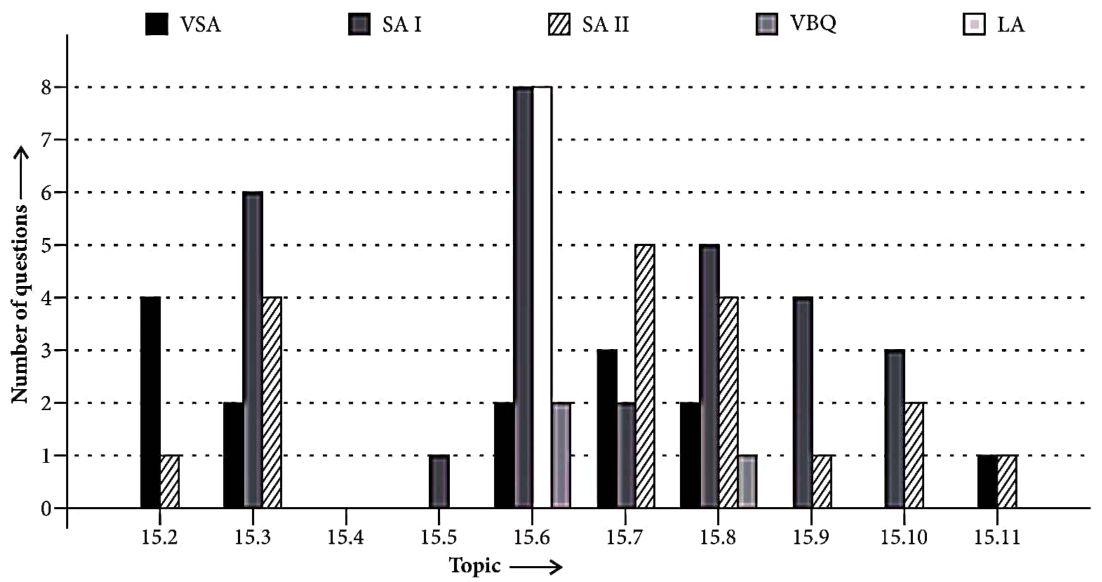
15 Communication Systems

Topicwise Analysis of Last 10 Years' CBSE Board Questions



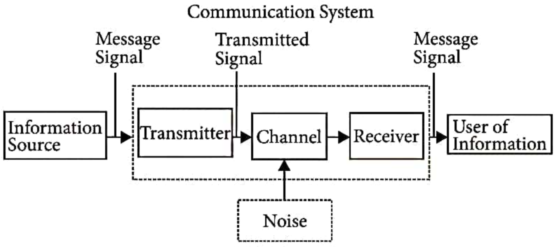
- Maximum weightage is of *Propagation of Electromagnetic Waves.*
- Maximum VSA type questions were asked from *Elements of Communication System.*
- Maximum SA I and SA II type questions were asked from *Propagation of Electromagnetic Waves.*
- No LA type questions were asked till now.

QUICK RECAP

- **Communication :** The process of transmission and reception of information over extented distances.
- **Elements of a communication system**
  A communication system is the set up used in the transmission and reception of information from one place to another.

Every communication system has three essential elements :

- Transmitter
- Medium/channel
- Receiver



Block diagram of a generalised communication system.

- In a communication system, the transmitter is located at one place, the receiver is located at some other place (far or near) separate from the transmitter and the channel is the physical medium that connects them.

  There are two basic modes of communication

  - Point-to-point : In point-to-point communication mode, communication takes place over a link between a single transmitter and a receiver *e.g.* telephony.
  - Broadcast : In the broadcast mode, there are a large number of receivers corresponding to a single transmitter. *e.g.* radio and television.

Terminology used in electronic communication system

- **Transducer :** Any device that converts one form of energy into another is known as transducer.
- **Signal :** Information converted in electrical form and suitable for transmission is known as signal. Signals can be either analog or digital.
- **Noise :** It refers to the unwanted signals that tend to disturb the transmission and processing of message signals in a communication system.
- **Transmitter :** A transmitter processes the incoming message signal so as to make it suitable for transmission through a channel and subsequent reception.
- **Receiver :** A receiver extracts the desired message signals from the received signals at the channel output.
- **Attenuation :** The loss of strength of a signal while propagating through a medium is known as attenuation.
- **Amplification :** It is the process of increasing the strength of a signal using some suitable electronic circuit.
- **Range :** It is the largest distance between a source and a destination up to which the signal is received with sufficient strength.
- **Bandwidth :** It refers to the frequency range over which an equipment operates or the portion of the spectrum occupied by the signal.
- **Modulation :** It is the phenomenon of superimposing the low frequency message signal (called the modulating signal) on a high frequency wave (called the carrier wave).
- **Demodulation :** The process of retrieval of information from the carrier wave at the receiver is known as demodulation. Demodulation is the reverse process of modulation.

  Repeater : A repeater is the combination of a receiver and a transmitter. It increases the strength of the signal to increase the range of communication.

Bandwidth of signals

- For speech signals, frequency range is from 300 Hz to 3100 Hz. Thus bandwidth of speech signals is 2800 Hz (3100 Hz – 300 Hz).
- The audible range of frequencies is from 20 Hz to 20 kHz. As the frequencies produced by musical instruments are high, therefore, approximate bandwidth for music is 20 kHz.
- For transmission of pictures, video signals require a bandwidth of 4.2 MHz.

Bandwidth of transmission medium

- The commonly used transmission media are wire, free space and optical fibre cable.
- Coaxial cable is a widely used wire medium. It offers a bandwidth of approximately 750 MHz. These cables are normally operated below 18 GHz.
- Communication through free space using radio waves takes place over a very wide range of frequencies ranging from a few hundreds of kHz to a few GHz.
- Optical fibre communication is used in the frequency range of 1 THz to 1000 THz (microwaves to ultraviolet). An optical fibre can offer a transmission bandwidth in excess of 100 GHz.

Earth's atmosphere

- The gaseous envelope which surrounds the earth is known as earth's atmosphere.
- The earth atmosphere mainly consists of nitrogen 78%, oxygen 21% along with a little portion of argon, carbon dioxide, water vapour, hydrocarbons, sulphur compounds and dust particles.
- The density of the atmospheric air goes on decreasing as we go up.
  - **Ionosphere** : It extends from 65 km to 400 km. In this region, the temperature rises to some extent with height, hence it is called thermosphere. The ionosphere which is composed of ionised matter (*i.e.*, electrons and positive ions) plays an important role in space communication. The ionosphere is subdivided into four main layers as *D*, *E*, F_1 and F_2 as shown in the table.

Name of the stratum (layer)		Approximate height over earth's surface	Exists during	Frequencies most affected
Troposphere		10 km	Day and night	VHF (up to several GHz)
D (part of Stratosphere)	PARTS OF IONOSPHERE	65-75 km	Day only	Reflects LF, absorbs MF and HF to some degree
E (part of Stratosphere)		100 km	Day only	Helps surface waves, reflects HF
F_1 (part of Mesosphere)		170-190 km	Daytime, merges with F_2 at night	Partially absorbs HF waves yet allowing them to reach F_2
F_2 (Thermosphere)		300 km at night, 250-400 km during daytime	Day and night	Efficiency reflects HF waves, particularly at night

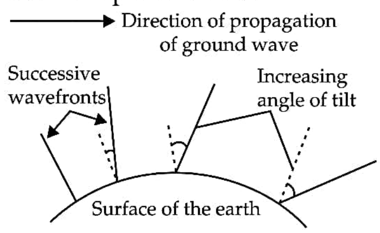
Propagation of electromagnetic waves in the atmosphere

- The radio waves emitted from a transmitter antenna can reach the receiver antenna by any of the following modes of propagation, depending on the factors like, frequency of operation of radio waves, distance between transmitter and receiver antennas etc. These are :
  - Ground wave propagation
  - Sky wave propagation
  - Space wave propagation

Ground wave propagation

Ground wave propagation : When the radio waves from the transmitting antenna propagate along the surface of the earth so as to reach the receiving antenna, the wave propagation is known as ground wave or surface wave propagation.

