Communication is the act of transmission of information. In electronics, the term ‘communication’ refers to sending, receiving and processing of information electronically.

Elements of Communication:

A communication system used electrical, electronic and optical modes for transmission of information from one place to another. It consists of the following three parts:
1. Transmitter
2. Communication channel
3. Receiver

Transmitter
A transmitter transmits the information or message signal after modifying it into a form suitable for transmission.
The message signal for communication can be analog signals or digital signals.
An analog signal is that in which current or voltage value varies continuously with time.
A digital signal is a discontinuous function of time. Such a a signal is usually in the form of pulses.
An analog signal can be converted suitably into a digital signal and viceversa.

Modulation: The message signal cannot travel over long distances. They are superimposed on a high frequency wave known as carrier wave.
The power of modulated signal is boosted using a suitable amplifier.
The amplified signal is radiated into space with the help of transmitting antenna.

Communication channel
The communication channel carries the modulated wave from the transmitting antenna to the receiving antenna.

Receiver
In the wireless (radio) communication the receiver consists of the following parts:
(i) A pick up antenna.
(ii) A demodulator It is reverse of modulator.
(iii) An amplifier
(iv) The transducer- A transducer is a device which converts a message signal into electrical signal and viceversa. Broadly it converts one form of energy into another. A transducer has either input or output in electrical form.
Two Basic Modes of Communication:
a) Point to point
b) Broadcast
Point to Point Mode of Communication:
Here, communication takes place over a link between a single transmitter and a receiver. Telephony is an example of such a mode of communication.

Broadcast Mode of Communication:
Here, there are a large number of receivers corresponding to a single transmitter. Radio and television are examples of broadcast mode of communication.

Analog Mode of Transmission:
An analog message is physical quantity that varies with time usually in a smooth and continuous fashion.

Digital Mode of Transmission:
A digital message is an ordered sequence of symbols selected from a finite set of discrete elements.

Basic terminology used in Electronic Communication systems

(i) Transducer: Any device that converts one form of energy into another can be termed as a transducer. 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.

(ii) Signal: Information converted in electrical form and suitable for transmission is called a signal. Signals can be either analog or digital. Analog signals are continuous variations of voltage or current. They are essentially single-valued functions of time. Sine wave is a fundamental analog signal. All other analog signals can be fully understood in terms of their sine wave components. Sound and picture signals in TV are analog in nature. Digital signals are those which can take only discrete stepwise values. Binary system that is extensively used in digital electronics employs just two levels of a signal. ‘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 systems such as the binary coded decimal (BCD). American Standard Code for Information Interchange (ASCII) is a universally popular digital code to represent numbers, letters and certain characters.

(iii) Noise: Noise refers to the unwanted signals that tend to disturb the transmission and processing of message signals in a communication system. The source generating the noise may be located inside or outside the system.

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

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

(vi) Attenuation: The loss of strength of a signal while propagating through a medium is known as attenuation.

(vii) Amplification: It is the process of increasing the amplitude (and consequently the strength) of a signal using an electronic circuit called the amplifier (reference Chapter 14). Amplification is necessary to compensate for the attenuation of the signal in communication systems. The energy needed for additional signal strength is obtained from a DC power source. Amplification is done at a place between the source and the destination wherever signal strength becomes weaker than the required strength.

(viii) Range: It is the largest distance between a source and a destination up to which the signal is received with sufficient strength.

(ix) Bandwidth: Bandwidth refers to the frequency range over which an equipment operates or the portion of the spectrum occupied by the signal.

(x) Modulation: The original low frequency message/information signal cannot be transmitted to long distances. Therefore, at the transmitter, information contained in the low frequency message signal is superimposed on a high frequency wave, which acts as a carrier of the information. This process
is known as modulation. As will be explained later, there are several types of modulation, abbreviated as AM, FM and PM.

(xi) **Demodulation:** The process of retrieval of information from the carrier wave at the receiver is termed demodulation. This is the reverse process of modulation.

(xii) **Repeater:** A repeater is a combination of a receiver and a transmitter. A repeater, picks up the signal from the transmitter, amplifies and retransmits it to the receiver sometimes with a change in carrier frequency. Repeaters are used to extend the range of a communication system as shown in below figure. A communication satellite is essentially a repeater station in space.

![Image of repeater station in space]

**Earth's atmosphere**

The various regions of earth's atmosphere are:

- **Troposphere** It extends upto a height of 12 km.
- **Stratosphere** It extends from 12 km to 50 km.
- There is an ozone layer in stratosphere.
- **Mesosphere** It extends from 50 km to 80 km.
- **Ionosphere** It extends from 80 km to 400 km. It is composed of ionised matter i.e. electrons and positive ions. It plays an important role in space communication.

**Frequency ranges**

The various frequency ranges used in radiowaves or microwave communication system are shown below:

1. Medium frequency band (M.F.) 300 to 3000 kHz.
2. High frequency band (H.F.) 3 to 30 MHz.
3. Very high frequency band (V.H.F.) 30 to 300 MHz.
4. Ultra high frequency band (U.H.F.) 300 to 3000 MHz.
5. Super high frequency band (S.H.F.) 3000 to 30,000 MHz.
6. Extra high frequency band (E.H.F.) 30 to 300 GHz.

