CHAPTER – 15

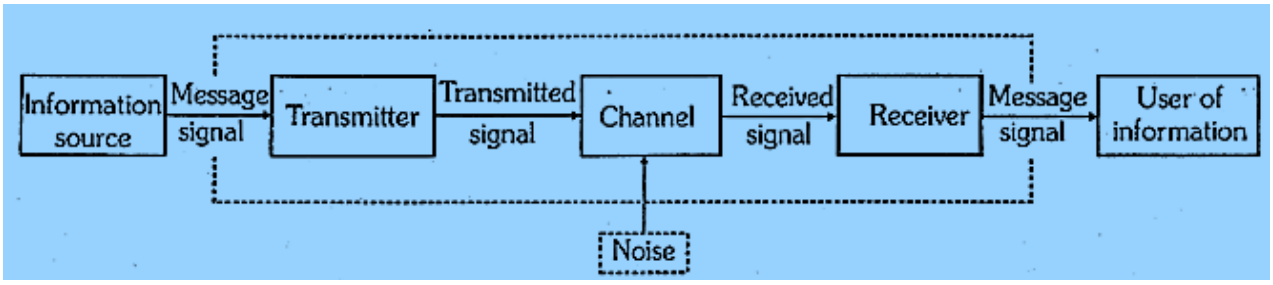
COMMUNICATION SYSTEMS

Communication means transmission of information. Everyone experiences the need to impart or receive Information continuously in the surrounding and for this , we speak, listen, send message by a messenger, use coded signaling methods through smoke or flags or beating of drum etc. and these days we are using telephones, TV, radio, satellite communication etc.

Propagation Of Light

Every communication system has three essential elements –

(i) transmitter
(ii) medium/ channel
(iii) receiver



Transmitter converts the message signal into an electric signal and transmits through channel. The receiver receives the transmitted signal and reconstructs the original message signal to the end user. There are two basic modes of communication:

(i) point-to-point and

(ii) broadcast.

In point-to-point communication mode, communication takes place over a link between a single transmitter and a single receiver as in telephony. In the broadcast mode, there are a large number of receivers corresponding to a single transmitter. Radio and television are most common examples of broadcast mode of communication.

Basic terminology Used in Electronic Communication systems:

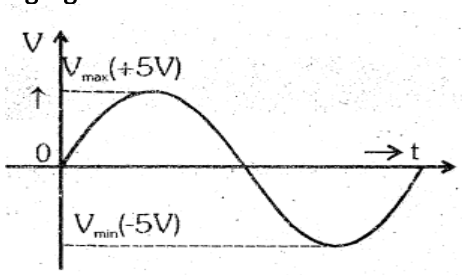
(i) Transducer. Transducer is the device that converts one form of energy into another. Microphone, photo detectors and piezoelectric sensors are types of transducers.

(ii) Signal - Signal is the information converted in electrical form. Signals can be analog or digital. Sound and picture signals in TV are analog.

It is defined as a single-valued function of time which has a unique value at every instant of time.

Signals are two types:

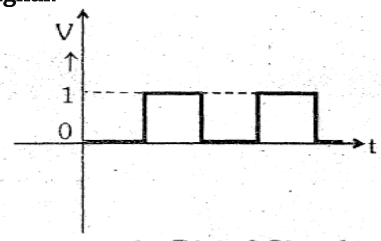
(a) Analog Signal:



An Analog Signal

A continuously varying signal (Voltage or Current) is called an analog signal. A decimal number with system base 10 is used to deal with analog signal.

(b) Digital Signal:-



An Digital Signal

A signal that can have only discrete stepwise values is called a digital signal. A binary number system with base 2 is used to deal with digital signals.

(iii) Noise: There are unwanted signals that tend to disturb the transmission and processing of message signals. The source of noise can be inside or outside the system.

(iv) Transmitter: A transmitter processes the incoming message signal 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: It is the loss of strength of a signal while propagating through a medium. It is like damping of oscillations.

(vii) Amplification: It is the process of increasing the amplitude (and therefore the strength) of a signal using an electronic circuit called the amplifier. Amplification is absolutely necessary to compensate for the attenuation of the signal in communication systems.

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

(ix) Bandwidth: It is 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 distance. So, at the transmitter end, 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.

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

(xii) Repeater: A repeater acts as a receiver and a transmitter. A repeater picks up the signal which is coming from the transmitter, amplifies and retransmits it with a change in carrier frequency. Repeaters are necessary to extend the range of a communication system as shown in figure. A communication satellite is basically a repeater station in space.

Bandwidth

Bandwidth of signals:

Different signals used in a communication system such as voice, music, picture, computer data etc. all have different ranges of frequency. The difference of maximum and minimum frequency in the range of each signal is called bandwidth of that signal.

Bandwidth can be of message signal as well as of transmission medium.

(i) Bandwidth for analog signals

Signal	Frequency range	Bandwidth required
Speech Music Picture TV	300–3100 Hz High frequencies produced by musical instrument Audible range = 20 Hz – 20 kHz Contains both voice and picture	3100–300 = 2800 Hz 20 kHz 4.2 MHz 6 MHz

(ii) Bandwidth for digital signal

Basically, digital signals are rectangular waves and these can be splited into a superposition of sinusoidal waves of frequencies n_0, $2n_0$, $3n_0$, $4n_0$, nn_0, where n is an integer extending to infinity. This implies that the infinite band width is required to reproduce the rectangular waves. However, for practical purposes, higher harmonics are neglected for limiting the bandwidth.

Propagation Of Electromagnetic Waves

In case of radio waves communication, an antenna at the transmitter radiates the electromagnetic waves (em waves). The em waves travel through the space and reach the receiving antenna at the other end. As the em wave travels away from the transmitter, their strength keeps on decreasing. Many factors influence the propagation of em waves including the path they follow.

Ground Wave Propagation:

(a) The radio waves which travel through atmosphere following the surface of earth are known as ground waves or surface waves and their propagation is called ground wave propagation or surface wave propagation.