- The radio waves which progress along the surface of the earth are known as ground waves or surface waves. These waves are vertically polarised in order to prevent short circuiting of the electric component. These

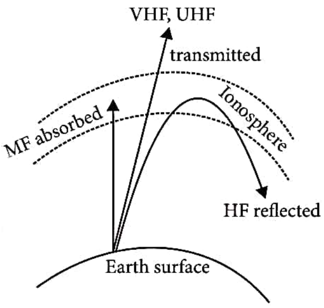


waves induce currents in the ground as they propagate due to which some energy is lost by absorption. Apart from it, as ground wave or surface wave propagates over the surface of earth, the wavefront of the wave gradually tilts over the surface of the earth as shown in the figure and the tilt of the wavefront of the wave increases as the wave propagates over the earth. As a result of which, the strength of the wave decreases with the propagation of wave along the surface of earth. It is due to this tilt that, the propagation of ground wave is limited.

- The ground wave propagation is suitable for low and medium frequency, *i.e.*, up to 2 MHz only, hence it is also known as medium wave propagation. The maximum range of ground or surface wave propagation depends on :
  - Frequency of the radio waves
  - Power of the transmitter

Sky wave propagation : When the radio waves from the transmitting antenna reach the receiving antenna after reflection in the ionosphere, the wave propagation is known as sky wave propagation. The sky wave propagation is also known as ionosphere propagation.

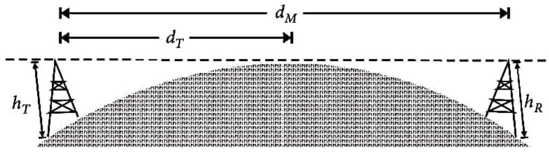
- The sky waves are the radio waves of frequency between 2 MHz to 30 MHz.
- These radio waves can propagate through atmosphere and are reflected back by the ionosphere of earth's atmosphere.



- With the help of sky wave propagation, communication over a very long distance around the globe is possible.
- **Critical frequency :** It is that highest frequency of radio wave, which when sent straight (*i.e.* normally) towards the layer of ionosphere gets reflected from ionosphere and returns to the earth. If the frequency of the radio wave is more than critical frequency, it will not be reflected by ionosphere.
  - The critical frequency of a sky wave for reflection from a layer of atmosphere is given by
    $\upsilon_c = 9(N_{max})^{1/2}$,
    where N_{max} is the maximum electron density of ionosphere (electron/m^3).

Space wave propagation : When the space waves from the transmitting antenna reach the receiving antenna either directly or after reflection from the ground in the earth troposphere's region, the wave propagation is known as space wave propagation. Space wave propagation is also known as tropospherical propagation and line of sight propagation.

- The space waves are the radiowaves of very high frequency (*i.e.*, between 30 MHz to 300 MHz or more).



Line of sight communication by space waves

- The space waves travel in straight line from transmitting antenna to receiving antenna.
- The space waves are used for the line of sight communication as well as for the satellite communication.
- The space wave propagation is used for television broadcast, microwave link and satellite communication.
- If h is the height of the transmitting antenna, then the distance to the horizon is given by
  $d = \sqrt{2hR}$
  where R is the radius of the earth.
  For TV signal, area covered = $\pi d^2 = \pi 2hR$
  Population covered = population density × area covered
- The maximum line of sight distance d_M between two antennas having heights h_T and h_R above the earth is given by
  $d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$
  where h_T is the height of the transmitting antenna and h_R is the height of the receiving antenna and R is the radius of the earth.

Modulation and its necessity

Low frequencies cannot be transmitted to long distances as such. Therefore, they are superimposed on a high frequency carrier signal by a process known as modulation.

- Need for modulation
  - Size of the antenna
  - Effective power radiated by an antenna
  - Mixing up of baseband signals from different transmitters
- **Types of modulation :** In modulation, some characteristic of the carrier signal like amplitude, frequency or phase varies in accordance with the modulating or message signal giving rise to following three types of modulation :
  - Amplitude modulation
  - Frequency modulation
  - Phase modulation
- **Pulse modulation :** The carrier wave is in the form of the pulses. The pulse modulation can be classified as :
  - Pulse amplitude modulation (PAM)
  - Pulse duration modulation (PDM) or pulse width modulation (PWM)
  - Pulse position modulation (PPM).

Amplitude modulation

- In amplitude modulation, the amplitude of carrier wave is varied in accordance with the amplitude of modulating signal.
  - The amplitude modulated signal is represented as

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

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

where

$\omega_c = 2\pi\upsilon_c$ = angular frequency of carrier wave

$\omega_m = 2\pi\upsilon_m$ = angular frequency of modulating signal

A_m, A_c = amplitude of modulating and carrier waves respectively

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

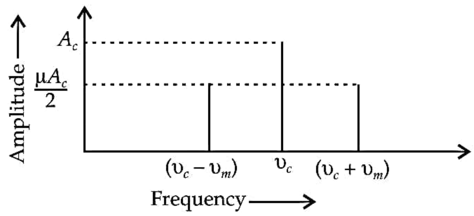
  - The amplitude modulated signal contains three frequencies, viz. υ_c, $\upsilon_c + \upsilon_m$ and $\upsilon_c - \upsilon_m$. The first frequency is the carrier frequency. Thus, the process of modulation does not change the original carrier frequency but produces two new frequencies $(\upsilon_c + \upsilon_m)$ and $(\upsilon_c - \upsilon_m)$ which are known as sideband frequencies.

    $\upsilon_{SB} = \upsilon_c \pm \upsilon_m$ where

    frequency of lower side band $\upsilon_{LSB} = \upsilon_c - \upsilon_m$,

    frequency of upper side band $\upsilon_{USB} = \upsilon_c + \upsilon_m$

- The frequency spectrum of the amplitude modulated signal is shown in the figure.



- Bandwidth of AM signal = $\upsilon_{USB} - \upsilon_{LSB} = 2\upsilon_m$
- Average power per cycle in the carrier wave is

$$P_c = \frac{A_c^2}{2R}$$

where R is the resistance

- Total power per cycle in the modulated wave

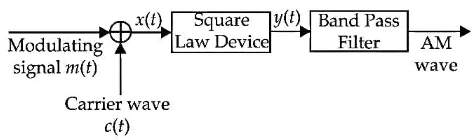
$$P_t = P_c\left(1 + \frac{\mu^2}{2}\right)$$

- If I_t is rms value of total modulated current and I_c is the rms value of unmodulated carrier current, then

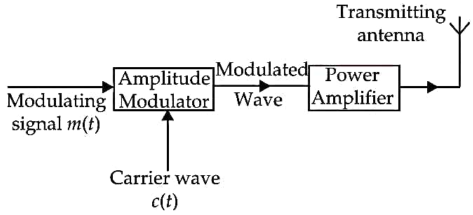
$$\frac{I_t}{I_c} = \sqrt{1 + \frac{\mu^2}{2}}$$

Production of amplitude modulated wave

- Amplitude modulated waves can be produced by application of the message signal and the carrier wave to a non-linear device, followed by a band pass filter.
- The block diagram of a simple modulator for obtaining an AM signal is shown in the figure below.

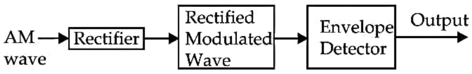


- The amplitude modulated signal so obtained cannot be transmitted as such. It is to be amplified first and then fed to an antenna of appropriate size for radiation. The block diagram of a transmitter is shown in figure below.



Detection of amplitude modulated wave

- The block diagram of a detector for AM signal is shown in the figure below.