**Propagation of electromagnetic waves**

The propagation of electromagnetic waves depend on the properties of the waves and the environment. Radio waves ordinarily travel in straight lines except where the earth and its atmosphere alter their path. Radio wave is propagated from the transmitting to the receiving antenna mainly in three different ways depending on the frequency of the wave. They are:

1. Ground (surface) wave propagation
2. Space wave propagation
3. Sky wave (or) ionospheric propagation

**Ground (surface) wave propagation**

Ground or surface waves are the radio waves which travel along the surface of the earth as shown in below figure. Ground wave propagation takes place when the transmitting and receiving antennas are close to the ground. Ground wave propagation is of prime importance only for medium and long wave signals. All medium wave signals received during the daytime use surface wave propagation.
Space wave propagation
Radio waves propagated through the troposphere of the Earth are known as space waves. Troposphere is the portion of the Earth’s atmosphere which extends up to 15 km from the surface of the Earth. Space wave usually consists of two components as shown in below figure.
(i) A component which travels straight from the transmitter to the receiver.
(ii) A component which reaches the receiver after reflection from the surface of the Earth.
Space wave propagation is particularly suitable for the waves having frequency above 30 MHz.

Sky wave (or) ionospheric propagation
The ionosphere is the upper portion of the atmosphere, which absorbs large quantities of radiant energy like ultra violet rays, cosmic rays etc., from the sun, becoming heated and ionised. This ionized region contains free electrons, positive and negative ions. Radio waves in the short wave band, radiated from an antenna at large angles with ground, travel through the atmosphere and encounters the ionised region in the upper atmosphere. Under favourable circumstances, the radiowaves get bent downwards due to refraction from the different parts of the ionised region and again reach the earth at a far distant point. Such a radio wave is called the sky wave and such a propagation of radio wave is known as sky wave propagation or ionospheric propagation. Long distance radio communication is thus possible through the sky wave propagation.

Reflection of electromagnetic waves by ionosphere
The electromagnetic waves entering into the ionosphere, are reflected by the ionosphere. In fact, the actual mechanism involved is refraction. The refractive indices of the various layers in the ionosphere do not remain constant and it varies with respect to electron density and the frequency of the incident wave. As the ionisation density increases for a wave approaching the given layer at an angle, the refractive index of the layer is reduced. Hence, the incident wave is gradually bent farther and farther away from the normal as shown in below figure until some point. When the electron density is large, the angle of refraction becomes 90\(^0\) and the wave, then travel towards the Earth.
Skip distance and skip zone

In the skywave propagation, for a fixed frequency, the shortest distance between the point of transmission and the point of reception along the surface is known as the *skip distance*. When the angle of incidence is large for the ray $R_1$ as shown in below figure, the sky wave returns to the ground at a long distance from the transmitter. As this angle is slowly reduced, naturally the wave returns closer and closer to the transmitter as shown by the rays $R_2$ and $R_3$.

If the angle of incidence is now made significantly less than that of ray $R_3$, the ray will be very close to the normal to be returned to the Earth. If the angle of incidence is reduced further, the radio waves penetrate through the layer as shown by the rays $R_4$ and $R_5$. For a particular angle of incidence, the distance between the point of transmission and the point of reception is minimum. The minimum distance between the transmitter and the ray like $R_3$ which strikes the Earth is called as the skip distance. As we move away from the transmitter, the ground wave becomes lesser and lesser significant. A stage comes when there is no reception due to the ground waves. This point lies somewhere in the skip distance. The region between the point where there is no reception of ground waves and the point where the sky wave is received first is known as skip zone. In the *skip zone*, there is no reception at all.

Modulation

*In radio broadcasting, it is necessary to send audio frequency signal* (eg. music, speech etc.) *from a broadcasting station over great distances to a receiver*. The music, speech etc., are converted into audio signals using a microphone. The energy of a wave increases with frequency. So, the audio frequency ($20 – 20000$ Hz) is not having large amount of energy and cannot be sent over long
distances. Therefore, if audio signal is to be transmitted properly, the audio signal must be superimposed on high frequency wave called carrier.

The resultant waves are known as modulated waves and this process is called as modulation. This high frequency wave (Radio frequency wave) is transmitted in space through antenna. At the receiver end, the audio signal is extracted from the modulated wave by the process called demodulation. The audio signal is then amplified and reproduced into sound by the loud speaker.

A high frequency radio wave is used to carry the audio signal. On adding the audio signal to carrier, any one of the characteristics namely amplitude or frequency or phase of the carrier wave is changed in accordance with the intensity of the audio signal. This process is known as modulation and may be defined as the process of changing amplitude or frequency or phase of the carrier wave in accordance with the intensity of the signal. Some of the modulation process namely, (i) amplitude modulation, (ii) frequency modulation and (iii) phase modulation.

