COMMUNICATION SYSTEMS

Important Points:

1. The exchange of information between a sender and receiver is called communication.

2. The arrangement of devices to transfer the information is called communication system.

3. Every communication system has three basic elements. 1) Transmitter 2) channel 3) Receiver

4. Information:

i) The information is in the form of electric signal which is suitable for sending. This is of two types.

a) Analog voltage signal in which information is converted into continuous variations of voltage (or) current.

b) Digital voltage signal in which the information is converted into stepwise vibrations of current (or) voltage.

ii) A device which converts one form of energy into another form is called transducer.

Ex: Microphone, speaker etc.

5. Transmitter:

Transmitter first converts the message into equivalent electrical variations. It is then called a signal. The signals in communication (speech, music etc) are at low frequency and cannot be transmitted to longer distance. For long distance transmission, the signals are superimposed on a high frequency waves called carrier waves. This process is called modulation. The process of changing some character (amplitude, frequency (or) phase) of a carrier wave in accordance with the intensity of the signal is known as modulation. The basic modes of modulation are 1) Amplitude modulation (AM) 2) Frequency Modulation (FM) and 3) Phase Modulation (PM)

6. Antenna:

Antenna plays an important role in communication. The linear size of the antenna should be nearly $\frac{\lambda}{4}$.

7. Channel:

Earth's atmosphere has an important role in the transmission of modulated waves. There are three modes of propagation.

1) Ground wave propagation 2) Sky wave propagation 3) Space wave propagation

8. World Wide Web (WWW) was invented by **Tim Berners-Lee**

Very Short Answer Questions

1. What are the basic blocks of a communication system?

A. Every communication system has three basic elements.

1) Transmitter 2) Transmission Channel 3) Receiver

2. What is "World wide web" (WWW)?

A. WWW may be regarded as the encyclopedia of knowledge accessible to everyone round the clock throughout the year. **Tim Berners-Lee** invented the World Wide Web.

3. Mention the frequency range of speech signals?

A. Frequency range of speech signals is 300 Hz to 3100 Hz.

4. What is sky wave propagation?

A. Long distance short wave communication is possible by ionosphere reflection. Sky wave propagation is used in the frequency ranges from few MHz to about 30 MHz. EM waves with frequencies move than 30 MHz will escape through the ionosphere.

5. Mention the various parts of the ionosphere?

A. (i) D layer (part of stratosphere) (ii) E layer (part of stratosphere)

(iii) F_1 layer (part of Mesosphere) (ii) F_2 layer (Thermosphere)

6. Define modulation. Why is it necessary?

A. The process of combining low (audio) frequency signal with high frequency signal is called modulation.

Need for Modulation: Modulation is necessary to transmit a signal in the audio frequency range over a long distance on account of

(i) Suitable size of the antenna

(ii) Suitable effective power radiated by the antenna

(iii) Avoid mixing up of signals from different transmitters

7. Mention the basic methods of modulation?

A. **1) Amplitude Modulation (AM):** In this method the amplitude of carrier wave is varied in accordance with the modulating signal. keeping the frequency and phase of carrier wave constant.

2) Frequency Modulation (FM): In this method frequency of carrier wave is varied in accordance with the modulating signal keeping the amplitude and phase of the carrier wave remains same.

3) Phase Modulation (PM): In this method phase of carrier wave is varied in accordance with the modulating signal keeping the amplitude and frequency of the carrier wave remains same.

8. Which type of communication is employed in Mobile Phones?

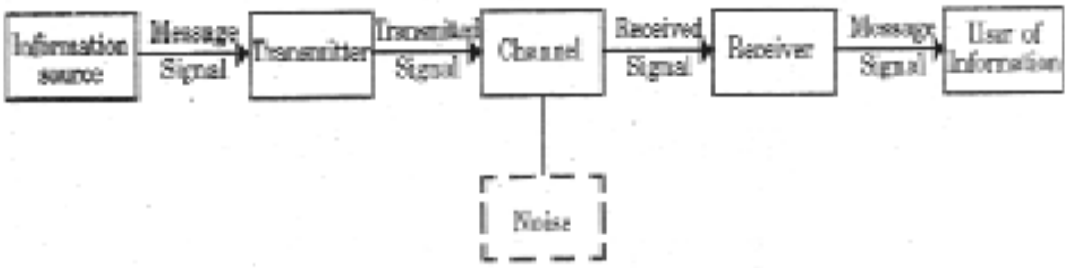
A. In mobile phones, point-to-point communication mode is employed. In point-to-point communication mode, communication takes place over a link between a transmitter and a signal transmitter and a receiver.

