CONTENTS

PRINCIPLES OF COMMUNICATION SYSTEM

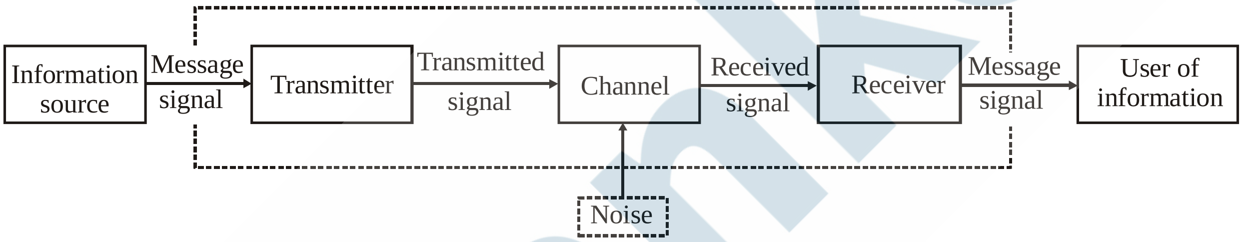
1. INTRODUCTION

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 signalling methods through smoke or flags or beating of drum etc. and these days we are using telephones, TV, radio, satellite communication etc. The aim of this chapter is to introduce the concepts of communication namely the mode of communication, the need for modulation, production and detection of amplitude modulation.

Elements of a Communication System :

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 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 braoadcast mode of communication. However the communication system can be classified as follows :

Types of Communication Systems

- On the basis of nature of Information
  - (1) Speech Transmission (Radio)
  - (2) Picture Transmission (TV)
  - (3) Fascimile Transmission (FAX)
  - (4) Data Transmission (Internet)
- On the basis of signal transmitted
  - (1) Analog
  - (2) Digital
- On the basis of transmission Channel
  - (1) Line communication
    - (a) Two wire Transmission line
    - (b) Coaxial cable
    - (c) Optical fibre
  - (2) Space communication
- On the basis of type of modulation
  - (1) Continuous wave modulation
    - (a) Amplitude
    - (b) Frequency
    - (c) phase
  - (2) Pulse Modulation
    - (a) PAM
    - (b) PTM — PPM, PWM
    - (c) PCM

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 transducer. They convert information into electrical signal.

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

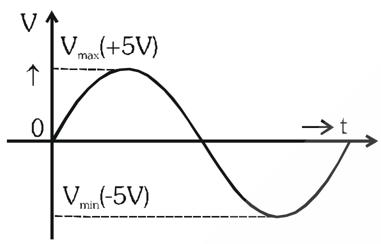
It is defined as a single–valued function of time which has a unique value at every instant of time.

(1) Analog Signal :–

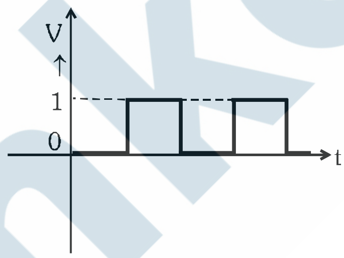
A continuously varying signal (Voltage or Current) is called an analog signal. A decimal number with system base 10 is used to deal with analog signal.

(2) 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.



An Analog Signal



An Digital Signal

(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 signals 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.

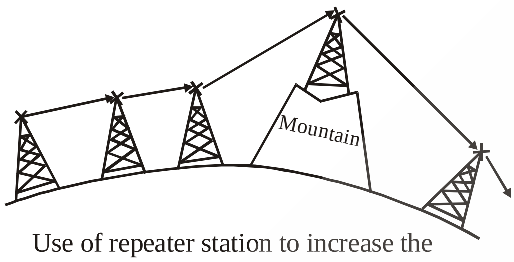
(viii) Range : It is the largest distance between the source and the destination upto which the signal gets received with sufficient strength.

(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 connot be transmitted to long distances. 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.



Use of repeater station to increase the range of communication

BANDWIDTH

Bandwidth of signals :

Different signals used in a comminication 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

Bandwdith for some analog sinals are listed below :

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

(ii) Bandwidth for digital signal

Basically digital signals are rectanglar waves and these can be splitted into a superposition of sinusoidal waves of frequencies ν_0, $2\nu_0$, $3\nu_0$, $4\nu_0$, $n\nu_0$, 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

Band width of Transmission Medium

Different types of transmission media offer different band width in which some of are listed below

Frequency Bands			
	Service	**Frequency range**	**Remarks**
1	Wire (most common : Coaxial Cable)	750 MHz (Bandwidth)	Normally operated below 18 GHz
2	Free space (radio waves)	Few hundred kHz to GHz	
	(i) Standard AM broadcast	540kHz -1600 kHz	
	(ii) FM	88-108 MHz	
	(iii) Television	54-72 MHz 76-88 MHz 174-216 MHz 420-890 MHz	VHF (Very) high frequencies) TV UHF (Ultra hight frequency) TV
	(iv) Cellular mobile radio	896-901 MHz 840-935 MHz	Mobile to base Station Base station to mobile
	(v) Satellite Communication	5.925-6.425 GHz 3.7 - 4.2 GHz	Uplinking Downlinking
3	Optical communication using fibres	1THz-1000 THz (microwaves-ultra violet)	One single optical fibre offers bandwidth > 100 GHz

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. The composition of the earth's atmosphere also plays a vital role in the propagation of em waves, as summarised below.