- For detection of AM wave, the essential condition is

$$\frac{1}{\upsilon_c} << RC$$

where υ_c is the carrier wave frequency and RC is the time constant of the circuit.

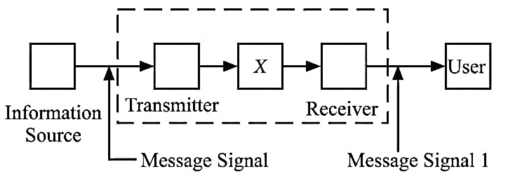
- **The Internet :** It is a system with billions of users worldwide. Its applications include :
  (i) E-mail
  (ii) File transfer
  (iii) World Wide Web (WWW)
  (iv) E-commerce
  (v) Chat
- Modem is a modulator and demodulator.
- FAX or facsimile means exact reproduction of the document like a picture, letter, map etc. at a distant place.
- **Mobile telephony**
  The concept of mobile telephony was developed first in 1970's and it was fully implemented in the following decade. The central concept of this system is to divide the service area into a suitable number of cells centred on an office called MTSO (Mobile Telephone Switching Office). Mobile telephones operate typically in the UHF range of frequencies.
  (about 800-950 MHz).

Previous Years' CBSE Board Questions

15.2 Elements of Communication System

VSA (1 mark)

1. Name the essential components of a communication system. *(AI 2016)*
2. Which basic mode of communication is used for telephonic communication? *(AI 2015)*
3. The figure given below shows the block diagram of a generalized communication system. Identify the element labelled '*X*' and write its function.



(Delhi 2014)

4. Draw a block diagram of a generalized communication system. *(Delhi 2014C)*

SA II (3 marks)

5. Distinguish between point to point and broadcast modes of communication. Give an example of each *(Foreign 2016, Delhi 2015C)*

15.3 Basic Terminology Used in Electronic Communication Systems

VSA (1 mark)

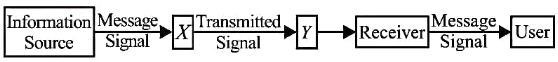
6. Write the function of a transmitter in a communication system. *(Foreign 2013)*
7. What is the function of a repeater used in communication system ? *(Delhi 2012C, Foreign 2011)*

SA I (2 marks)

8. Explain the terms (i) Attenuation and (ii) Demodulation used in communication system. *(Delhi 2016)*
9. A devices *X* used in communication system can convert one form of energy into another. Name the device *X*. Explain the function of a repeater in a communication system. *(Foreign 2016)*
10. Write the functions of the following in communication system.
    (i) Transducer (ii) Repeater *(AI 2014)*
11. Mention the function of any two of the following used in communication system :
    (i) Transducer (ii) Repeater
    (iii) Transmitter (iv) Bandpass filter *(Delhi 2012)*
12. Draw a block diagram showing the important components in a communication system. What is the function of a transducer? *(Foreign 2011)*
13. Explain the function of a repeater in a communication system. *(Delhi 2010)*

SA II (3 marks)

14. Answer the following questions:
    (a) Define bandwidth and describe briefly its importance in communicating signals.
    (b) Distinguish between digital and analogue signals.
    (c) Write the functions of transducer and repeater. *(Foreign 2015)*
15. (a) Given a block diagram of a generalized communication system.



Identify the boxes '*X*' and '*Y*' and write their functions. *(Delhi 2015C)*

16. Write the function of each of the following used in communication system :
    (i) Transducer
    (ii) Repeater
    (iii) Transmitter *(Delhi 2013)*
17. What is a digital signal? Explain the function of modem in data communication. Write two advantages of digital communication. *(Delhi 2007)*

15.5 Bandwidth of Transmission Medium

SA I (2 marks)

18. Name any two types of transmission media that are commonly used for transmission of signals. Write the range of frequencies of signals for which these transmission media are used. *(AI 2010C)*

15.6 Propagation of Electromagnetic Waves

VSA (1 mark)

19. Is it necessary for a transmitting antenna to be at the same height as that of receiving antenna for LOS communication? *(Foreign 2015)*

20. What is sky wave propagation? *(Delhi 2009)*

SA I (2 marks)

21. (i) Which mode of propagation is used by shortwave broadcast services having frequency range from a few MHz upto 30 MHz ? Explain diagrammatically how long distance communication can be achieved by this mode.
(ii) Why is there an upper limit to frequency of waves used in this mode ? *(AI 2016, 2/3, AI 2010)*

22. Explain briefly how ground waves are propagated? Why can't this mode be used for long distance using high frequency? *(AI 2013C)*

23. Which mode of wave propagation is suitable for television broadcast and satellite communication and why? Draw a suitable diagram depicting this mode of propagation of wave. *(AI 2012C)*

24. What is sky wave communication? Why is this mode of propagation restricted to the frequencies only upto few MHz? *(AI 2011)*

25. In standard AM broadcast, what mode of propagation is used for transmitting a signal? Why is this mode of propagation limited to frequencies upto a few MHz? *(Foreign 2010)*

26. By what percentage will the transmission range of a TV tower be affected when the height of the tower is increased by 21%? *(Delhi 2009)*

27. A TV tower has a height of 150 m. By how much the height of tower be increased to double its coverage range? *(Delhi 2009)*

28. 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 maximum distance between them, for satisfactory communication in the LOS mode? (Radius of earth = 6400 km) *(Delhi 2008)*

SA II (3 marks)

29. Describe briefly, by drawing suitable diagrams, the (i) sky wave and (ii) space wave modes of propagation. Mention the frequency range of the waves in these modes of propagation. *(Foreign 2014, AI 2011C)*

30. 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) *(AI 2013)*

31. Name the three different modes of propagation of electromagnetic waves. Explain, using a proper diagram the mode of propagation used in the frequency range from a few MHz to 40 MHz. *(Delhi 2012)*

32. 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. *(AI 2012)*

33. 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 *(Delhi 2011)*

34. (a) Draw a schematic diagram describing the three modes of propagation of electromagnetic wave in the atmosphere. Indicate clearly which one of these (i) achieves long distance communication by ionospheric reflection and

(ii) is used for line of sight (LOS) as well as satellite communication.

(b) Write an expression for the maximum 'line of sight' distance d_M between the two antenna's having heights H_1 and H_2 above the Earth's surface. *(Delhi 2010C)*

35. What is the space wave propagation? Give two example of communication system which use space wave mode.
A TV tower is 80 m tall. Calculate the maximum distance upto which the signal transmitted from the tower can be received. *(Delhi 2010)*

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

VBQ (4 marks)

37. 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 e.m. waves which can be transmitted by an antenna of height 20 m. (Given radius of the earth = 6400 km)
(Delhi 2014)

38. Anuj's mother was having constant headache. After a medical check-up, she was diagnosed with tumour. Anuj realized there was a telecommunication tower very close to their house. He enquired from the doctor if the radiation from the tower could have caused the tumour. As the doctor supported his anxiety, he lodged a compliant with the police and ultimately succeeded in getting the tower removed to a distance place away from the residential colony. Answer the following :
(i) What values were displayed by Anuj?
(ii) Anuj made a rough estimate about the height of the antenna to be about 20 m from the ground. Calculate the maximum distance upto which radiations from the tower are likely to reach. Use the value of radius of the Earth = 6400×10^3 m.
(Delhi 2014C)

15.7 Modulation and its Necessity

VSA (1 mark)

39. Distinguish between amplitude modulation and frequency modulation. *(AI 2015C)*

40. How does the effective power radiated from a linear antenna depend on the wavelength of the signal to be transmitted ?
(Delhi 2014 C)

41. What should be the length of dipole antenna for a carrier wave of frequency 6×10^8 Hz?
(AI 2007)

SA I (2 marks)

42. Write two factors which justify the need of modulating a low frequency signal into high frequencies before transmission.
(AI 2015, 2010)

43. Why are high frequency carrier waves used for transmission? *(Delhi 2009)*

SA II (3 marks)