Short Answer Questions

1. Draw the block diagram of a generalized communication system and explain it briefly?

A. The exchange of information between a sender and receiver is called communication. It is the act of transmission of information. The arrangement of devices to transfer the information is called communication system.

The block diagram of a generalised communication system is shown.



i) Information Source:

A transducer converts the information into electrical signals called message signals.

ii) Transmitter:

Transmitter first converts the message into equivalent electrical variations. The signals in communication (speech, music etc) are at low frequency. Hence these are superimposed on a high frequency waves called carrier waves. This process is called modulation.

iii) Channel:

The channel is the physical medium that connects them depending upon the type of communication system. A channel may be in the form of wires (or) cables connecting the transmitter and the receiver, or it may be wireless.

3) Receiver:

It receives a corrupted version of transmitted signal. The receiver reconstructs a recognizable form of the original message signal for delivering it to the user information.

2. What is a Ground wave? When is it used for communication?

A. **Ground Wave Propagation:**

A wave which glides over the surface of the earth is called as ground wave and the mode of propagation is called as surface wave propagation.

Explanation:

The radio waves travel very close to the surface of the earth. These are vertically polarized because any horizontal component of electric field in contact with the earth is short circuited by the earth. These waves induce charge in the earth. At longer wavelengths, the antennas have large physical size and they are located on the ground. In standard AM broadcast, ground based vertical towers are generally used as transmitting antennas. For these type of antennas ground has a strong influence on the propagation of the signal. The maximum range of coverage depends upon the transmitted power and frequency (less than 2 MHz). Ground has high conductivity; due to this ground waves will propagate long distance over sea.

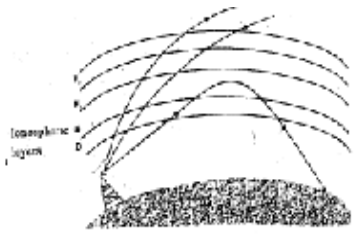
3. What are sky waves? Explain sky wave propagation, briefly?

A. **Sky Waves:**

Long distance short wave communication is possible by ionosphere reflection. The lower frequency limit depends on the absorption in Ionosphere, noise level at the receiver, since the losses in ionosphere decrease with frequency. The upper limit of frequency depends on the distance of transmission, height and electron density in the different layers ionosphere.

Explanation:

Sky wave propagation is used in the frequency ranges from few MHz to about 30 MHz. EM waves with frequencies more than 30 MHz will escape through the ionosphere. Above 200 MHz ionosphere becomes completely transparent. Due to this, these waves cannot be reflected back to the earth.



Sky wave propagation

4. What is space wave communication? Explain?

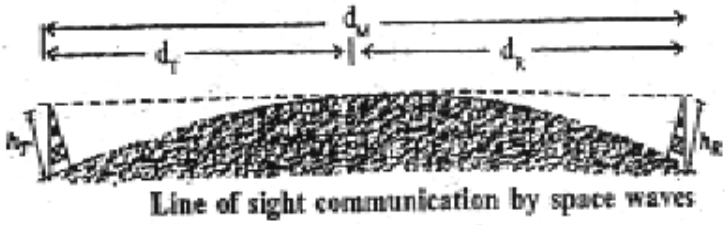
A. **Space Wave Communication:**

Electromagnetic waves of frequency above 30 MHz use space wave (or) direct wave propagation. This is used for line-of-sight (LOS) communication (radar) and satellite communication (mobile telephone).

