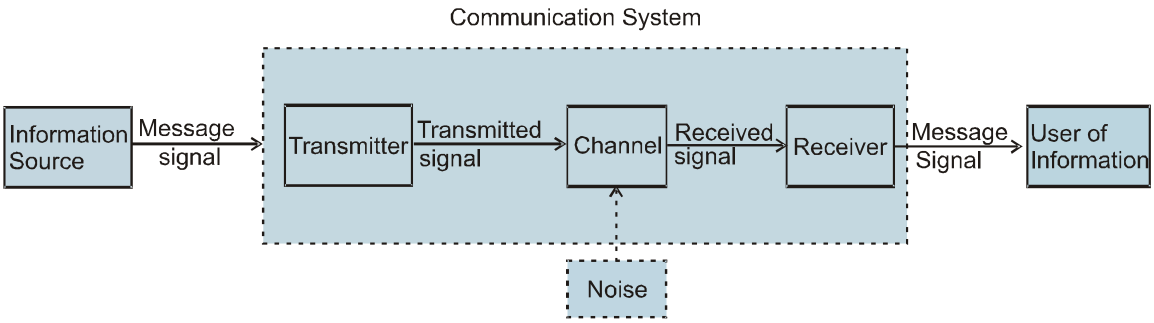
PRINCIPLE OF COMMUNICATION

INTRODUCTION

Communication is the act of transmission of information. Every living creature in the world experiences the need to impart or receive information almost continuously with others in the surrounding world. For communication to be successful, it is essential that the sender and the receiver understand a common language. Man has constantly made endeavors to improve the quality of communication with other human beings. languages and methods used in cummication have kept evolving from prehistoric to modern times, to meet the growing demands in terms of speed and complexity of information.

ELEMENTS OF A COMMUNICATION SYSTEM

Communication pervades all stages of life of all living creatures. Irrespective of its nature, every communication system has three essential elements transmitter, medium/channel and receiver. The block diagram shown in figure-1 depicts the general form of a communication system.



FIGURE–1

In a communication system, the transmitter is located at one place, the receiver is located at some other place (far or near) separate from the transmitter and the channel is the physical medium that connects them. 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. The purpose of the transmitter is to convert the message signal produced by the source of information into a form suitable for transmission through the channel. If the output of the information source is a non-electrical signal like a voice signal, a tranducer converts it to electrical form before giving it as an input to the transmitter. When a transmitted signal propagates along the channel it may get distorted due to channel imperfection. Moreover, noise adds to the transmitted signal and the receiver receives a corrupted version of the transmitted signal. The receiver has the task of operating on the received signal. It reconstructs a recognisable form of the original message signal for delivering it to the user of information.

There are two basic modes of communication : Point -to-point and broadcast.

In point-to-point communication mode, communication takes place over a link between a single transmitter and a receiver. Telephony is an example of such a mode of communication. In contrast, in the broadcast mode, there are a large number of receivers corresponding to a single transmitter. Radio and television are example of broadcast mode of communication.

(1) Digital and analog signals to be transmitted are usually of low frequency and hence cannot be transmitted as such.

(2) these signals require some carrier to be transported. These carriers are known as carrier waves or high frequency signals.

(3) The process of placement of a low frequency (LF) signal over the high frequency (HF) signal is known as modulation.

BASIC TERMINOLOGY USED IN ELECTRONIC COMMUNICATION SYSTEMS

By now, we have become familiar with some terms like information source, transmitter, receiver, channel, noise, etc. It would be easy to understand the principles underlying any communication, if we get ourselves acquainted with the following basic terminology.

(i) Transducer : Any device that converts one form of energy into another can be termed as a transducer. In electronic communication systems, we usually come across devices that have either their inputs or outputs in the electrical form. An electrical transducer may be defined as a device that converts some physical variable (pressure, displacement, force, temperature, etc) into corresponding variations in the electrical signal at its output.

(ii) Signal : Information converted in electrical form and suitable for transmission is called a signal. Signals can be either analog or digital. Analog signals are continuous variations of voltage or current. They are essentially single-valued functions of time. Sine wave is a fundamental analog signal. All other analog signals can be fully understood in terms of their sine wave components. Sound and picture signals in TV are analog in nature. Digital signals are those which can take only discrete stepwise values. Binary system that is extensively used in digital electronics employs just two levels of a signal '0' corresponds to a low level and '1' corresponds to a high level of voltage/current. There are several coding schemes useful for digital communication. They employ suitable combinations of number sytems such as the binary coded decimal (BCD). American Standard Code for Information Interchange (ASCII) is a universally popular digital code to represent numbers, letters and certain characters.

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

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

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

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

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

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

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

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

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

(xii) Repeater : A repeater is a combination of a receiver and a transmitter. A repeater, picks up the signal from the transmitter amplifies and retransmits it to the receiver sometimes with a change in carrier frequency. Repeaters are used to extend the range of a communication system as shown in figure-2 below. A communication satellite is essentially a repeater station in space.

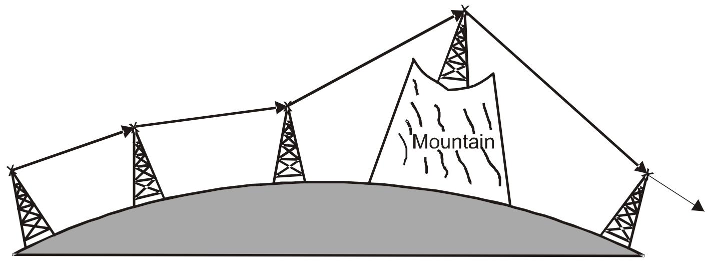


FIGURE-2 : use of repeater station to increase the range of communication

BANDWIDTH OF SIGNALS

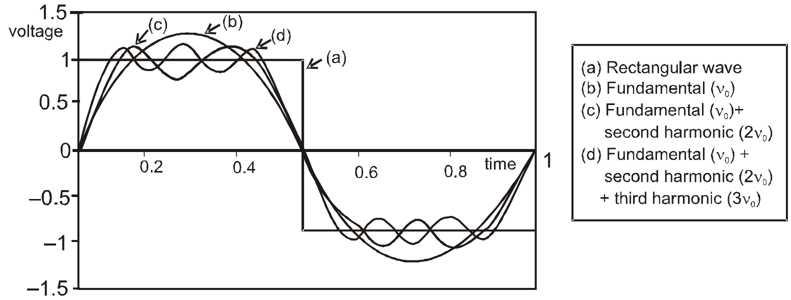
In a communication system, the message signal can be voice, music picture or computer data. Each of these signals has different ranges of frequencies. The type of communication system needed for a given signal depends on the band of frequencies which is considered essential for the communication process.

For speech signals, frequency range 300 Hz to 3100 Hz is considered adequated. Therefore speech signal requires a bandwidth of 2800Hz (3100 Hz – 300Hz) for commerical telephonic communication.

To transmit music, an approximate bandwidth of 20 kHz is required because of the high frequencies produced by the muscial instruments. The audible range of frequencies extends from 20 Hz to 20 kHz.

Video signals for transmission of pictures requires about 4.2 MHz of bandwidth. A TV signal contains both voice and picture and is usually allocated 6 MHz of bandwidth for transmission.

In the preceeding paragraph, we have considerd only analog signals. Digital signals are in the form of rectangular waves as shown in figure-3 below. One can show that this rectangular wave can be decomposed 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 and $\nu_0 = 1/ T_0$.



FIGURE–3

The fundamental (ν_0), fundamental (ν_0) + second harmonic ($2\nu_0$), and fundamental (ν_0) + second harmonic ($2\nu_0$) + third harmonic ($3\nu_0$), are shown in the same figure to illustrate this fact.

It is clear that to reproduce the rectangular wave shape exactly we need to superimpose all the harmonics ν_0, $2\nu_0$, $3\nu_0$, $4\nu_0$ ......which implies an infinite band width. However, for practical purposes, the contribution from higher harmonics can be neglected, thus limiting the bandwidht. As a result received waves are a distorted version of the transmitted one. If the bandwidth is large enough to accommodate a few harmonics, the information is not lost and the rectangular signal is more or less recovered. This is so because the higher the harmonic, less is its contribution to the wave form.

BANDWIDTH OF TRANSMISSION MEDIUM

Similar to message signals, different type of transmission media offer different bandwidths. The commonly used transmission media are wire, free space and fiber optic cable.Coaxial cable is a widely used wire medium, which offers a bandwidth of approximately 750 MHz. Such cables are normally operated below 18 GHz. Communication through free space using radio waves takes place over a very wide range of frequencies: from a few hundreds of kHz to a few GHz. This range of frequencies is further subdivided and allocated for various services. Optical communication using fibers is performed in the frequency range of 1 THz to 1000 THz (microwaves to ultraviolet). An optical fiber can offer a transmission bandwidth in excess of 100 GHz.

PROPAGATION OF ELECTROMAGNETIC WAVES

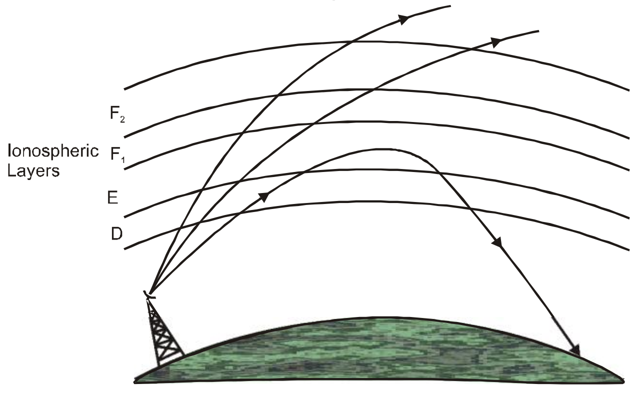
In communication using radio waves, an anetnna at the transmitter radiates the electromagnetic wave (em waves), which travel through the space and reach the receiving antenna at the other end. As the em wave travels away from the transmitter, the strength of the wave keeps on decreasing. Several factors influenece the propagation of em waves and the path they follow. At this point, it is also important to understand the composition of the earth's atmosphere as it plays a vital role in the propagation of em waves.

Ground wave

To radiate signals with high efficiency, the antennas should have a size comparable to the wavelength λ of the signal (at least ~$\lambda/4$). At longer wavelengths (i.e., at lower frequencies), the antennas have large physical size and they are located on or very near to the ground. In standard AM broadcast, ground based vertical towers are generally used as transmitting antennas. For such antennas, ground has a strong influence on the propagation of the signal. The mode of propagation is called surface wave propagation and the wave glides over the surface of the earth. A wave induces current in the ground over which it passes and it is attenuated as a result of absorption of energy by the earth. The attenuation of surface waves increases very rapidly with increase in frequency. The maximum range of coverage depends on the transmitted power and frequency (less than a few MHz).

Sky waves

In the frequency range from a few MHz up to 30 to 40 MHz, long distance communication can be achieved by ionospheric reflection of radio waves back towards the earth. This mode of propagation is called sky wave propagation and is used by short wave broadcast services. The ionosphere is so called because of the presence of a large number of ions or charged particles. It extends from a height of ~65 Km to about 400 Km above the earth's surface. Ionisation occurs due to the absorption of the ultraviolet and other high-energy radiation coming from the sun by air molecules. The ionosphere is further subdivided into several layers. The degree of ionisation varies with the heights. The density of atmosphre decreases with heigth. At great heights the solar radiation is intense but there are few molecules to be ionised. Close to the earth, even though the molecular concentration is very high, the radiation intensity is low so that the ionisation is again low. However at some intermediate height, there occurs a peak of ionisation density. The ionosphere layer acts as a reflector for a certain range of freqeuncies (3 to 30 MHz). Electromagnetic waves of frequencies higher than 30 MHz penetrate the ionosphere and escape. These phenomena are shown in the figure-4 below. The phenomenon of bending of em waves so that they are diverted towards the earth is similar to total internal reflection in optics.



D – Part of stratosphere (65 to 75 km height)

E – Part of stratosphere (100 km height)

F_1 – Part of mesosphere (170 to 190 km height)

F_2 – Part of thermosphere (250 to 400 km height)

FIGURE–4: Sky wave propagation

Space wave

Another mode of radio wave propagation is by space waves. A space wave travels in a straight line from transmitting antenna to the receiving antenna. Space waves are used for line-of-sight (LOS) communication as well as satellite communication.

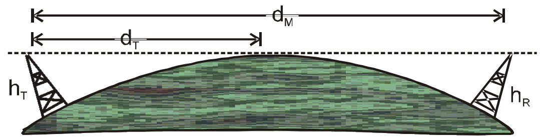


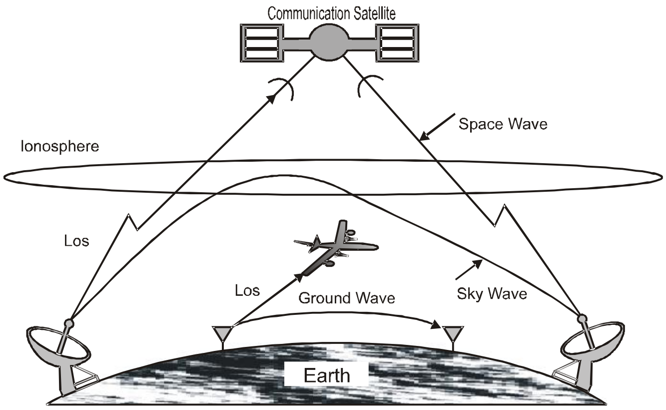
FIGURE-5: Line of sight communication by space waves.

At frequencies above 40 MHz, communication is essentially limited to line-of-sight paths. At these frequencies, the antennas are relatively smaller and can be placed at heights of many wavelengths above the ground. Because of line-of-sight nature of propagation, direct waves get blocked at some point by the curvature of the earth as illustrated in figure-5 below. If the signal is to be received beyond the horizon then the receiving antenna must be high enough to line-of-sight waves.

If the transmitting antenna is at a heigth h_T, then you can show that the distance to the horizon d_T is given as $d_T = \sqrt{2Rh_T}$, where R is the radius of the earth (approximately 6400 km). d_T is also called the radio horizon of the transmitting antenna. With reference to figure above the maximum line-of-sight distance d_M between the two antennas having height h_T and h_R above the earth is given by

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

where h_R is the height of receiving antenna.



FIGURE–6: Various propagation modes for em waves

Television broadcast, microwave links and satellite communication are some examples of communication systems that use space wave mode of propagation. Figure–6 below summarises the various modes of wave propagation discussed so far.

Solved Example

Example 1. In which frequency range, space waves are normally propagated **[EAMCET 2002]**

(1) HF (2) VHF (3) UHF (4) SHF

Answer : (3)

Example 2. An antenna behaves as resonant circuit only when its length is **[MNS 2002]**

(1) $\frac{\lambda}{2}$ (2) $\frac{\lambda}{4}$

(3) λ (4) $\frac{\lambda}{2}$ or integral multiple of $\frac{\lambda}{2}$

Answer : (4)

Example 3. The process of superimposing signal frequency (i.e. audio wave) on the carrier wave is known as **[AIIMS 1987]**

(1) Transmission (2) Reception (3) Modulation (4) Detection

Solution. (3) Carrier + signal $\rightarrow$ modulation.

Example 4. Long distance short-wave radio broadcasting uses **[AFMS 1996]**

(1) Ground wave (2) Ionospheric wave (3) Direct wave (4) Sky wave

Answer : (3)

Example 5. The maximum distance up to which TV transmission from a TV tower of height h can be received is proportional to **[AIIMS 2003]**

(1) $h^{1/2}$ (2) h (3) $h^{3/2}$ (4) h^2

Solution : (1) $d = \sqrt{2hR} \Rightarrow d \propto h^{1/2}$

Example 6. 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.