Table 4 Layers of atmosphere and their interaction with the propagating em waves

Atmospheric stratum (layer)	Height over earth's surface (approx)	Exists during	Frequencies most likely affected
1. Troposphere	10 km	Day and night	VHF (upto several GHz)
2. Ionosphere			
(i) D (part of stratosphere)	65-75 km	Day only	Reflects LF, absorbs MF & HF to some degree
(ii) E (part of stratosphere)	100 km	Day only	Helps surface waves, reflects HF
(iii) F_1 (Part of Mesosphere)	170-190 km	Daytime, merges with F_2 at night	Partially absorbs HF waves yet allowing them to reach F_2
(iv) F_2 (Thermosphere)	300 km at night, 250-400 km during daytime	Day and night	Efficiently reflects HF waves particularly at night

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 suitabel for low and medium frequency i.e. upto 2 or 3 MHz only.

(d) The ground wave propagation is generally used for local band 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 ionoopheric 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 radiowaves which when sent straight (i.e. normally) towards the layer of ionosphere gets refelcted from ionosphere and returns to the earth is called critical frequency.. If 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 radiowaves 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 derectly or after reflection from ground in the earth's troposphere region. That is why the space wave propagation is also called as tropospherical 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 maximum line-of sight distance d_m between the two antennas 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 aviod interference :

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

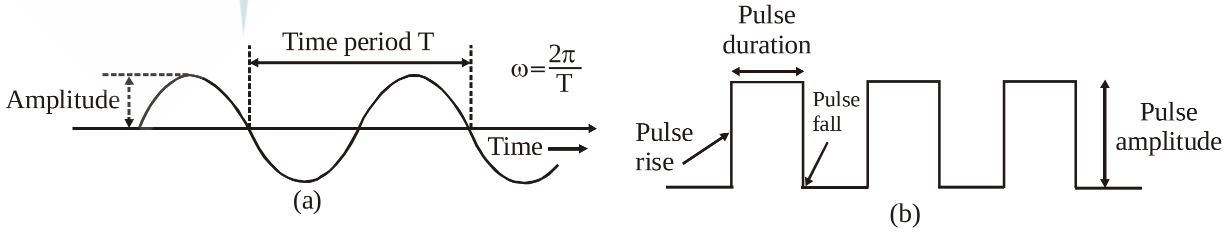
(ii) To design antennas of practicable size :

The minimum height of antenna (not of antenna tower) should be $\lambda/4$ where λ is wavelength of modulating signal. This minimum size becomes impracticable because the frequency of the modulating signal can be upto 5 kHz which corresponds to a wavelength of $3 \times 10^8/5 \times 10^3 = 60$ km. This will require an antenna of the minimum height of $\lambda/4 = 15$ 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 (frequency)^2 i.e. $(\ell/\lambda)^2$. 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

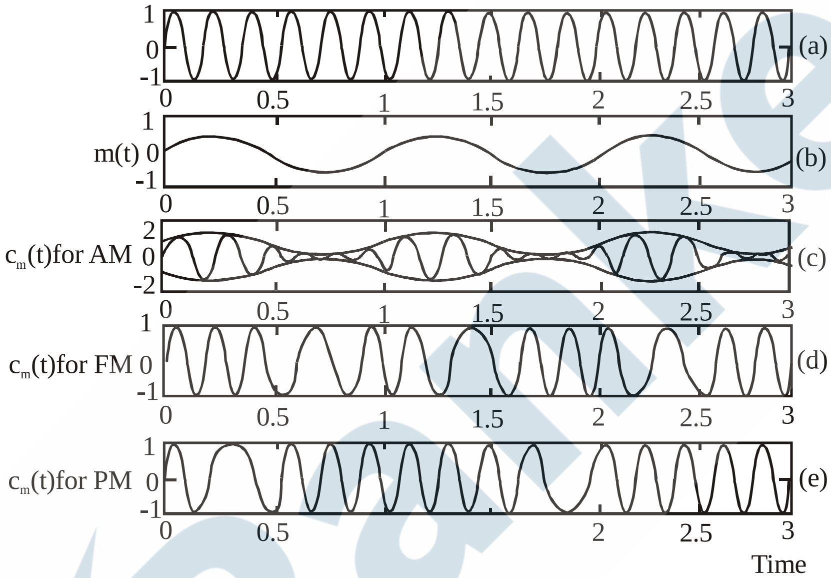


Carrier wave : Sinusoidal

A sinusoidal carrier wave can be represented as

$c(t) = A_C \sin(\omega_c t + \phi)$

where c(t) is the signal strength (voltage or current), A_C is the amplitude, ω_c $(= 2\pi f_c)$ is the angular frequency and ϕ is the initial phase of the carrier wave. Thus, modulation can be affected by varying, any of three parameters, viz A_c, ω_c and ϕ, 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 modulatin :
(d) frequency modulation : and (e) phase modulation

Carrier Wave Pulses :

Similarly, the significant characteristics of a pulse are : Pulse Amplitude, Pulse duration or pulse Width, and pulse Position (denoting the time of rise or fall of the pulse amplitude) Hence, different types of pulse modulation are (a) pulse amplitude modulation (PAM), (b) Pulse duration modulation (PDM) or pulse width modulation (PWM), and (c) Pulse position modulation (PPM).