Explanation:

The maximum line-of sight distance d_M between the transmitting and receiving antennas of height respectively is,

$d_{\max} = d_t + d_r = \sqrt{2Rh_t + 2Rh_r} =$ Where R is radius of earth.



Line of sight communication by space waves

Television broadcast, microwave links and satellite communication are examples of communication systems that use space wave mode of propagation.

5. What do you understand by modulation? Explain the need for modulation?

A. **Modulation:**

The process of combining audio frequency signal with high frequency signal is called **Modulation**.

Need for modulation:

The signals in communication (speech, music etc) are at low frequency and cannot be transmitted to longer distance. For long distance transmission, the signals are superimposed on a high frequency waves called carrier waves. This process is called modulation. The process of changing some character (amplitude, frequency (or) phase) of a carrier wave in accordance with the intensity of the signal is known as modulation.

Modulation is of three types:

i) Amplitude Modulation:

In India amplitude modulation is used in radio broad - casting. The amplitude of the high frequency carrier wave is changed in accordance with the intensity of the signal, frequency being constant.

ii) Frequency Modulation:

In T.V. transmission, frequency modulation is used for sound signal and amplitude modulation is used for picture signal. The frequency of the carrier wave is changed in accordance with the intensity of the signal, amplitude being same. In frequency modulation, power loss will be least and noise can be reduced.

iii) Phase Modulation:

Phase of the carrier wave changes in accordance with the modulating signal.

6. What should be the size of the antenna or aerial? How the power radiated is related to length of the antenna and wavelength?

A. **(i) Size of Antenna:** For transmitting a signal we need an antenna. Each antenna should have a size comparable to wavelength of signal (at least $\lambda/4$ in size)

For example, for a signal of frequency $\nu = 20kHz$

Length of antenna or wavelength $\lambda = \frac{c}{\nu} = \frac{3\times10^8}{20\times10^3} = 15km$

(ii) Effective power radiated by antenna: The power emitted by linear antenna of length l while emitting radio waves of wavelength λ is

$$P \propto \left(\frac{l}{\lambda}\right)^2$$

For signals of low frequency, wavelength λ is large and power (P) is small.

For good transmission we require high power and hence high frequency signal is required

7. Explain amplitude modulation?

A. In amplitude modulation the amplitude of the carrier is varied in accordance with the information signal.

Let c(t) = $A_e \sin \omega_c t$ represent carrier wave and $m(t) = A_m \sin \omega_m t$ represent the frequency the message or the modulating signal where $\omega_m = 2\pi f_m$ is the angular frequency of the message signal. The modulated signal c_m(t) can be written as

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

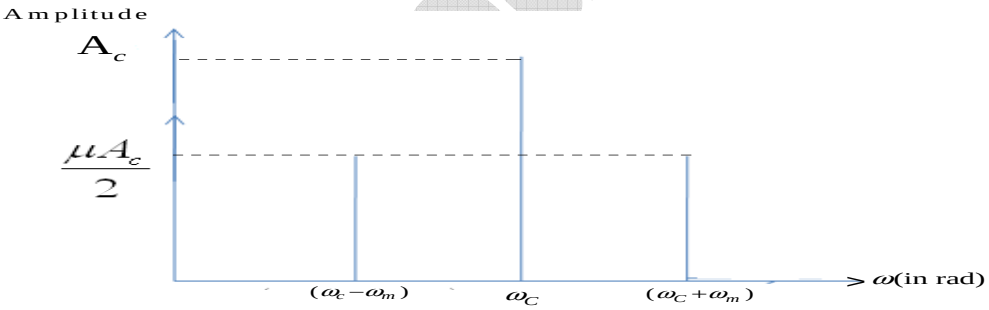
$$= A_c \left(1 + \frac{A_m}{A_e} \sin \omega_m t\right) \sin \omega_c t$$

(Or) $c_m(t) = A_e \sin \omega_e t + \mu A_e \sin \omega_m t \sin \omega_e t$

Here $\mu = A_m / A_e$ is the modulation index, μ in practice, is kept ≤ 1 to avoid distortion.