**Amplitude modulation (AM)**

When the amplitude of high frequency carrier wave is changed in accordance with the intensity of the signal, the process is called **amplitude modulation**.

In the amplitude modulation, only the amplitude of the carrier wave is changed. The frequency and the phase of the carrier wave remains constant. The below figure shows the principle of amplitude modulation.

Fig. a shows the audio electrical signal of frequency $f_s$. Fig b shows a carrier wave of constant amplitude with frequency $f_c$. Fig c is the amplitude modulated wave. It is to be noted that the amplitudes of both positive and negative half cycles of carrier wave are changed in accordance with the signal. Thus the amplitude of the modulated wave possesses the frequency of the audio signal wave.

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**Modulation factor**

An important term in amplitude modulation is modulation factor which describes the extent to which the amplitude of the carrier wave is changed by the audio signal. It is defined as the ratio of the change of amplitude in carrier wave after modulation to the amplitude of the unmodulated carrier wave.
modulation factor, \( m = \frac{\text{Amplitude change of carrier wave after modulation}}{\text{Amplitude of carrier wave before modulation}} \)

\[ i.e. \quad m = \frac{\text{Signal amplitude}}{\text{Carrier amplitude}} \]

**Frequency modulation (FM)**

When the frequency of carrier wave is changed in accordance with the intensity of the signal, the process is called frequency modulation. In frequency modulation, the amplitude and phase of the carrier wave remains constant. Only, the frequency of the carrier wave is changed in accordance with the signal.

The frequency variation of the carrier wave depends upon the instantaneous amplitude of the signal as shown in Fig (a). When the signal voltage is zero at A,C,E and G, the carrier frequency is unchanged. When the signal approaches its positive peaks at B and F, the carrier frequency is increased to maximum as shown by closely spaced cycles in Fig (c). But during the negative peak of signal as at D, the carrier frequency is reduced to minimum as shown by widely spaced cycles in Fig.(c). The louder signal causes greater frequency change in modulated carrier as indicated by increased bunching and spreading of the waves as compared with relatively weaker signal.

![Diagram](image)

The frequency of an FM transmitter without signal input is called the resting frequency or centre frequency \( f_o \) and this is the allotted frequency of the transmitter. When the signal is applied, the carrier frequency deviates up and down from its resting value \( f_o \).

**Phase modulation (PM)**

In phase modulation, the phase of the carrier wave is varied in accordance with the amplitude of the modulating signal and the rate of variation is proportional to the signal frequency. The waveform of the phase modulated wave is similar to that of FM wave. The phase modulation, generally uses a smaller bandwidth than FM. In other words, more information can be sent in a given bandwidth in phase modulation. Therefore, phase modulation facilitates highest transmission speeds on a given bandwidth. In phase modulation also, there is a frequency shift in the carrier wave frequency. The frequency shift depends on (i) amplitude of the modulating signal and (ii) the frequency of the signal. One great
advantage of the phase modulation lies in the fact that the FM signal produced from PM signal is very stable. Also, the centre frequency called resting frequency is extremely stable.

**AMPLITUDE MODULATED (AM) TRANSMITTER**
The below figure gives the block diagram of amplitude modulated radio transmitter. It consists of two sections (i) Audio frequency (AF) section and (ii) Radio frequency (RF) section.

**AF section**
The AF section of the transmitter generates the modulating wave (signal). The conversion of sound energy into electrical energy is performed by the microphone.

![Amplitude Modulation Block Diagram](image)
The electrical energy available from the microphone is very low. Hence, it is amplified through an amplifier. The output from the AF amplifier is fed to the AF power amplifier. The power amplifier provides the required audio frequency power. The output of the AF power amplifier is given to the modulator. A modulator is an electronic circuit with transistor and passive components, which performs the process of modulation.

**RF section**
In the RF section, the high frequency carrier wave is generated by a crystal controlled oscillator. The output of the crystal controlled oscillator is power amplified by RF power amplifier. The buffer isolates the RF power amplifier from the oscillator. This arrangement keeps the frequency of the crystal controlled oscillator as a constant. In the modulator the RF wave and modulating AF signal are mixed to produce the amplitude modulated wave. The output of this section is fed to the antenna for transmission.

**FREQUENCY MODULATED (FM) TRANSMITTER**
Frequency modulated systems are operated usually at a frequency above 40 MHz. Frequency modulated broadcasting is done in television sound, mobile radio etc. The functional block diagram of a FM transmitter employing phase modulation is shown in below figure. The phase modulation is essentially a frequency modulation.

![Frequency Modulation Block Diagram](image)
It consists of a crystal oscillator, which produces the carrier wave and the output of this is fed into the phase modulator. The buffer is a low frequency amplifier which isolates the crystal oscillator from the phase modulator.
The modulating signal is produced from a microphone. Since this AF modulating signal has uneven power, it is fed into a network called pre-emphasis network, where all the frequencies in the modulating signal are made to have equal power. The output of the pre-emphasis network is then amplified and sent for phase modulation. The modulated output is then power amplified using a power amplifier and then fed into the transmitting antenna for transmission.

