	(c)	68.	(a)	69.	(b)	70.	(d)	71.	(a)	72.	(a)	73.	(d)	74.	(a)	75.	(b)
76.	(d)	77.	(b)	78.	(a)	79.	(a)	80.	(b)	81.	(a)	82.	(b)	83.	(d)	84.	(d)	85.	(c)	86.	(b)	87.	(c)	88.	(c)	89.	(a)	90.	(c)
91.	(b)	92.	(b)	93.	(a)	94.	(c)	95.	(b)	96.	(d)	97.	(d)	98.	(a)	99.	(d)	100.	(d)	101.	(d)	102.	(c)	103.	(c)	104.	(d)	105.	(d)
106.	(a)	107.	(c)	108.	(a)	109.	(a)	110.	(c)	111.	(a)	112.	(b)	113.	(b)	114.	(d)	115.	(c)	116.	(a)	117.	(c)	118.	(b)	119.	(a)	120.	(a)
121.	(c)	122.	(b)	123.	(a)	124.	(a)	125.	(a)	126.	(c)	127.	(a)	128.	(c)	129.	(c)	130.	(c)	131.	(a)	132.	(d)	133.	(c)	134.	(b)	135.	(c)
136.	(c)	137.	(d)	138.	(a)	139.	(b)	140.	(b)	141.	(a)	142.	(c)	143.	(c)	144.	(a)	145.	(b)	146.	(b,c, d)	147.	(a,b, d)	148.	(b, d)	149.	(b, d)	150.	(d)

Hints *and* Explanations

1. (*c*) A modern communication system acts as a messenger. It sends as a input signal in the form of message through communication channel to receive an output signal at the end of receiver.



2. (*c*) Languages and methods used in communication have kept evolving from prehistoric to modern times, to meet the growing demands in terms of speed and complexity of information such as videophones, voicemail and satellite conferences.

7. (*c*) A receiver reconstructs a recognisable form of the original message signal for delivering it to the user's information.

8. (*c*) In a point to point communication mode, communication takes place over a link between a transmitter and a receiver.It is also known as peer-to-peer communication.

10. (*c*) The transmission media can be both, guided as well as unguided. In guided medium, signal is guided along a solid medium such as transmission line, while in unguided medium, signal is transmitted and received by wireless medium.

11. (*a*) A guided medium can provide point to point communication.

13. (*b*) ARPANET was a project undertaken by the US department of defence.

14. (*a*) ARPANET allowed file transfer from one computer to another connected to the network by using File Transfer Protocol (FTP).

15. (*b*) Fibre optical systems are superior and more economical as compared to traditional communication systems because it is used to transmit more information and is immune to electromagnetic interference.

16. (*d*) The modern communication system is based on electrical, electronic or optical signals. For example, a microphone converts speech signal into electrical signals.

17. (*a*) The fax or facsimile telegraphy is the electronic transmission and reproduction of a document at a distinct place. It is the most popular example of a digital communication system.

19. (*b*) A transducer is a device that converts a signal in one form of energy to another form of energy. So, amplifier is not a transducer.

20. (*a*) An electrical transducer may be defined as a device that converts some physical variable/pressure, displacement, force, temperature, etc) into corresponding variations in the electrical signal at its output.

21. (*d*) For efficient transmission, size of antenna = $\lambda/4$

25. (*c*) Digital signals are those which cannot take only discrete stepwise values.

26. (*a*) Fading in the signal received is due to interference of waves or attenuation which decreases in strength of a signal.

29. (*b*) The energy needed for additional signal strength is obtained from a DC power source in order to amplify the amplitude of a signal.

35. (*c*) Rectangular wave can be decomposed into a superposition of sinusoidal waves of frequencies $\nu_0, 2\nu_0, 3\nu_0, 4\nu_0, \cdots, n\nu_0$, where n is an integer extends to infinity.

36. (*c*) The information is not lost and the rectangular signal is more or less recovered.This is so because the higher the harmonic less is its contribution to the waveform.

37. (*a*) High frequency carrier wave provides a larger bandwidth for higher date rate transmission from sender to receiver or *vice-versa*.

40. (*b*) No signal, in general, is a single frequency sinosoid, but it spreads over a range of frequencies called the signal bandwidth.

41. (*a*) A range of frequencies between two bands, *i.e.,* upper and lower limit is called the signal bandwidth.

47. (*b*) Optical communication using fibres is performed in the frequency range of 1 THz to 1000 THz (microwaves to ultraviolet).It lies in extremely-high-frequency band (EHF).