Solution : $d_m = \sqrt{2\times64\times10^5\times32} + \sqrt{2\times64\times10^5\times50}$ 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

Example 7. In a communication system, noise is most likely to affect the signal

(1) At the transmitter (2) In the channel or in the transmission line

(3) In the information source (4) At the receiver

Answer : (2)

Example 8. The waves used in telecommunication are

(1) IR (2) UV (3) Microwave (4) Cosmic rays

Solution : (3) In telecommunication microwaves are used.

Example 9. Television signals on earth cannot be received at distances greater than 100 km from the transmission station. The reason behind this is that

(1) The receiver antenna is unable to detect the signal at a distance greater then 100 km

(2) The TV programme consists of both audio and video signals

(3) The TV signals are less powerful than radio signals

(4) The surface of earth is curved like a sphere

Answer : (4)

Modulation and its necessity

As already mentioned, the purpose of a communication system is to transmit information or message signals. Message signals are also called baseband signals, which essentially designate the band of frequencies representing the original signal, as delivered by the source of information. No signal, in general, is a single frequency sinusoid, but it spreads over a range of frequencies called the signal bandwidth. Suppose we wish to transmit an electronic signal in the audio frequency (AF) range (baseband signal frequency less than 20 kHz) over a long distance directly. Let us find what factors prevent us from doing so and how we overcome these factors.

Size of the antenna or aerial

For transmitting a signal, we need an antenna or an aerial. This antenna should have a size comparable to the wavelength of the signal (at least $\lambda/4$ in dimension) so that the antenna properly senses the time variation of the signal. For an electromagnetic wave of frequency 20 kHz. the wavelength λ 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. We can obtain transmission with reasonable antenna lengths if transmission frequency is high (for example, if υ is 1MHz, then λ is 300 m). Therefore, there is a need of translating the information contained in our original low frequency baseband signal into high or radio frequencies before transmission.

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 $(\ell/\lambda)^2$. This implies that for the same antenna length, the power radiated increases with decreasing λ, i.e., increasing frequency. Hence, the effective power radiated by a long wavelength baseband signal would be small. For a good transmission, we need high powers and hence this also points out to the need of using high frequency transmission.

Mixing up of signals from different transmitters

Another important argument against transmitting basband signals directly is more practical in nature. Suppose many people are talking at the same time or many transmitters are transmitting baseband information signals simultaneously. As these signals will get mixed up and there is no simple way to distinguish between them.

This points out towards a possible solution by using communication at high frequencies and allotting a band of frequencies to each message signal for its transmission.

The above arguments suggest that there is a need for translating the original low frequency baseband message or information signal into high frequency wave before transmission such that the translated signal continues to possess the information contained in the original signal.

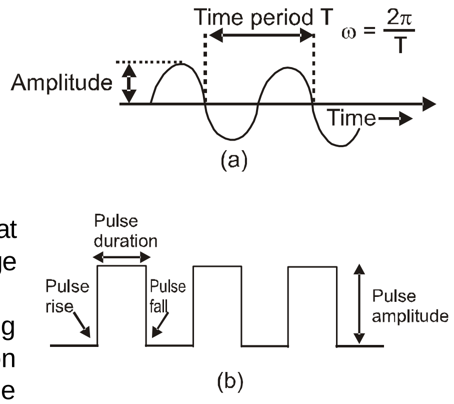


FIGURE-7: (a) Sinusoidal, and (b) pulse shaped signals

In doing so, we take the help of a high frequency signal, 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-7 below.

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 $(= 2\pi\upsilon_c)$ is the angular frequency and ϕ is the initial phase of the carrier wave. During the process of modulation, any of the three parameters, i.e. A_c, ω_C and ϕ, of the carrier wave can be controlled by the message or information signal. This results in three types of modulation. (i) Amplitude modulation (AM), (ii) frequency modulation (FM) and (iii) pulse modulation (PM) as shown below.

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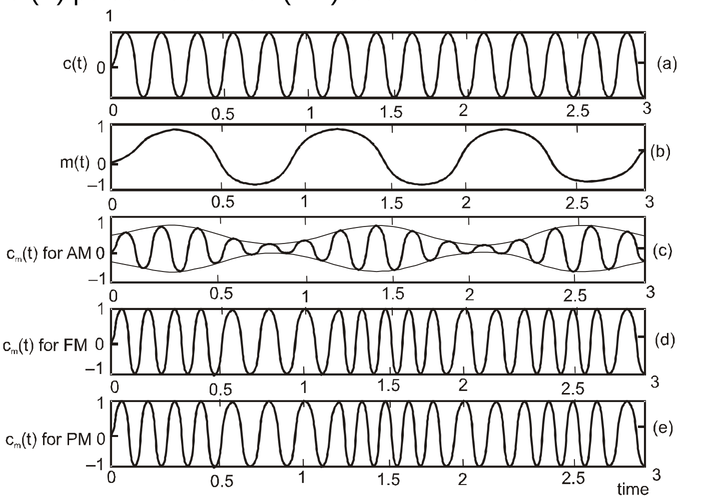
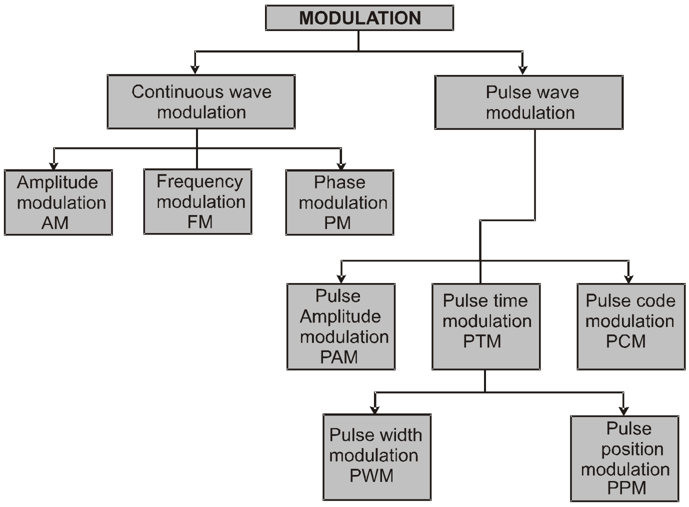


FIGURE-8

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) as shown in Fig. 15.7(b). 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). In this chapter, we shall confine to amplitude modulation only.



Amplitude Modulation

In amplitude modulation the amplitude of the carrier is varied in accordance with the information signal. Here we explain amplitude modulation process using a sinusoidal signal as the modulating signal.

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

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

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

Note that the modulated signal now contains the message signal. This can also be seen from figure–8(c). From Eq. (i), we can write,

$$c_m(t) = A_c \sin \omega_c t + \mu A_c \sin \omega_m t \sin \omega_c t \qquad \text{..........(ii)}$$

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

Using the trignomatric relation sin A sin B = 1/2 (cos (A – B) – cos (A + B),

we can write c_m (t) of Eq. (ii) as

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

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 waves each with a frequency slightly different from, known as side bands. The frequency spectrum of the amplitude modulated signal is shown in figure–9.

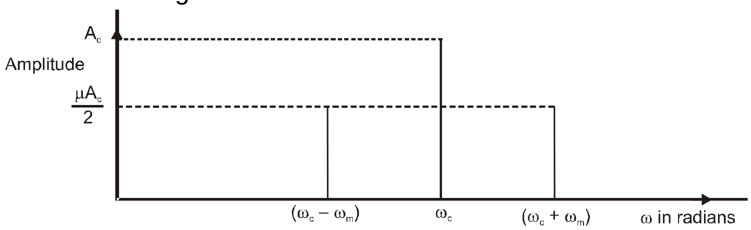


FIGURE-9: A plot of amplitude versus ω for an amplitude modulated signal

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

Modulation index : The ratio of change of amplitude of carrier wave to the amplitude of original carrier wave is called the modulation factor or degree of modulation or modulation index (m_a).

$$m_a = \frac{\text{Change in amplitude of carrier wave}}{\text{Amplitude of original carrier wave}} = \frac{kA_m}{A_c}$$

where k = A factor which determines the maximum change in the amplitude for a given amplitude E_m of the modulating. If k = 1 then $m_a = \frac{A_m}{A_c} = \frac{A_{max} - A_{min}}{A_{max} - A_{min}}$

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

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

Side band frequencies and band width in AM wave

(i) Side band frequencies : The AM wave contains three frequency f_c, ($f_c + f_m$) and ($f_c - f_m$), f_c is called carrier frequency,

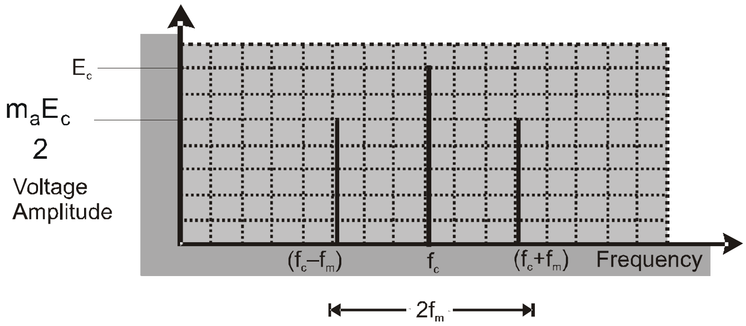
($f_c + f_m$) : Upper side band (USB) frequency

($f_c - f_m$) : Lower side band (LBS) frequency

Side band frequency are generally close to the carrier frequency.

(ii) Band width : The two side bands lie on either side of the carrier frequency at equal frequency interval f_m.

So, band width = ($f_c + f_m$) – ($f_c - f_m$) = $2f_m$



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

Hence (i) carrier power $P_c = \frac{\left(\frac{A_c}{\sqrt{2}}\right)^2}{R} = \frac{A_c^2}{2R}$

(ii) Total power of side bands $P_{sb} = \frac{\left(\frac{m_aA_c}{2\sqrt{2}}\right)^2}{R} = \frac{\left(\frac{m_aA_c}{2\sqrt{2}}\right)}{2R} = \frac{m_a^2A_c^2}{4R}$

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

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

(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

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

Limitation of amplitude modulation

(i) Noisy reception
(ii) Low efficiency
(iii) Small operating range
(iv) Poor audio quality

PRODUCTION OF AMPLITUDE MODULATED WAVE :

Amplitude modulation can be produced by a variety of methods. A conceptually simple method is shown in the block diagram of figure–10.

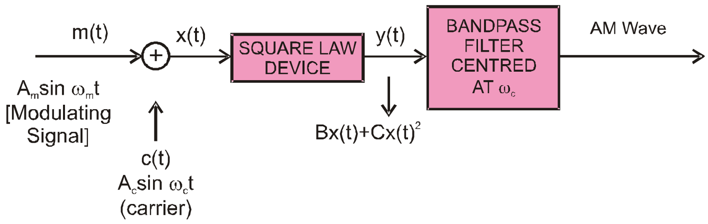


FIGURE-10: Block diagram of a simple modulator for obtaining an AM signal

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

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

where B and C are constants. Thus,

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

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

$$+ CA_m A_c \cos(\omega_c - \omega_m)t - CA_m A_c \cos(\omega_c + \omega_m)\,t \qquad \text{..........(v)}$$

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

In equation (v), there is a dc term $C/2\ (A_m^2 + A_c^2)$ and sinusoids of frequencies $\omega_m, 2\omega_m, \omega_c, 2\omega_c, \omega_c - \omega_m$ and $\omega_c + \omega_m$. As shown in figure–10 this signal is passed through a band pass filter which rejects dc and the sinusoids of frequencies ω_m, $2\omega_m$ and $2\omega_c$ and retains the frequencies ω_c, $\omega_c - \omega_m$ and $\omega_c + \omega_m$. The output of the band pass filter therefore is of the same form as equation (iii) and is therefore an AM wave.

It is to be mentioned that the modulated signal cannot be transmitted as such. The modulator is to be followed by a power amplifier which provides the necessary power and then the modulated signal is fed to an antenna of appropriate size for radiation as shown in figure.

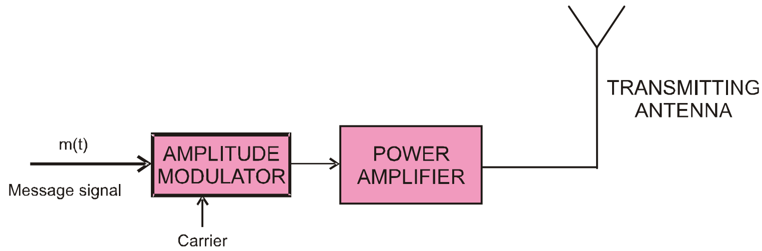


FIGURE-11: Block diagram of a transmitter

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-12.

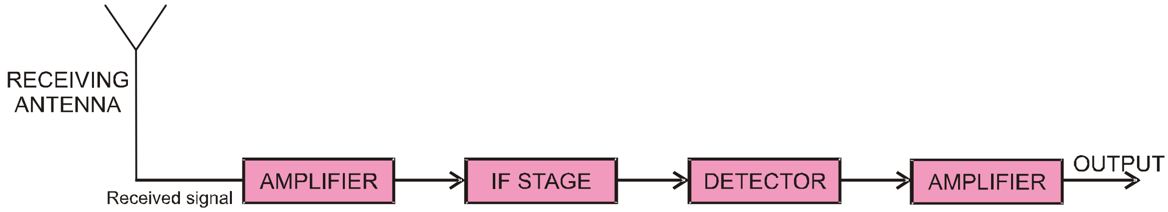


FIGURE-12: Block diagram of a receiver

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 form of a block diagram in figure-13.

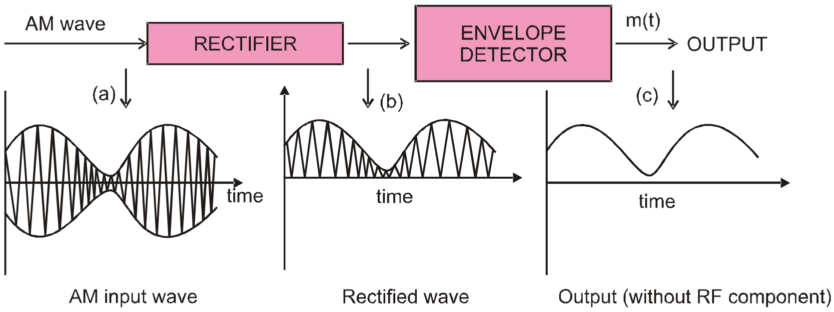


FIGURE-13: Block diagram of a detector for AM signal.
The quantity on y–axis can be current or voltage

The modulated signal of the form given in (a) of figure-13 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).