44. (a) Explain any two factors which justify the need of modulating a low frequency signal.
(b) Write two advantages of frequency modulation over amplitude modulation.
(Delhi 2016)

45. 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. *(Delhi 2013)*

46. Give reasons for the following :
(i) For ground wave transmission, size of antenna (l) should be comparable to wavelength (λ) of signal *i.e.*, $l = \lambda/4$.
(ii) Audio signals, converted into an electromagnetic wave, are not directly transmitted.
(2/3, Foreign 2013, Delhi 2011C)

47. (a) Distinguish between sinusoidal and pulse-shaped signals.
(b) Explain, showing graphically, how a sinusoidal carrier wave is superimposed on a modulating signal to obtain the resultant amplitude modulated (AM) wave. *(AI 2012C)*

48. What is modulation? Explain the need of modulation for a low frequency information signal. With the help of diagrams, differentiate between PAM and PDM. *(AI 2007)*

15.8 Amplitude Modulation

VSA (1 mark)

49. How are side bands produced? *(Delhi 2015)*

50. Why are broadcast frequencies (carrier waves) sufficiently spaced in amplitude modulated wave? *(Foreign 2013)*

SA I (2 marks)

51. (i) Define modulation index.
(ii) Why is it kept low ?
(iii) What is the role of a bandpass filter? *(AI 2016)*

52. A message signal of frequency 10 kHz and peak voltage 10V is used to modulate a carrier of frequency 1 MHz and peak voltage 20 V. Determine.
(i) the modulation index,
(ii) the side bands produced. *(Delhi 2013C)*

53. A carrier wave of peak voltage 12 V is used to transmit a message signal. Calculate the peak voltage of the modulating signal in order to have a modulation index of 75%. *(Delhi 2012C, AI 2010)*

54. (i) Define modulation index.
(ii) Why is the amplitude of modulating signal kept less than the amplitude of carrier wave? *(Delhi 2011)*

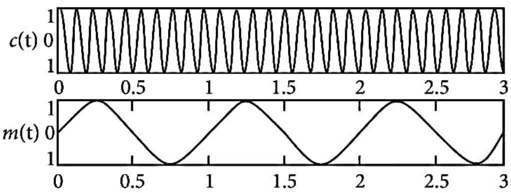
55. For an amplitude modulated wave, the maximum amplitude is found to be 10 V while the minimum amplitude is 2V. Calculate the modulation index, Why is modulation index generally kept less than one? *(Foreign 2011)*

SA II (3 marks)

56. (i) Define modulation index. Why is its value kept, in practice, less than one?
(ii) A carrier wave of frequency 1.5 MHz and amplitude 50 V is modulated by a sinusoidal wave of frequency 10 kHz producing 50% amplitude modulation. Calculate the amplitude of the AM wave and frequencies of the side bands produced. *(AI 2015)*

57. Give reasons for the following :
The amplitude of modulating signal is kept less than that of the carrier wave. *(1/3, Foreign 2013, Delhi 2011C)*

58. State the two main reason explaining the need of modulation for transmission of audio signals.



The diagrams, given above, show a carrier $c(t)$, that is to be (amplitude) modulated by a modulating signal $m(t)$. Draw the general shape of the resulting AM wave. Define its 'modulation index'. *(AI 2010C)*

59. 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. *(Delhi 2008)*

VBQ (4 marks)

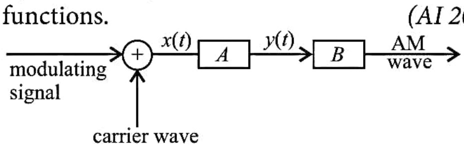
60. Arnab was talking on his mobile to his friend for a long time. After his conversation was over, his sister Anita advised him that if his conversation was of such a long duration, it would be better to talk through a land line.
Answer the following questions :
(a) Why is it considered harmful to use a mobile phone for a long duration?
(b) Which values are reflected in the advice of his sister Anita?
(c) A message signal of frequency 10 kHz is superposed to modulate a carrier wave of frequency 1 MHz. Determine the sidebands produced. *(AI 2014C)*

15.9 Production of Amplitude Modulated Wave

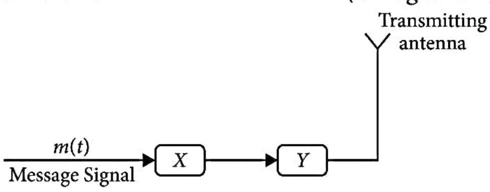
SA I (2 marks)

61. Define the term modulation. Draw a block diagram of a simple modulator for obtaining AM signal. *(Foreign 2014, Delhi 2009)*

62. 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. *(AI 2013)*



63. Figure shows a block diagram of a transmitter. Identify the boxes '*X*' and '*Y*' and write the their functions. *(Foreign 2012)*



64. Draw a block diagram of a simple amplitude modulation. Explain briefly how amplitude modulation is achieved. *(AI 2008)*

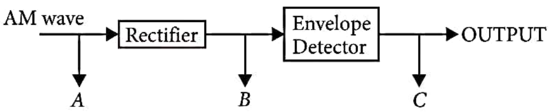
SA II (3 marks)

65. 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. *(AI 2014)*

15.10 Detection of Amplitude Modulated Wave

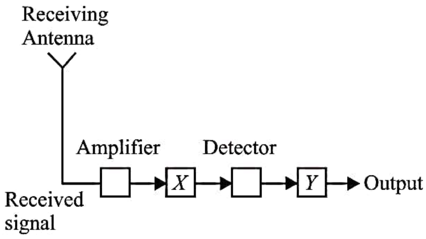
SA I (2 marks)

66. (a) Describe briefly the three factors which justify the need for translating a low frequency signal into high frequency before transmission.
(b) Figure shows a block diagram of a detector for AM signal.

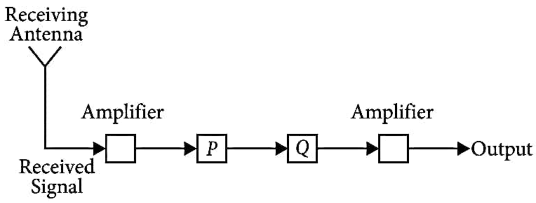


Draw the waveforms for the (i) input AM wave at *A*, (ii) output *B* at the rectifier and (iii) output signal at *C*. *(AI 2013C)*

67. In the given block diagram of a receiver, identify the boxes labelled as *X* and *Y* and write their functions. *(AI 2012, Delhi 2011C)*



68. (a) Identify the boxes, '*P*' and '*Q*' in the block diagram of a receiver shown in the figure.



(b) Write the functions of the block '*P*' and '*Q*'. *(Delhi 2012C)*

SA II (3 marks)

69. What is meant by 'detection of a modulated signal'? Draw block diagram of a detector for AM waves and state briefly, showing the waveforms, how the original message signal is obtained. *(Delhi 2013C)*

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

15.11 Additional Information

VSA (1 mark)

71. Why is the frequency of outgoing and incoming signals different in a mobile phone? *(Delhi 2015C)*

SA II (3 marks)

72. (b) Explain the basic concept of mobile telephony. *(Foreign 2016)*

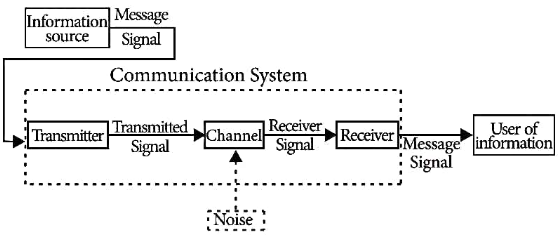
Detailed Solutions

1. Essential components of a communication system are transmitter, transmission medium or communication channel and receiver.

2. Point to point communication mode is used for telephonic communication.

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

4. Block diagram of communication system :



5. Point to point communication : The communication takes place over a link between a single transmitter and receiver is called point to point communication. Telephony is an example of such a system.
Broadcast mode : In such a mode, large number of receivers is linked to a single transmitter. Radio is an example of such a system.