(b) The ground wave transmission becomes weaker with increase in frequency because more absorption of ground waves takes place at higher frequency during propagation through atmosphere.
(c) The ground wave propagation is suitable for low and medium frequency i.e., up to 2 or 3 MHz only.
(d) The ground wave propagation is generally used for brand broadcasting and is commonly called medium wave.
(e) The maximum range of ground or surface wave propagation depends on two factors:
(I) The frequency of the radio waves and
(ii) Power of the transmitter.

Sky Wave Propagation:

(a) The sky waves are the radio waves of frequency between 2 MHz to 30 MHz
(b) The ionospheric layer acts as a reflector for a certain range of frequencies (3 to 30 MHz). Electromagnetic waves of frequencies higher than 30 MHz penetrate the ionosphere and escape.
(c) The highest frequency of radio waves which when sent straight (i.e., normally) towards the layer of ionosphere gets reflected from ionosphere and returns to the earth is called critical frequency. It is given by $f_c = 9\ (N_{max})^{1/2}$, where N is the number density of electron/m^3.

Space wave propagation:

(a) The space waves are the radio waves of very high frequency (i.e., between 30 MHz to 300 MHz or more).
(b) The space waves can travel through atmosphere from transmitter antenna to receiver antenna either directly or after reflection from ground in the earth's troposphere region. That is why the space wave propagation is also called as tropospheric propagation or line of sight propagation.
(c) The range of communication of space wave propagation can be increased by increasing the heights of transmitting and receiving antenna.
(d) If the transmitting antenna is at a height h_T, then you can show that the distance to the horizontal d_T is given as $\boxed{d_T = \sqrt{2Rh_T}}$, where R is the radius of the earth (approximately 6400 km). d_T is also called the radio horizon of transmitting antenna. The maximum line–of sight distance d_M between the two antenna having heights h_T and h_R above the earth is given by:

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

where h_R is the height of receiving antenna.

Modulation

It is a process by which any electrical signal called input / baseband or modulating signal, is mounted onto another signal of high frequency which is known as carrier signal.

It is defined as the process by which some characteristic (called parameter) of carrier signal is varied in accordance with the instantaneous value of the baseband signal.
The signal which results from this process is known as modulated signal.

Need for Modulation:

(I) To avoid interference:

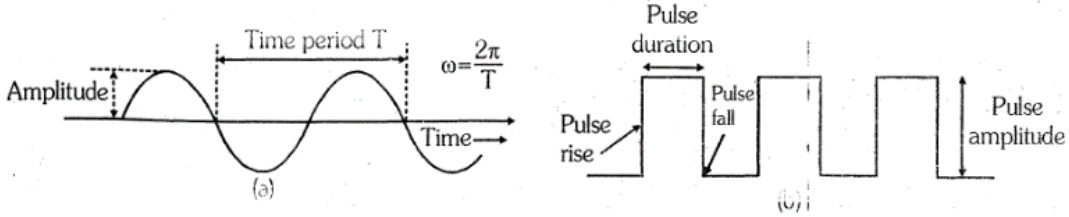
If many modulating signals travel directly through the same transmission channel, they will interfere with each other and result in distortion.

(ii) To design antennas of practicable size:

The minimum height of antenna (not of antenna tower) should be l/4 where l is wavelength of modulating signal. This minimum size becomes impracticable because the frequency of the modulating signal can be up to 5 kHz which corresponding to a wavelength of
$3 \times 10^8/5\times 10^3 = 60$ km. This will require an antenna of the minimum height of l/4 = 15 km. This size of an antenna is not practical.

(iii) Effective Power Radiated by an Antenna:

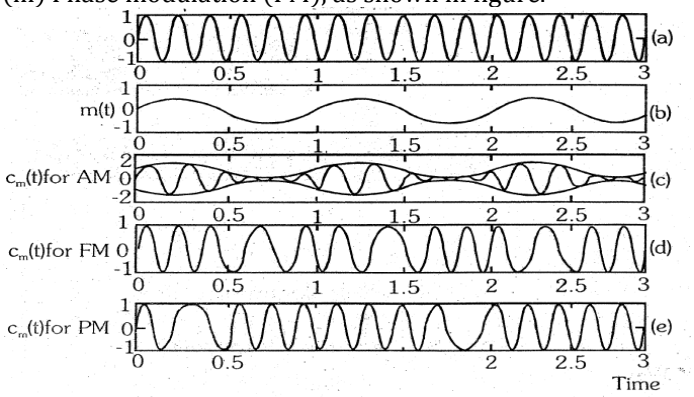
A theoretical study of radiation from a linear antenna (length l) shows that the power radiated is proportional to $(\text{frequency})^2$ i.e. $(l/l)^2$. For a good transmission, we need high powers and hence this also points out to the need of using high frequency transmission.
The above discussion suggests that there is a need for translating the original low frequency baseband message signal into high frequency wave before transmission. In doing so, we take the help of a high frequency signal, which we already know now, is known as the carrier wave, and a process known as modulation which attaches information to it. The carrier wave may be continuous (sinusoidal) or in the form of pulses, as shown in figure.



Carrier wave: sinusoidal

A sinusoidal carrier wave can be represented as
$c(t) = A_C \sin(w_c t + f)$
where c(t) is the signal strength (voltage or current), A_C is the amplitude, w_c (= $2pf_c$) is the angular frequency and f is the initial phase of the carrier wave. Thus, modulation can be affected by varying, any of three parameters, viz A_c, w_c and f, of the carrier wave can as per the parameter of the message or information signal. This results in three types of modulation:

(i) Amplitude modulation (AM)
(ii) Frequency modulation (FM) and
(iii) Phase modulation (PM), as shown in figure.



Modulation of a carrier wave : (a) a sinusoidal carrier wave (b) a modulating signal : (c) amplitude modulation : (d) frequency modulation : and (e) phase modulation

Amplitude Modulation

In amplitude modulation the amplitude of the carrier is varies in accordance with the information signals. Let $c(t) = A_c \sin w_c t$ represent carrier wave and $m(t) = A_m \sin w_m t$ represents the message or the modulating signal where $w_m = 2pf_m$ is the angular frequency of the message signal. The modulated signal $c_m(t)$ can be written as

$$c_m(t) = (A_c + A_m \sin w_m t) \sin w_c t$$

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

Here **$m = A_m/A_c$ is the modulation index**

$V_{max.} = A_c + A_m$ (See figure)

$V_{min.} = A_c - A_m$

$$\mu = \frac{V_{max.} - V_{min}}{V_{max.} + V_{min}}$$

In practice, m is kept £ 1 to avoid distortion.