**Radio receiver**
The functional block diagram of a simple radio receiver is shown in below figure. The receiving antenna receives the radiowaves from different broadcasting stations. The desired radiowave is selected by the radio frequency amplifier, which employs a tuned parallel circuit. The tuned RF amplifier amplifies this selected radiowave. The amplified radiowave is fed to the detector circuit which consists of a PN diode. This circuit extracts the audio signal from the radiowave. The output of the detector is the audio signal, which is amplified by one or more stages of audio amplification. The amplified audio signal is given to the loud speaker for sound reproduction.

**Superheterodyne AM receiver**
The shortcomings of straight radio receiver were overcome by the invention of superheterodyne receiver. All the modern receivers utilise the superheterodyne circuit. The functional block diagram of AM receiving system of superheterodyne type is shown in below figure.

**(i) RF amplifier**
The RF amplifier uses a tuned parallel circuit. The radiowaves from various broadcasting stations are intercepted by the receiving antenna and are coupled to this stage. This stage selects the desired radiowave and enhances the strength of the wave to the desired level.

**(ii) Mixer and local oscillator**
The amplified output of RF amplifier is fed to the mixer stage, where it is combined with the output of a local oscillator. The two frequencies beat together and produce an intermediate frequency (IF). The intermediate frequency is the difference between oscillator frequency and radio frequency. The output of
this section is always equal to the intermediate frequency 455 kHz. For example, if 600 kHz station is tuned, then local oscillator will produce a frequency of 1055 kHz and consequently the output from the mixer will have frequency of 455 kHz. By achieving this fixed intermediate frequency, the amplifier circuit in such receivers can be made to operate with maximum stability, selectivity and sensitivity.

(iii) **IF amplifier**
The output of the mixer circuit is fed to the tuned IF amplifier. This amplifier is tuned to one frequency (i.e. 455 KHz ) and is amplified.

(iv) **Detector**
The output from the IF amplifier is coupled with input of a detector. The audio signals are extracted from the IF output. Usually a diode detector circuit is used because of its low distortion and excellent audio fidelity (reproducing ability).

(v) **AF amplifier**
The detected AF signal is usually weak and so it is further amplified by the AF amplifier. Then, the output signal from the amplifier is fed to the loud speaker, which converts the audio signal into sound waves corresponding to the original sound at the broadcasting station.

**Satellite communication**
(i) A satellite communication is possible through geostationary satellites. At least three geostationary satellites are required which are 120° apart from each other, to cover the entire globe of earth.
(ii) The satellite communication is a mode of communication and receiver through satellite.
(iii) A communication satellite is a space craft, provided with microwave receiver and transmitter. It is placed in an orbit around the earth.

**Remote sensing**
(i) Remote sensing is done through a satellite. The satellite moves in a fixed orbit around the earth in a way such that it passes over a given location on the earth at the same local time. The orbit of such a satellite is known as Sun synchronous orbit.
(ii) Such satellites provide us with data critical to weather production, agriculture forecasting, resource exploration and environmental monitoring.
(iii) The India remote sensing satellites are IRSIA, IRSIB and IRSIC.
(iv) Such satellite takes repeated photographs of the particular location of the earth during its repeated journeys over that location. The comparative study of photographs leads to required results.

**Optical fibres**
An optical fibre is a long thread consisting of a central core of glass or plastic of uniform refractive index. It is surrounded by a cladding of material of refractive index less than that of the core and a protective jacket of insulating material.
There are three types of optical fibre configuration:
(i) Single mode step index fibre.  (ii) Multimode step index fibre.  (iii) Multimode graded index fibre.

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Prepared by: M. S. KumarSwamy, TGT(Maths)
- **Critical angle**: It is that angle of incidence in the denser medium for which the angle of refraction in rarer medium is 90°.
  \[ \frac{\mu_1}{\mu_2} = \frac{\sin \theta_C}{\sin 90^\circ} = \sin \theta_C \]
- If the rarer medium is air, \( \mu_1 = 1 \)
  \[ \mu_2 = \frac{1}{\sin \theta_C} \]
- In optical fibre, critical angle is given by \( \cos \theta_C = \frac{\sqrt{\mu_i^2 - \mu_r^2}}{\mu_i} \)
- Optical fibres are used in optical communication.
- The optical communication system is more economical than other systems of communications and it has larger information carrying capacity and provides high quality service.
- Optical fibre cables are of small size and weight as compared to metallic cables and hence occupy small space for its operation.
- Optical fibres are most suitable for digital transmission and switching system.

**LED and diode lasers in communication**

Light emitting diode (LED) and diode lasers are preferred sources for optical communication links to the following features.
(i) Each produces light of suitable power required in optical communication.
(ii) Diode laser provides light which is monochromatic and coherent. This light is obtained as a parallel beam. It is used in very long distance transmission.
(iii) LED provides almost monochromatic light. This is suitable for small distance transmission. It is, in fact, a low cost device as compared to diode lasers.