Ex.1 A separate high freq. wave (i.e. carrier wave) is needed in modulation why ?

Ans. 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.

Amplitude Modulation :

In amplitude modulation the amplitude of the carrier is varied in accordance with the information signals. Let $c(t) = A_c \sin\omega_c t$ represent carrier wave and $m(t) = A_m \sin \omega_m t$ represent 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

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

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

Note that the modulated signal now contains the message signal & it can be written as :

$c_m(t) = A_c \sin\omega_c t + \mu A_c \sin\omega_m t \sin\omega_c t \qquad ......(2)$

Here **$\mu = A_m/A_c$ is the modulation index**

Often, μ is expressed in percentage and is called the percentage modulation. Importance of modulation index is that it determine the quality of the transmitted signal. When modulation index is small, variation in carrier amplitude will be small. Therefore, audio signal being transmitted will be weak. As the modulation index increases, the audio signal on reception becomes clearer. If the modulation index becomes greater than one, the signal gets lost partially.

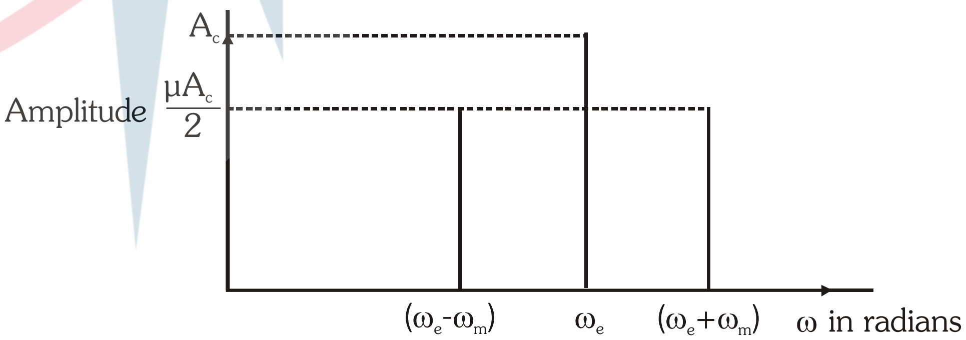
If a carrier wave is modulated by several sine waves the total modulated index m_t is given by

$$m_t = \sqrt{m_1^2 + m_2^2 + m_3^2 + ...}$$

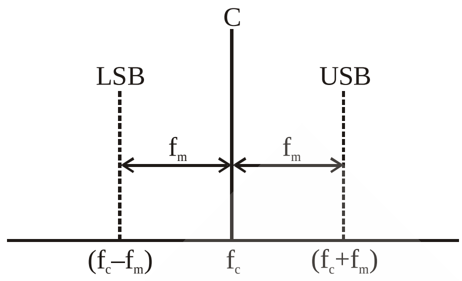
Using the trignomatric relation sinA sinB = ½ (cos (A – B) – cos (A + B), we can write $c_m(t)$ of eq. (15.4)as

$$c_m(t) = A_c \sin\omega_c t + \frac{\mu A_c}{2}\cos(\omega_c - \omega_m)\,t - \frac{\mu A_c}{2}\cos(\omega_c + \omega_m)\,t \qquad ......(3)$$

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



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



$f_{SB} = f_c \pm f_m$

$\therefore$ Frequency of lower side band is

$f_{LSB} = f_c - f_m$ ... (4)

and frequency of upper side band is

$f_{USB} = f_c + f_m$

Band width of amplitude modulated wave is

$= f_{USB} - f_{LSB}$

$= (f_f + f_m) - (f_c - f_m) = 2f_m$ .... (5)

Band width = twice the frequency of the modulating signal

Phase modulation & frequency modulation are 2 different types of angular modulation.

Power in AM waves : Power dissipated in any circuit $P = \dfrac{V_{rms}^2}{R}$

Hence : (i) Carrier power $P_c = \dfrac{\left(\dfrac{E_c}{\sqrt{2}}\right)^2}{R} = \dfrac{E_c^2}{2R}$

(ii) Total power of side bands $P_{sb} = \dfrac{\left(\dfrac{m_a E_c}{2\sqrt{2}}\right)^2}{R} \times 2 = \dfrac{m_a^2 E_c^2}{4R}$

(iii) Total power of AM wave $P_{Total} = P_c + P_{ab} = \dfrac{E_c^2}{2R}\left(1 + \dfrac{m_a^2}{2}\right)$

(iv) $\dfrac{P_t}{P_c} = \left(1 + \dfrac{m_a^2}{2}\right)$ and $\dfrac{P_{ab}}{P_t} = \dfrac{m_a^2/2}{\left(1 + \dfrac{m_a^2}{2}\right)}$