6. It processes the incoming message signal on suitable carrier waves so as to make it suitable for transmission through a channel and subsequent reception.

7. A repeater is a combination of a transmitter and a receiver which picks up signal from the transmitter, amplifies and retransmits it to the receiver.

8. (i) Attenuation : The loss of strength of signal during its propagation through the transmission medium is called attenuation. Repeater is used to compensate the attenuation.
(ii) Demodulation : The process of recovering the original information signal from the modulated wave at the receiver end is called demodulation. It is the reverse process of modulation.

9. *X* is transducer.
Repeater : A repeater accepts the signal from the transmitter, amplifies and retransmits it to the receiver.

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

11. (i) Transducer : *Refer to answer 11(i).*
(ii) Repeater : *Refer to answer 11(ii).*
(iii) Transmitter : *Refer to answer 7.*
(iv) Bandpass filter : It rejects low and high frequencies and allow a band of frequencies to pass through as per the requirement

12. *Refer to answer 4.*
Functions of a transducer is to convert one form of energy into another form.

13. *Refer to answer 8.*

14. (a) Bandwidth is the range of frequency over which an equipment operates or the part of the spectrum occupied by the signal. In the communication system the message signal may be voice, music, pictures or computer data. Each signal has different range of frequency. Hence, it has a different bandwidth. The type of communication for a given signal depends on the band of frequency that is considered essential for the communication.
(b)

	Digital signals		Analogue signals
1.	They are discontinuous function of time or discrete time signals.	1.	They are continuous functions of time.
2.	They use discrete values to represent information. They are represented by square waves.	2.	They use a continuous range of values to represent information. They are represented by sine waves or other continuous graphs.

(c) *Refer to answer 11.*

15. (a) $X \rightarrow$ Transmitter
$Y \rightarrow$ Channel

Functions :

Transmitter : It processes the incoming message/information signals so as to make it suitable for transmission through a channel and subsequent reception.

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

16. (i) *Refer to answer 11(i).*
(ii) *Refer to answer 11(ii).*
(iii) *Refer to answer 7.*

17. Digital signal is an information signal in the from of binary coded pulse.

Function of modem : At the transmitting station modem changes digital output from a computer (or any business machine) to a form (analog signals) which can be easily sent via a communication channel. At the receiving end modem reverses the process.

Advantages of digital communication : (any two)

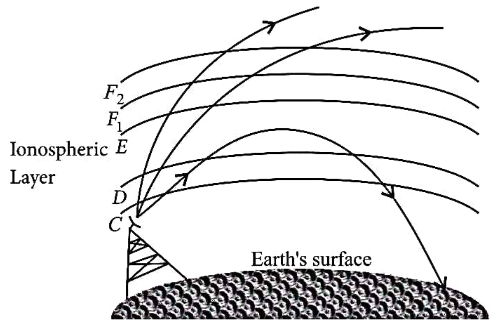
1. Digital communication is more error and noise free communication.
2. Much easier for receiver to detect pulses.
3. Data rate is faster.
4. Large number of signals can be sent through a single channel.

18. The commonly used transmission media are wire, free space and fibre optic cable. Coaxial cable is a widely used wire medium which offers a bandwidth of approximately 750 MHz. Communication through free space using radio waves takes place over a very wide range of frequencies from 540 kHz to 4.2 GHz.

19. No, for the line of sight communication, the two antenna may not be at the same height.

20. When the radiowaves from the transmitting antenna reach the receiving antenna after reflection in the ionosphere, the wave propagation is called sky wave propagation.

21. (i) Sky wave propagation is used by shortwave broadcast services having frequency range from few MHz to 30 MHz.

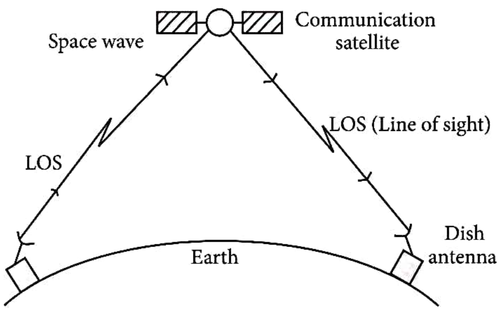


Long distance communication can be achieved by reflection of radio waves by the ionosphere, back towards the Earth. This ionosphere layer acts as a reflector only for a certain range of frequencies (few MHz to 30 MHz).

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

22. Ground waves are radiated by antenna that travel parallel or at lower angles with respect to earth's surface. As ground wave passes over the surface of earth, its energy is absorbed by earth's atmosphere, therefore they die out after travelling a short distance. Hence ground wave propagation can be sustained only at low frequencies 500Hz – 1500 kH. Higher frequencies are highly damped.

23. Space waves mode of propagation is suitable for television broadcast and satellite communication. Space wave provides a Line-of-sight (LOS) communication which is essential for communication at frequency above 40 MHz.



24. Sky wave communication : It is the mode of wave propagation in which the radio wave emitted from the transmitting antenna and reach the receiving antenna after reflection by the ionosphere.

In sky wave propagation, the radio waves of frequency range from generally 1710 kHz to 40 MHz are used. This mode of propagation is used by short wave broadcast service.

The electromagnetic waves of frequencies greater than 40 MHz penetrate the ionosphere and escape.

25. In standard AM broadcast surface wave propagation mode is used for transmitting a signal. Above a frequency of few MHz (1.6 MHz), the electromagnetic waves penetrate the ionosphere and escape.

26. The range of TV transmission is

$d = \sqrt{2hR}$ ...(i)

When height of the tower (h) is increased by 21% then $h_1 = 1.21\ h$

$\therefore\ d_1 = \sqrt{2h_1R}$

$d_1 = \sqrt{2 \times 1.21hR} = 1.1\sqrt{2hR}$

$d_1 = 1.1\ d = 1.10d$

$\therefore$ TV coverage is increased by 10%.

27. The range of TV transmission is

$d = \sqrt{2Rh}$

Since, the height of tower be increased to double. So,

$d_1 = 2d$

$\sqrt{2Rh_1} = 2\sqrt{2Rh}$

$2Rh_1 = 4\ (2Rh)$

$h_1 = 4h$ [$\because h = 150$ m]

$h = 4 \times 150 = 600$ m

$\therefore$ Increase in height of tower = 600 – 150 = 450.

28. Here $h_T = 36$ m, $h_R = 49$ m

and $R = 6400$ km $= 6400000 = 64 \times 10^5$ m

$\therefore$ Maximum line-of-sight (LOS) distance d_M between the two antennae is

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

$d_M = \sqrt{2 \times 64 \times 10^5 \times 36} + \sqrt{2 \times 64 \times 10^5 \times 49}$

$d_M = 8 \times 6 \times 10^2 \times \sqrt{2 \times 10} + 8 \times 7 \times 10^2 \times \sqrt{2 \times 10}$

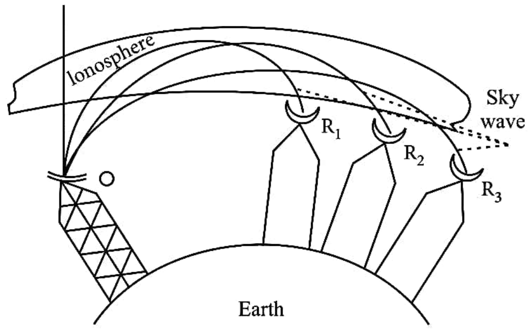
$= 48 \times 10^2 \times \sqrt{20} + 56 \times 10^2 \times \sqrt{20}$

$= 104 \times 10^2 \times \sqrt{20} = 104 \times 10^2 \times 2\sqrt{5}$

$= 208 \times \sqrt{5} \times 10^2$

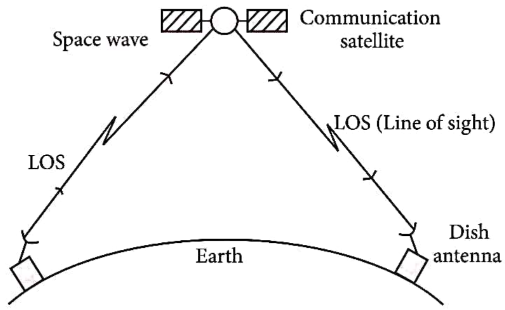
$= 208 \times 2.236 \times 100 = 46.51$ km

29. (i) Sky wave : The radio waves which are reflected back to earth by ionosphere are known as sky waves and mode of propagation of sky waves is known as sky wave propagation. Frequency range of sky wave propagation is from few MHz upto 30 to 40 MHz.