**Line communication**

Transmission lines are used to interconnect points separated from each other. For example interconnection between a transmitter and a receiver or a transmitter and antenna or an antenna and a receiver are achieved through transmission lines.

The most commonly used two wire lines are
(i) parallel wire lines (ii) twisted pair wire lines (iii) coaxial wire lines

Parallel wire lines are never used for transmission of microwaves. This is because at the frequency of microwaves, separation between the two wires approaches half a wavelength (i.e. \( \lambda/2 \)). Therefore, radiation loss of energy becomes maximum.

Primary constants of a transmission line
(i) The four line parameters are resistance \( R \), inductance \( L \), capacitance \( C \) and conductance \( G \).
(ii) Series impedance \( Z = R + j\omega L \)
(iii) Shunt admittance \( Y = G + j\omega C \).
COMMUNICATION SYSTEMS

MARKS WEIGHTAGE – 5 marks

Important Questions and Answers

VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)

1. What is ground wave propagation?
   Ans: Ground Wave Propagation: Ground wave propagation is one in which electromagnetic waves glide on the surface of earth between two antennas on the ground.

2. What is space wave propagation?
   Ans: Space Wave Propagation: It is the straight line propagation of electromagnetic wave from transmitting antenna to receiving antenna both installed on the ground.

3. What is sky wave propagation?
   Ans: Skywave propagation is a mode of propagation in which communication of radiowaves (in the frequency range 30 MHz–40 MHz) takes place due to reflection from the ionosphere.

4. Name three different types of modulation used for a message signal using a sinusoidal continuous carrier wave.
   Ans: The three different modulation are: Amplitude modulation, Frequency modulation, Phase modulation

5. Write the range of frequencies suitable for space wave communication.
   Ans: The range suitable is above 40 MHz.

6. Give reason - “For ground wave transmission, size of antenna (1) should be comparable to wavelength (l) of signal i.e., = l/ 4.”
   Ans: For high efficiency of signal radiation, the antennas should have a size of at least $\frac{\lambda}{4}$

7. What should be the length of dipole antenna for a carrier wave of frequency $5 \times 10^8$ Hz?
   Ans: Length of dipole antenna = $\frac{\lambda}{4} = \frac{1 \times \frac{c}{v}}{4} = \frac{3 \times 10^8}{4 \times 5 \times 10^8} = 0.15m$

8. Optical and radio telescopes are built on the ground while X-ray astronomy is possible only from satellites orbiting the Earth. Why?
   Ans: The visible radiations and radiowaves can penetrate the earth's atmosphere but X-rays are absorbed by the atmosphere.

9. The small ozone layer on top of the stratosphere is crucial for human survival. Why?
   Ans: The ozone layer absorbs ultraviolet and other low wavelength radiations which are harmful to living cells of human bodies and plants; hence ozone layer is crucial for human survival.

10. What is the line of sight communication?
    Ans: The propagation of a radio wave in a straight line from transmitting to receiving antenna on the ground is called line of sight communication.

11. Why is it not possible to use sky wave propagation for transmission of TV signals?
    Ans: TV signals have high frequency range 100 to 200 MHz. Ionospheric layers do not reflect back such high frequency signals. Hence, sky waves cannot be used for transmission of TV signals.

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

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

   \[ m(t) \text{ in volt} \]
   \[ 1 \]
   \[ 2 \]
   \[ t \text{ in second} \]

   Ans: Modulation index, \( \mu = \frac{\text{Amplitude of modulated signal}}{\text{Amplitude of carrier waves}} \)

   \[ \Rightarrow \frac{A_m}{A_c} = \frac{1m}{2m} = 0.5 \]

14. Why is communication using line of sight mode limited to a frequencies above 40 MHz?
   Ans: Line of sight mode is limited above 40 MHz, as these waves cannot propagate as sky waves.

15. What are the three basic units of a communication system?
   Ans: The three basic units of communication are transmitter, medium /channel and receiver.

16. What is the meaning of the term attenuation in communication system?
   Ans: The loss of strength of a signal while propagating through a medium is known as attenuation.

17. What is the function of a transmitter in a communication system?
   Ans: A transmitter processes the incoming message signal, makes it suitable for transmission.

18. What does the term transducer mean in an electronic communication system?
   Ans: In electronic communication system a transducer is a device that converts signals (emw) to electrical form or vice-versa.

19. Name the mode of propagation of radio waves which travel in a straight line from the transmitting antenna to the receiving antenna.
   Ans: Space Waves

20. Name the type of communication in which the signal is a discrete and binary coded version of the message or information.
   Ans: Binary coded signals are in the form of pulse.

SHORT ANSWER TYPE QUESTIONS (2 MARKS/3 MARKS)

21. Explain the function of a repeater in a communication system.
   Ans: A repeater is a combination of a receiver and a transmitter. Repeaters are used to increase the range of communication of signals. A repeater picks up the signal from the transmitter, amplifiers and retransmits it to the receiver, sometimes with a change in carrier frequency. A typical example of repeater station is a communication satellite.