(v) Maximum power in the AM (without distortion) will occur when $m_a = 1$

i.e., $P_t = 1.5\ P = 3P_{ab}$

(vi) If I_c = Unmodulated current and I_t = total or modulated current

$$\Rightarrow \frac{P_t}{P_c} = \frac{I_t^2}{I_c^2} \Rightarrow \frac{I_t}{I_c} = \sqrt{\left(1 + \frac{m_a^2}{2}\right)}$$

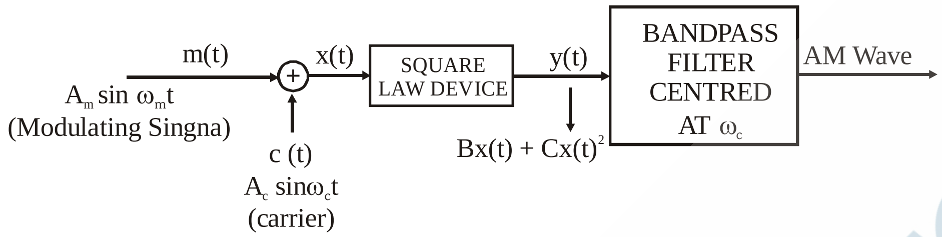
Ex.2 A message signal of frequency 10 kHz and peak voltage of 10 volts is used to modulate a carrier of frequency 1 Mhz and peak voltage of 20 volts. Determine (a) modulation index, (b) the side bands produced.

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

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

Production of Amplitude modulated Wave :

Ampitude modulation can be produced by a veriety of methods. A conceptually simple method is shown in the block diagram of figure.



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

$$y(t) = B\,x(t) + Cx^2(t) \qquad ......(4)$$

where B and C are constants. Thus,

$$y(t) = BA_m \sin\omega_m t + BA_c \sin \omega_c t$$

$$+ C\,[A_m{}^2 \sin^2 \omega_m t + A_c{}^2 \sin^2 \omega_c t + 2A_m A_c \sin\omega_m t \sin\omega_c t] \qquad ......(5)$$

$$= BA_m \sin\omega_m t + BA_c \sin \omega_c t$$

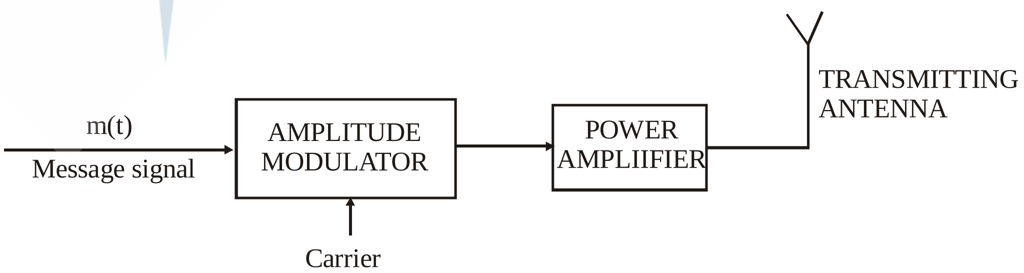
$$\frac{CA_m^2}{2} + A_c^2 - \frac{CA_m^2}{2}\cos 2\omega_m t - \frac{CA_c^2}{2}\cos 2\omega_c t$$

$$+ CA_m A_c \cos(\omega_c - \omega_m)\,t - CA_m A_c \cos(\omega_c + \omega_m)\,t \qquad ......(6)$$

where the trigonometric relations $\sin^2 A = (1 - \cos 2A)/2$ and the relation for sinA sinB mentioned earlier are used.

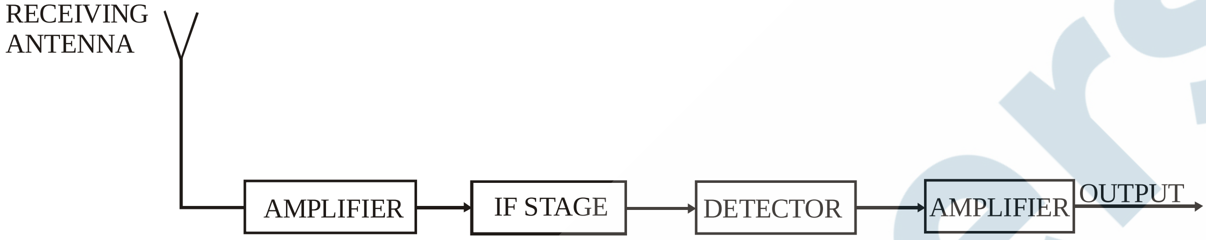
In equation (6), there is a dc term C/2 $(A_m^2 + A_c^2)$ and sinusoids of frequencies ω_m, $2\omega_m$, $\omega_c - \omega_m$ and $\omega_c + \omega_m$. The output of the band pass filter therefore is of the same form as equation (3) and is therefore an AM wave.

It is to be mentioned that the modulated signal connot be transmitted as such. The modulator is to be followed by a power amplifier which provides the necesary power and then the modulated signal is fed to an antenna of appropriate size for radiation as shown in figure.