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

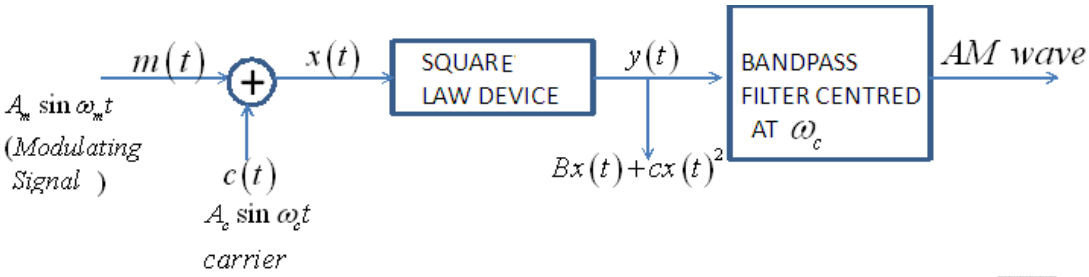
Here $\omega_c - \omega_m$ and $\omega_c + \omega_m$ are respectively called the lower side and upper side frequencies. The modulated signal now consists of the carrier wave of frequency ω_c plus two sinusoidal wave each with a frequency slightly different from, known as side bands. The frequency spectrum of the amplitude modulated signal is shown in figure.



As long as the broadcast frequencies are sufficiently space out so that sidebands do not overlap, different stations can operate without interfering with each other.

8. How can an amplitude modulated wave be generated?

Amplitude modulation can be produced by a variety of methods. One of the simplest method is shown in the block diagram



Let the modulating signal be represented by $m(t) = A_m \sin \omega_m t$. ... (1)

Let the carrier signal be represented by $c(t) = A_c \sin \omega_c t$ ... (2)

The resulting signal obtained by adding above equations i.e.,

$$x(t) = A_m \sin \omega_m t + A_c \sin \omega_c t \quad \text{... (3)}$$

Let x(t) is passed through a square law device which is a non-linear device which produces and output

$$y(t) = B\,x(t) + C\left[x(t)\right]^2 \quad \text{... (4)}$$

Where B and C are constants. Thus,

$$y(t) = BA_m \sin \omega_m t + BA_c \sin \omega_c t + C\left[A_m^2 \sin^2 \omega_m t + A_c^2 \sin^2 \omega_c t + 2A_m A_c \sin \omega_m t \sin \omega_c t\right]$$

$$= BA_m \sin \omega_m t + BA_c \sin \omega_c t + \frac{CA_m^2}{2} + A_c^2 - \frac{CA_m^2}{2}\cos 2\omega_m t - \frac{CA_c^2}{2}\cos 2\omega_c t + CA_m A_c \cos(\omega_c - \omega_m)t$$

$$-CA_m A_c \cos(\omega_c + \omega_m)t$$

The output $y(t)$ consist of one dc component $\frac{C}{2}\left(A_m^2 + A_c^2\right)$ and six sinusoids of frequencies $\omega_m, 2\omega_m, \omega_c, 2\omega_c, \omega_c - \omega_m$ *and* $\omega_c + \omega_m$.

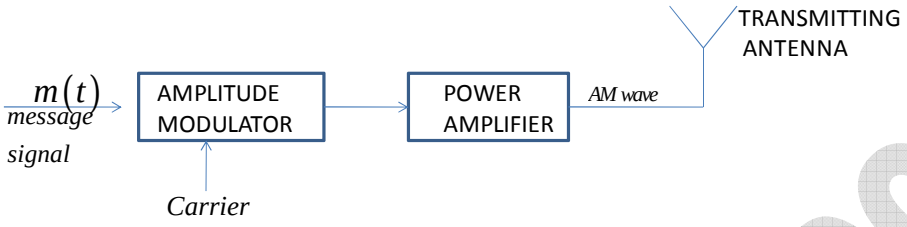
When this signal is passed through a band pass filter centered at ω_c which rejects dc and the sinusoids of frequencies $\omega_m, 2\omega_m,$ *and* $2\omega_c$ are allows the frequencies

$\omega_m, \omega_c - \omega_m$ *and* $\omega_c + \omega_m$.