This is essentially just a half wave rectifier which charges a capacitor 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, τ = (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

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

which, provided that T << τ, is approximately the same as

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

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 rang. 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

$$1/ f_m >> t >> 1/f_c$$

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

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

Solved Example

Example 10. AM is used for broadcasting because

(1) It is more noise immune than other modulation systems

(2) It requires less transmitting power compared with other systems

(3) Its use avoids receiver comlexity

(4) No other modulation system can provide the necessary bandwidth faithful transmission

Answer : (3)

Example 11. Range of frequencies allotted for commercial FM radio broadcast is **[MNR 1997]**

(1) 88 to 108 MHz (2) 88 to 108 kHz (3) 8 to 88 MHz s (4) 88 to 108 GHz

Answer : (1)

Example 12. If μ_1 and μ_2 are the refractive indices of the materials of core and cladding of an optical fibre, then the of light due to its leakage can be minimised by having **[BVP 2003]**

(1) $\mu_1 > \mu_2$ (2) $\mu_1 < \mu_2$ (3) $\mu_1 = \mu_2$ (4) None of these

Answer : (1)

Example 13. The radio waves of frequency 300 MHz to 3000 MHz belong to **[AMU 2002]**

(1) High frequency band (2) Very high frequency band

(3) Ultra high frequency band (4) Super high frequency band

Answer : (3)

Example 14. The maximum peak to peak voltage of an AM wire is 24 mV and the minimum peak to peak voltage is 8 mV. The modulation factor is

(1) 10% (2) 20% (3) 25% (4) 50%

Solution : (4) Here, $V_{max} = \frac{24}{2}$ = 12 mV and $V_{min} = \frac{8}{2}$ = 4 mV

Now, $m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} = \frac{12-4}{12+4} = \frac{8}{16} = \frac{1}{2}$ = 0.5 = 50%

Example 15. If a number of sine waves with modulation indices n_1, n_2, n_3 ....modulate a carrier wave, then total modulation index (n) of the wave is

(1) $n_1 + n_2$ ....+ 2($n_1 + n_2$ ....) (2) $\sqrt{n_1 - n_2 + n_3 ....}$

(3) $\sqrt{n_1^2 + n_2^2 + n_3^2 ....}$ (4) None of these

Answer : (3)

Example 16. An AM wave has 1800 watt of total power content, for 100% modulation the carrier should have power content equal to

(1) 1000 watt (2) 1200 watt (3) 1500 watt (4) 1600 watt

Solution : (2) $P_t = P_c$; Here $m_a = 1 \Rightarrow 1800 = P_c \Rightarrow P_c = 1200$ W

FREQUENCY MODULATION

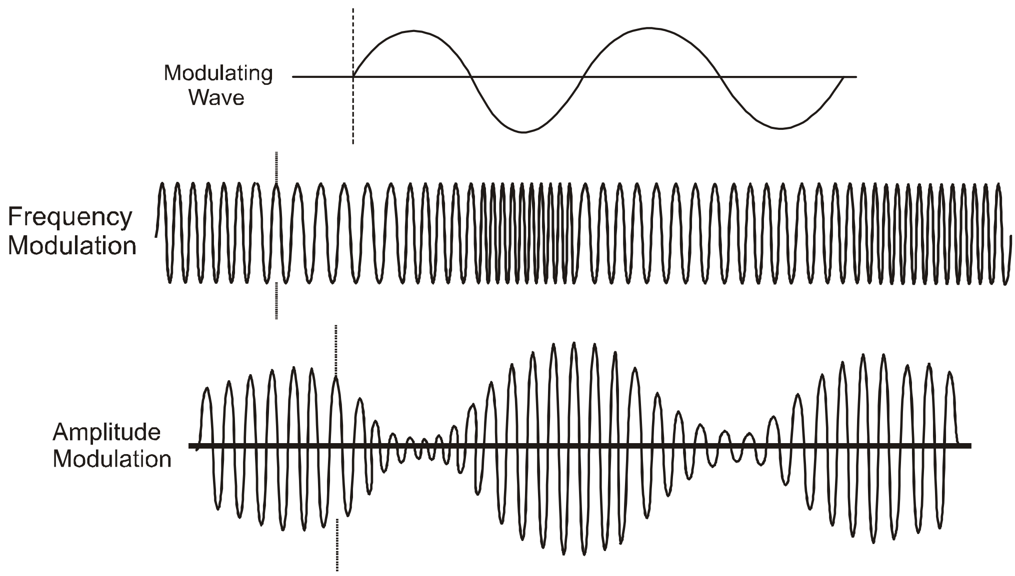
(Note : In JEE-Main Syllabus but not for CBSE Board Syllabus)

It is the second type of continuous wave or sinusoidal wave modulation.

In this mode of modulation, the frequency of the carrier signal varies in accordance with the modulating signal. The amplitude of the carrier wave is fixed while its frequency is changing.

In frequency modulation, the frequency of the carrier wave is modified in accordance with the amplitude of the modulating wave.

The amplitidue of the carrier remains unchanged at all times. In other words, the amplitude of the modulated wave remains the same as the amplitude of the carrier wave. The frequency of the carrier is made to fluctuate symmetrically above and below its unmodulated frequency. As an example, a carrier frequency, of 1000 kHz may be caused to swing between 925 kHz and 1075 kHz



or any other amount chosen in accordance with the signal voltage. In frequency modulation, the deviation of the carrier frequency from its average value is proportional to the instantaneous amplitude of the modulating signal. When the signal voltage is zero, the carrier frequency is unchanged. When the signal approaches its positive peaks, the carrier frequency is increased to maximum as indicated by the closely spaced cycles. However, during the negative peaks of signal, the carrier frequency is reduced to minimum as shown by widely spaced cycles.

NECESSITY OF FREQUENCY MODULATION

1. Various electrical machines and noises cause amplitude disturbance in the transmission of amplitude-modulated wave. This makes the reception noisy. So, there is a need for different type of modulation which can reduce the noise factor. Frequency modulation (FM) was proposed as a means of improving the signal-to-noise ratio of a radio system. The first practical system was put forward in 1936 as an alternative to AM in an effort to make radio transmissions more resistant to noise.

2. Fidelity or audio quality of amplitude modulated transmission is poor. This type of transmission is also not good for musical programmes. There is a need to eliminate amplitude-sensitive noise. This is possible if we eliminate amplitude variation. In other words, there is a need to keep the amplitude of the carrier constant. This is precisely what we do in frequency modulation.

FM is preferred for transmission of music

Frequency modulation (FM) gives better quality transmission and has a larger bandwidth. In FM signals, the intelligence (information or message signal) is in the form of frequency variations and, therefore, the atmospheric or man-made noises (which are generally amplitude changes) do little harm. It is preferred for transmission of music. The range of frequencies allotted for commercial FM radio and TV -broadcast are given in table below

Range of Frequencies allotted for FM Radio and TV Broadcast

Nature of broadcast	Frequency band
FM radio	88 to 108 MHz
VHF TV	47 to 230 MHz
UHF TV	470 to 960 MHz

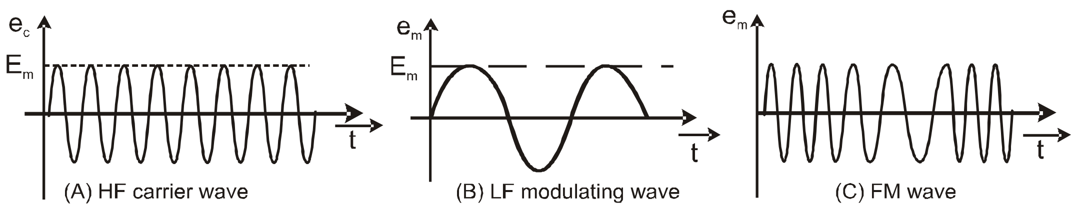
Frequency Modulation (FM)

The process of changing the frequency of a carrier wave in accordance with the audio frequency signal is known as frequency modulation

(1) Audio quality of AM transmission is poor. There are need to eliminate amplitude sensitive noise. This is possible if we eliminate amplitude variation. (i.e., a need to keep the amplitude of the carrier constant). This is precisely what we do in FM.

(2) In FM the overall amplitude of FM wave remains constant at all times.

(3) In FM the total transmitted power remains constant.



(A) HF carrier wave (B) LF modulating wave (C) FM wave

(4) Frequency deviation : The maximum change in frequency from mean value (v_c) is known as frequency deviation. This is also the change or shift either above or below the frequency v_c and is called as frequency deviation.

$$\therefore \quad \delta = (f_{max} - f_c) = f_c - f_{min} = k_f \cdot \frac{E_m}{2\pi}$$

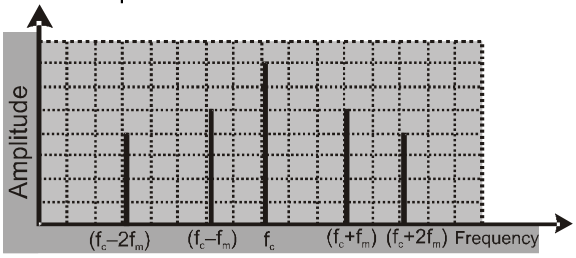
k_f = Constant of proportionality. It determines the maximum variation in frequency of the modulated wave for a given modulating signal.

(5) Carrier swing (CS) : The total variation in frequency from the lowest to the highest is called the carrier swing i.e., CS = 2 × Δf

(6) Frequency modulation index (m_f) : The ratio of maximum frequency deviation to the modulating frequency is called modulation index. $m_f = \frac{\delta}{f_m} = \frac{f_{max} - f_c}{f_m} = \frac{f_c - f_{min}}{f_m} = \frac{k_f E_m}{f_m}$

(7) Frequency spectrum : FM side band modulated signal consist of infinite number of side bands whose frequencies are ($f_c \pm f_m$), ($f_c \pm 2f_m$), ($f_c \pm 3f_m$).........

The number of side bands depends on the modulation index m_f.



In FM signal, the information (audio signal) is contained in the side bands. Since the side bands are separated from each other by the frequency of modulating signal f_m so

Band width = $2n \times f_m$; where n = number of significant side band pairs

(8) Deviation ratio : The ratio of maximum permitted frequency deviation to the maximum permitted audio frequency is known as deviation ratio. Thus, deviation ratio = $\frac{(\Delta f)_{max}}{(f_m)_{max}}$

(9) Percent modulation : The ratio of actual frequency deviation to the maximum allowed frequency deviation is defined as percent modulation. Thus, percent modulation, m = $\frac{(\Delta f)_{actual}}{(\Delta f)_{max}}$

FREQUENCY-MODULATED COMMUNICATION (Height of Transmitting Antenna)

The TV signals are frequency-modulated. Their transmission cannot be obtained by ground wave propagation. This is because the signals get absorbed by ground due to their high frequency. The transmission via sky wave propagation is also not desirable. This is becasuse the ionosphere is unable to reflect radio waves of frequencies greater than 40 MHz.

The only way for the transmission of TV signals is that the receiving antenna should directly intercept the signal from the transmitting antenna.

The transmitted waves, travelling in a straight line, directly reach the receiver end and are then picked up by the receiving antenna as shown in figure. It can be seen that due to the finite curvature of the earth, such waves cannot be seen beyond the tangent points R_1 and R_2. The effective reception range of the broadcast is essentially the region from R_1 to R_2 which is covered by the line of sight in a conventional sense. Hence, sometimes this mode of communication is termed as **line of sight communication.**

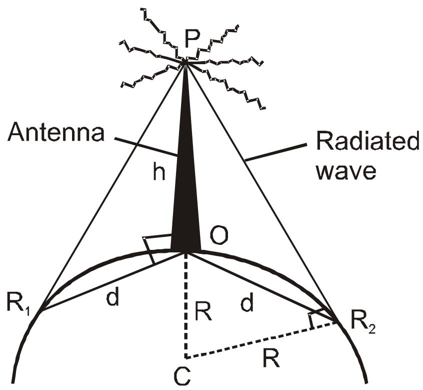


Fig. Ray-path of transmitted waves following space-wave (or line of sight) mode of propagation. The transmitter is located at the ground on a tall tower.

For large TV coverage, the transmission of TV signal is done from a tall antenna.

Consider a TV antenna OP of height h. The transmitted signal cannot be received beyond points R_1 and R_2. This is due to curvature of earth.

Clearly, OR_1 and OR_2 are the maximum distances, from the antenna, upto which the transmission signal can be received.

Let $OR_1 = OR_2 = d$ [d is half the total range]

The TV signal will be received in a circle of radius d.

The relation between height h of the TV antenna and the maximum distance d upto which the TV signal can be received can be derived on the basis of geometrical considerations.

From right-angled triangle CR_2P, $CP^2 = CR_2^2 + PR_2^2$

In right-angled triangle POR_2, $PR_2^2 = h^2 + d^2$

[Note that $\angle POR_2$ can be taken as right angle.]

Also, $CR_2 = CO = R$ and $CP = R + h$

From Equation (1),

$$(R + h)^2 = R^2 + (h^2 + d^2)$$

or $R^2 + h^2 + 2Rh = R^2 + h^2 + d^2$ or $d = \sqrt{2Rh}$

It is clear from this equation that if h is large, d will be large. This explains as to why the television broadcasts are made from tall antennas.

If one wishes to send signals at far away stations, then either Repeater transmitting stations are necessary or h is increased (by locating the transmitter on a satellite). However, much before the advent of satellites, radio broadcast covered distances much longer than the line of sight propagation. This was found possible due to the presence of an ionised layer in the upper portion of earth's atmosphere called ionosphere. This mode of propagation known as ionospheric propagation or sky wave propagation.

Solved Example

Example 17. A TV tower has a height of 75m. What is the maximum distance and area up to which this TV transmission can be received? Take radius of the earth as 6.4×10^6 m.

Solution : $d = \sqrt{2Rh} = \sqrt{2 \times 6.4 \times 10^6 \times 75} = 3.1 \times 10^4$ m = 31 km

Area covered = πr^2 = **3018 km²**

Example 18. A TV tower has a height of 100 m. How much population is covered by the TV broadcast if the average population density around the tower is 1000 km^{-2} ? Given : radius of earth = 6.37×10^6 m.

Solution : h = 100 m, R = 6.37×10^6 m, Average population density = 1000 km^{-2} = 1000 $(10^3)^{-2}$ m^{-2} = $10^{-3} m^{-2}$

Distance up to which the transmission could be viewed, $d = \sqrt{2hR}$

Total area over which transmission could be viewed = $\pi d^2 = 2\pi hR$

Population covered = $10^{-3} \times 2\pi hR = 10^{-3} \times 2 \times 3.14 \times 100 \times 6.37 \times 10^6$ = **40 lakh**

Demodulation

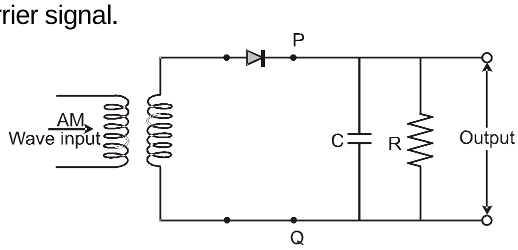
The process of extracting the audio signal from the modulated wave is known as demodulation or detection.

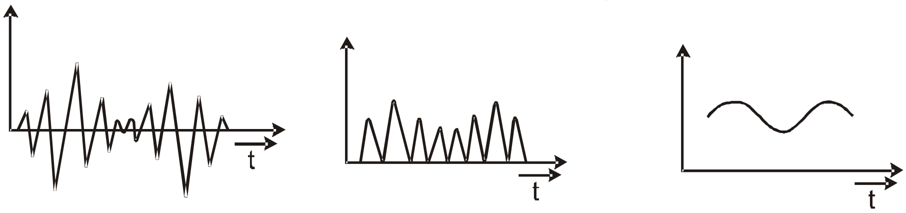
The wireless signals consist of radio frequency (high frequency) carrier wave modulated by frequency (low frequency). The diaphragm of a telephone receiver of a loud speaker cannot vibrate with high frequency. So it is necessary to separate the audio frequenies from the radio frequency carrier wave.

Simple demodulator circuit

A diode can be used to detect or demodulate an amplitude modulated (AM) wave. A diode basically acts as a rectifier i.e., it reduces the modulated carrier wave into positive envelope only.