22. A TV tower is 80 tall. Calculate the maximum distance upto which the signal transmitted from the tower can be received.
23. “A communication satellite is essentially a repeater station in space.” Justify this statement by analyzing the function of a repeater.

Ans: A repeater is a combination of a receiver and a transmitter. It picks up signals, amplifies and retransmits it. A satellite also receives signals, amplifies them and retransmits them to the ground station. Thus the given statement is justified.

24. What is the range of frequencies used for TV transmission? What is common between these waves and light waves?

Ans: Range of frequencies for T.V. transmission are 54 MHz to 890 MHz. The common feature between these waves and light waves is that both travel at the same speed and both are electromagnetic waves.

25. Name any two types of transmission media that are commonly used for transmission of signals. Write the range of frequencies for which these transmission media are used.

Ans: Sky waves and ground waves.

- Sky waves: Range few MHz up to 30 to 40 MHz
- Ground waves: < few MHz

26. Distinguish between ‘Analog and Digital signals’.

Ans:

- Analog signals: They are the continuous variations of voltage or current.
- Digital signals: They are the signals which can take only discrete values.

27. Mention the function of any two of the following used in communication system: (i) Transmitter (ii) Bandpass Filter

Ans: 
(i) Transmitter: A device which processes the incoming message signal so as to make it suitable for transmission through a channel and for its subsequent reception.
(ii) Bandpass filter: A bandpass filter blocks lower and higher frequencies and allows only a band of frequencies to pass through.

28. Why is sky wave mode propagation restricted to frequencies upto 40 MHz?

Ans: Sky wave propagation is restricted to frequency up to 40 MHz because the radio waves of frequencies more than 40 MHz penetrate into the ionosphere.

29. Give three examples where space wave mode of propagation is used.

Ans: Space wave propagation (LOS) is used in
(i) Television broadcast
(ii) Microwave link
(iii) Satellite communication

30. What is the ground wave communication? On what factors does the maximum range of propagation in this mode depend?

Ans: When the waves propagate near to the surface, the waves glide over the surface of the earth, they are called ground waves. The maximum range of coverage depends on the transmitted power and frequency.

31. Distinguish between sinusoidal and pulse shaped signals.

Ans: When the signal is in the form of continuous variation of amplitude and can be written in the sinusoidal form, it is called a sinusoidal signal. When the signal is in the form of discrete variations or pulse, it is called a pulse signal.
32. What is the length of a dipole antenna to transmit signals of frequency 200 MHz?

**Ans:** The length of the antenna should be at least \( \frac{\lambda}{4} \)

For a carrier frequency \( 5 \times 10^8 \text{Hz} \)

\[ \lambda = \frac{c}{v} = \frac{3 \times 10^8}{5 \times 10^8} = 0.6m \]

Therefore Length of antenna = \( \frac{0.6}{4} = 0.15m \)

33. Why is frequency modulation preferred over amplitude modulation for transmission of music?

**Ans:** In frequency modulation, naturally occurring noise is reduced, whereas in amplitude modulation, due to attenuation the signal is distorted and causes noise or disturbance in the signal.

34. Why is Audio signals, converted into an electromagnetic wave, are not directly transmitted.

**Ans:** Audio signals need a wave of at least size 15 km, which is impractical and signals of different transmitters would mix up.

35. Why is the amplitude of a modulating signal is kept less than the amplitude of carrier wave.

**Ans:** The amplitude of the modulating signal is kept less than the carrier waves so that no distortion occurs in the modulated wave.

36. 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?

**Ans:** In standard AM broadcast, ground wave is used as mode of propagation. This mode is limited up to a few MHz, because the attenuation of surface waves increases very rapidly with increase in frequency.

37. Why do we need a higher Bandwidth for transmission of music compared to that for commercial telephonic communication ?

**Ans:** Higher bandwidth is required for transmission of music because of the high frequencies produced by the musical instruments of the range 20 Hz – 20 KHz. Speech signals range from 300 Hz - 3100 Hz.

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

**Ans:** In frequency modulation the frequency of the carrier wave is modulated. In amplitude modulation, amplitude of the carrier wave is modulated. Due to attenuation, amplitude decrease affecting the amplitude modulation. Thus AM is more susceptible to noise than FM.

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

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

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

40. Write two factors justifying the need of modulation for transmission of a signal. [AI 2009]

**Ans:** Two factors justifying the need of modulation for transmission of a signal are:

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

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

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

41. **Distinguish between sky wave and space wave propagation.** Give a brief description with the help of suitable diagrams indicating how these waves are propagated. [AI 2009]

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

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

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

42. **Write two factors justifying the need of modulating a signal.** A carrier wave of peak voltage 12 V is used to transmit a message signal. What should be the peak voltage of the modulating signal in order to have a modulation index of 75%? [AI 2010]

**Ans:** Need of modulation:

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

(ii) For effective transmission, the size of the antenna should be at least of the size \( \frac{\lambda}{4} \), where \( \lambda \) is wavelength of signal to be sent. For an e.m. wave of the frequency of the order of audio signal, we need an antenna of size 3.75 km, which is practically impossible. Hence these low frequency base band signals are first converted into high frequencies, through modulation.