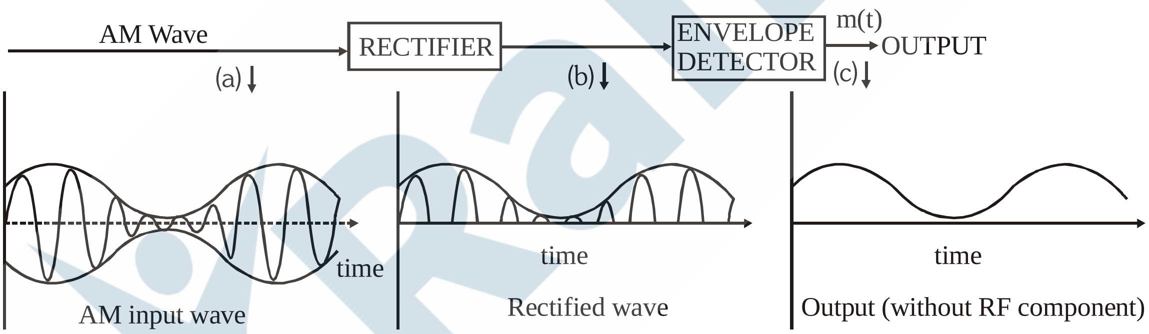


Detection of Amplitude Modulated Wave :

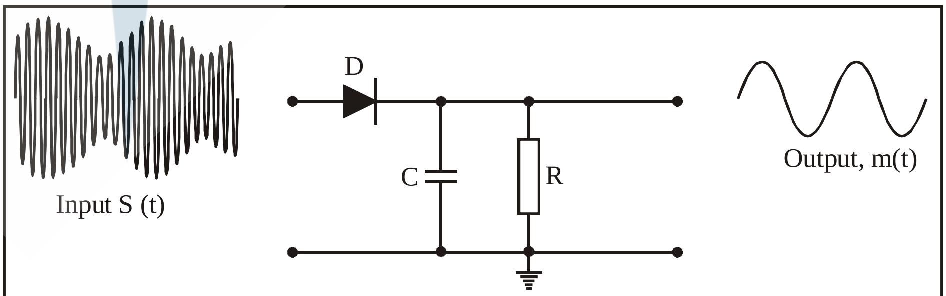
The transmitted message gets attenuated in propagating through the channel. The receiving antenna is therefore to be followed by an amplifier and a detector. In addition, to facilitate further processing, the carrier frequency is usually changed to a lower frequency by what is called an intermediate frequency (IF) stage preceding the detection. The detected signal may not be strong enough to be made use of and hence is required to be amplified. 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 ω_c and $\omega_c \pm \omega_m$. In order to obtain the original message signal m(t) of angular frequency ω_m, a simple method is shown in the from 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).



Envelope Detector (AM Demodulator/Detector)

This is essentially just a half wave rectifier which charges a capacitor to a voltage to the peak voltage of the incoming AM waveform, S(t). When the input wave's amplitude increases, the capacitor voltage in increased via the rectifying diode. When the input's amplitude falls, the capacitor voltage is reduced by being discharged by a 'bleed' resistor, R. The main advantage of this form of AM Demodulator is that it is very simple and cheap!

The circuit relies upon the behaviour of the diode-allowing current through when the input is +ve with respect to the capacitor voltage, hence 'topping up' the capacitor voltage to the peak level, but blocking any current from flowing back out through the diode when the input voltage is below the capacitor voltage.

Consider what happens when we have a carrier frequency, f_c, and use an envelope detector whose time constant, $\tau = (RC)$. The time between successive peaks of the carrier will be $T = \frac{1}{f_c}$

Each peak will charge the capacitor to some voltage, V_{peak}, which is proportional to the modulated amplitude of the AM wave. Between each peak and the next the capacitor voltage will therefore be discharged to

$$V'_{peak} = V_{peak}\ \mathrm{Exp}\ \{-T/\tau\}$$

which, provided that $T << \tau$, is approximately the same as

$$V'_{peak} \approx V_{peak}\ [1-T/\tau]$$

The peak-to-peak size of the ripple, ΔV, will therefore be

$$\Delta V \approx \frac{V_{peak} T}{\tau} = \frac{V_{peak}}{f_c \tau}$$

A sudden, large reduction in the amplitude of the input AM wave means that capacitor charge isn't being 'topped up' by each cycle peak. The capacitor voltage therefore falls exponentially until it reaches the new, smaller, peak value. In practice the modulating signal is normally restricted to a specific frequency range. This limits the maximum rate of fall of the AM wave's amplitude. We can therefore hope to avoid negative peak clipping by arranging that the detector's time constant $\tau << t_m$ where

$$t_m = 1/f_m$$

and f_m is the highest modulation frequency used in a given situation.