The AM wave input is shown in figure. It appears at the output of the diode across PQ as a rectified wave (since a diode conducts only in the positive half cycle). This rectified wave after passing through the RC network does not contain the radio frequency carrier componet. Instead, it has only the envelope of the modulated wave. In the actual circuit the value of RC is chosen such that $\frac{1}{f_c} << RC$; where f_c = frequency of carrier signal.





(A) **(B)** **(C)**

Data Transmission and Retrieval :

The term data is applied to a representation of facts, concepts or instructions suitable for communication interpretation or processing by human beings or by automatic means. Data in most cases consists of pulse type of signals.

The pulse code modulated (PCM) signal is a series of 1's and 0's. The following three modulation techinques are used to transmit a PCM signal.

(1) Amplitude shift keying (ASK) : Two different amplitudes of the carrier represent the two binary values of the PCM signal. This method is also known as on-off keying (OOK)

(1) : Presence of carrier of same constant amplitude.

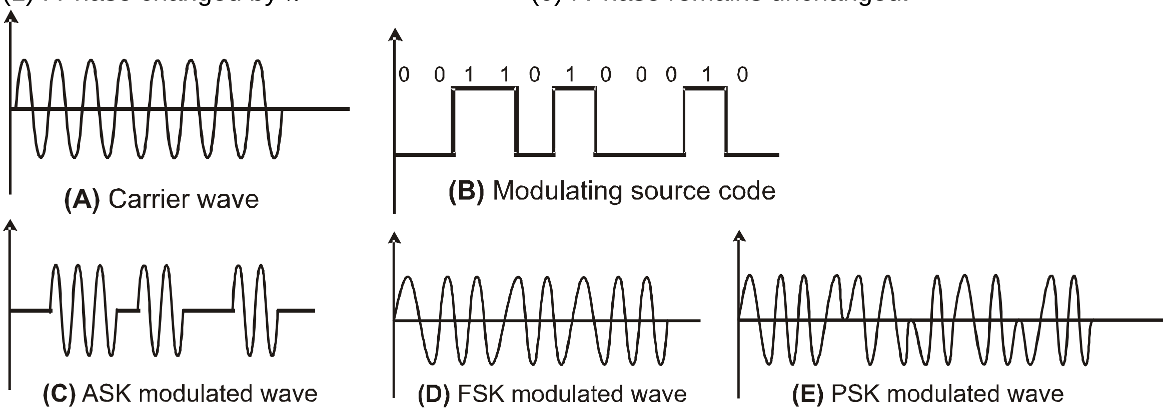
(0) : Carrier of zero amplitude.

(2) Frequency shift keying (FSK) : The binary values of the PCM signal are represented by two frequencies.

(1) : Increase in frequency (0) : Frequency unaffected

(3) Phase shift keying (PSK) : The phase of the carrier wave is changed in accordance with modulating data signal.

(1) : Phase changed by π (0) : Phase remains unchanged.



(A) Carrier wave **(B)** Modulating source code

(C) ASK modulated wave **(D)** FSK modulated wave **(E)** PSK modulated wave

Solved Example

Example 19. What is the modulation index of an over modulated wave

(1) 1 (2) zero (3) < 1 (4) > 1

Solution : (4) When $m_a > 1$ then carrier is said to be over modulated.

Example 20. Which of the following is the disadvantage of FM over AM

(1) Larger band width requirement (2) Larger noise

(3) Higher modulation power (4) Low efficiency

Solution : (1) Frequency modulation requires much wider channel (7 to 15 times) as compared to AM.

Example 21. When the modulating frequency is doubled, the modulation index is halved and the modulating voltage constant the modulation system is

(1) Amplitude modulation (2) Phase modulation

(3) Frequency modulation (4) All of the above

Answer : (3)

Example 22. Indicate which one of the following system is digital

(1) Pulse position modulation (2) Pulse code modulation

(3) Pulse width modulation (4) Pulse amplitude modulation

Answer : (2)

Example 23. In an FM system a 7 kHz signal modulates 108 MHz carrier so that frequency deviation is 50 kHz. The carrier swing is

(1) 7.143 (2) 8 (3) 0.71 (4) 350

Answer : (1)

Example 24. Sinusoidal carrier voltage of frequency 1.5 MHz and amplitude 50 V is amplitude modulated by sinusiodal voltage of frequency 10 kHz producing 50% modulation. The lower and upper side-band frequencies in kHz are

(1) 1490, 1510 (2) 1510, 1490 (3) $\frac{1}{1490}, \frac{1}{1510}$ (4) $\frac{1}{1510}, \frac{1}{1490}$

Solution : (1) Here, f_c = 1.5 MHz = 1500 kHz, f_m = 10 kHz

$\therefore$ Lower side band frequency

= $f_c - f_m$ = 1500 kHz – 10 kHz = 1490 kHz

Upper side band frequency = $f_c + f_m$ = 1500 kHz + 10 kHz = 1510 kHz

Example 25. If f_0 and f_f represent the carrier wave frequencies for amplitude and frequency modulations respectively, then

(1) $f_0 > f_f$ (2) $f_0 < f_f$ (3) $f_0 = f_f$ (4) $f_0 \geq f_f$

Answer : (2)

Example 26. The frequency of a FM transmitter without signal input is called

(1) Lower side band frequency (2) Upper side band frequency

(3) Resting frequency (4) None of these

Answer : (3)

Example 27 What type of modulation is employed in India for radio transmission

(1) Amplitude modulation (2) Frequency modulation

(3) Pulse modulation (4) None of these

Answer : (1)

Example 28. Consider telecommunication through optical fibres. Which of the following statements is not true **[AIEEE 2003]**

(1) Optical fibres may have homogeneous core with a suitable cladding

(2) Optical fibres can be of graded refractive index

(3) Optical fibres are subject to electromagnetic interference from outside

(4) Optical fibres have extremely low transmission loss

Answer : (3)

Example 29 The phenomenon by which light travels in an optical fibres is **[DCE 2001]**

(1) Reflection (2) Refraction

(3) Total internal reflection (4) Transmission

Answer : (3)

[Only for Board Syllabus, not for JEE Syllabus]

A. INTERNET

Introduction :

Invention of computers changed the working style of people in twentieth century. Its capability to tirelessly and sequentially do arithmetical and logical operations made the human life simpler and faster. Offices, universities, banks, schools etc. nothing remained unaffected by use of computers. This was not enough and before the end of twentieth century we succeeded in creating a global network of computers that provides ways to exchanged information and to communicate among all computers connected to the network. This global network of computers is what we now call internet (or simply net). Internet, in fact, is the short form of INTER-NET work which is the interconnected network of all worldwide servers.

Networking of computers : The way Internet works

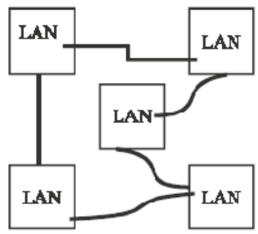
Two or more than two computers are said to be networked when they are able to exchange information between them. This sharing of information can be through wires connecting these computers or some wireless means of communication like Wi-Fi.

Networking of computers at small scale (e.g. within an office, a building or a school) is called Local Area networking (LAN). One can also connect devices like printer, scanner, etc. to a LAN as shown in the figure below.

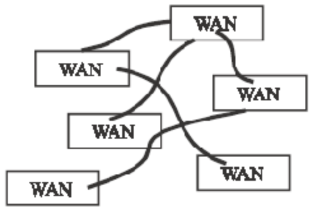
A Local Area Network (LAN)

A Local Area Network (LAN)

One can built such a local area network of computers within an institution by connecting all or some of their computers. Every LAN has some main computers called server computers. These servers are used to connect LAN to other networks through telephone lines or satellites. In this way by connecting various LAN, a Wide Area Network (WAN) is created as shown in the figure.



Various inter linked WAN together constitute what we call an Internet as shown in the figure. All information related to a local network is stored in server computer of LAN. The servers of every LAN act as channel for information exchange between computers connected to LAN and also servers of other networks. Every computer that extracts information from a server is called a client computer.



Formation of Internet

First network of computers called Advanced Research Projects Agency NET work (ARPANET) was developed by US Department of Defense in 1969. By 1990, many countries of the world came up with a common set of rules for Internet communication among computers called protocols. Nowadays, standard sets of protocols called Transmission control Protocol/Internet Protocol (TCP/ IP) are used for exchange of information trough Internet.

It is important to note that the exchange of information on Internet is very fast (at the speed of light) as electronic signals (messages) of computers are communicated through electromagnetic waves.

In India, Internet was started in November 1988 by VSNL (Videsh Sanchar Nigam Limited) in Mumbai.

On Internet, information is provided / available through webpages to may contain text, images videos, etc. one can move from on webpage on Internet to another through a system called interlinked hypertext documents. In this system, one webpage is linked to another webpage by providing hyperlinking (a way of highlighting) to any text, image of video. This way of accessing information on Internet through interlinking of webpage is called www or World Wide Web.

Anyone can provide specific information on Internet by making a couple of webpages containing that information. Such a set of webpages together constitute a website. One can design a website of own organization containing information about its different aspects and its activities.

Anyone can connect its computer to the internet network through various Internet Service Providers (ISP) by paying a prescribed fee. Commonly, mobile network companies also acts as ISP.

Applications of Internet

People use Internet for many purposes like searching and viewing information on any topic of interest, for sending electronic mails (e-mails), for e-banking, e-shopping (e-commerce), e-booking (e-ticketing) etc. This list of uses of Internet is endless.

(i) Internet Surfing : Moving on Internet from one webpage/website to another is called Internet surfing. It is an interesting way of searching and viewing information on any topic of interest.

(ii) E-mail : E-mail means "electronic mail". This is the most used application of Internet. E-mail is a way of sending texts written on computers through Internet. Along with text one can send images and videos too. This is cheapest and fastest way of sending messages.

For using this facility of Internet one needs to create a personal email account with an email-Id (identity) or email address. Email-Id is like an identity card (Name and address) through which people can identify and communicate to you through Internet. A few websites provides free email accounts and Ids to Internet users. These email-Ids are password protected and thus no one other than whom it belongs can use them. Internet Service Provides (ISP) also provide email-Ids.

"prakrittyagi @gmail.com" is an emal Id. Its two parts :

(i) Part before @ sign: prakrittyagi

It is personal information part. Here it denotes a name Prakrit Tyagi

(ii) Part after @ sign : gmail.com

It is called a domain name. It provides information about the server that is providing this email facility.

A message sent through email is instantly delivered to the addressee because communication of messages is by means of electromagnetic waves through Internet. Beauty of email lies in the fact that a message is stored in a email account even at a time when its user is not connected to Internet, which can be viewed later.

Email's use is increasing day by day. We can even send personalized greeting cards through email. To day it has become an extremely popular communication tool.

(iii) E-banking : It is an electronic payment system allowing customers to proceed for financial transactions on a website operated by that financial institution (usually a bank). For this purpose, customer needs to be a member of that institution, needs to have internet access and must register with the institution for the service. In turn, the financial institution provides the login number and password to the customer for his/her unique identifiction. With the help of this facility a customer can link his account with any other facilities such a checking on line status of the balance, check book requisition, loan, recurring, credit card, debit card etc.

(iv) E-shopping (E-commerce) : Virtual Malls are available on Internet where on can view and order to purchase various products. Buying products through product selling websites is called e-shopping. These websites provide the buyer pay cash on delivery or making on-line payments (using e-banking or credit cards) options. Similarly, there are websites on which one can upload (put) photographs of products, which you want to sell. This trading of products using Interned along with many other market related activities is called e-commerce.

(v) E-booking (e-ticketing) : It is an application developed for ticket reservation through the Internet to help the travel and tourism industry. It helps consumers to book flight tickets, railway tickets, hotels, holiday packages, insurance and other services online.

To book an e-ticket, a customer needs to visit a home page of an Airline Company or Indian Railways. Once he/she enters the travel preference, gets an opportunity to view the available flights/ trains through an appropriate interface. Once the choice is fixed, the customer needs to flights/ trains through an appropriate interface. Once the choice is fixed, the customer needs to select the mode for transfer of money. Once the payment is done through an authentic mode (like e-banking), an online ticket is issued to the customer.

(vi) Social Networking : It is service providing a platform to the people having same interests to build a social network. It is a web-based service allows an individual to create his/her own profile, list of user with whom they want to connect. The service allows the user to share their ideas, pictures, events, activities etc, with their group. Facebook, Twitter, Google+ etc. are some popular social networking sites.

B. MOBILE TELEPHONY

Introduction :

As we look around, in markets, on trains and buses, people crossing streets, we can see many individual talking on cell phones or mobile phones. Mobile phones have change the way we live and communicate. With advancement of technology, look and utility of mobile phone has also undergone change. In latest mobile phones, along with making and receiving phone calls one can also :

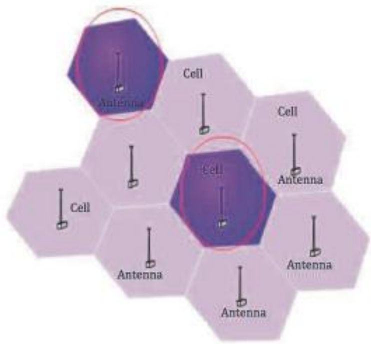
- Store contact information
- Make task or to-do lists
- Keep track of appointments and set reminders
- Use the built- in calculator for simple math
- Send or receive e-mail
- Get information (news, entertainment, stock quotes) from the Internet
- Play games
- Listen radio/music and watch TV
- Send text messages
- Take photos and videos etc.

In a say, today's mobile phone is a handy computer equipped with Internet.

In ordinary land line phones, phone instruments are connected to a telephone exchange through electric wires, which in turn connect our phone calls to the other phones. However, wire connections limit the mobility of a land line phone. Mobile phone technology has successfully overcome this limitation. Mobile phone is a low power operated device (transmitter), which can wirelessly send and receive radio frequency signals. Before this, walkie-talkie was also a wireless system of communication. You must have seen a policeman talking on his wireless set. After completing one sentence, he says “Over” and them listens. This was because the same radio frequency is used for both sending and receiving the audio signal. However, in a mobile phone, the outgoing and incoming signals use different frequencies, so the two individuals can talk and listen at the same time.

Working principle of Mobile phone

In a mobile phone, it is possible to talk while moving. This becomes possible because of a cellular radio network technology (a replacement of telephone exchange system). Under a cellular radio network a given physical area is divided into smaller parts call cells (or cell zones). To completely cover a given area use of hexagonal cells is a best possible way as shown in the figure.



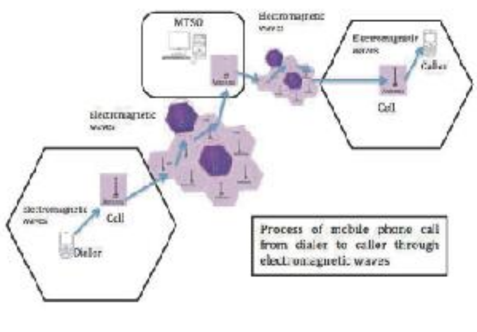
In every hexagonal cell a radiop antenna is intalled to receive and send radio signals to and from mobile phones physically present within the cell. All antennas present within an area are connected to each other through a network (the way computers are connected in internet).

All network related works including handling of all the incoming and outgoing calls are managed by a central control room called Mobile Telephone switching Office (MTSO). i.e. MTSO is basically a telephone exchange for mobile phone calls.