(ii) Space wave : A radiowave that travels directly from a high transmitting antenna to the receiving station is called a space wave.

Space wave communication is used for line of sight as well as satellite communication.



30. Space waves/radio wave/ microwave

Frequency range above 40 MHz

Maximum distance, $d_m = \sqrt{2h_TR} + \sqrt{2h_RR}$

$d_m = \sqrt{2 \times 6400 \times 10^3 \times 45} + \sqrt{2 \times 6400 \times 10^3 \times 20}$

$= (24 + 16) \times 10^3$ m $= 40 \times 10^3$ m

31. Three modes of propagation of electromagnetic waves are :

(i) Ground waves

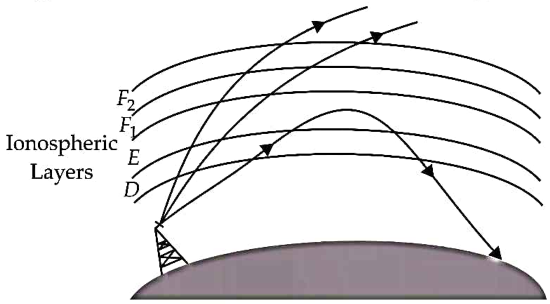
(ii) Sky waves

(iii) Space waves

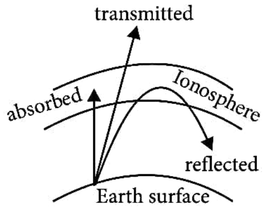
In the frequency range from a few MHz to 40 MHz, the sky wave propagation is used.

In the ionosphere of the earth's atmosphere, there are a large number of ions or charged particles.

It extends from a height of about 65 km to about 400 km above the earth's surface. Ionisation occurs due to the absorption of the ultraviolet and other high-energy radiation coming from the sun by air molecules. The ionosphere is further subdivided into several layers, D, E, F_1 and F_2. The degree of ionisation varies with the height. The density of atmosphere decreases with height. At great heights the solar radiation is intense but there are few molecules to be ionised. Close to the earth, even though the molecular concentration is very high, the radiation intensity is low so that the ionisation is again low. However, at some intermediate heights, there occurs a peak of ionisation density. The ionospheric layer acts as a reflector for a certain range of frequencies (3 to 40 MHz). Electromagnetic waves of frequencies higher than 40 MHz penetrate the ionosphere and escape. These phenomena are shown in the figure.

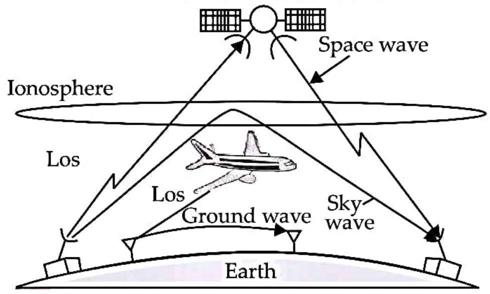


32. (i) Ground wave or surface wave propagation
(ii) Sky wave propagation or ionospheric propagation
(iii) Space wave propagation/Line of sight propagation.
In sky wave propagation, radio waves transmitted by transmitting antenna are directed towards the ionosphere. The radiowaves having frequency range 2 MHz to 30 MHz are reflected back by the ionosphere.



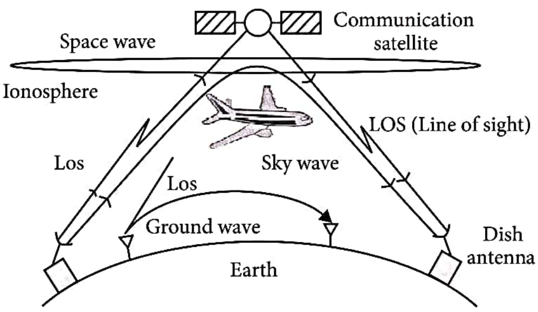
In sky wave propagation, radio signals can be transmitted to the stations which otherwise become inaccessible to the ground due to curvature of earth. Thus due to reflection by ionosphere, radio wave signals can be transmitted virtually from any one place to the other on surface of earth. So it is useful for very long distance radio communication. Thus for long distance radio broadcasts through sky wave propagation, we use short wave bands.

33. The diagram below is showing various propagation modes for em waves.



(i) Standard AM broadcast → 540 kHz to - 1600 KHz.
(ii) Television → 76 - 88 MHz and 420 - 890 MHz
(iii) Satellite communication → 5.925 - 6.425 GHz (Up link)
3.7 - 4.2 GHz (Down link)

34. (a) Various propagation modes of Electromagnetic waves (EMW) is shown below



(i) Sky wave : A radio wave transmitted towards the sky and reflected back by the ionosphere towards the desired location of the earth is called a sky wave. By this mode long distance communication is achieved by ionospheric reflection.

(ii) Space wave : A radiowave that travels directly from a high transmitting antenna to the receiving station is called a space wave.
Space wave communication is used for line of sight as well as satellite communication.
(b) The maximum line-of-sight distance d_M between the two antennas having H_1 and H_2 above the earth is given by

$$d_M = \sqrt{2RH_1} + \sqrt{2RH_2}$$

where R is the radius of the earth.

35. If a radiowave transmitted from an antenna, travelling in a straight line, directly reaches the receiving antenna, it is called a space wave. The space wave propagation is also called line of sight propagation. TV broadcast and satellite communication are examples of communication systems which use space wave mode.

Here $h = 80$ m = 0.080 km, $R = 6400$ km

$\therefore$ Coverage range, $d = \sqrt{2Rh}$

$\therefore \quad d = \sqrt{2 \times 6400 \times 0.080} = \sqrt{6400 \times 0.16}$

= 80 × 0.4 = 32 km

36. LOS means line-of-sight communication. Space waves are used for line of sight (LOS) communication.

If h_T and h_R the heights of transmitting antenna and the receiving antenna respectively, then the maximum line-of sight distance d_M between the two antennas is given by

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

where $R \rightarrow$ radius of the earth.

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

37. (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 increased 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, $R = 6400$ km $= 64 \times 10^5$ m; $h = 20$ m, $d = ?$

Range of the transmitting antenna,

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

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

$$= \sqrt{4 \times 64 \times 10^6}$$

$\Rightarrow \quad d = 16000$ m

38. (i) Concern for others, helpfulness, presence of mind, responsible citizen.

(ii) Given, $h = 20$m, $R = 6400 \times 10^3$m $= 6.4 \times 10^6$m

We know that

$$d = \sqrt{2hR} = \sqrt{2 \times 20 \times 6.4 \times 10^6}$$

$\Rightarrow \quad d = 16$ km

39.

Amplitude modulation	Frequency modulation
The amplitude of carrier wave changes in accordance with the information (signal) wave.	The frequency of carrier wave changes in accordance with the information (signal) wave.

40. The power radiated by a linear antenna of length L is proportional to $(L/\lambda)^2$, where λ is the signal wavelength. Since for efficient transmission, the signal should be transmitted with high power, the signal should be of small wavelength or high frequency.