52. (*c*) A communication link between a fixed base station and mobile units on a ship or aircraft works on 30 to 470 MHz.

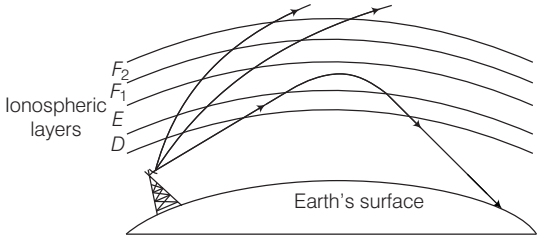
55. (*b*) To radiate signals with high efficiency, the antennas should have a size comparable to the wavelength λ of the signal (atleast $\sim \lambda/4$). So, lesser the wavelength, the higher will be frequency of a signal.

56. (*b*) A ground receiver in line-of-sight communication cannot receive direct waves due to curvature of earth.

60. (*d*) Ionisation occurs due to the absorption of ultraviolet and very high energy radiation coming from the sun by air molecules.

61. (*a*) The degree of ionisation varies with the height.So,the density of atmosphere decreases with height.

62. (*a*) Electromagnetic waves of frequencies higher than 30 MHz penetrate the ionosphere and escape. These phenomena are shown in the figure.



63. (*d*) Radio waves are propagated through ground, sky and space waves. It has frequency from 300 Hz to as low as 3 kHz and corresponding wavelength ranging from 1 mm to 100 km.

64. (*c*) Sky wave propagation is possible for the radio waves of frequency range from 3 MHz to 30 MHz and not in the range 50-80 MHz.

66. (*b*) A space wave travels in a straight line from transmitting antenna to the receiving antenna because its frequency is below 2 MHz. So, it cannot travel over the horizon or behind obstacles.

69. (*b*) If the signal is to be received beyond the horizon, then the receiving antenna must be high enough to intercept the line of sight waves.

72. (*a*) The maximum Line of Sight (LoS) distance d_M between the two antennas having heights h_T and h_R is

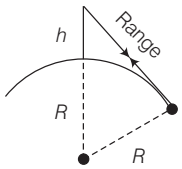
$$d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

$$d = \sqrt{2\times 64\times 10^5\times 32} + \sqrt{2\times 64\times 10^5\times 50}\ \text{m}$$

$$= 64\times 10^2\times\sqrt{10} + 8\times 10^3\times\sqrt{10}\ \text{m}$$

$$= 144\times 10^2\times\sqrt{10}\ \text{m} = 45.5\ \text{km}$$

74. (*a*) Range of radar on earth's surface (optical distance, for space wave, *i.e.,* line of view).



$$\text{Range} = \sqrt{(R+h)^2 - R^2} = \sqrt{2Rh + h^2}$$

$$\simeq \sqrt{2Rh} = \sqrt{2\times 6400\times\frac{1}{2}}\ \text{km} = 80\ \text{km}$$

75. (*b*) The highest frequency of radio waves that can be reflected by the ionosphere is called maximum usable frequency (MUF), so $\text{MUF} = \dfrac{\text{Critical frequency}}{\cos\theta}$.

77. (*b*) $d_M = \sqrt{2Rh_R} + \sqrt{2Rh_T}$

where, h_R and h_T are the heights of receiving and transmitting antenna and R is the radius of the earth.

$$40\times 10^3 = \sqrt{2\times 6400\times 10^3\times h} + \sqrt{2\times 6400\times 10^3\times 20}$$

$$40\times 10^3 = \sqrt{2\times 6400\times 10^3\times h} + 16\times 10^3$$

$$h = \frac{[(40-16)\times 10^3]^2}{2\times 6.4\times 10^6} = 45\ \text{m}$$

78. (*a*) Here, height of a transmitting antenna, *i.e.,* d_T =128 km = r radius of Earth, *i.e.,* R = 6400km

$\therefore$ Height of a transmitting antenna, $d_T = \sqrt{2Rh_T}$

$$h_T = \frac{d_T^2}{2R} = \frac{(128\ \text{km})^2}{2\times 6400\ \text{km}} = 1.28\ \text{km} = 1280\ \text{m}$$

79. (*a*) As maximum distance on Earth from transmitter upto which a signal can be received is $d_T = \sqrt{2Rh}$, $d_T \propto h^{1/2}$ where, R is radius of Earth and is constant.