Every cell antenna has a working range of minimum 1.5 to 2 km and maximum up to 48 to 56 or more km are around it. When a mobile phone is switched on, MTSO records its location by identifying the cell in which it is present. When a mobile phone user moves from one cell zone to another cell zone, MTSO of its own switches mobile phone link to new cell antenna. This way, user gets an uninterrupted link to talk while on move. Also, mobile phones use high frequency radio waves for conversation. Audio signals of these waves are better. As mobile phones works on cell division of physical areas they are also referred as cell phones.

Scientific process of a mobile phone call

When we dial a mobile number from your mobile phone, an oscillator circuit (frequency generator) inside the mobile generates a particular frequency electromagnetic wave. This electromagnetic wave carrying called number’s information is transmitted through antenna of your mobile to the antenna of the cell in which we are present. The cell antenna in turn transfers this signal to MTSO. The MTSO computer system identifies the location (cell) of the mobile phone you have dialed and connects you to that phone. The caller mobile on receiving your signal generates again through an oscillator circuit your ID (mobile number) and displays it.



This whole process happens with in a few seconds as all the signals are transferred through electromagnetic wave, which travel at the speed of light. Here, it is important to note that mobile phone call is transferred from dialer cell antenna to MTSO and MTSO to caller cell antenna only through cell antenna lying in between. That is why phone network is also called terrestrial cellular network.

Mobile Phone numbering system

Due to mobility of a mobile phone it is necessary to identify every mobile phone. Forth is, a SIM (subscriber Identity Module) card in inserted in every mobile phone. SIM card is like an identity card of its user. It is a small IC (integrated circuit) chip with a unique SIM number and a mobile phone number. A typical SIM card is shown in the figure. All SIM cards are issued by mobile operator companies and their information is provided to MTSO. After SIM verification, MTSO activates the mobile number of the user. This makes a mobile phone usable. Every mobile number in India is of 10 digits.

All mobile numbers in India have the prefix 9, 8 or 7. As per National Numbering Plan 2003, the way to split mobile number is as XXXX-NNNNNN where XXXX is Network operator digits and NNNNNN is the subscriber number digits. To regulate the use of mobile phones system in India a Telecome Regulatory Authority of India (TRAI) was established in 1997 by an act of Parliament.

Mobile network Generation (1G, 2G, 3G & 4G)

With increasing use of mobile phones and advancement of technology it is pertinent to make the mobile phone networks more efficient. The efficiency of mobile networks in mentioned by word 'Generation' and abbreviation 'G'. 1G were first generation of mobile networks, which were based on analogue radio signals. 2G were narrow band digital signal based networks with good quality of calls. They provided world over connectivity. 3G networks increased the data transfer speed for efficient use of Internet on mobile phone. 4G networks are going to provide a high-speed interned facility on mobile phones for surfing net, chatting, viewing television, listening music etc.

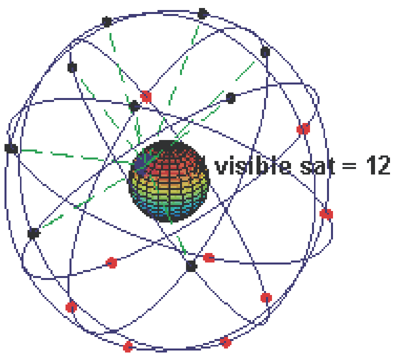
C. Global positioning system

Since ages man has invented various instruments to assist him in navigation on earth. Magnetic compass is one of the oldest navigational instrument man has been using for many centuries for direction identification on earth's surface Global Positioning System (GPS) based devices are the latest navigation assistance devices used these days. GPS devices provide accurate real time location and much more information to its user for easier and comfortable navigation even through his or her local streets. A commonly available GPS device is shown in the figure. When fitted in a car, it shows speed of the car, time, longitude coordinates and map of near-by area.

What is Global Positioning System (GPS)?

Global positioning system GPS in a method of identifying location or position of any point (or a person) on earth using a system of 24 satellites, which are continuously orbiting, observing, monitoring and mapping the earth surface. Every such satellite revolves around earth twice a day at a distance of about 20000 km from it. The given figure shows sketch view of 24 GPS satellites orbiting around the earth.

The orbits of these satellites are so aligned that at least four of them always keep looking any given point on earth surface. This is minimum necessary requirement for correct and accurate location identification through this system. In the given figure, the given location at the instant is visible to 12 satellites.



Working principle of a GPS device

For using the GPS system of satellites, a person needs a GPS device fitted with a transmitter / receiver for sending/receiving signals (electromagnetic radio waves) so that it can link up with GPS satellites in real time. The unique location (or longitude coordinates) of a GPS user is determined by measuring its distance from at least three GPS satellites. Based on these distance measurements, the location calculations are done by the microprocessor (computing device) fitted in the GPS device.

For measuring distance of three GPS satellites from the GPS device user, the time taken by a radio signal to travel from device to satellites and back are recorded by the GPS device.

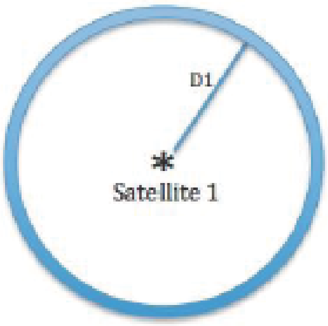
For, example, if a radio signal takes 0.140 seconds to travel back from a satellite-1 to its GPS user.

Then, Distance of satellite-1 from user = $\frac{(\text{Speed of light} \times \text{times})}{2} = \frac{3 \times 10^8 \text{m/s} \times 0.140\text{s}}{2}$

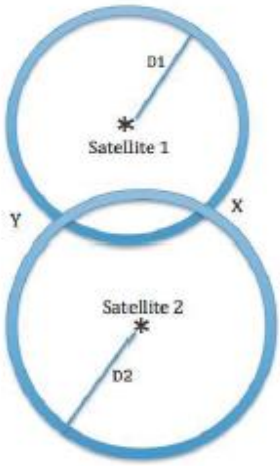
$= \frac{4200\text{km}}{2} = 21000$ km

Following the above method, let D1, D2 and D3 be the distances of three satellites from a GPS device user. From this information, the identification of unique location of the GPS device user is done as follows :

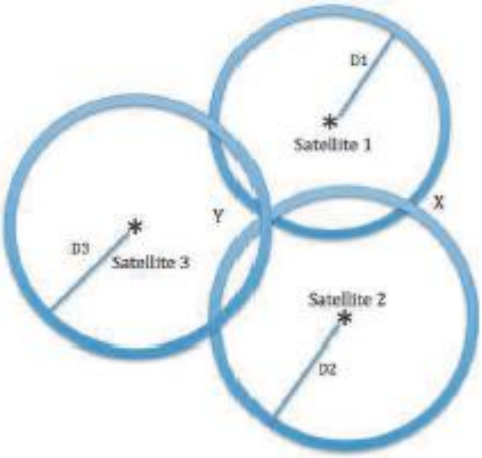
(1) If user is at distance "D1" from satellite-1. Then user's location can be anywhere on a circumference of circle of radius "D1" from satellite-1 as shown in fig below.



(2) If user is at a distance "D2" from satellite-2. The user's location can be either at intersecting points X or Y of circumferences of circles of radius D1 and D2 from satellite-1 and 2 respectively as shown in figure below.



(3) If user is at a distance "D3" from satellite-3. Then user's location will be at the intersecting point of circumferences of circles of radius D1, D2 and D3 from satellite-1, 2 and 3 respectively as shown in fig(c). i.e. here user is at point Y.



This way, minimum three satellites together provide the exact location (longitude coordinates) of the GPS device user on his display board.

If a person is at some height on earth surface, then using distance information from minimum 4-GPS satellites even altitude of the user can also be measured.

It may be noted that since all 24-GPS satellites orbit in predefined orbits, therefore their locations are precisely predetermined. It is these known location of 3 or 4-GPS satellites (3 or 4 sets of longitude coordinates) and their distances to GPS device that assist a GPS user (i.e. its computing device) in locating its own longitude coordinates.

Applications of GPS

Global positioning system has many day-to-day applications :

- It helps in navigation on water, air and land.
- It assists in map designing of a location.
- It helps automatic vehicle movements (without man)
- One can measure speed of moving object using this technology
- One can locate change in position of glaciers, mountains heights.
- It assists in keeping standard time world over.
- It assists in tracking animals and birds and studying their movements by attaching GPS devices to their bodies.
- it assists in airplane traffic movement.
- It assists visually impaired in location identification.

Now-a-days, various devices like mobile phones, i-pad etc. come equipped with pre-loaded geographical maps and GPS software which identifies the location of these devices using GPS system. GPS is a free service available to anyone in the world with a GPS device

Exercise-1

✍ **Marked Questions can be used as Revision Questions.**

PART-I: SINGLE CHOICE QUESTIONS

1. If a carrier wave of 1000 kHz is used to carry the signal, the length of transmitting antenna will be equal to -
(1) 3 m (2) 30 m (3) 300 m (4) 3000 m

2. In amplitude modulation -
(1) only the amplitude is changed but frequency remains same
(2) both the amplitude and frequency change equally
(3) both the amplitude and frequency change unequally
(4) none the these

3. Modulation factor determines -
(1) only the strength of the transmitted signal (2) only the quality of the transmitted signal
(3) both the strength and quality of the signal (4) none of the above

4. Degree of modulation –
(1) can take any value (2) should be less than 100%
(3) should exceed 100% (4) none of these

5.✍ If the maximum and minimum voltage of an AM wave are $V_{max.}$ and $V_{min.}$ respectively then modulation factor–
(1) $m = \frac{V_{max.}}{V_{max.} + V_{min.}}$ (2) $m = \frac{V_{min.}}{V_{max.} + V_{min.}}$ (3) $m = \frac{V_{max.} + V_{min.}}{V_{max.} - V_{min.}}$ (4) $m = \frac{V_{max.} - V_{min.}}{V_{max.} + V_{min.}}$

6. The AM wave contains three frequencies, viz :
(1) $\frac{f_c}{2}, \frac{f_c + f_s}{2}, \frac{f_c - f_s}{2}$ (2) $2f_c$, $2(f_c + f_s)$, $2(f_c - f_s)$
(3) f_c,$(f_c + f_s)$, $(f_c - f_s)$ (4) f_c , f_c, f_c

7. Which of the following is/are the limitations of amplitude modulation?
(1) Clear reception (2) High efficiency
(3) Small operating range (4) Good audio quality

8. In which of the region of earth's atmosphere temperature decreases with height?
(1) Ionosphere (2) Stratosphere (3) Troposphere (4) Mesosphere

9.✍ In an amplitude modulated wave, for audio frequency of 500 cps, the appropriate carrier frequency will be :
(1) 50 c/s (2) 100 c/s (3) 500 c/s (4) 50000 c/s

10. In A.M., the total modulation index should not exceed one or else :
(1) the system will fail (2) distortion will result
(3) amplifier will be damaged (4) none of the above

11. An 'antenna' is :
(1) inductive (2) capacitive
(3) resistive above its resonance frequency (4) none of the above

12. The Q of a resonant transimission line is

(1) $Q = \frac{\omega}{LR}$ (2) $Q = \frac{\omega R}{L}$ (3) $Q = \frac{L}{R}$ (4) $Q = \frac{\omega L}{R}$

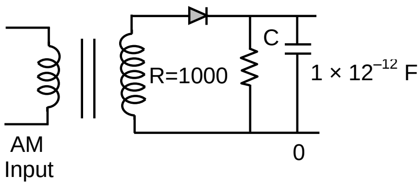
13. Range of frequencies allotted for commercial FM radio broadcast is -

(1) 88 to 108 MHz (2) 88 to 108 kHz (3) 8 to 88 MHz (4) 88 to 108 GHz

14. Which of the following is not transducer?

(1) Loudspeaker (2) Amplifier (3) Microphone (4) All of these

15. In the given detector circuit, the suitable value of carrier frequency is



(1) <<10^9 Hz

(2) <<10^5 Hz

(3) >> 10^9 Hz

(4) None of these

16. Amplitude modulation has

(1) One carrier (2) One carrier with high frequency

(3) One carrier with two side band frequencies (4) One carrier with infinite frequencies

17. Through which mode of propagation, the radio waves can be sent from one place to another

(1) Ground wave propagation (2) Sky wave propagation

(3) Space wave propagation (4) All of them

18. Sinusoidal carrier voltage of frequency 1.5 MHz and amplitude 50 V is amplitude modulated by sinusoidal voltage of frequency 10 kHz producing 50% modulation. The lower and upper side-band frequencies in kHz are

(1) 1490, 1510 (2) 1510, 1490 (3) $\frac{1}{1490}, \frac{1}{1510}$ (4) $\frac{1}{1510}, \frac{1}{1490}$

19. In an amplitude modulation with modulation index 0.5, the ratio of the amplitude of the carrier wave to that of the side band in the modulated wave is

(1) 4 : 1 (2) 1 : 1 (3) 1 : 2 (4) 2 : 1

20. A carrier frequency of 1MHz and peak value of 10V is amplitude modulated with a signal frequency of 10kHz with peak value of 0.5 V. Then the modulation index and the side band frequencies respectively are

(1) 0.05 and 1 ± 0.010 MHz (2) 0.5 and 1 ± 0.010 MHz

(3) 0.05 and 1 ± 0.005 MHz (4) 0.5 and 1 ± 0.005 MHz

21. In amplitude modulation, the bandwidth is

(1) Twice the audio signal frequency (2) Thrice the audio signal frequency

(3) Thrice the carrier wave frequency (4) Twice the carrier wave frequency

PART-II: NUMERICAL VALUE QUESTIONS

1.✍ For a carrier frequency of 100 kHz and a modulating frequency of 5 kHz, the width of AM transmission in kHz is:

2. A transmitter supplies 9 kW to the aerial when unmodulated. The power radiated when modulated to 40% in kW is :

3. The antenna current of an AM transmitter is 8A when only carrier is sent but increases to 8.96 A when the carrier is sinusoidal modulated. The percentage modulations is -

4. The total power content of an AM wave is 900 W. For 100% modulation, the power transmitted by each side band in 10n W. Find the value of n :

5. 1000kHz carrier wave is amplitude modulated by the signal frequency 200 – 4000Hz. The channel width of this case in kHz is :

6. The area of the region covered by the TV broadcast by a TV tower of 100 m height is $n\pi \times 10^3$ km^2. Find n (radius of the earth = 6.4×10^6 m)

7. The distance of coverage of a transmitting antenna is 12.8 km. Then, the height of the antenna in m is (Given that radius of earth = 6400 km)

8. If the maximum amplitude of an amplitude modulated wave is 25 V and the minimum amplitude is 5 V, the modulation index is n/3. Find n -

Exercise-2

✍ **Marked Questions can be used as Revision Questions.**

* **Marked Questions may have more than one correct option.**

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. This question has Statement –1 and Statement –2. Of the four choices given after the statements, choose the one that best describes the two statements. **[AIEEE - 2011, 4/120, –1]**

Statement –1

Sky wave signals are used for long distance radio communication. These signals are in general, less stable than ground wave signals.

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 false.

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

(3) Statement –1 is true, Statement –2 is true, Statement–2 is not the correct explanation of Statement–1

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

2. Which of the following four alternatives is not correct? **[AIEEE 2011, 11 May; 4/120, –1]**

We need modulation:

(1) to reduce the time lag between transmission and reception of the information signal

(2) to reduce the size of antenna

(3) to reduce the e fractional band width, that is the ratio of the signal band width to the centre frequency

(4) to increase the selectivity.