The above implies that we can avoid negative peak clipping by choosing a small value of τ. However, to minimise ripple we want to make τ as large as possible. In practice we should therefore choose a value

$$1/f_m >> \tau >> 1/f_c$$

to minimise the signal distortions caused by these effects. This is clearly only possible if the modulation frequency $f_m << f_c$. Envelope detector only work satisfactorily when we ensure this inequality is true. With the modulation index and the resistor the capacitor can be computed by

$$C \le \frac{\sqrt{\left(\frac{1}{m}\right)^2 - 1}}{2\pi R f_m (\max)}$$

EXERCISE-S

1. Is it necessary for a transmitting antenna to be at the same height as that of the receiving antenna for 'line-of-sight communication? A TV transmitting antenna is 81m tall. How much service area can it cover if the receiving antenna is at the ground level?

2. 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%?

3. For an amplitude modulated wave, the maximum amplitude is found to be 10V while the minimum amplitude is found to be 2V. Determine the modulation index μ.

4. If the sum of the heights of transmitting and receiving antennas in line of sight of communication is fixed at h, show that the range is maximum when the two antennas have a height h/2 each.

EXERCISE-O

SINGLE CORRECT TYPE QUESTIONS

1. If a carrier wave of 1000 kHz is used to carry the signal, the length of transmitting antenna will be equal to :-

(A) 3 m (B) 30m (C) 300 m (D) 3000 m

2. The maximum range of ground or surface wave propagation depends on :-

(A) the frequency of the radio waves only (B) power of the transmitter only

(C) both of them (D) none of them

3. For television broadcasting, the frequency employed is normally :-

(A) 30-300MHz (B) 30-300 GHz (C) 30-300KHz (D) 30-3OOHz-

4. The audio signal :-

(A) can be sent directly over the air for large distance

(B) cannot be sent directly over the air for large distance

(C) possess very high frequency

(D) none of the above

5. For a carrier frequency of 100 kHz and a modulating frequency of 5 kHz what is the width of AM transmission-

(A) 5 kHz (B) 10kHz (C) 20 kHz (D) 200 KHz

6. Three waves A, B and C of frequencies 1600 kHz, 5 MHz and 60 MHz, respectively are to be transmitted from one place to another. Which of the following is the most appropriate mode of communication :

(A) A is transmitted via space wave while B and C are transmitted via sky wave.

(B) A is transmitted via ground wave, B via sky wave and C via space wave.

(C) B and C are transmitted via ground wave while A is transmitted via sky wave.

(D) B is transmitted via ground wave we while A and C are transmitted via space wave.

7. A speech signal of 3kHz is used to modulate a carrier signal of frequency 1 MHz, using amplitude modulation. The frequencies of the side bands will be

(A) 1.003 MHz and 0.997 MHz. (B) 3001 kHz and 2997 kHz.

(C) 1003 kHz and 1000 kHz. (D) 1 MHz and 0.997 MHz.

8. A message signal of frequency ω_m is superposed on a carrier wave of frequency ω_e to get an amplitude mediated wave (AM) The frequency of the AM wave will be

(A) ω_m (B) ω_e (C) $\frac{\omega_e + \omega_m}{2}$ (D) $\frac{\omega_e - \omega_m}{2}$

9. A basic communication system consists of

(A) transmitter (B) information source. (C) user of information.

(D) channel (E) receiver.

Choose the correct sequence in which these are arranged in a basic communication system :-

(A) ABCDE (B) BADEC (C) BDACE (D) BEADC

10. **Statement 1 :** Skywave can not be observed on moon.

Statement 2 : Atmosphere of variable refractive index is require for propagation of skywave.

(A) Both Statement-1 and Statement-2 are true, and Statement-2 is the correct explanation of Statement-1

(B) Both Statement-1 and Statement-2 are true but Statement-2 is not the correct explanation of Statement- 1.

(C) Statement-1 is true but Statement-2 is false.

(D) Statement-1 is false but Statement-2 is true.

11. **Statement 1 :** Ground wave communication is effective only allow frequencies in the range 500kHz to about 1500 kHz.

Statement 2 : The decrease in the intensity of the signal due to absorption by the earth and its atmosphere is higher for higher frequencies.

(A) Both Statement-1 and Statement-2 are true, and Statement-2 is the correct explanation of Statement-1.

(B) Both Statement-1 and Statement-2 are true but Statement-2 is not the correct explanation of Statement-I .

(C) Statement-1 is true but Statement-2 is false.

(D) Statement-1 is false but Statement-2 is true.

MULTIPLE CORRECT TYPE QUESTIONS

12. An audio signal of I5kHz frequency cannot be transmitted over long distances without modulation because

(A) the size of the required antenna would be at least 5 km which is not convenient.

(B) the audio signal cannot be transmitted through skywaves.

(C) the size of the required antenna would be at least 20 km, which is not convenient.

(D) effective power transmitted would be very low, if the size of the antenna is less than 5 km.

13. Audio sine waves of 3 kHz frequency are used to amplitude modulate a carrier signal of 1.5 MHz. Which of the following statements are true?

(A) The side band frequencies are 1506 kHz and 1494 kHz.

(B) The bandwidth required for amplitude modulation is 6kHz.

(C) The bandwidth required for amplitude modulation is 3 MHz.

(D) The side band frequencies are 1503 kHz and 1497 kHz.

EXERCISE-JM

1. This questions has Statement-1 and Statement-2. Of the four choice given after the statements, choose the one that best describes the two statements.