80. (*b*) Here, $h_T = 20$ m, $R = 6.4\times 10^6$ m $= 64\times 10^5$ m

If the receiving antenna is at ground level,

Range, $d = \sqrt{2h_TR}$

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

$$= 16\times 10^3\ \text{m} = 16\ \text{km}$$

Area covered, $A = \pi d^2 = \dfrac{22}{7}\times(16)^2 = 804.6\ \text{km}^2$

If the receiving antenna at a height of 25 m, then

Range, $d_1 = \sqrt{2h_TR} + \sqrt{2h_RR}$

$$= \sqrt{2\times 20\times(64\times 10^5)} + \sqrt{2\times 25\times 64\times 10^5}$$

$$= 16\times 10^3 + 17.9\times 10^3$$

$$= 33.9\times 10^3\ \text{m} = 33.9\ \text{km}$$

Area covered, $A_1 = \pi d_1^2 = \dfrac{22}{7}\times(33.9)^2 = 3611.8\ \text{km}^2$

Percentage increase in area $= \dfrac{A_1 - A}{A}\times 100$

$$= \left(\frac{3611.8 - 804.6}{804.6}\right)\times 100 = 348.9\%$$

81. (*a*) Given, $h_T = 36$ m

$h_R = 49$ m

$R = 6400$ km

Maximum distance between transmitting and receiving antenna,

i.e., $d_M = d_T + d_R = \sqrt{2Rh_T} + \sqrt{2Rh_R}$

$$= \sqrt{2(6400)(36\times 10^{-3})} + \sqrt{2(6400)(49\times 10^{-3}\ \text{km})}$$

$$= 21.5 + 25 = 46.5\ \text{km}$$

82. (*b*) Area of broadcast, $A = \pi d^2 = \pi(2hR)$

Given, $h = 100$ m and $R = 6.4\times 10^6$ m

$\Rightarrow$ $A = \pi(2\times 100\times 6.4\times 10^6)$

$$= 1.28\pi\times 10^3\ \text{km}^2$$

85. (*c*) Frequency, *i.e.,* $\nu = 20$ kHz $= 20\times 10^3$ Hz

Speed of light, *i.e.,* $c = 3\times 10^8$ ms^{-1}

So, $\nu = \dfrac{c}{\lambda}$

Wavelength, *i.e.,* $\lambda = \dfrac{c}{\nu} = \dfrac{3\times 10^8}{2\times 10^4} = 1.5\times 10^4\ \text{m} = 15\ \text{km}$

($\because$ 1km = 1000 m)

For an electromagnetic wave of frequency 20 kHz, the wavelength λ is 15 km.Obviously, such a long antenna is not possible to construct and operate.

87. (*c*) Wavelength of an antenna, $\lambda = \frac{c}{v} = \frac{3 \times 10^8 \text{ ms}^{-1}}{3 \times 10^8 \text{ Hz}} = 1\text{m}$

Length of the dipole antenna $= \lambda / 2 = \frac{1}{2} = 0.5$ m

89. (*a*) For good transmission, we need high powers and hence this also points out to the need of using high frequency transmission.

90. (*b*) The fundamental radio antenna is a metal rod which has a length equal to $\lambda / 2$ in free space at the frequency of operation.

95. (*b*) As, we know, an amplitude modulated wave, the bandwidth is twice the frequency of modulating signal. Therefore, amplitude modulation (AM), the frequency of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.

98. (*a*) Here, modulation index, $\mu = 0.5$

Amplitude of the carrier wave $= A_c$

Amplitude of the sideband $= \mu \frac{A_c}{2}$

Ratio $= \frac{2}{\mu} = \frac{2}{0.5} = \frac{4}{1}$

102. (*c*) Using the trigonometric relation $\sin A \sin B = 1/2$ $[\cos (A - B) - \cos (A + B)]$, we can write $c_m (t)$ of equation $c_m (t) = A_c \sin \omega_c t + \mu A_c \sin \omega_m t \sin \omega_c t$ as

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

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

103. (*c*) Frequency associated with AM are $f_c - f_m, f_c, f_c + f_m$

Thus, frequency of the resultant signal is/are carrier frequency $f_c = 2000$ kHz, LSB frequency $f_c - f_m = 2000$ kHz – 5kHz = 1995 kHz and USB frequency $f_c + f_m = 2005$ kHz

104. (*d*) Here, $\nu_s = 12$kHz

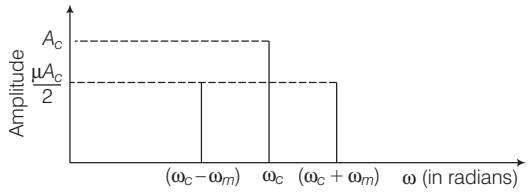
$\nu_c = 2.51$ MHz $= 2510$ kHz

Upper side band frequency $= 2510 + 12 = 2522$ kHz

Lower side band frequency $= 2510 - 12 = 2498$kHz

106. (*a*) The modulated signal consists of the carrier wave of frequency ω_c plus two sinusoidal waves each with a frequency slightly different known as sidebands.