3.✍ A radar has a power of 1kW and is operating at a frequency of 10 GHz. It is located on a mountain top of height 500m. The maximum distance upto which it can detect object located on the surface of the earth (Radius of earth = 6.4×10^6 m) is : **[AIEEE - 2012, 4/120, –1]**

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

4. 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; 4/120, –1]**

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

5. If a carrier wave c(t) = A $\sin\omega_C t$, were to be amplitude modulated by a modulating signal m(t) = A $\sin\omega_m t$, the equation representing the modulated signal [$C_m(t)$], and its modulatgion index, would be respectively :

(1) $C_m(t) = A(1 + \sin\omega_C t)\sin\omega_m t$ and 1 (2) $C_m(t) = A(1 + \sin\omega_C t)\sin\omega_m t$ and 2

(3) $C_m(t) = A(1 + \sin\omega_m t)\sin\omega_c t$ and 1 (4) $C_m(t) = A(1 + \sin\omega_m t)\sin\omega_c t$ and 2

6. For sky wave propagation, the radio waves must have a frequency range in between :

[JEE (Main) 2014_ONLINE TEST]

(1) 1 MHz to 2 MHz (2) 45 MHz to 50 MHz

(3) 35 MHz to 40 MHz (4) 5 MHz to 25 MHz

7. Long range radio transmission is possible when the radiowaves are reflected from the ionosphere. For this to happen the frequency of the radiowaves must be in the range : **[JEE (Main) 2014_ Online Test]**

(1) 8–25 MHz (2) 80–150 MHz (3)150–500 kHz (4) 1–3 MHz

8. A signal 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; 4/120, –1]**

(1) 2 MHz only (2) 2005 kHz, and 1995 kHz

(3) 2005 kHz, 2000 kHz and 1995 kHz (4) 2000 kHz and 1995 kHz

9. Choose the correct statement : **[JEE(Main)-2016; 4/120, –1]**

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

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

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

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

10. 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 frequency is not contained in the modulated wave ? **[JEE (Main) 2017; 4/120, –1]**

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

11. 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, 4/120, –1]**

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

12. In a communication system operating at wavelength 800 nm, only one percent of source frequency is available as signal bandwidth. The number of channels accommodated for transmitting TV signals of band width 6 MHz are (Take velocity of light c = 3×10^8 m/s, h = 6.6×10^{-34} J-s]

[JEE(Main)-2019_09-01-2019_Shift-2]

(1) 3.75×10^6 (2) 3.86×10^6 (3) 6.25×10^5 (4) 4.87×10^5

13. A TV transmission tower has a height of 140 m and the height of the receiving antenna is 40 m. What is the maximum distance upto which signals can be broadcasted from this tower in LOS (Line of sight) mode ? (Given : radius of earth = 6.4×10^6 m) **[JEE(Main)-2019_10-01-2019_Shift-1]**

(1) 80 km (2) 40 km (3) 48 km (4) 65 km

14. The modulation frequency of an AM radio station is 250 kHz, which is 10% of the carrier wave. If another AM station approaches you for licence what broadcast frequency will you allot ?

[JEE(Main)-2019_10-01-2019_Shift-2]

(1) 2750 kHz (2) 2250 kHz (3) 2900 kHz (4) 2000 kHz

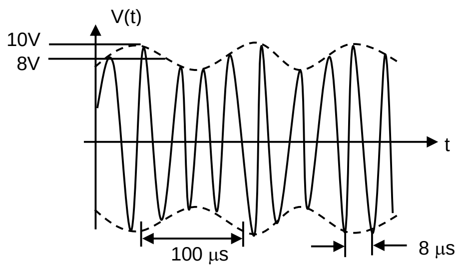
15. An amplitude modulated signal is given by $V(t) = 10\,[1 + 0.3\cos(2.2 \times 10^4 t)\sin(5.5 \times 10^5 t)]$. Here t is in seconds. The sideband frequencies (in kHz) are, [Given $\pi = 22/7$]

[JEE(Main)-2019_11-01-2019_Shift-1]

(1) 892.5 and 857.5 (2) 89.25 and 85.75

(3) 1785 and 1715 (4) 178.5 and 171.5

16. An amplitude modulated signal is plotted below : **[JEE(Main)-2019_11-01-2019_Shift-2]**



Which one of the following best describes the above signal ?

(1) $(9 + \sin(2.5\pi \times 10^5 t))\sin(2\pi \times 10^4 t)$ V

(2) $(1 + 9\sin(2\pi \times 10^4 t))\sin(2.5\pi \times 10^5 t)$V

(3) $(9 + \sin(2\pi \times 10^4 t))\sin(2.5\pi \times 10^5 t)$V

(4) $(9 + \sin(4\pi \times 10^4 t))\sin(5\pi \times 10^5 t)$V

17. A 100 V carrier wave is made to vary between 160 V and 40 V by a modulating signal. What is the modulation index ? **[JEE(Main)-2019_12-01-2019_Shift-1]**

(1) 0.4 (2) 0.6 (3) 0.5 (4) 0.3

18. The wavelength of the carrier waves in a modern optical fiber communication network is closed to :

[JEE(Main)-2019_08-04-2019_Shift-1]

(1) 1500 nm (2) 2400 nm (3) 600 nm (4) 900 nm

19. A signal $A\cos\omega t$ is transmitted using $\upsilon_0 \sin\omega_0 t$ as carrier wave. The correct amplitude modulated (AM) signal is : **[JEE(Main)-2019_09-04-2019_Shift-1]**

(1) $\upsilon_0 \sin w_0 t + A\cos\omega t$ (2) $\upsilon_0 \sin\omega_0 t + \frac{A}{2}\sin(\omega_0 - \omega)t + \frac{A}{2}\sin(\omega_0 + \omega)t$

(3) $\upsilon_0 \sin[\omega 0(1 + 0.01A\sin\omega t)t]$ (4) $(\upsilon_0 + A)\cos\omega t \sin\omega_0 t$

20. Given below in the left column are different modes of communication using the kinds of waves given in the right column. **[JEE(Main)-2019_10-04-2019_Shift-1]**

A.	Optical Fibre Communication	P.	Ultrasound
B.	Radar	Q.	Infrared Light
C.	Sonar	R.	Microwaves
D.	Mobile Phones	S.	Radio Waves

From the options given below, find the most appropriate match between entries in the left and the right column.

(1) A - Q, B-S, C-P, D-R
(2) A-S, B-Q,C-R, D-P
(3) A-Q, B-S, C-R, D-P
(4) A-R, B-P, C-S, D-Q

21. A message signal of frequency 100 MHz and peak voltage 100 V is used to execute amplitude modulation on a carrier wave of frequency 300 GHz and peak voltage 400 V. The modulation index and difference between the two side band frequencies are : **[JEE(Main)-2019_10-04-2019_Shift-1]**

(1) 4 ; 1×10^8 Hz
(2) 0.25 ; 1×10^8 Hz
(3) 0.25 ; 2×10^8 Hz
(4) 4 ; 2×10^8 Hz

Answers

EXERCISE # 1

PART-I

1.	(3)	**2.**	(1)	**3.**	(3)
4.	(2)	**5.**	(4)	**6.**	(3)
7.	(3)	**8.**	(3)	**9.**	(4)
10.	(2)	**11.**	(1)	**12.**	(3)
13.	(1)	**14.**	(2)	**15.**	(1)
16.	(3)	**17.**	(4)	**18.**	(1)
19.	(1)	**20.**	(1)	**21.**	(1)

PART-II

1.	10.00	**2.**	09.72	**3.**	71.00
4.	15.00	**5.**	08.00	**6.**	01.28
7.	12.80	**8.**	02.00		

EXERCISE # 2

PART - I

1.	(4)	**2.**	(1)	**3.**	(1)
4.	(2)	**5.**	(3)	**6.**	(3)
7.	(1)	**8.**	(3)	**9.**	(4)
10.	(2)	**11.**	(1)	**12.**	(3)
13.	(4)	**14.**	(4)	**15.**	(2)
16.	(3)	**17.**	(2)	**18.**	(1)
19.	(2)	**20.**	(2)	**21.**	(3)

Exercise-1

✍ **Marked Questions can be used as Revision Questions.**
✍ **चिन्हित प्रश्न दोहराने योग्य प्रश्न है।**

PART-I: SINGLE CHOICE QUESTIONS

भाग-I: एकल विकल्पीय प्रश्न (SINGLE CHOICE QUESTIONS)

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

यदि 1000 kHz की एक वाहक तरंग का उपयोग सिग्नल ले जाने (carry) में किया जाना हो तो प्रसारक (transmitting) ऐन्टिना की लम्बाई होगी -

(1) 3 m (2) 30 m (3*) 300 m (4) 3000 m

2. In amplitude modulation -

(1*) only the amplitude is changed but frequency remains same

(2) both the amplitude and frequency change equally

(3) both the amplitude and frequency change unequally

(4) none the these

आयाम मोडयूलेशन में -

(1*) केवल आयाम परिवर्तित होता है लेकिन आवृति वही रहती है।

(2) आयाम तथा आवृति दोनो समान रूप से बदलते है।

(3) आयाम तथा आवृति दोनो असमान रूप से बदलते है।

(4) इनमें से कोई नही

3. Modulation factor determines -

(1) only the strength of the transmitted signal (2) only the quality of the transmitted signal

(3*) both the strength and quality of the signal (4) none of the above

मोडयूलेशन घटक निर्धारित करता है -

(1) केवल ट्रान्समिटेड सिग्नल की शक्ति (प्राब्ल्य) (2) केवल ट्रान्समिटेड सिग्नल की गुणवत्ता

(3*) सिग्नल का प्राब्ल्य तथा गुणवता दोनों (4) उपरोक्त में से कोई नही

4. Degree of modulation – मोडयूलेशन डिग्री का मान –

(1) can take any value (2*) should be less than 100%

(3) should exceed 100% (4) none of these

(1) कोई भी मान हो सकता है (2*) 100% से कम होना चाहिये

(3) 100% से अधिक होना चाहिये (4) इनमें से कोई नही

5. If the maximum and minimum voltage of an AM wave are $V_{max.}$ and $V_{min.}$ respectively then modulation factor–

एक AM तरंग के वोल्टेज के अधिकतम मान $V_{max.}$ तथा न्यूनतम मान $V_{min.}$ है तो मोडयूलेशन फेक्टर (factor) होगा–

(1) $m = \frac{V_{max.}}{V_{max.} + V_{min.}}$ (2) $m = \frac{V_{min.}}{V_{max.} + V_{min.}}$ (3) $m = \frac{V_{max.} + V_{min.}}{V_{max.} - V_{min.}}$ (4*) $m = \frac{V_{max.} - V_{min.}}{V_{max.} + V_{min.}}$

6. The AM wave contains three frequencies, viz : एक AM तरंग तीन आवृतियॉ रखती है, यह है :

(1) $\frac{f_c}{2}, \frac{f_c + f_s}{2}, \frac{f_c - f_s}{2}$ (2) $2f_c$, $2(f_c + f_s)$, $2(f_c - f_s)$

(3*) f_c, $(f_c + f_s)$, $(f_c - f_s)$ (4) f_c , f_c, f_c

7. Which of the following is/are the limitations of amplitude modulation?

निम्न में से कौनसी आयाम मोडयूलेशन की सीमाऐ है ?

(1) Clear reception (2) High efficiency

(3*) Small operating range (4) Good audio quality

(1) संकेतो का स्पष्ट रूप से प्राप्त होना (Clear reception) (2) उच्च क्षमता

(3*) छोटी ऑपरेटिंग परास (4) अच्छी श्रव्य (audio) गुणवत्ता

8. In which of the region of earth's atmosphere temperature decreases with height?

(1) Ionosphere (2) Stratosphere (3*) Troposphere (4) Mesosphere

पृथ्वी के वायु मण्डल के कौनसे भाग में ऊँचाई बढने के साथ ताप में कमी होती जाती है?

(1) आयनमण्डल (2) समताप मण्डल (Stratosphere)

(3*) ट्रोपोस्फीयर (Troposphere) (4) मेसोस्फीयर (Mesosphere)

9. In an amplitude modulated wave, for audio frequency of 500 cps, the appropriate carrier frequency will be :

500 cps के ध्वनि आवृति के आयाम माड्यूलित तरंग में वाहक तरंग की उपयुक्त आवृति होगी।

(1) 50 c/s (2) 100 c/s (3) 500 c/s (4*) 50000 c/s

10. In A.M., the total modulation index should not exceed one or else :

(1) the system will fail (2*) distortion will result

(3) amplifier will be damaged (4) none of the above

आयाम माड्यूलेशन में मोड्यूलेशन गुणंक एक से ज्यादा नही होना चाहिए अन्यथा।

(1) तंत्र (असफल) हो जाएगा (2*) विकृती उत्पन्न हो जाएगी

(3) प्रवर्धक नष्ट हो जाएगा (4) उपर्युक्त कोई नही

11. An 'antenna' is : एक ऐन्टीना होता है।

(1*) inductive (2) capacitive

(3) resistive above its resonance frequency (4) none of the above

(1*) प्रेरकीय (2) धारितीय

(3) इसकी अनुनादी आवृति के ऊपर प्रतिरोधी (4) उपरोक्त में से कोई नही

12. The Q of a resonant transimission line is : एक अनुनादी संचरण रेखा के लिये Q है –

(1) $Q = \frac{\omega}{LR}$ (2) $Q = \frac{\omega R}{L}$ (3*) $Q = \frac{L}{R}$ (4) $Q = \frac{\omega L}{R}$

13. Range of frequencies allotted for commercial FM radio broadcast is -

व्यवसायिक FM रेडियों के लिये नियुक्त की गई (allotted) आवृत्तियों का परास है–

(1*) 88 to 108 MHz (2) 88 to 108 kHz (3) 8 to 88 MHz (4) 88 to 108 GHz

(1*) 88 से 108 MHz तक (2) 88 से 108 kHz तक (3) 8 से 88 MHz तक (4) 88 से 108 GHz तक

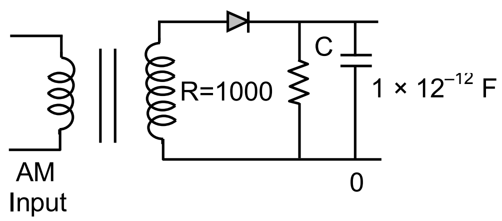
14. Which of the following is not transducer? निम्न में से कौनसा ट्रांसड्यूसर नही है?

(1) Loudspeaker (2*) Amplifier (3) Microphone (4) All of these

(1) लाउडस्पीकर (2*) प्रवर्धक (3) माइक्रोफोन (4) उपरोक्त सभी

15. In the given detector circuit, the suitable value of carrier frequency is

दिये गये संसूचक परिपथ में वाहक आवृति का योग्य मान है–



(1*) $<<10^9$ Hz (2) $<<10^5$ Hz (3) $>> 10^9$ Hz (4) None of theseइनमें से कोई नहीं

Ans. **(1)**

Sol. Using $\frac{1}{f_{carrier}} << RC$ लेने पर

We get time constant हम समय नियतांक प्राप्त करते है, $RC = 1000 \times 10^{-12} = 10^{-9}s$

Now अब $v = \frac{1}{T} = \frac{1}{10^{-9}} = 10^{9}$ Hz

Thus, the value of carrier frequency should be much less than 10^9 Hz, say 100 kHz.

इस प्रकार वाहक आवृति का मान 10^9 Hz से बहुत ज्यादा कम होना चाहिए माना 100 kHz.