41. $\lambda = \dfrac{c}{\upsilon} = \dfrac{3 \times 10^8}{6 \times 10^8} = 0.5$ m

Length of dipole antenna, $l = \dfrac{\lambda}{4} = 0.125$ m

42. Need of modulating a low frequency signal :

(i) Low energy : The audio/video signals when converted into em waves do not have sufficient high energy to travel upto long distances, because of their lower frequency. Hence these signals are modulated with high frequency carrier waves, before being sent and are demodulated or separated from the carrier waves at the receiving end.

(ii) Size of antenna : For the effective transmission by an antenna, the size of the antenna should be at least of the size $\lambda/4$, where λ is wavelength of signal to be sent.

43. High frequency carrier waves are used to increase operating range, to reduce antenna length and convert the wide band signal into narrow band signal. Then the signal can be easily recovered and distinguished from other signals at the receiving station.

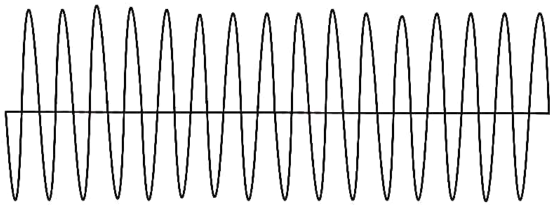
44. (a) *Refer to answer 42.*

(b) Advantages of frequency modulation over amplitude modulation :

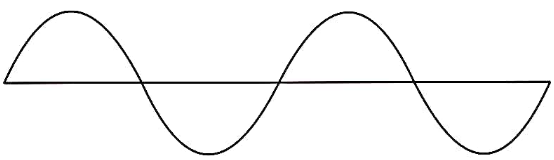
(i) Frequency of a wave does not change while travelling through different media, while amplitude of a wave changes while travelling through different media. An amplitude modulated wave carries information in terms of variation of amplitude, which can get disturbed. This is why FM signal is less susceptible to noise than AM signal.

(ii) In FM transmission, all the transmitted power is useful, whereas in AM transmission most of the power wastes in transmitting carrier wave, with no useful information.

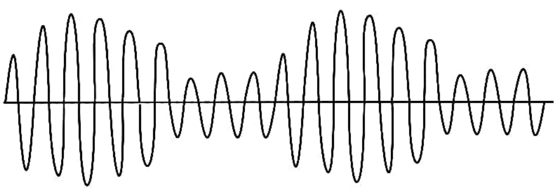
45. Three important factor to justify the need of modulating a message signal
(i) Practical antenna length.
(ii) Effective power radiated by antenna.
(iii) Mixing up of signals from different transmitters.
Amplitude Modulation : When the modulating wave is superimposed on a high frequency carrier wave in a manner that the frequency of a modulated wave is same as that of carrier wave but amplitude of carrier wave is modified in accordance with the modulating wave, the process is called amplitude modulation.



Carrier wave
(a)



Modulating sine-wave signal



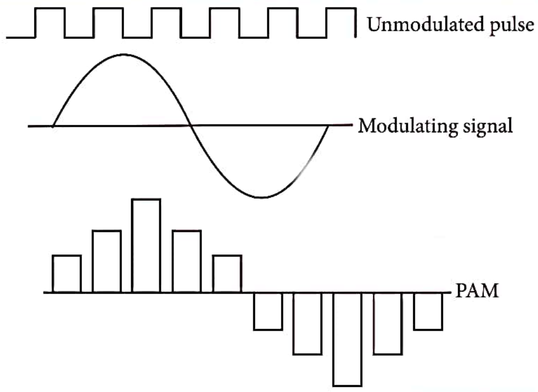
Amplitude-modulated wave

46. (a) When the size of the antenna is comparable to wavelength of the signal, the time variations of the signal are properly sensed by the antenna.
(b) The e.m. wave of audio signal frequency would have a very high wavelength. It would, therefore, need an antenna, whose size would be practically unattainable.

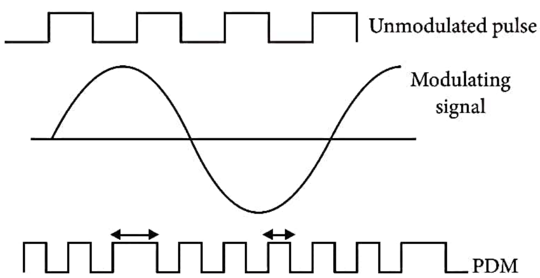
47. (a) A continuous time varying current or voltage signal is called sinusoidal signals.
The signal which have two levels of current or voltage represented by 0 and 1 are called pulse shaped signals.
(b) *Refer to answer 45.*

48. The process of superimposing information signal on a high frequency carrier waves is known as modulation. In modulation some characteristics of the transmitted carrier wave is varied in accordance with the information signal.
Need of modulation : *Refer to answer 42.*

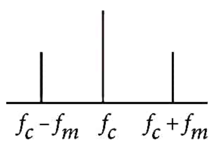
PAM : Amplitudes of the pulse (carrier wave) varies according to modulating signal.



PDM : Pulse duration varies in accordance with the modulating signal.



49. Side bands are produced during the modulation.
When a message signal is superimposed on a carrier wave then there exists the sum and difference of the two frequencies of different waves.



These are called side bands. In amplitude modulation, side bands are :
Lower side band frequency = $f_c - f_m$
Upper side band frequency = $f_c + f_m$

50. To avoid mixing up of signals from different transmitters the broadcast frequencies are sufficiently spaced in amplitude modulated wave. This can be done by modulating the signals on high frequency carrier waves, *e.g.*, frequency band for satellite communication is 5.925 – 6.425 GHz.

51. (i) Modulation index is the ratio of the amplitude of modulating signal to that of carrier wave. It is given by
$\mu = A_m / A_c$
Where A_m is the amplitude of modulated wave A_c is the amplitude of carrier wave.
(ii) It is kept low to avoid distortion.
(iii) Role of a bandpass filter is that it rejects low and high frequencies and allows a band of frequencies to pass through it.

52. (i) Here, $E_m = 10$ V, $E_c = 20$ V
Therefore, modulation index,
$$\mu = \frac{E_m}{E_c} = \frac{10}{20} = 0.5$$
(ii) Here, $f_m = 10$ kHz, $f_c = 1$ MHz = 1,000 kHz
Therefore, side bands are produced at
$f_{min} = f_c - f_m = 1{,}000 - 10$
$f_{min} = 990$ kHz
and $f_{max} = f_c + f_m = 1{,}000 + 10$
$f_{max} = 1{,}010$ kHz.

53. Here, $A_c = 12$ V, $A_m = ?$
Modulation index, $\mu = 75\% = 0.75$
Since $\mu = \frac{A_m}{A_c}$
$\Rightarrow \quad 0.75 = \frac{A_m}{12}$
$A_m = 0.75 \times 12 = 9$ V

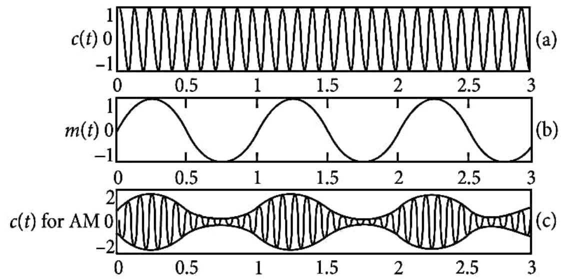
54. (i) *Refer to answer 51(i).*
(ii) *Refer to answer 52.*

55. $A_{max} = 10$ V
$A_{min} = 2$ V
Modulation index
$$\mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} = \frac{10-2}{10+2} = \frac{8}{12} = 0.67$$
Generally, the modulation index is kept less then one to avoid distortion.