Modulation index, \( \mu = \frac{A_m}{A_c} \)

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

\( \therefore A_m = 0.75 \times 12 = 9 \) V
43. Which mode of propagation is used by short wave broadcast services having frequency range from a few MHz upto 30 MHz? Explain diagrammatically how long distance communication can be achieved by this mode. Why is there an upper limit to frequency of waves used in this mode? [AI 2010]
Ans: Sky wave propagation is used by short wave broadcast services having frequency range from a few MHz upto 30 MHz.

Sky waves are used for long distance radio communication. The successive reflection of these radiowaves at the earth’s surface and the ionosphere make it possible to transmit these waves from one part to another part of the earth.
These waves are reflected by ionosphere by means of total internal reflection, which arises due to change in refractive indices of different layers of ionosphere. Critical frequency of reflection for a particular layer is given by \( f_c = 9 \sqrt{N_{\text{max}}} \) where \( N_{\text{max}} \) = maximum electron density in the given layer.
For any frequency greater than \( f_c \) ionosphere is not able to reflect the radiowave. Hence there exists an upper limits to frequency of waves used in this mode.

44. (i) Define modulation index. (ii) Why is the amplitude of modulating signal kept less than the amplitude of carrier wave? [AI 2011]
Ans: (i) Modulation index: The modulation index of an amplitude modulated wave is defined as the ratio of the amplitude of modulating signal \( A_m \) to the amplitude of carrier wave \( A_c \).

\[ \mu = \frac{A_m}{A_c} \]

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

45. 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 [AI 2011]
Ans: The diagram below is showing various propagation modes for em waves.
(i) 540 – 1600 KHz
(ii) 54 – 72 MHz
  76 – 88 MHz
  174 – 216 MHz
  420 – 890 MHz
(iii)5.925 – 6.425 GHz
  3.7 – 4.2 GHz
46. In the given block diagram of a receiver, identify the boxes labelled as X and Y and write their functions. [AI 2012]

Ans: 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.

47. 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 = \(6.4 \times 10^6\) m) [AI 2013]

Ans: Space waves/radio wave/micro wave
Frequency range above 40 MHz
Maximum distance, \(d_m = \sqrt{2h_xR} + \sqrt{2h_yR}\)
\[
\Rightarrow d_m = \sqrt{2 \times 6400 \times 10^3 \times 45} + \sqrt{2 \times 6400 \times 10^3 \times 20}
\]
\[
= (24 + 16) \times 10^3 \text{ m} = 40 \times 10^3 \text{ m}
\]
48. 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]

Ans: (i) Ground wave or surface wave propagation
(ii) Sky wave propagation or ionospheric propagation
(iii) Space wave propagation/Line of sight propagation

**Sky wave propagation:** 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. Sky waves are also amplitude modulated waves and are for long distance radio communication. 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. The successive reflection of these radiowaves at the earth’s surface and the ionosphere make it possible to transmit these waves from one part to another part of the earth.

Ionosphere is a layer of atmosphere having charged particles, ions and electrons, which extends from about 60 to 350 kms from the surface of earth.

Ionosphere is subdivided into layer as C, D, E, $f_1$ and $F_2$. These different layer of ionosphere reflect the radio waves of different frequencies.
(i) Medium frequencies (MF) of frequencies up to 3 MHz are absorbed by ionosphere.
(ii) High frequencies (HF) of frequencies up to 30 MHz are reflected back by ionosphere.
(iii) Very high and ultra high frequencies (VHF and UHF) of frequencies above 40 MHz are only bend by ionosphere, but are not reflected back towards earth.

The ionosphere consists of positively charged ions and electrons. Such a system is known as ‘plasma’, which has a characteristic frequency called ‘Plasma frequency’ given by $f_p = 9\sqrt{N}$ where $N$ is the electron density (in m$^{-3}$) in the concerned layer of ionosphere.

When any radiation reaches the region of electron density $N$ at normal incidence, it will be reflected. The ‘critical frequency’ for reflection is therefore given by $f_p = 9\sqrt{N_{max}}$

$f_c$ turns out to be 4 MHz, 5 MHz and 8 MHz for $E$, $F_1$ and $F_2$ layers respectively.
Any wave directed at a certain angle gets reflected by ionosphere and returns to earth. The distance from the transmitter, measured along the surface of earth, to the point where sky wave returns after reflection from ionosphere is called skip distance for a single hop. Using multiple hops or beaming at different angles, we can increase the propagation range.

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.

49. 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]

Ans: 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 \( \omega_m, 2\omega_m, 2\omega_c \) and gives the AM wave as its output.

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

Ans:
Given \( h_T = 36 \) m, \( h_R = 49 \) m, and \( R_e = 6400 \) km = \( 6.4 \times 10^6 \) m.