The output of the band pass filter is

$$y'(t) = BA_c \sin \omega_c t + CA_m A_c \cos(\omega_c - \omega_m)t - CA_m A_c \cos(\omega_c + \omega_m)t$$

Clearly, $y'(t)$ has the same form as that of an AM wave. The AM signal generated by the modulator cannot be transmitted as such as it has to be provided necessary power to cover the desired range. This is done by feeding the AM signal to a power amplifier. The amplified AM signal is fed to an antenna of appropriate size for onward transmission.

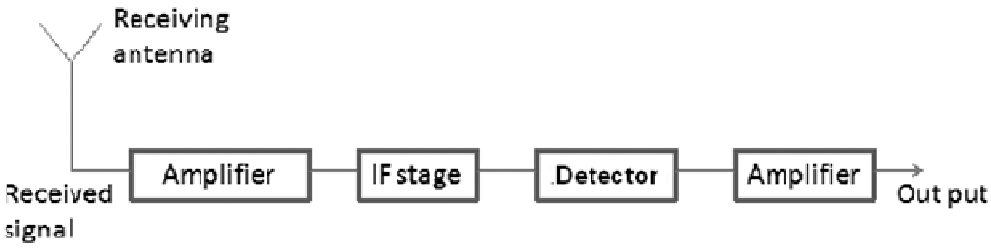


9. How can an amplitude modulated wave be detected?

A. The process of recovering the modulating signal from the modulated carrier wave is called detection and the circuit that performs this function is called a detector.

The transmitted message gets attenuated in propagating through the channel. The receiving antenna is followed by amplifier and a detector. The carrier frequency is changed to a lower frequency called Intermediate Frequency (IF) preceding detection. The detected signal may not be strong enough, hence amplification is required.

A block diagram of a typical receiver is shown in the figure

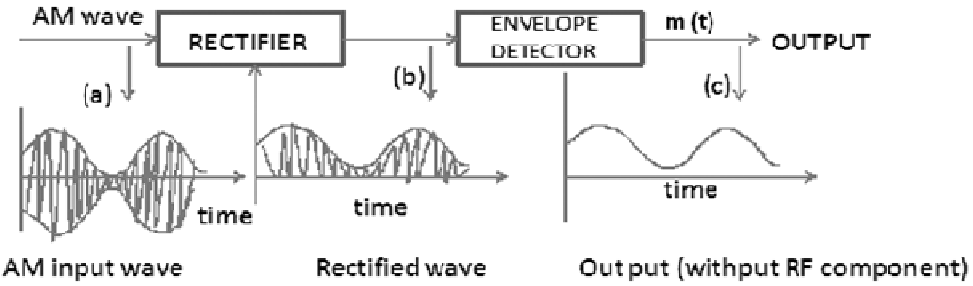


The IF signal contains the frequencies ω_c *and* $\omega_c \pm \omega_m$. To obtain original message signal m(t) of angular frequency ω_m, simple AM detector is shown in diagram.

The AM wave from the IF stage is passed through a rectifier (diode) which produces rectified wave.

The envelope of this rectified wave has a frequency ω_m and is the message signal m (t).

The rectified signal passed through an envelope detector to retrieve m (t) as shown in figure.



The modulated signal of the form given in (a) of fig is passed through a rectifier to produce the output shown in (b). This envelope of signal (b) is the message signal. In order to retrieve m (t), the signal is passed through an envelope detector (which may consist of a simple RC circuit).

PROBLEMS

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

Sol. $d_m = \sqrt{2\times 64\times 10^5 \times 32} + \sqrt{2\times 64\times 10^5 \times 50}\ m$

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

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

2. **A message signal of frequency 10 kHz and peak voltage of 10 volts is used to modulate a carrier of frequency 1 MHz and peak voltage of 20 volts Determine (a) Modulation Index, (b) The Side Bands Produced**

Sol. (a) Modulation index = 10/20 = 0.5

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