Statement-1 : Sky wave signals are used for long distance radio communication. These signals are in general, less stable than ground wave signals. **[AIEEE-2011]**

Statement-2 : The state of ionosphere varies from hour to hour, day to day and season to season.

(1) Statement-1 is true, Statement-2 is true, Statement-2 is the correct explanation of statement-1

(2) Statement-1 is true, Statement-2 is true, Statrment-2 is not the correct explanation of Statement-1

(3) Statement-1 is false, Statement-2 is true

(4) Statement-1 is true, Statement-2 is false

2. A radar has a power of 1 kW and is operating at a frequency of 10 GHz. It is located on a mountain top of height 500 m. The maximum distance up to which it can detect object located on the surface of the earth (Radius of earth = 6.4×10^6 m) is : **[AIEEE-2012]**

(1) 40 km (2) 64 (3) 80 km (4) 16km

3. A diode detector is used to detect an amplitude modulated wave of 60% modulation by using a condenser of capacity 250 pico farad in parallel with a load resistance 100 kilo ohm. Find the maximum modulated frequency which could be detected by it. **[JEE Main-2013]**

(1) 10.62kHz (2) 5.31 MHz (3) 5.31 kHz (4) 10.62MHz

4. A single of 5 kHz frequency is amplitude modulated on a carrier wave of frequency 2 MHz. The frequencies of the resultant signal is/are - **[JEE Main-2015]**

(1) 2005 kHz, 2000 kHz and 1995 kHz (2) 2000 kHz and 1995 kHz

(3) 2 MHz only (4) 2005 kHz and 1995 kHz

5. Choose the correct statement : **[JEE Main-2016]**

(1) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the frequency of the audio signal.

(2) In amplitude modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.

(3) In amplitude modulation the frequency of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.

(4) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.

6. In amplitude modulation, sinusoidal carrier frequency used is denoted by ω_c and the signal frequency is denoted by ω_m. The bandwidth ($\Delta\omega_m$) of the signal is such that $\Delta\omega_m << \omega_c$. Which of the following frequencies is not contained in the modulated wave ? **[JEE Main-2017]**

(1) $\omega_m + \omega_c$ (2) $\omega_c - \omega_m$ (3) ω_m (4) ω_c

7. A telephonic communication service is working at carrier frequency of 10 GHz. Only 10% of it is utilized for transmission. How many telephonic channels can be transmitted simultaneously if each channel requires a bandwidth of 5 kHz ? **[JEE Main-2018]**

(1) 2×10^4 (2) 2×10^5 (3) 2×10^6 (4) 2×10^3

CBSE PREVIOUS YEAR'S QUESTIONS

1. A.T.V. tower has a height of 400 m at a given place. Calculate as coverage range, if the radius of the earth is 6400 km. **[2; CBSE-2004]**

2. Why is shortwave bind used for long distance radio broadcast? **[1; CBSE-2004]**

3. Distinguish between analog and digital communication Write any two modulation techniques employed for the digital data. Describe briefly any one of the techniques used. **[3; CBSE-2005]**

4. A ground receiver stations receiving a signal at (a) 5MHz and (b) 100 MHz, transmitted from a ground transmitter at a height of 300 m located at a distance of 100 km. Identify whether it is coming via space wave or sky wave propagation or satellite transponder. (Given the value of radius of the earth is 6400 km and maximum electron density, N_{max} = 1012 m^{-3}).**[3; CBSE-2005]**

5. Consider an optical communication system operating at λ – 800 nm. Suppose, only 1% of the optical source frequency is the available channel band-width for optical communication. How many channels can be accommodated for transmitting **[3; CBSE-2006]**

(a) audio-signals requiring a band-width of 8 kHz,

(b) video TV signals requiring an approximate band-width of 4.5 MHz? Support your answer with suitable calculations.

6. Distinguish between frequency modulation and amplitude modulation. Why is an FM signal less susceptible to noise than an AM signal? **[3; CBSE-2006]**

7. Give any one difference between FAX and e-mail systems of communication. **[1; CBSE-2006]**

8. What is modulation? Explain the need of modulating a low frequency information signal. With the help of diagrams, differentiate between PAM and PDM. **[3; CBSE-2007]**

9. What should be the length of dipole antenna for a carrier wave of frequency 6 x 10^8 Hz? **[1; CBSE-2007]**

10. A transmitting antenna at the top of a tower has a height of 36m and the height of the receiving antenna is 49m. What is the maximum distance between them for satisfactory communication in the LOS mode? (Radius of earth = 6400km). **[3; CBSE-2008]**

11. What is meant by term ‘modulation’? Draw a block diagram of a simple modulator for obtaining an AM signal. **[2; CBSE-2009]**

12. Why is high frequency carrier waves used for transmission? **[2; CBSE-2009]**

13. By what percentage will the transmission range of a TV tower be affected when the height of tower is increased by 21%? **[12; CBSE-2009]**