Using the trigonometric relation $\sin A \sin B = \frac{1}{2}[\cos(A-B) - \cos(A+B)]$, we can write $c_m(t)$ of eq. (b) as

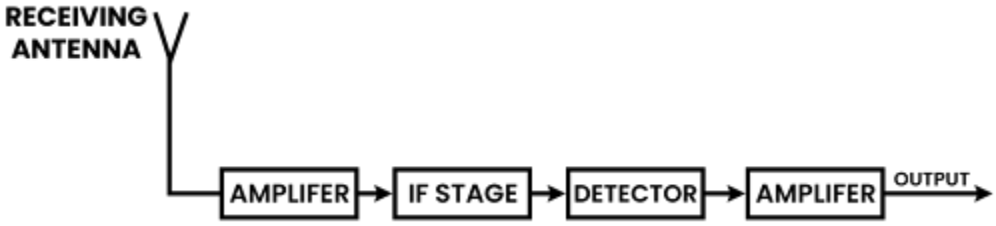
$$c_m(t) = A_c \sin\omega_c t + \frac{\mu A_c}{2}\cos(\omega_c - \omega_m)t - \frac{\mu A_c}{2}\cos(\omega_c + \omega_m)t$$

Power in AM Wave: -

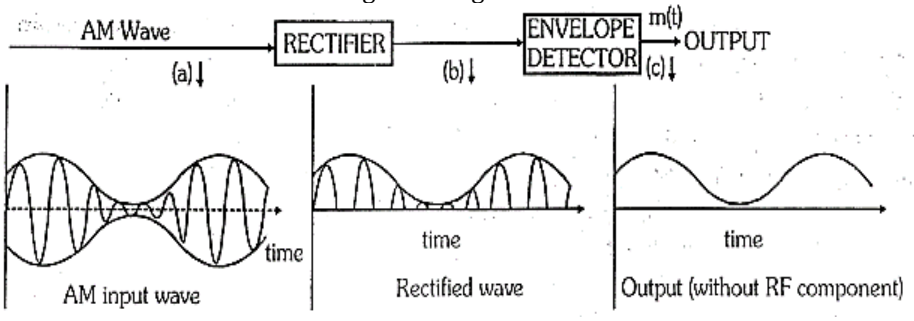
Power of carrier wave: $P_c = \frac{V_c^2}{2R}$; R

Detection of Amplitude Modulated Wave:

The transmitted message gets attenuated in propagating through the channel. The receiving antenna is therefore to be followed by an amplifier and a detector. In addition, to facilitate further processing, the carrier frequency is usually changed to a lower frequency by what is called an intermediate frequency (IF) stage preceding the detection. The detected signal may not be strong enough to be made use of and hence in required to be amplitude. A block diagram of a typical receiver is shown in figure.



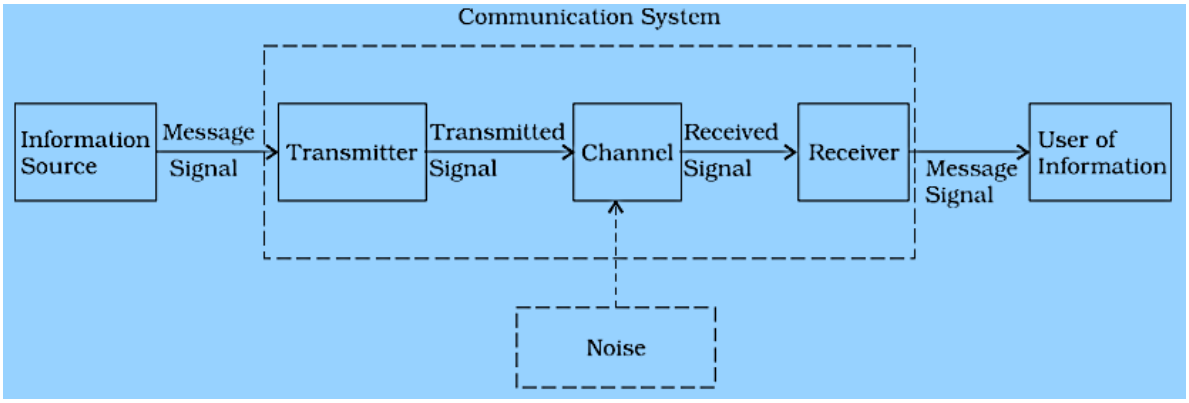
Detection is the process of recovering the modulating signal from the modulated carrier wave. We just saw that the modulated carrier wave contains the frequencies w_c and $w_c \pm w_m$. In order to obtain the original message signal m(t) of angular frequency w_m, a simple method is shown in the form of a block diagram in figure.



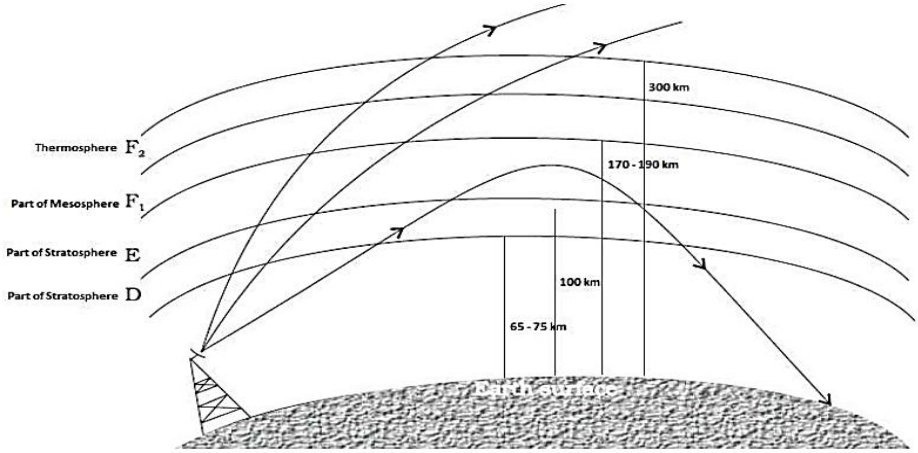
The modulated signal of the form given in (a) of above figure is passed through a rectifier to produce the output shown in (b). This envelope of signal (b) is the message signal in order to retrieve m(t), the signal is passed through an envelope detector (which may consist of a simple RC circuit).