$\Rightarrow \frac{v_m}{v_s} = \sqrt{\frac{L_s}{L_m}} \Rightarrow L_s < L_m$

16. Amplitude modulation has

(1) One carrier

(2) One carrier with high frequency

(3*) One carrier with two side band frequencies

(4) One carrier with infinite frequencies

आयाम मॉडुलन रखता है—

(1) एक वाहक

(2) उच्च आवृति का एक वाहक

(3*) दो पार्श्व बैण्ड आवृतियों वाला एक वाहक

(4) अनन्त आवृतियों का एक वाहक

17. Through which mode of propagation, the radio waves can be sent from one place to another

(1) Ground wave propagation

(2) Sky wave propagation

(3) Space wave propagation

(4*) All of them

प्रसारण के किस मोड़ में रेडियो तरंगो को एक स्थान से दूसरे स्थान पर भेजा जा सकता है—

[PC-103-E] [JIPMER 2003]

(1) भू-तरंग प्रसारण

(2) उच्च आवृति का एक वाहक

(3) दो पार्श्व बैण्ड आवृतियों वाला एक वाहक

(4*) अनन्त आवृतियों का एक वाहक

18. Sinusoidal carrier voltage of frequency 1.5 MHz and amplitude 50 V is amplitude modulated by sinusoidal voltage of frequency 10 kHz producing 50% modulation. The lower and upper side-band frequencies in kHz are

1.5 MHz आवृति तथा 50 आयामक का ज्यावक्रीय वाहक विभव को 10 kHz आवृति वाले ज्यावक्रीय विभव द्वारा आयाम मॉडुलित करने पर 50% माडुलन उत्पन्न करता है। निम्न तथा उच्च पार्श्व बैण्ड आवृतियाँ kHz है–

(1*) 1490, 1510 (2) 1510, 1490 (3) $\frac{1}{1490},\frac{1}{1510}$ (4) $\frac{1}{1510},\frac{1}{1490}$

19. In an amplitude modulation with modulation index 0.5, the ratio of the amplitude of the carrier wave to that of the side band in the modulated wave is

मॉडुलन सूचकांक 0.5 की एक आयाम मॉडुलन में मॉडुलित तरंग में वाइक तरंग का पार्श्व बैण्ड से आयामक अनुपात है–

(1*) 4 : 1 (2) 1 : 1 (3) 1 : 2 (4) 2 : 1

20. A carrier frequency of 1MHz and peak value of 10V is amplitude modulated with a signal frequency of 10kHz with peak value of 0.5 V. Then the modulation index and the side band frequencies respectively are

(1*) 0.05 and 1 ± 0.010 MHz (2) 0.5 and 1 ± 0.010 MHz

(3) 0.05 and 1 ± 0.005 MHz (4) 0.5 and 1 ± 0.005 MHz

1MHz की एक वाहक आवृति तथा 10V का उच्चमान एक 10kHz की सिग्नल आवृति तथा 0.5 V के उच्च मान के साथ आयाम मॉडुलित हो गया है तो मॉडुलन सूचकांक तथा पार्श्व बैण्ड आवृतियाँ क्रमशः है–

(1*) 0.05 तथा 1 ± 0.010 MHz (2) 0.5 तथा 1 ± 0.010 MHz

(3) 0.05 तथा 1 ± 0.005 MHz (4) 0.5 तथा 1 ± 0.005 MHz

21. In amplitude modulation, the bandwidth is

(1*) Twice the audio signal frequency

(2) Thrice the audio signal frequency

(3) Thrice the carrier wave frequency

(4) Twice the carrier wave frequency

आयाम मॉडुलन में, बैण्ड चौड़ाई है–

(1*) श्रव्य सिग्नल आवृति से दुगुनी

(2) श्रव्य सिग्नल आवृति से तीनगुनी

(3) वहक तरंग आवृति से तीन गुनी

(4) वहक तरंग आवृति से दुगुनी

PART-II: NUMERICAL VALUE QUESTIONS

भाग-II : संख्यात्मक प्रश्न (NUMERICAL VALUE QUESTIONS)

1. For a carrier frequency of 100 kHz and a modulating frequency of 5 kHz, the width of AM transmission in kHz is:

100 kHz आवृति की एक वाहक आवृति तथा 5 kHz की मोडयूलेटिंग आवृति के लिये AM ट्रान्समिशन की चौडाई (width) का मान kHz में होगा –

Ans. **10.00**

2. A transmitter supplies 9 kW to the aerial when unmodulated. The power radiated when modulated to 40% in kW is :

एक प्रेषित जब अमाडुलित होता है तो एरियल को 9 kW आपूर्ती देता है। जब 40% से माडुलित होता है तो विकिरित शक्ति kW में होगी –

Ans. **9.72**

Sol. $P_t = \left[1+\frac{m^2}{2}\right] = 9\left[1+\frac{(0.4)^2}{2}\right] = 9\left[1+\frac{0.16}{2}\right]$

$(\therefore m = 40\% = 0.4)$

$= 9\,(1.08) = 9.72$ kW

3. The antenna current of an AM transmitter is 8A when only carrier is sent but increases to 8.96 A when the carrier is sinusoidal modulated. The percentage modulations is -

एक AM प्रेषित के ऐंटीना की धारा 8A है जब केवल वाहक भेजा गया है लेकिन जब एक ज्यावक्रीय मॉडुलित हो जाते है तो यह 8.96 A से बढ़ जाती है। प्रतिशत मॉडुलन है–

Ans. **71.00**

Sol. We know that हम जानते है $\left(\frac{I_t}{I_c}\right)^2 = 1+\frac{m^2}{2}$

Here यहाँ, $I_t = 8.96$ A and तथा $I_c = 8$A

$\therefore \left(\frac{8.96}{8}\right)^2 = 1+\frac{m^2}{2}$ or या $1.254 = 1 + \frac{m^2}{2}$

or या $\frac{m^2}{2} = 0.254$

or या $m^2 = 0.508$ or या $m = 0.71 = 71\%$

4. The total power content of an AM wave is 900 W. For 100% modulation, the power transmitted by each side band in 10n W. Find the value of n :

एक AM तरंग की कुल तृप्त शक्ति 900 W है। 100% माडुलन के लिए प्रत्येक पार्श्व बैण्ड द्वारा प्रेषित शक्ति यदि 10n W है, तो n का मान ज्ञात कीजिए।

Ans. **15.00**

Sol. $P_c = P_t\left[\frac{2}{2+m^2}\right] = 900\left[\frac{2}{2+1}\right] = 600W$

Now अब, $P_{LSB} = \frac{m^2}{4} \times P_c = \frac{1}{4} \times 600 = 150$ W

5. 1000kHz carrier wave is amplitude modulated by the signal frequency 200 – 4000Hz. The channel width of this case in kHz is :

1000 kHz आवृति की वहक तरंग 200 – 4000Hz सिग्नल आवृति द्वारा आयाम मॉडुलित हो जाती है। इस स्थिति के चैनल की चौड़ाई kHz में होगी –

Ans. **8.00**

6. The area of the region covered by the TV broadcast by a TV tower of 100 m height is $n\pi \times 10^3$ km^2. Find n (radius of the earth = 6.4×10^6 m)

100 मीटर की ऊँचाई के एक TV टॉवर द्वारा TV प्रसारण $n\pi \times 10^3$ km^2 क्षेत्रफल का क्षेत्र को आच्छादित करता है, तो n का मान ज्ञात कीजिए। (पृथ्वी की त्रिज्या = 6.4×10^6 m)

Ans. **1.28**

7. The distance of coverage of a transmitting antenna is 12.8 km. Then, the height of the antenna in m is (Given that radius of earth = 6400 km)

एक प्रेषक ऐन्टीना 12.8 किमी की दूरी तक सेवाऐं देता है तो ऐन्टीने की ऊँचाई मीटर में है (दिया है कि पृथ्वी की त्रिज्या = 6400 किमी)

Ans. **12.80**

8. If the maximum amplitude of an amplitude modulated wave is 25 V and the minimum amplitude is 5 V, the modulation index is n/3. Find n -

यदि एक आयाम मॉडुलित तरंग का अधिकतम आयाम 25 V है तथा न्यूनतम आयाम 5 V है तो मॉडुलित सूचकांक n/3 है, तो n का मान ज्ञात कीजिए।

Ans. **2.00**

Exercise-2

✍ **Marked Questions can be used as Revision Questions.**
✍ **चिन्हित प्रश्न दोहराने योग्य प्रश्न है।**

* **Marked Questions may have more than one correct option.**
* **चिन्हित प्रश्न एक से अधिक सही विकल्प वाले प्रश्न है -**

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

भाग - I : JEE (MAIN) / AIEEE (पिछले वर्षो) प्रश्न

1. This question has Statement –1 and Statement –2. Of the four choices given after the statements, choose the one that best describes the two statements.

[AIEEE - 2011, 4/120, –1]

Statement –1

Sky wave signals are used for long distance radio communication. These signals are in general, less stable than ground wave signals.

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 false.

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

(3) Statement –1 is true, Statement –2 is true, Statement–2 is not the correct explanation of Statement–1

(4*) Statement–1 is false, Statement –2 is true

इस प्रश्न में प्रकथन –1 एवं प्रकथन –2 दिये गये हैं। प्रकथनों के बाद दिये गये चार विकल्पों में से उस विकल्प को चुनिये जो कि प्रकथनों का सही वर्णन करता है। **[AIEEE - 2011, 4/120, –1]**

प्रकथन –1

लम्बी दूरी के रेडियो संचरण के लिये व्योम तरंग सिग्नल का प्रयोग किया जाता है। साधारणतया, यह सिग्नल भू तरंग सिग्नल की अपेक्षा कम स्थायी होते हैं।

प्रकथन –2:

आयन मंडल की अवस्था घंटा–प्रतिघंटा, दिन–प्रतिदिन और ऋतु–प्रतिऋतु बदलती रहती है।

(1) प्रकथन –1 सही हैं, प्रकथन–2 गलत हैं

(2) प्रकथन –1 सही है, प्रकथन –2 सही है और प्रकथन –2 प्रकथन–1 की सही व्याख्या करता है।

(3) प्रकथन –1 सही है, प्रकथन –2 सही है और प्रकथन –2 प्रकथन–1 की सही व्याख्या नहीं करता है।

(4*) प्रकथन –1 गलत है, प्रकथन –2 सही है।

2. Which of the following four alternatives is not correct? **[AIEEE 2011, 11 May; 4/120, –1]**

We need modulation:

(1*) to reduce the time lag between transmission and reception of the information signal

(2) to reduce the size of antenna

(3) to reduce the e fractional band width, that is the ratio of the signal band width to the centre frequency

(4) to increase the selectivity.

निम्नलिखित विकल्पों में से कौनसा सही नहीं है ? **[AIEEE 2011, 11 May; 4/120, –1]**

हमें माडुलेशन की आवश्यकता होती हे :

(1*) सूचना सिग्नल की संचरण और प्राप्ति के बीच समय अन्तराल को घटाने के लिए।

(2) एन्टीना का आकार घटाने के लिए।

(3) आंशिक बैण्ड चौड़ाई अर्थात् सिग्नल बैण्ड चौड़ाई का केन्द्रीय आवृत्ति से अनुपात घटाने के लिए।

(4) वरण क्षमता में वृद्धि के लिए।

3. A radar has a power of 1kW and is operating at a frequency of 10 GHz. It is located on a mountain top of height 500m. The maximum distance upto which it can detect object located on the surface of the earth (Radius of earth = 6.4×10^6 m) is : **[AIEEE - 2012, 4/120, –1]**

एक राडार की शक्ति 1kW है और यह 10 GHz की आवृत्ति पर परिचालित है। यह 500m ऊँचाई पर पहाड़ के एक शीर्ष पर स्थित है। कितनी दूरी पर रखी पृथ्वी (पृथ्वी की त्रिज्या = 6.4×10^6 m) के पृष्ठ पर स्थित वस्तु को यह राडार संसूचित कर सकेगा : **[AIEEE - 2012, 4/120, –1]**

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

4. 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; 4/120, –1]**

एक डायोड संसूचक को, 250 पिको फैरड वाले संधारित्र को 100 किलो ओहम के लोड प्रतिरोध के साथ समान्तर क्रम में लगाकर, 60% माडुलेशन वाली आयाम माडुलक तरंग का पता लगाने में प्रयुक्त किया गया है। इसके द्वारा अधिकतम माडुलित आवृति जिसे ज्ञात किया जा सकता है : **[JEE (Main) - 2013; 4/120, –1]**

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

5._ If a carrier wave c(t) = A $\sin\omega_c t$, were to be amplitude modulated by a modulating signal m(t) = A $\sin\omega_m t$, the equation representing the modulated signal [$C_m(t)$], and its modulatgion index, would be respectively : **[JEE(MAIN) 2013_ONLINE TEST]**

(1) $C_m(t) = A(1 + \sin\omega_c t)\sin\omega_m t$ and 1 (2) $C_m(t) = A(1 + \sin\omega_c t)\sin\omega_m t$ and 2

(3) $C_m(t) = A(1 + \sin\omega_m t)\sin\omega_c t$ and 1 (4) $C_m(t) = A(1 + \sin\omega_m t)\sin\omega_c t$ and 2

यदि एक वाहक तरंग c(t) = A $\sin\omega_c t$ मोड्युलित संकेत m(t) = A $\sin\omega_m t$ के द्वारा आयाम मोड्युलित है, तब मोड्युलित संकेत [$C_m(t)$] को प्रदर्शित करने वाली समीकरण तथा इसका मोड्युलेशन सूचकांक होगा **[JEE(MAIN) 2013_ONLINE TEST]**

(1) $C_m(t) = A(1 + \sin\omega_C t)\sin\omega_m t$ तथा 1 (2) $C_m(t) = A(1 + \sin\omega_C t)\sin\omega_m t$ तथा 2

(3) $C_m(t) = A(1 + \sin\omega_m t)\sin\omega_c t$ तथा 1 (4) $C_m(t) = A(1 + \sin\omega_m t)\sin\omega_c t$ तथा 2

Ans. **(3)**

Sol. $c_m(t) = (A_C + A_m \sin \omega_m t) \sin \omega_c t = A\left(1+\sin\omega_m t\right) \sin \omega_c t$

Modulation index मोड्युलेशन सूचकांक $m_a = \dfrac{A_m}{A_c} = \dfrac{A}{A} = 1$

6. For sky wave propagation, the radio waves must have a frequency range in between :

[JEE (Main) 2014_ONLINE TEST]

(1) 1 MHz to 2 MHz (2) 45 MHz to 50 MHz (3*) 35 MHz to 40 MHz (4) 5 MHz to 25 MHz

आकाश तरंग प्रसारण के लिए रेडियो तरंगो की परास निम्न आवृति के बीच होनी चाहिए–

(1) 1 MHz से 2 MHz (2) 45 MHz से 50 MHz (3*) 35 MHz से 40 MHz (4) 5 MHz से 25 MHz

Ans. **(3)**

7. Long range radio transmission is possible when the radiowaves are reflected from the ionosphere. For this to happen the frequency of the radiowaves must be in the range : **[JEE (Main) 2014_Online Test]**

लम्बी दूरी का रेडियो वितरण तब संभव है जब रेडियो तरंगे आयनमण्डल से परावर्तित होती हो। ऐसा होने के लिए रेडियो तरंगो की आवृति निम्न परास की होनी चाहिए– **[JEE (Main) 2014_ Online Test]**

(1*) 8–25 MHz (2) 80–150 MHz (3)150–500 kHz (4) 1–3 MHz

Ans. **(1)**

8. A signal 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; 4/120, –1]**

(1) 2 MHz only (2) 2005 kHz, and 1995 kHz

(3*) 2005 kHz, 2000 kHz and 1995 kHz (4) 2000 kHz and 1995 kHz

5 kHZ आवृत्ति के किसी संकेत (सिग्नल) का 2 mHz आवृत्ति की वाहक तंरग पर आयाम मॉडुलन किया गया है । तो, परिणामी सिग्नल (संकेत) की आवृत्ति होगी : **[JEE(Main)-2015; 4/120, –1]**

(1) 2 MHz केवल (2) 2005 kHz, तथा 1995 kHz

(3*) 2005 kHz, 2000 kHz तथा 1995 kHz (4) 2000 kHz तथा 1995 kHz

Ans. **(3)**

Sol. $f_c = 2MHz = 2000\ KHz$

$f_m = 5KHz$

Resultant frequencies are

परिणामी आर्वतिया

$\equiv f_C + f_m, f_c, f_c - f_m$

= 2005 KHz, 2000, 1995 KHz

9. Choose the correct statement : **[JEE(Main)-2016; 4/120, –1]**

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

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

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

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

सही कथन चुनियें : **[JEE(Main)-2016; 4/120, –1]**

(1) आयाम माडुलन में उच्च आवृत्ति की वाहक तरंग की आवृत्ति में बदलाव ध्वनि सिग्नल के आयाम के अनुपाती है।

(2) आवृत्ति माडुलन में उच्च आवृत्ति की वाहक तरंग के आयाम में बदलाव ध्वनि सिग्नल के आयाम के अनुपाती है।

(3) आवृत्ति माडुलन में उच्च आवृत्ति की वाहक तरंग के आयाम में बदलाव ध्वनि सिग्नल के आवृत्ति के अनुपाती है।

(4) आयाम माडुलन में उच्च आवृत्ति की वाहक तरंग के आयाम में बदलाव ध्वनि सिग्नल के आयाम के अनुपाती है।

Ans. **(4)**

Sol. In amplitude modulation amplitude of carrier wave (high frequency) is varied in proportion to the amplitude of signal.