14. 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% ? **[12; CBSE-2010]**

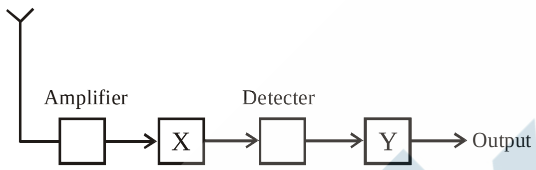
15. Which mode of propagation is used by short wave broadcast services having frequency range from a few MHz upto 30 MHz ? Explain diagrammatically how long distance communication can be achieved by this mode. Why is there an upper limit to frequency of waves used in this mode ? **[3; CBSE-2010]**

16. What is sky wave communication ? Why is this mode of propagation restricted to the frequencies only upto few MHz? **[2; CBSE-2011]**

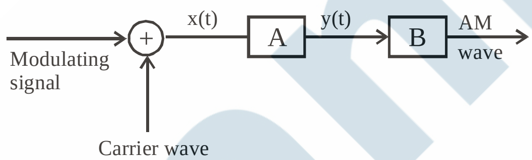
17. Write briefly any two factors which demonstrate the need for modulating a signal. Draw a suitable diagram to show amplitude modulation using a sinusoidal signal as the modulating signal. **[3; CBSE-2011]**

18. 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. **[3; CBSE-2012]**

19. In the given block diagram of a receiver, identify the boxes labeled as X and Y and write their functions. **[2; CBSE-2012]**



20. 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. **[12; CBSE-2013]**



21. 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 x 10^6m) **[3; CBSE-2013]**

22. Write the functions of the following in communication systems.

(i) Transmitter (ii) Modulator **[2; CBSE-2014]**

23. Write two basic modes of communication Explain the process of amplitude modulation. Draw a schematic sketch showing how amplitude modulated signal is obtained by superposing a modulating signal over a sinusoidal carrier wave. **[3; CBSE-2014]**

24. What is the function of a band pass filter used in a modulator for obtaining AM signal ? **[1; CBSE-2015]**

25. Differentiate between amplitude modulated (AM) and frequency modulated (FM) waves by drawing suitable diagrams. Why is FM signal preferred over AM signal ? **[2; CBSE-2015]**

26. Name the three different modes of propagation in a communication system. **[3; CBSE-2015]**

State briefly why do the electromagnetic waves with frequency range from a few MHz upto 30 MHz can reflect back to the earth. What happens when the frequency range exceeds this limit ?

27. A signal of 5 kHz frequency is amplitude modulated on a carrier wave of frequency 2 MHz. What are the frequencies of the side bands produced ? **[CBSE-2016]**

28. Why is base band signal not transmitted directly ? Give any two reasons. **[CBSE-2016]**

29. What is space wave propagation? State the factors which limit its range of propagation. Derive an expression for the maximum line of sight distance between two antennas for space wave propagation. **[CBSE-2016]**

30. (a) How is amplitude modulation achieved ?

(b) The frequencies of two side bands in an AM wave are 640 kHz and 660 kHz respectively. Find the frequencies of carrier and modulating signal. What is the bandwidth required for amplitude modulation ? **[CBSE-2017]**

31. Draw a block diagram of a generalized communication system. Write the functions of each of the following: **[CBSE-2017]**

(a) Transmitter

(b) Channel

(c) Receiver

32. Which modes of propagation is used by short wave broadchast services? **[CBSE-2018]**

33. A carrier wave of peak voltage 15 V is used to transmit a message signal. Find the peak voltage of the modulating signal in order to have a modulation index of 60%. **[CBSE-2018]**

34. (a) Give three reasons why modulation of a message signal is necessary for long distance transmission.

(b) Show graphically an audio signal, a carrier wave and an amplitude modulated wave.

[CBSE-2018]

ANSWER KEY

EXERCISE-S

1. **Ans.** No. Service area will be $A = \pi d_7^2 = \frac{22}{7} \times 162 \times 6.4 \times 10^6 = 3258 \text{ km}^2$.

2. **Ans.** $\mu = 0.75 = \frac{A_m}{A_c}$; $A_m = 0.75 \times 12 = 9V$

3. **Ans.** Since the AM wave is given by $(A_c + A_m) \sin \omega_m t) \cos \omega_m t$, the maximum amplitude is $M1 = A_c + A_m$. Hence the modulation index is

$$m = \frac{A_m}{A_c} = \frac{8}{12} = \frac{2}{3}$$

with $M_2 = 0$, clearly, $m = 1$ irrespective of M_1

EXERCISE-O

SINGLE CORRECT TYPE QUESTIONS

1. Ans. (C)	**2. Ans. (C)**	**3. Ans. (A)**	**4. Ans. (B)**	**5. Ans. (B)**	**6. Ans. (B)**
7. Ans. (A)	**8. Ans. (B)**	**9. Ans. (B)**	**10. Ans. (A)**	**11. Ans. (A)**	

MULTIPLE CORRECT TYPE QUESTIONS

12. Ans. (A,B,D) **13. Ans. (B,D)**

EXERCISE-JM

1. Ans. (1)	**2. Ans. (3)**	**3. Ans. (3)**	**4. Ans. (1)**	**5. Ans. (2)**	**6. Ans. (3)**
7. Ans. (2)					