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

\[ \Rightarrow d_m = \sqrt{2 \times 6.4 \times 10^6 \times 36} + \sqrt{2 \times 6.4 \times 10^6 \times 49} \]

\[ = 3.578 \times 10^3 (6 + 7) = 3.578 \times 10^3 \times 13 \text{ m} \]

\[ = 46.5 \times 10^3 \text{ m} = 46.5 \text{ km} \]

51. Draw a plot of the variation of amplitude versus \( \omega \) for an amplitude modulated wave. Define modulation index. State its importance for effective amplitude modulation.

Ans:
Plot of variation of amplitude versus $\omega$ for amplitude modulated wave is shown in fig.

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

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

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

Ans: Transmission range of a TV tower

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

If height is increased by 21%, new height, $h' = h + \frac{21}{100}h = 1.21h$

If $d'$ is the new range, then

$$\frac{d'}{d} = \sqrt{\frac{h'}{h}} = \sqrt{1.21} = 1.1$$

% increase in range,

$$\frac{\Delta d}{d} \times 100\% = \frac{d' - d}{d} \times 100\%$$

$$= \left(\frac{d'}{d} - 1\right) \times 100\% = (1.1 - 1) \times 100\% = 10\%$$

53. What does the term ‘LOS communication’ mean? Name the types of waves that are used for this communication. Give typical examples, with the help of a suitable figure, of communication systems that use space wave mode propagation.

Ans: LOS Communication: It means “Line of sight communication”.

Space waves are used for LOS communication.

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

Communication System using Space wave mode propagation are (i) LOS communication and Fig. shows LOS communication system.
If transmitting antenna and receiving antenna have heights \( h_T \) and \( h_R \) respectively, then Radio horizon of transmitting antenna,
\[ d_T = \sqrt{2h_T R_e} \]
where \( R_e \) is radius of earth and radio horizon of receiving antenna.
\[ d_R = \sqrt{2h_R R_e} \]
\[ \therefore \] Maximum line of sight distance, \( d_M = d_T + d_R = \sqrt{2h_T R_e} + \sqrt{2h_R R_e} \)

(ii) Television, broadcast, microwave links and satellite communication
The satellite communication is shown in fig. The space wave used is microwave.

54. Why are high frequency carrier waves used for transmission?
**Ans:** Use of high frequency carrier wave in transmission of signals:
(i) High frequency carrier wave reduces the size of antenna as
\[ h = \frac{\lambda}{2} \text{ or } \frac{\lambda}{4} \]
(ii) High frequency carrier wave radiates more power in space as \( P \propto \lambda^2 \)
(iii) High frequency carrier wave avoids mixing up of message signals.

55. What is meant by term ‘modulation’? Draw a block diagram of a simple modulator for obtaining an AM signal.
**Ans:** Meaning of Modulation: The original low frequency message/information signal cannot be transmitted over long distances. Therefore, at the transmitter end, information contained in the low frequency message signal, is superimposed on a high frequency carrier signal by a process known as modulation.

56. Define the terms ‘amplitude modulation’
**Ans:** In amplitude modulation, the amplitude of modulated (carrier) wave varies in accordance with amplitude of information (signal) wave. When amplitude of information increases, the amplitude of modulated wave increases and vice versa. In this case the amplitude of modulated wave is not constant.

57. What is meant by detection of a signal in a communication system? With the help of a block diagram explain the detection of AM signal.
**Ans:** Detection is the process of recovering the modulating signal from the modulated carrier wave.
Explanation of Detection with the help of a block diagram:

The modulated carrier wave contains frequencies \( w_c \pm w_m \). The detection means to obtain message signal \( m(t) \) of frequency \( w_m \). The method is shown in the form of a block diagram.

The modulated signal is passed through a rectifier. It produces rectified wave [fig. (b)]; the envelope of which is the message signal.

The rectified wave is passed through an envelope detector, whose output is the required message signal \( m(t) \).

58. If a low frequency signal in the audio frequency range is to be transmitted over long distances, explain briefly the need of translating this signal to high frequencies before transmission.

**Ans:** The modulation is needed due to

(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.

59. The figure given below shows the block diagram of a generalised communication system. Identify the element labelled ‘X’ and write its function.

**Ans:** X represents communication channel.

Function: It connects the transmitter to the receiver.

60. What is ground wave communication? On what factors does the maximum range of propagation in this mode depend?

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

The maximum range of propagation in this mode depends on

(i) transmitted power and

(ii) frequency (less than a few MHz)
61. Draw a suitable diagram to show amplitude modulation using a sinusoidal signal as the modulating signal.

Ans:

![Amplitude Modulation Diagram](image)

(a) Carrier wave \( E_c = E_c \sin \omega_c t \)

(b) Modulating wave \( e_m \)

(c) Modulated wave \( e(t) \)

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

Ans: Here, \( A_{\text{max}} = 10 \text{ V} \) and \( A_{\text{min}} = 2 \text{ V} \)

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

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

63. Draw a block diagram showing the important components in a communication system. What is the function of a transducer?

Ans: Block diagram of communication system:

![Communication System Block Diagram](image)

Function of a transducer is to convert one form of energy into another form.