107. (*c*) The frequency spectrum of the amplitude modulated signal is shown in figure.



108. (*a*) Here, $A_m = 10$ V, $A_c = 20$ V

As we know modulation index,

$$(\mu) = A_m / A_c = 10 / 20 = 0.5$$

109. (*a*) The sidebands of a modulated message signal is $\omega_c - \omega_m$ and $\omega_c + \omega_m$ are $(1000 + 10) = 1010$ kHz andd $(1000 - 10$ kHz$) = 990$ kHz

110. (*c*) Here, $A_c = 100$ V, M_2 (minimum voltage amplitude of AM wave) $= 70$ V

Since, $M_2 = A_c (1 - \mu)$

So, modulation index

i.e., $\mu = 1 - \frac{M_2}{A_c} = 1 - \frac{70 \text{ V}}{100 \text{ V}} = 1 - 0.7 = 0.3$

111. (*a*) Given, $A_c = 10$ V, $\mu = 50\% = \frac{50}{100} = \frac{1}{2}$

As modulating index

$$\mu = \frac{A_m}{A_c}, A_m = \mu A_c = \frac{1}{2} (10\text{V}) = 5 \text{ V}$$

112. (*b*) Modulation index,

$$\mu = \frac{E_{\max} - E_{\min}}{E_{\max} + E_{\min}} = \frac{10 - 2}{10 + 2} = \frac{2}{3} \times 100 = 66.67\%$$

113. (*b*) Here, $m_1 = 0.3$ and $m_2 = 0.4$

Total modulation index *i.e.,*

$$m = \sqrt{m_1^2 + m_2^2} = \sqrt{0.3^2 + 0.4^2} = \sqrt{0.09 + 0.16} = \sqrt{0.25} = 0.5$$

114. (*d*) The modulator is to be followed by a power amplifier which provides the necessary power and the modulated signal is fed to an antenna of appropriate size for radiation.

116. (*a*) In the communication system, AM is used for broadcasting because it avoids receiver complexity level to maintain high strength of a modulating signal.

122. (*b*) Digital signals can be transmitted over long distances without error because of their ability to overcome with noise. Analog signals determine the amplitude and frequency, respectively of the waveform of the voltage current. It pick up unwanted singnals.

123. (*a*) To transmit music, an approximate bandwidth of 20 kHz is required because the high frequencies are produced by the musical instruments.

124. (*a*) A TV signal contains both voice and picture and is usually allocated 6 MHz of bandwidth for transmission.

125. (*a*) For transmitting a signal, aerial or antenna should have a size comparable to the wavelength of the signal atleast $\lambda / 4$ in dimension. So, it properly senses the time variation of the signal.

126. (*c*) Digital signals are the values in the form of 0 or 1. It represents discrete values in the binary bits which are non-continuous set of values.

127. (*a*) To reproduce the rectangular wave shape exactly we need to superimpose all the harmonics $v_0, 2v_0, 3v_0, 4v_0, \cdots$, which implies an infinite bandwidth. However, for practical purposes, the contribution from higher harmonics can be neglected, thus limiting the bandwidth. As a result, received waves are a distorted version of the transmitted one.

129. (*c*) In satellite communication, the frequency used is more than 40 MHz. The uplink and downlink frequencies are different to avoid distortion of signal and the orbit of geostationary satellite lies in the equatorial plane at an inclination of 0°.

131. (*a*) In sky wave propagation, radio wave reaches the receiver after the reflection from ionosphere.

133. (*c*) (i) The message signal is in the AM range and cannot be transmitted beyond some distance as it possesses small energy (due to low frequency).

(ii) The height of the antennas required are so large that it is impossible to build them.

134. (*b*) '0' corresponds to a low level and '1' corresponds to a high level of voltage/current. There are several coding schemes useful for digital communication. They employ suitable combinations of number system such as the Binary Coded Decimal (BCD). American Standard Code for Information Interchange (ASCII) is a universally popular digital code to represent number, letters and certain characters.