SUMMARY

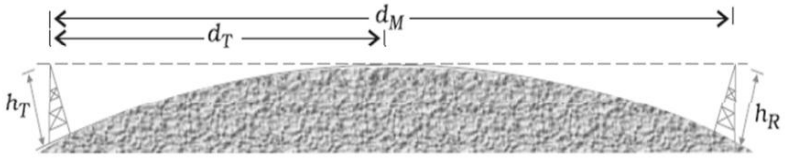
- **Elements of Communication:**



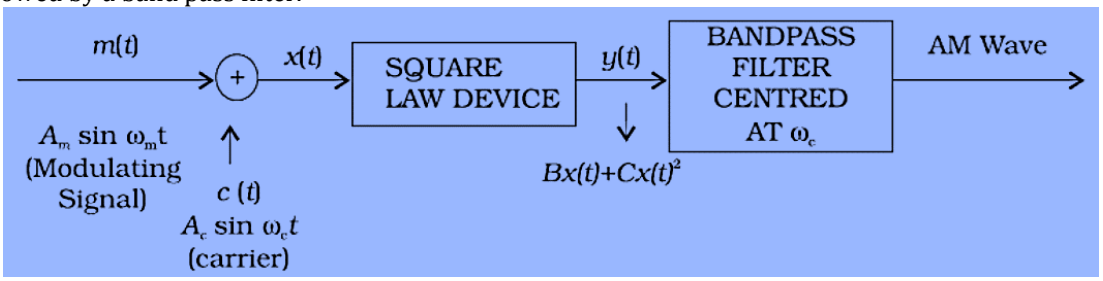
- **Two Basic Modes of Communication:**
  (a) Point to point
  (b) Broadcast
- **Point to Point Mode of Communication:**
  Here, communication takes place over a link between a single transmitter and a receiver. Telephony is an example of such a mode of communication.
- **Broadcast Mode of Communication:**
  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.
- **Operational advantages of digital communication system over analog communication systems:**
  1. An improved security messages.
  2. Increased immunity to noise and external interference.
  3. A common format for encoding different kinds of message signals for the purpose of transmission.
  4. Flexibility in configuration digital communication system.
- **Basic Terminology used in Electronic Communication Systems:**
  Transducer, signal, noise, transmitter, receiver, attenuation, amplification, range, bandwidth, modulation, demodulation, repeater
- **Undesirable Effects in the Source of Signal Transmission:**
  Attenuation, distortion, interference and noise are the undesirable effects in the source of signal transmission.
- **Bandwidth of Signals:**
  (a) The speech signal requires a bandwidth of 2800 Hz (3100 Hz – 300 Hz) for commercial telephonic communication.
  (b) For frequencies produced by musical instruments, the audible range of frequencies extends from 20 Hz to 20 kHz.
  (c) Video signals for transmission of pictures require about 4.2 MHz of bandwidth.
  (d) A TV signal contains both voice and picture and is usually allocated 6 MHz of bandwidth for transmission.
- **Bandwidth of Transmission Medium:**
  The commonly used transmission media are wire, free space and fiber optic cable.
- **Propagation of Electromagnetic Waves:**
  For transmission over long distances, signals are radiated into space using devices called antennas. The radiated signals propagate as electromagnetic waves and the mode of propagation is influenced by the presence of the earth and its atmosphere. Near the surface of the earth, electromagnetic waves propagate as surface waves. Surface wave propagation is useful up to a few MHz frequencies. Long distance communication between two points on the earth is achieved through reflection of electromagnetic waves by ionosphere. Such waves are called sky waves. Sky wave propagation takes place up to frequency of about 30 MHz. Above this frequency, electromagnetic waves essentially propagate as space waves. Space waves are used for line-of-sight communication and satellite communication.



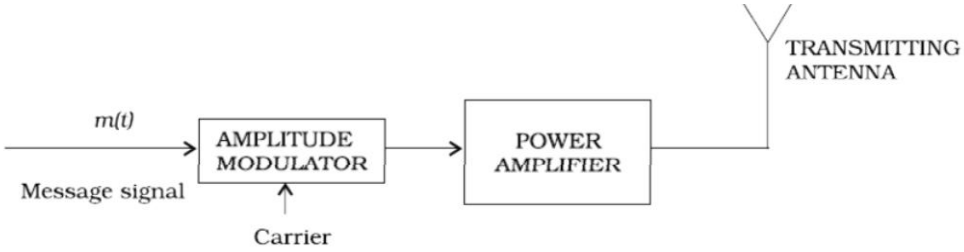
- **Radio Wave Propagation is by Space Waves:**



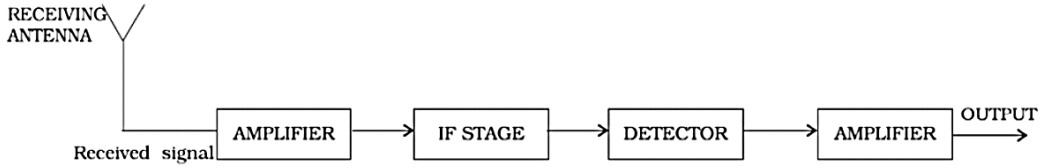
- **Modulation:**
  The process of changing some characteristic such as amplitude, frequency or phase of a carrier wave in accordance with the intensity of the signal is known as modulation.
- **Types of Modulation:**
  (a) Amplitude modulation
  (b) Frequency modulation
  (c) Phase modulation.
- **Amplitude Modulation:**
  The amplitude of the carrier wave changes according to the intensity of the signal. The amplitude variation of the carrier wave is at the signal frequency f_s.
- **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.