56. (i) *Refer to answer 51(i) and (ii).*
(ii) Modulation index, $\mu = \frac{A_m}{A_c}$
It is the ratio of amplitude of base band signal and amplitude of carrier wave.
It is kept less than one to prevent distortion in modulated signal.
Here, $\mu = 0.5 = \frac{A_m}{A_c}$, $A_c = 50$ V
$f_c = 1.5$ MHz $= 1.5 \times 10^6$ Hz, $f_m = 10$ kHz $= 10^4$ Hz
So, amplitude of AM wave
$A_{max} = A_c[1 + \mu] = 50[1 + 0.5] = 75$ V
Frequencies of upper side band $= f_c + f_m$
$= 1.5 \times 10^6 + 10 \times 10^3 = 1510$ kHz
Frequencies of lower side band
$= f_c - f_m = 1.5 \times 10^6 - 10 \times 10^3 = 1490$ kHz

57. *Refer to answer 51(ii).*

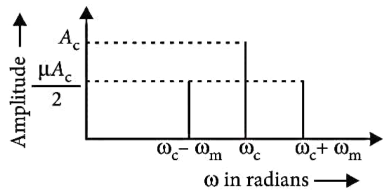
58. The general shape of the resulting AM wave is shown in Fig.



Modulation of a carrier wave : (a) a sinusoidal carrier wave; (b) a modulating signal; (c) amplitude modulation;

Refer to answer 51(i).

59. A plot of amplitude versus ω for an amplitude modulated wave :

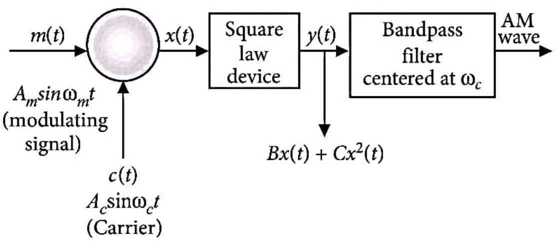


Refer to answer 51(i).

Importance : The amplitude modulation index (μ) determines the quality of the transmitted index. When modulation index is small, variation in carrier amplitude will be small.

60. (a) The radiation emitted by cell phones can damage delicate working of the inner ear. It may cause hearing loss also.
(b) Social responsibility, awareness and concerned to others.
(c) Here, $f_m = 10$ kHz, $f_c = 1$ MHz = 1000 kHz
Therefore, side bands are produced at
$f_{min} = f_c - f_m = 1000 - 10 = 990$ kHz
and $f_{max} = f_c + f_m = 1000 + 10 = 1010$ kHz

61. Modulation is the process in which low frequency massage signal is superimposed on high frequency carrier wave so that they can be transmitted over long distances.



62. 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 with frequencies ω_c, $\omega_c - \omega_m$ and $\omega_c + \omega_m$.

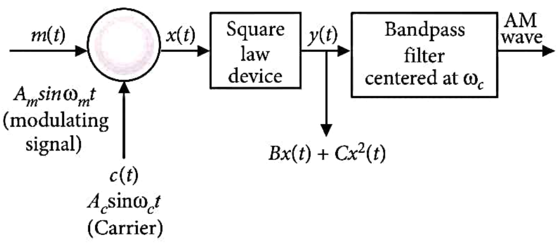
63. $X \rightarrow$ Amplitude modulator

$Y \rightarrow$ Power amplifier

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

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

64. Production of amplitude modulation wave : A conceptually simple method to produce AM wave is shown in the following block diagram.



Here the modulating signal A_m sin $\omega_m t$ is added to the carrier signal A_c sin $\omega_c t$ to produce the signal $x(t)$. This signal $x(t)$ A_m is passed though a square law device which produces an output

$y(t) = Bx(t) + Cx^2(t)$

Where B and C are constants.

This signal is passed though a band pass filter which rejects dc. The output of the band pass filter is therefore, an AM wave.

65. 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 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

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

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

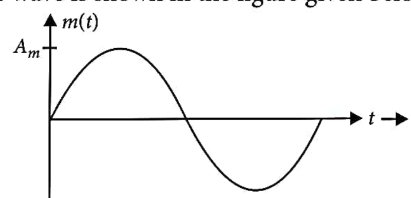
$$\therefore \; c_m(t) = A_c \sin\omega_c t + \mu A_c \sin\omega_m t \sin\omega_c t$$

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

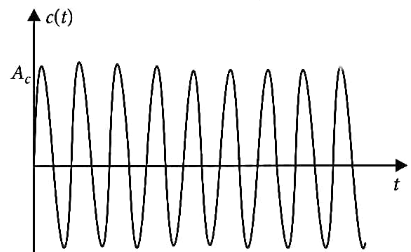
$\omega_c - \omega_m$ and $\omega_c + \omega_m$ are the lower side band and upper side band, respectively.

Production of amplitude modulated wave :

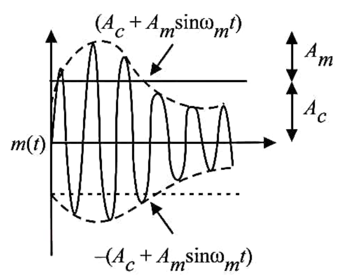
Amplitude modulated signal is obtained by superposing a modulating signal over a sinusoidal carrier wave is shown in the figure given below :



Modulating signal



Carrier wave



Amplitude-modulated wave

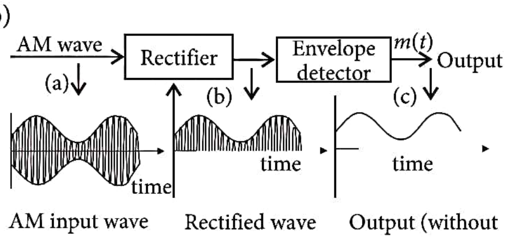
66. (a) The three factors of modulation are

(i) Transmission of audio frequency electrical signals need long impracticable antenna.

(ii) The power radiated at audio frequency is quite small, hence transmission is quite lossy.

(iii) The various information signals transmitted at low frequency get mixed and hence can not be distinguished.

(b)



Block diagram of detector for AM signal.

67. 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.

68. P = Intermediate frequency (IF) stage

Q = Detector

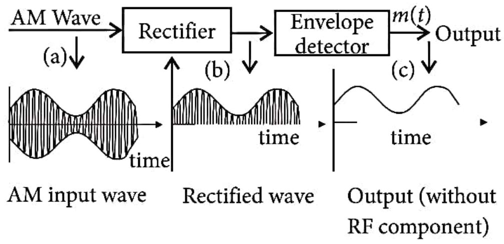
If Stage : IF stage changes the carrier frequency to a lower frequency.

Detector : It detects the envelope of the AM wave because this envelop is the modulating signal containing the information.

69. Detection is the process of recovering the modulating signal from the modulated carrier wave.

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

The original message signal $m(t)$ of angular frequency ω_m can be obtained from AM signal by using a simple method shown in the form of the block diagram.



Block diagram of detector for AM signal.

The modulated signal of the form given in (a) of above figure is passed through a rectifier. The rectifier conducts during the positive half cycles only. Hence, the output signal shown in (b), is still amplitude modulated, but consists of positive half cycles only. In order to retrieve the original message signal $m(t)$, the signal is passed through an envelope detector (which may consist of a simple RC circuit). The output of envelope detector is then the original message signal $m(t)$ as shown in (c) of figure.

70. *Refer to answer 69.*

71. The outgoing and incoming signals have different frequencies which make possible for two persons to talk and listen simultaneously.

72. Mobile telephony is the method of providing telephone services to phones that can be moved around freely and does not require to stay fixed in one location. They use the cellular radio network technology. A radio antenna is installed in every hexagonal cell for receiving and sending radio signals from and to the mobile phones physically present in the cell in a particular area. All cell antennas are connected to each other through a network. When someone dials a mobile number an electromagnetic wave of particular frequency is generated by an electronic oscillator circuit inside the mobile. This wave carries dialled number's information and is transmitted to cell antenna through antenna of the dialled mobile.