135. (*c*) For speech signal, frequency range from 300 Hz to 3100 Hz is considered adequate. Therefore, speech signal requires a bandwidth of 2800 Hz (3100 Hz − 300 Hz) for commercial telephonic communication.

To transmit music, an approximate bandwidth of 20 kHz is required because of the high frequencies produced by the musical instruments.

The audible range of frequencies extends from 20 Hz to 20 kHz.

Video signals for transmission of pictures require about 4.2 MHz of bandwidth. A TV signal contains both voice and picture and is usually allocated 6 MHz of bandwidth for transmission.

142. (*c*) The maximum Line of Sight (LOS) distance d_M between the two antennas having heights h_T and h_R is $d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$, where h_R and h_T is the height of receiving and transmitting antenna.

143. (*c*) Comparing the given equation with

$$c_m(t) = A_c(1 + \mu \sin \omega_m t) \sin \omega_c t$$

Amplitude of carrier wave

i.e., $A_c = 10\text{ V}, \mu = 0.4$

$$\nu_m = \frac{\omega_m}{2\pi} = \frac{3140}{2 \times 3.14} = 0.5\text{ kHz}$$

Frequency of carrier wave,

$$\nu_c = \frac{\omega_c}{2\pi} = \frac{2.2 \times 10^6}{2\pi} = 350\text{ kHz}$$

Minimum amplitude,

$$M_1 = A_c(1 + \mu) = 10(1 + 0.4) = 14\text{ V}$$

Maximum amplitude,

$$M_2 = A_c(1 - \mu) = 10(1 - 0.4) = 6\text{ V}$$

144. (*a*) Frequency components of AM wave are ν_c, $(\nu_c - \nu_m)$ and $(\nu_c + \nu_m)$ *i.e.*, 350 kHz, (350 − 0.5) = 349.5 kHz and (350 + 0.5) = 350.5 kHz.

145. (*b*) Amplitude of the frequency components are

$$A_c, \frac{\mu A_c}{2}, \frac{\mu A_c}{2}, \textit{i.e.}, 10\text{V}, 2\text{V and } 2\text{ V}$$

146. (*b,c,d*) Range, $d_T = \sqrt{2Rh_T}$

Given, height of tower $h = 240$ m

For LOS (Line of Sight) communication.

$$d = \sqrt{2Rh} = \sqrt{2 \times 6.4 \times 10^6 \times 240}$$

$$= 55.4 \times 10^3\text{ m} = 55.4\text{ km}$$

Thus, the range of 55.4 km covers the distance 24 km, 55 km and 50 km.

147. (*a,b,d*) Transmission of a signal depends on three factors. These are size of antenna, medium of transmission and power of transmitted wave.

Given, frequency of the wave to be transmitted is

$$\nu_m = 15\text{ kHz} = 15 \times 10^3\text{ Hz}$$

Wavelength, $\lambda_m = \frac{c}{\nu_m} = \frac{3 \times 10^8}{15 \times 10^3} = \frac{1}{5} \times 10^5\text{ m}$

Size of the antenna required, $l = \frac{\lambda}{4} = \frac{1}{4} \times \left(\frac{1}{5} \times 10^5\right)$

$$= 5 \times 10^3\text{ m} = 5\text{km}$$

The audio signals are of low frequency waves. Thus, they cannot be transmitted through sky waves as they are absorbed by atmosphere.

If the size of the antenna is less than 5 km, the effective power transmission would be very low because $l \to$ high, $\lambda \to$ low, $P \propto \left(\frac{l}{\lambda}\right)^2$

148. (*b, d*) Given, $\omega_m = 3$ kHz

$$\omega_c = 1.5\text{ MHz} = 1500\text{ kHz}$$

Now, sideband frequencies

$$\omega_c \pm \omega_m = (1500 \pm 3)$$

$$= 1503\text{ kHz and } 1497\text{ kHz}$$

Also, bandwidth $= 2\omega_m = 2 \times 3 = 6$ kHz

149. (*b,d*) The modulation index (m) of amplitude modulated wave is

$$m = \frac{\text{amplitude of message signal } (A_m)}{\text{amplitude of carrier signal } (A_c)}$$

If $m > 1$, then $A_m > A_c$.

In this situation, there will be distortion of the resulting signal of amplitude modulated wave.