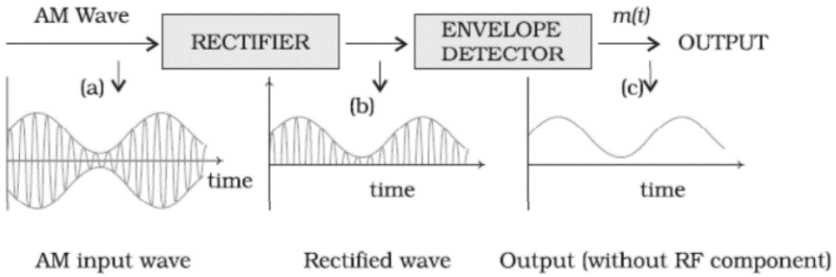
- **Modulation Factor:**
  The ratio of change of amplitude of carrier wave to the amplitude of normal carrier wave is called modulation factor (m).
- **Classification of Pulse Modulation:**
  Pulse modulation could be classified as: Pulse Amplitude Modulation (PAM), Pulse Duration Modulation (PDM) or Pulse Width Modulation (PWM) and Pulse Position Modulation (PPM).
- **Demodulation:**
  Demodulation is the process of recovering the signal intelligence from a modulated carrier wave.
- **Transmitter:**



- **Receiver:**

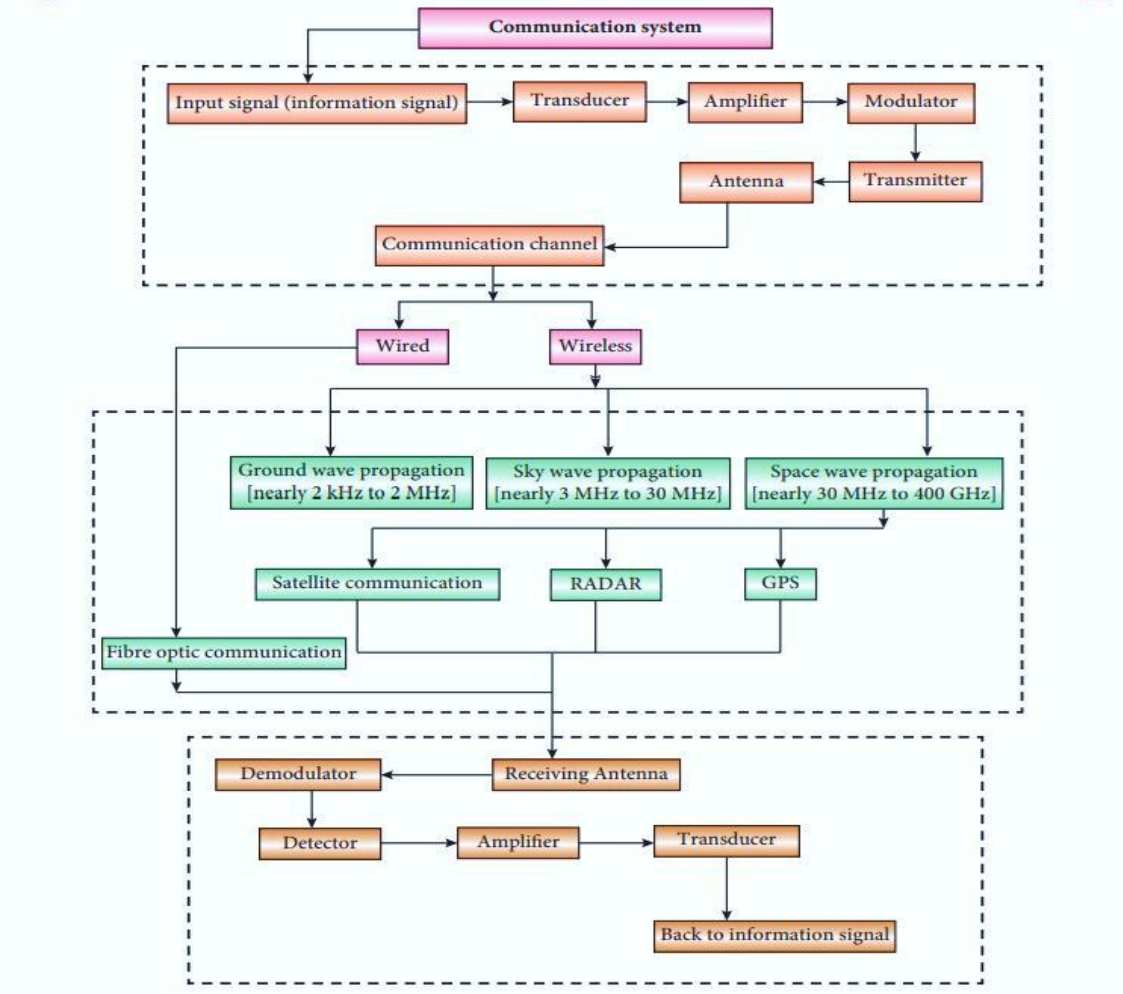


- **Detection of an AM signal:**
  AM detection, which is the process of recovering the modulating signal from an AM waveform, is carried out using a rectifier and an envelope detector.



- **Internet:**
  It permits communication and sharing of all types of information between any two or more computers connected through a large and complex network. The application includes,
  (a) E- mail
  (b) File transfer
  (c) WWW
  (d) E- commerce
  (e) Chat
- **Mobile Telephony:**
  The concept of this system is to divide the service area into a suitable number of cells centered on an office called MTSO (Mobile Telephone Switching Office). Each cell contains a low-power transmitter called a base station and caters to a large number of mobile receivers (popularly called cell phones). When a mobile receiver crosses the coverage area of one base station, it is necessary for the mobile user to be transferred to another base station. This procedure is called handover or handoff.
- **Facsimile (FAX):**
  It scans the contents of a document (as an image, not text) to create electronic signals. These signals are then sent to the destination (another FAX machine) in an orderly manner using telephone lines. Then the signals are reconverted into a replica of the original document

MIND MAP


Communication system
Input signal (information signal)
Transducer
Amplifier
Modulator
Antenna
Transmitter
Communication channel
Wired
Wireless
Ground wave propagation [nearly 2 kHz to 2 MHz]
Sky wave propagation [nearly 3 MHz to 30 MHz]
Space wave propagation [nearly 30 MHz to 400 GHz]
Satellite communication
RADAR
GPS
Fibre optic communication
Demodulator
Receiving Antenna
Detector
Amplifier
Transducer
Back to information signal

PRACTICE EXERCISE

MCQ

Q1. A transducer used at the transmitting end, serves the purpose of converting
(a) electrical signal to sound form
(b) sound signal to electrical form
(c) electrical signal to magnetic form
(d) sound signal to magnetic form

Q2. During the process of transmission and reception the signal gets deteriorated due to
(a) noise introduced in the system
(b) distortion in the system
(c) both (a) and (b)
(d) neither (a) nor (b)

Q3. Reception of information involves
(a) decoding of signal
(b) storage of signal
(c) interpretation of signal
(d) All of the above

Q4. The term channel is used to indicate
(a) the amplitude range allocated to a given source
(b) the frequency range allocated to a given source
(c) the voltage-range allocated to a given source
(d) All of the above

Q5. There is a need of translating the information contained in our original low frequency baseband signal into ...X... or ...X... frequencies before transmission. Here, X and Y referee to
(a) low, radio (b) high, radio
(c) low, audio (d) high, video

Q6. Electromagnetic waves of audible frequency ranges from
(a) 10 Hz to 10,000 Hz (b) 20 Hz to 20,000 Hz
(c) 30 Hz to 30,000 Hz (d) None of these.

Q7. Ionosphere as a whole is
(a) +vely charges (b) –vely charges
(c) electrically neutral (d) can't say

Q8. Space wave communication is limited
(a) to the line-of-sight distance
(b) by earth's curvature
(c) either (a) or (b)
(d) both (a) and (b)

Q9. During ground wave propagation the transmitted waves gets attenuated because
(a) earth surface absorbs the waves
(b) frequency of the waves is too low
(c) energy content of these waves is high
(d) earth surface offers resistance

Q10. Long range propagation is not possible by space wave propagation because
(a) height of troposphere is quite small
(b) height of troposphere is large
(c) troposphere absorbs transmitted wave
(d) None of these.

ASSERTION AND REASONING

Directions: Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.
(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

Q1. Assertion: Amplification is necessary to compensate for the attenuation of the signal in communication system.
Reason: Amplification is the process of increasing the amplitude and consequently the strength of signal using an electronic circuit.

Q2. Assertion: The loss of strength of a signal while propagating through a medium is known as attenuation.
Reason: Transmitter helps to avoid attenuation.

Q3. Assertion: Telephony is an example of point-to-point communication mode.
Reason: In point-to-point communication modes, communication takes places over a link between a single transmitter and a receiver.

SHORT ANSWER QUESTIONS

Q1. A separate high freq. wave (i.e., carrier wave) is needed in modulation why?

Q2. Name the essential, components of a communication system.

Q3. Name the two basic modes of communication system.

Q4. Why is sky wave propagation of signals restricted to a frequency of 30 MHz?

Q5. State two reasons why high frequency carrier waves are needed in transmitting a message signal.

NUMERICAL TYPE QUESTIONS

Q1. How many AM broadcast stations can be accommodated in a 100 kHz bandwidth if the highest modulating frequency is 5 kHz.

Q2. A modulated carrier wave has maximum and minimum amplitudes of 800 mV and 200 mV. What is the percentage modulation?

HOMEWORK EXERCISE

MCQ

Q1. Wave obtained on superimposition of audible frequency e.m. wave is known as
(a) carrier wave (b) high frequency wave
(c) modulating wave (d) modulated wave

Q2. Picture signal of TV-signal is
(a) amplitude modulated (b) frequency modulated
(c) phase modulated (d) pulse modulated

Q3. In frequency modulation
(a) the amplitude of modulated wave varies as frequency of carrier wave
(b) the frequency of modulated wave varies as amplitude of modulating wave
(c) the frequency of modulated wave varies as frequency of modulating wave
(d) the frequency of modulated wave varies as frequency of carrier wave

Q4. The function of an amplitude limitter in an FM-receiver is
(a) to reduce the amplitude of the signal to suit IF amplifier
(b) to amplify low frequency signal
(c) to eliminate any change in amplitude of receiver FM signal
(d) None of these

Q5. Pre-emphasis in FM system is done to
(a) compress modulating signal
(b) expand modulating signal
(c) amplify lower frequency component of the modulating signal
(d) amplify higher frequency component of the modulating signal

Q6. The service area of space wave communication increases by
(a) increasing the height of transmitting antenna
(b) decreasing the height of receiving antenna
(c) increasing the height of both transmitting and receiving antenna
(d) decreasing the distance between transmitting and receiving antenna

Q7. 100% modulation in FM means
(a) actual frequency deviation > maximum allowed frequency deviation
(b) actual frequency deviation = maximum allowed frequency deviation
(c) actual frequency deviation t maximum allowed frequency deviation
(d) actual frequency deviation < maximum allowed frequency deviation

Q8. Which of the following frequencies will be suitable for beyond-the-horizon communication using sky waves?
(a) 10kHz (b) 10MHz
(c) 1GHz (d) 1000GHz

Q9. Frequencies in the UHF range normally propagate by means of:
(a) Ground waves. (b) Sky waves.
(c) Surface waves. (d) Space waves.