Maximum modulation frequency (m_f) of A_m wave is

$$m_f = \frac{\Delta\nu_{max}}{\nu_m(\max)}$$

$$= \frac{\text{frequency deviation}}{\text{maximum frequency value of modulating wave}}$$

If $m_f > 1$, then $\Delta\nu_{max} > \nu_m$. It means, there will be overlapping of both sidebands of modulated wave resulting into loss of information.

150. (*d*) Space wave range > 40 MHz

UHF range, $170 - 200$ MHz

151. (*a*) Range, $d = \sqrt{2hR}$

$$\therefore \quad \text{Service area} = \pi \times 2hR = \frac{22}{7} \times 2 \times 81 \times 6.4 \times 10^6$$

$$= 3258.5 \times 10^6 \text{ m}^2 = 3258.5 \text{ km}^2$$

152. (*b*) Given, maximum amplitude $A_{max} = 10$ V

Minimum amplitude, $A_{min} = 2$ V

Let A_c and A_m be the amplitudes of carrier wave and signal wave.

$$\therefore \quad A_{max} = A_c + A_m = 10 \quad \ldots(i)$$

and $$A_{min} = A_c - A_m = 2 \quad \ldots(ii)$$

Adding the Eqs. (i) and (ii), we get

$$2A_c = 12 \quad \text{or} \quad A_c = 6 \text{ V}$$

and $$A_m = 10 - 6 = 4 \text{ V}$$

Modulation index, $\mu = \frac{A_m}{A_c} = \frac{4}{6} = \frac{2}{3}$

When the minimum amplitude is zero, then *i.e.*, $A_{min} = 0$

$$A_c + A_m = 10 \quad \ldots(iii)$$

$$A_c - A_m = 0 \quad \ldots(iv)$$

By solving Eqs. (iii) and (iv), we get

$$2A_c = 10 \quad \text{or} \quad A_c = 5 \quad \text{and} \quad A_m = 5$$

Modulation index, $\mu = \frac{A_m}{A_c} = \frac{5}{5} = 1$

154. (*a*) For given building complex, $l = 100$ m, $\lambda = ?$

As length of the antenna, $l = \lambda/4$

$$\lambda \sim 4l \quad \Rightarrow \quad \lambda = 4 \times 100 = 400 \text{ m}$$

155. (*b*) Here, $P_i = 1$ kW $= 1000$ W, Length of path $= 5$ km, $P_o = ?$

Loss of power at a distance of 5 km $= 2 \times 5 = 10$ dB

As loss in dB $= 10 \log \frac{P_o}{P_i}$

$$\therefore \quad -10 = 10 \log \frac{P_o}{P_i}$$

$$\Rightarrow \quad \log \frac{P_i}{P_o} = 1 = \log 10$$

$$\Rightarrow \quad \frac{P_i}{P_o} = 10$$

$$\Rightarrow \quad P_o = \frac{P_i}{10} = \frac{1000}{10} = 100 \text{ W}$$

156. (*a*) Here, $\nu = 1$ MHz, $\Delta\nu = 3$ kHz $= 0.003$ MHz

Using amplitude modulation, the frequencies of the sideband

$$= (\nu + \Delta\nu) \text{ and } (\nu - \Delta\nu)$$

Upper sideband $= (\nu_c + \nu_m) = 1$ MHz $+ 3$kHz

$$= 1 \text{ MHz} + 0.03 \text{ MHz} = 1.003 \text{ MHz}$$

Lower sideband $= (\nu_c - \nu_m) = 1$ MHz $- 3$ kHz

$$= 1 \text{ MHz} - 0.003 \text{ MHz} = 0.997 \text{ MHz}$$

157. (*b*) The amplitude modulation (AM) carrier signal is given by $c_m(t) = (A_c + A_m \sin \omega_m t) \sin \omega_c t$ frequency is ω_c.

158. (*c*) The device which follows square law is used for modulation purpose. Characteristic shown by (i) and (iii) corresponds to linear devices. Characteristic shown by (ii) and (iv) corresponds to square law.

160. (*a*) A vibrating tuning fork produces analog signals which is a continuous set of values.

162. (*a,b,c*) As bandwidth of AM wave should be $2\omega_m = (\omega_c + \omega_m) - (\omega_c - \omega_m)$. Therefore, it is applicable for cases (i), (ii) and (iii). The case (iv) will reject the required signal for amplitude modulated wave.

163. (*b*) No. sky waves of Very High Frequency (VHF) and above, *i.e.*, above 30 MHz pass through the ionosphere into outer space.