Q10. What should be the maximum acceptance angle at the air core interface of an optical fiber if n_1 and n_2 are the refractive indices of the core and the cladding, respectively
(a) $\sin^{-1}(n_2/n_1)$ (b) $\sin^{-1}\sqrt{n_1^2 - n_2^2}$
(c) $\left[\tan^{-1}\frac{n_2}{n_1}\right]$ (d) $\left[\tan^{-1}\frac{n_1}{n_2}\right]$

Q11. Audio signal cannot be transmitted because
(a) The signal has more noise
(b) The signal cannot be amplified for distance communication
(c) The transmitting antenna length is very small to design
(d) The transmitting antenna length is very large and impracticable

Q12. In frequency modulation
(a) The amplitude of modulated wave varies as frequency of carrier wave
(b) The frequency of modulated wave varies as amplitude of modulating wave
(c) The amplitude of modulated wave varies as amplitude of carrier wave
(d) The frequency of modulated wave varies as frequency of modulating wave

Q13. The phenomenon by which light travels in an optical fiber is
(a) Reflection (b) Refraction
(c) Total internal reflection (d) Transmission

Q14. In an FM system a 7 kHz signal modulates 108 MHz carrier so that frequency deviation is 50 kHz. The carrier swing is
(a) 7.143 (b) 8
(c) 0.71 (d) 350

Q15. In a communication system, noise is most likely to affect the signal
(a) At the transmitter
(b) In the channel or in the transmission line
(c) In the information source
(d) At the receiver

ASSERTION AND REASONING

Directions: Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

Q1. Assertion: The information contained in our original low frequency baseband signal is to be translated into high or radio frequencies before transmission.
Reason: For transmitting a signal, the antenna should have a size comparable to the wavelength of the signal.

Q2. Assertion: When the height of a TV transmission tower is increased by three times, the range covered is doubled.
Reason: The range covered is proportional to the height of the TV transmission tower.

Q3. Assertion: Microwave communication is preferred over optical communication.
Reason: Information carrying capacity is directly proportional to bandwidth.

Q4. Assertion: FM broadcast is better than AM broadcast
Reason: Noise change is maximum in the amplitude of AM waves

Q5. Assertion**:** Television signals are not received through sky-wave propagation.
Reason**:** The ionosphere reflects electromagnetic waves of frequencies greater than a certain critical frequency.

Q6. Assertion: The electromagnetic waves of shorter wavelength can travel longer distances on earth's surface than those of longer wavelengths.
Reason**:** Shorter the wavelength, the larger is the velocity of wave propagation.

Q7. Assertion**:** A dish antenna is highly directional.
Reason**:** This is because a dipole antenna is omni directional.

SHORT ANSWER QUESTIONS

Q1. What is ground wave propagation?

Q2. What does the term 'attenuation' used in communication system mean?

Q3. Give one example of point-to-point communication mode.

Q4. Define the term 'modulation index' in communication system.

Q5. Which basic mode of communication is used for telephonic communication?

NUMERICAL TYPE QUESTIONS

Q1. The electron density of a layer of ionosphere at a height 150 km from the earth's surface is 9×10^9 per m^3. For the sky transmission from this layer up to a range of 250 km, find the critical frequency of the layer.

Q2. For sky wave propagation of a 10 MHz signal, what should be the minimum electron density in ionosphere?

PRACTICE EXERCISE SOLUTIONS

MCQ

S1. **(b)** The message from the information source may not be in electrical form so to convert this information i.e., in form of sound to electrical form a transducer like a microphone is used.

S2. **(c)** Noise the unwanted energy and distortion both occurring at various stage of a system leads to deterioration of signal as signal to noise ratio becomes so poor that signal becomes unintelligible and useless.

S3. **(d)** The received signals is either AM or FM so it needs to be demodulated i.e., decoded to get back original signal. It also needs to be stored and interpreted at receiving end

S4. **(b)** Channel indicate frequency range at which different R.F. signals all transmitted.

S5. **(b)** There is a need of translating the information contained in our original low frequency baseband signal into high or radio frequencies before transmission.

S6. **(b)** Sound waves such as speech or song etc. that a human being can hear ranges from 20 Hz to 20 kHz frequencies above 20 kHz cannot be heard by human ear.

S7. **(c)** Ionosphere contain free electron & + ve ions. In equilibrium, the no. of free electron is equal to the number of positive ions. So as a whole it is electrically neutral.

S8. **(d)** The space wave propagation is limited due to the line-of-sight distance and by the curvature of the earth.

S9. **(d)** During ground wave propagation of radio waves, a charge induced on the earth's surface which takes the form of current as the wave propagate. The earth offers resistance in the flow of induced current due to which the waves are attenuated

S10. **(a)** space wave propagation takes place in such a way that the radio waves transmitted at an angle from earth's surface gets reflected by the troposphere and then reaches the receiving antenna since the height of troposphere is quite small, long-range propagation by this mode is not possible.

ASSERTION AND REASONING

S1. **(a):** Amplification is necessary to compensate for the attenuation of the signal in communication systems.

S2. **(c):** A transmitter processes the incoming message signal, so as make it suitable for transmission through a channel and subsequent reception.

S3. **(a)**

SHORT ANSWER QUESTIONS

S1. This is because we cannot change any of the characteristics (amplitude, frequency or phase) of the audio signal as this would change the message to be communicated. So, keeping the audio signal same, the amplitude of freq. or phase of the high freq. carrier wave is modified in accordance with the modulating (i.e., audio signal) signal.

S2. Transmitter, medium (channel) and receiver are three essential components of communication system.

S3. Point to Point Communication and Broadcast are the two basic modes of communication.

S4. Sky wave propagation of signals is restricted to a frequency of 30 MHz, because waves of frequency greater than 30 MHz get penetrated through the ionosphere and thus, they do not get reflected by it.

S5. For the following reasons, high frequency carrier waves are needed in transmitting a message signal:

1. Length of transmitting antenna is short.
2. Power radiated is more.
3. Mixing of signals can be avoided.

NUMERICAL TYPE QUESTIONS

S1. Any station being modulated by a 5 kHz signal will produce an upper side frequency 5 kHz above its carrier and the lower side frequency 5 kHz below its carrier, thereby requiring a bandwidth of 10 kHz.

S2. Number of stations accommodated $= \frac{Total\ \text{bandwidth}}{\text{Bandwidth per station}} = \frac{100}{10} = 10$

S2. Percentage modulation

$$= \left(\frac{A_{max} - A_{min}}{A_{max} + A_{min}}\right) \times 100 = \left(\frac{800 - 200}{800 + 200}\right) \times 100$$

$$= \frac{600}{1000} \times 100 = 60\%$$

HOMEWORK EXERCISE SOLUTIONS

MCQ

S1. (d) On superimposition of two waves the audible frequency wave is the modulating wave and radio wave is the carrier wave, thus the resultant wave obtained is known as modulated wave as it is obtained by the process of modulation

S2. (a) Picture signal in amplitude modulated to avoid complication in development of transmitter & receiver structure.

S3. (b) In frequency modulation the frequency of the modulated wave is the linear function of the amplitude of the modulating wave.

S4. **(c)** The limiter removes from the carrier all amplitude variations which may cause by changes in the transmission path, by man-made static or natural static. This suppression of amplitude variation is necessary because FM-receives, a vary large improvement in S/ N results from this.

S5. (d) Pre-emphasis of higher frequency component is required in FM-system because high frequency terms of modulating signal have small amplitude and therefore small power relative to those of low frequency term.

S6. (c) Maximum range of space wave propagation

$$d = \frac{4}{3} \times 1.23\left[\sqrt{H_t} + \sqrt{H_r}\right]$$

$$\Rightarrow \quad d \propto H_t$$

$$d \propto H_r$$

$\therefore$ d increases if H_t and H_r i.e., height of transmitting and receiving antenna increases.

S7. (b)

$$m = \frac{\text{actual frequency deviation}}{\text{max. allowed frequency deviation}} \times 100\%$$

$$= \frac{(\Delta f) \text{ actual}}{(\Delta f)\, m} \times 100\%$$

$$\text{if } (\Delta f) \text{ actual } = (\Delta f)\, m$$

$$m = 100\%$$

S8. (b) 10MHz

For beyond-the-horizon communication, it is necessary for the signal waves to travel a large distance. 10KHz signals cannot be radiated efficiently because of the antenna size. The high energy signal waves $(1GHz - 1000GHz)$ penetrate the ionosphere. 10MHz frequencies get reflected easily from the ionosphere. Hence, signal waves of such frequencies are suitable for beyond-the-horizon communication.

S9. (d) Space waves Owing to its high frequency, an ultra-high frequency (UHF) wave can neither travel along the trajectory of the ground nor can it get reflected by the ionosphere. The signals having UHF are propagated through line-of-sight communication, which is nothing but space wave propagation.

S10. **(b)** Core of acceptance angle $\theta = \sin^{-1}\sqrt{n_1^2 - n_2^2}$

S11. **(d)** Following are the problems which are faced while transmitting audio signals directly.

(i) These signals are relatively of short range.

(ii) If *every* body started transmitting these low frequency signals directly, mutual interference will render all of them ineffective.

(iii) Size of antenna required for their efficient radiation would be larger *i.e.* about 75 *km*.

S12. **(b)** The process of changing the frequency of a carrier wave (modulated wave) in accordance with the audio frequency signal (modulating wave) is known as frequency modulation (FM).

S13. **(c)** In optical fibre, light travels inside it, due to total internal reflection.

S14. **(a)** Carrier swing $= \frac{\text{Frequency deviation}}{\text{Modulating frequency}} = \frac{50}{7} = 7.143$

S15. **(b)** In the channel or in the transmission line

ASSERTION AND REASONING

S1. **(a):** For transmitting a signal, we need an antenna or an aerial. This antenna should have a size comparable to the wavelength of the signal so that the antenna properly senses the time variation of the signal. For an electromagnetic wave frequency 20 kHz, the wavelength is 15 km. Obviously such a long antenna is not possible to construct and operate. Hence direct transmission of such baseband signals is not practical. Therefore, there is a need of translating the information contained in our original low frequency baseband signal into high or radio frequencies before transmission.

S2. **(c):** The range covered is not proportional to the height of the TV transmission tower. The range depends directly on square root of the height of the antenna i.e.

$S \propto \sqrt{h}$.

Let the height of the TV transmission tower be h and h' which covers the range S and S' respectively.

$\therefore\ S = \sqrt{2hR}$ and $S' = \sqrt{2h'R}$

For $S' = 2S$ i.e. $\sqrt{2h'R} = 2\sqrt{2h'R}$

S3. **(a):** Microwave communication is preferred over optical communication because microwave provide large number of channels and wide bandwidth compared to optical signals as information carrying capacity is directly proportional to bandwidth. So wider the bandwidth greater the information carrying capacity

S4. (a) FM broadcast is better than AM broadcast because in AM broadcast electric signals superimpose with the main signal. Both assertion and reason are correct and the reason is the correct explanation for the assertion. Hence, A is the correct option.

S5. (d) TV signals (frequency greater than 30 MHz) cannot be propagated through sky wave propagation.
Above critical frequency, an electromagnetic wave penetrates the ionosphere and is not reflected by it.

S6. (d) The electromagnetic waves of shorter wavelength do not suffer much diffraction from the obstacles of earth's atmosphere so they can travel long distance.
Also, shorter the wavelength, shorter is the velocity of wave propagation.

S7. (b) A dish antenna is a directional antenna because it can transmit or signals in all direction.

SHORT ANSWER QUESTIONS

S1. A radio wave that can travel directly from one point to another following the surface of the earth is called a ground wave propagation. Ground wave propagation is possible only when the transmitting and receiving antenna are close to the surface of the earth.

S2. Attenuation used in communication system means loss of strength of a signal during its propagation through the communication channel.

S3. Example of point-to-point communication mode : Telephone

S4. Modulation index is defined as the ratio of amplitude of modulating signal to the amplitude of carrier wave, i.e.,

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

S5. Point to point communication mode is used for telephonic communication.

NUMERICAL TYPE QUESTIONS

S1. $f_c = 9\sqrt{\mathrm{N_m}} = 9 \times \sqrt{9 \times 10^{10}}$
$= 2.7 \times 10^6$ Hz $= 2.7$ MHz

S2. The critical frequency of a sky wave for reflection from a layer of atmosphere is given by
$f_c = 9(N_{\max})1^{1/2}$
$\Rightarrow 10 \times 10^6 = 9(N_{\max})1^{1/2}$
$\Rightarrow N_{\max} = \left(\frac{10 \times 10^6}{9}\right)^2 \simeq 1.2 \times 10^{12}\ m^{-3}$