In frequency modulation frequency of carrier wave (high frequency) is varied in proportion to amplitude of signal.

आयाम मोड्युलेशन में वाहक तरंग (उच्च आवृत्ति) का आयाम संकेत के आयाम के अनुपात में परिवर्तित होता है।

आवृत्ति मोड्युलेशन में वाहक तरंग (उच्च आवृत्ति) की आवृत्ति संकेत के आयाम के अनुपात में परिवर्तित होती है।

10. 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 frequency is not contained in the modulated wave ?

आयाम मॉडूलन में ज्यावक्रिय वाहक आवृति को ω_c से तथा सिग्नल आवृति को ω_m से दर्शाते है। सिग्नल की बैण्ड चौडाई ($\Delta\omega_m$) को इस तरह चुनते है कि $\Delta\omega_m << \omega_c$, निम्न में से कौनसी आवृति मॉडूलित तरंग में नही होगी।

[JEE (Main) 2017; 4/120, –1]

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

Ans. **(2)**

Sol. 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

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

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

Note that the modulated signal now contains the message signal. From Eq. (i), we can write,

$$c_m(t) = A_c \sin \omega_c t + \mu A_c \sin \omega_m t \sin \omega_c t \quad \text{..........(ii)}$$

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

Using the trignomatric relation sin A sin B = 1/2 (cos (A – B) – cos (A + B),

we can write c_m (t) of Eq. (ii) as

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

In amplitude modulated wave, the frequencies contained are $\omega_c - \omega_m$, ω_c, $\omega_c + \omega_m$.

The frequency of ω_m is not contained in A.M. wave

Hindi. मान लीजिए $c(t) = A_C \sin \omega_c t$ वाहक तरंग को निरूपित करती है, तथा $m(t) = A_m \sin \omega_m t$ माडुलक सिग्नल अथवा संदेश को निरूपित करती है जबकि, $\omega_m = 2\pi f_m$ संदेश सिग्नल की कोणीय आवृत्ति है। तब माडुलित सिग्नल c_m (t) को इस प्रकार व्यक्त किया जा सकता है।

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

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

ध्यान दीजिए, अब संदेश सिग्नल माडुलित में अतंर्विष्ट है। समीकरण (i), से हम यह लिख सकते हैं।

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

यहाँ $\mu = A_m/A_c$ माडुलन सूचकांक है। विरूपण से बचाव के लिए व्यवहार में $\mu \leq 1$ रखा जाता है।

त्रिकोणमितीय संबंध sin A sin B = 1/2 (cos (A – B) – cos (A + B) का उपयोग करके हम समीकरण (ii) से c_m (t) को इस प्रकार व्यक्त कर सकते है।

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

आयाम मोडूलित तंरग में, सम्मिलित आवृतियाँ $\omega_c - \omega_m$, ω_c, $\omega_c + \omega_m$ है।

ω_m आवृति आयाम मोडुलित तंरग में सम्मिलित नहीं है।

11. 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, 4/120, –1]**

एक टेलीफोन संचरण सेवा, वाहक आवृत्ति 10 GHz. पर काम करती है। इसका केवल 10% संचार के लिये उपयोग किया जाता है। यदि प्रत्येक चैनल की बैंड चौड़ाई 5 kHz हो तो एक साथ कितने टेलीफोनिक चैनल संचारित किये जा सकते हैं ?

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

Ans. (1)

Sol. $N = \frac{1}{10} \frac{(10\text{kHz})}{(5\text{kHz})} = \frac{10^9}{5 \times 10^3} = \frac{10^6}{5} = 2 \times 10^5$

12. In a communication system operating at wavelength 800 nm, only one percent of source frequency is available as signal bandwidth. The number of channels accommodated for transmitting TV signals of band width 6 MHz are (Take velocity of light c = 3×10^8 m/s, h = 6.6×10^{-34} J-s) **[PC-PC-104_E]**

800 nm तरंगदैर्ध्य पर कार्य करते हुए एक संचार व्यवस्था में सिग्नल की कुल स्त्रोत आवृत्ति का मात्र एक प्रतिशत बैंड चौड़ाई के लिए उपयोग कर सकते हैं। 6 MHz बैंड चौड़ाई के TV सिग्नलों वाले कितने चैन्लों को इससे संचारित किया जा सकता हैं ? (दिया है : c = 3×10^8 m/s, h = 6.6×10^{-34} J-s] **[JEE(Main)-2019_09-01-2019_Shift-2]**

(1) 3.75×10^6 (2) 3.86×10^6 (3) 6.25×10^5 (4) 4.87×10^5

Ans. **(3)**

Sol. $f = \frac{C}{\lambda} = \frac{3 \times 10^8}{800 \times 10^{-9}}$

Signal bandwidth = $\frac{1}{100} \times f = \frac{3}{8} \times 10^{13}$

No. of signal = $\frac{\frac{3}{8} \times 10^{13}}{6 \times 10^6} = 6.25 \times 10^5$

13. A TV transmission tower has a height of 140 m and the height of the receiving antenna is 40 m. What is the maximum distance upto which signals can be broadcasted from this tower in LOS (Line of sight) mode ? (Given : radius of earth = 6.4×10^6 m) **[JEE(Main)-2019_10-01-2019_Shift-1]**

एक TV संचरण मीनार की ऊँचाई 140 m तथा अभिग्राही ऐन्टिना की ऊँचाई 40 m है। इस मीनार से दृष्टि रेखा विधा (LOS) में कितनी अधिकतम दूरी तक सिग्नल प्रसारित कर सकते है ? (दिया है, पृथ्वी की त्रिज्या = 6.4×10^6 m)

(1) 80 km (2) 40 km (3) 48 km (4) 65 km

Ans. **(4)**

Sol. $D = \sqrt{2h_T R} + \sqrt{2h_R R}$

$D = \sqrt{2 \times 140 \times 64 \times 10^5} + \sqrt{2 \times 40 \times 64 \times 10^5}$

$D = 8 \times 10^3 \left[\sqrt{28} + \sqrt{8}\right]$

$D = 8 \times 10^3 \left[2\sqrt{7} + 2\sqrt{2}\right]$

$D = 16 \times 10^3 [2.6 + 1.4]$

= 64000 m = 64 km $\simeq$ 65 km

14. The modulation frequency of an AM radio station is 250 kHz, which is 10% of the carrier wave. If another AM station approaches you for licence what broadcast frequency will you allot ?

एक AM रेडियों स्टेशन की माडुलन आवृत्ति 250 kHz है, जो कि उसकी वाहक तरंग आवृत्ति की 10% है। यदि एक और रेडियों स्टेशन लाइसेंस के लिए आता है तो आप कौन–सी प्रसार आवृत्ति आबंटित करेंगे ?

[JEE(Main)-2019_10-01-2019_Shift-2]

(1) 2750 kHz (2) 2250 kHz (3) 2900 kHz (4*) 2000 kHz

Ans. **(4)**

Sol. Interval between two carrier frequencies should be atleast two times of AM frequency

15. An amplitude modulated signal is given by $V(t) = 10 [1+ 0.3 \cos (2.2 \times 10^4 t) \sin (5.5 \times 10^5 t)]$. Here t is in seconds. The sideband frequencies (in kHz) are, [Given $\pi = 22/7$]

(1) 892.5 and 857.5 (2) 89.25 and 85.75 (3) 1785 and 1715 (4) 178.5 and 171.5

एक आयाम मॉडुलित सिग्लन निम्नवत् दिया गया है $V(t) = 10 [1+ 0.3 \cos (2.2 \times 10^4 t) \sin (5.5 \times 10^5 t)]$. यहाँ t सेकण्ड में है। पार्श्व बैण्ड की आवृत्तियाँ (kHzमें) होंगी : [दिया है $\pi = 22/7$] **[JEE(Main)-2019_11-01-2019_Shift-1]]**

(1) 892.5 तथा 857.5 (2) 89.25 तथा 85.75 (3) 1785 तथा 1715 (4) 178.5 तथा 171.5

Ans. **(2)**

Sol. $V(t) = 10 [1+ 0.3 \cos (2.2 \times 10^4 t) \sin (5.5 \times 10^5 t)]$

$V(t) = 10 + 1.5 [\sin (572 \times 10^3 t) + \sin (528 \times 10^3 t)]$

we get, $\omega_L + \omega_C = 572 \times 10^3 = 2\pi f_1$

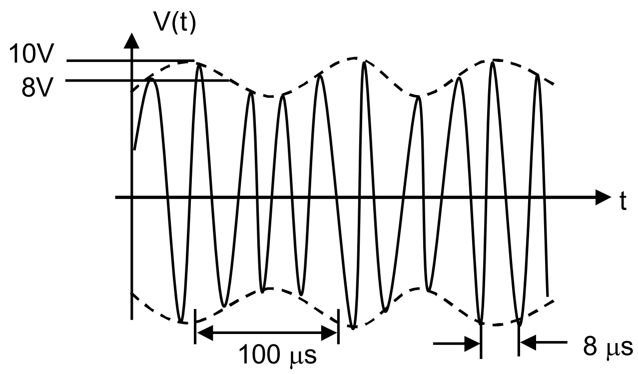
$f_1 = 572 \times 10^3/2\pi = 91$ kHz

$\omega_L - \omega_C = 528 \times 10^3 = 2\pi f_2$

$f_2 = 572 \times 10^3/2\pi = 84$ kHz

16. An amplitude modulated signal is plotted below :

एक आयाम–मॉडुलित सिग्नल को चित्र में दिखाया गया है :



Which one of the following best describes the above signal ?

निम्न में से कौन उपरोक्त सिग्नल को सबसे अच्छा दर्शाता है ?**[JEE(Main)-2019_11-01-2019_Shift-2]**

(1) $(9 + \sin(2.5\pi \times 10^5 t))\sin(2\pi \times 10^4 t)$ V

(2) $(1 + 9\sin(2\pi \times 10^4 t))\sin(2.5\pi \times 10^5 t)$V

(3*) $(9 + \sin(2\pi \times 10^4 t))\sin(2.5\pi \times 10^5 t)$V

(4) $(9 + \sin(4\pi \times 10^4 t))\sin(5\pi \times 10^5 t)$V

Ans. (3)

Sol. $\omega_s = \dfrac{2\pi}{100 \times 10^{-6}} = 2\pi \times 10^4 s^{-1}$

$\omega_c = \dfrac{2\pi}{8 \times 10^{-6}} = 2.5\pi \times 10^5 s^{-1}$

$V_{max} = V_c + V_s = 10$

$V_{min} = V_c - V_s = 8$

$\therefore \quad V_c = 9mV$

$V_s = 1mV$

Equation of AM wave AM तरंग का समीकरण

$V_{AM} = (V_c + V_s \sin \omega_s t) \sin \omega_c t$

$= \{9 + \sin (2\pi \times 10^4)t\} \times \sin(2.5\pi \times 10^5 t)$ (In mV)

17. A 100 V carrier wave is made to vary between 160 V and 40 V by a modulating signal. What is the modulation index ?

एक माडूलन सिग्नल के द्वारा 100 V की वाहक तरंग को 160 V तथा 40 V के बीच परिवर्तित करते है। माडूलन सूचकांक क्या होगा? **[JEE(Main)-2019_12-01-2019_Shift-1]**

(1) 0.4 (2) 0.6 (3) 0.5 (4) 0.3

Ans. (2)

Sol. $A_C = 100$

$A_C + A_m = 160$

$A_C - A_m = 40$

$A_C = 100, A_m = 60$

$\mu = \dfrac{A_m}{A_c} = 0.6$

18. The wavelength of the carrier waves in a modern optical fiber communication network is closed to :

एक आधुनिक प्रकाशीय फाइबर संचरण प्रणाली में वाहक तरंग की निकटतम तरंगदैर्ध्य है :

[JEE(Main)-2019_08-04-2019_Shift-1]

(1) 1500 nm (2) 2400 nm (3) 600 nm (4) 900 nm

Ans. **(1)**

Sol. For minimum attenuation λ = 1500 nm

19. A signal $A\cos\omega t$ is transmitted using $\upsilon_0\sin\omega_0 t$ as carrier wave. The correct amplitude modulated (AM) signal is : **[JEE(Main)-2019_09-04-2019_Shift-1]**

एक सिग्नल $A\cos\omega t$ का संचार वाहर तरंग $\upsilon_0\sin\omega_0 t$ से किया जाता है। सही आयाम मॉडुलित सिग्नल होगा :

(1) $\upsilon_0 \sin w_0 t + A\cos\omega t$

(2) $\upsilon_0 \sin\omega_0 t + \frac{A}{2}\sin(\omega_0 - \omega)t + \frac{A}{2}\sin(\omega_0 + \omega)t$

(3) $\upsilon_0\sin[\omega 0(1 + 0.01A\sin\omega t)t]$

(4) $(\upsilon_0 + A)\cos\omega t \sin\omega_0 t$

Ans. **(2)**

Sol. $x = (\upsilon_0 + A\cos\omega t)\sin\omega_0 t$

$x = \upsilon_0\sin(\omega_0 t) + A\cos\omega t\sin\omega_0 t$

$x = \upsilon_0\sin(\omega_0 t) + \frac{A}{2}[\sin(\omega_0 - \omega)t] + \frac{A}{2}\sin(\omega_0 + \omega)t$

20. Given below in the left column are different modes of communication using the kinds of waves given in the right column.

A.	Optical Fibre Communication	P.	Ultrasound
B.	Radar	Q.	Infrared Light
C.	Sonar	R.	Microwaves
D.	Mobile Phones	S.	Radio Waves

From the options given below, find the most appropriate match between entries in the left and the right column. **[JEE(Main)-2019_10-04-2019_Shift-1]**

नीचे बाएँ स्तम्भ में विभिन्न संचार विधायें एवं दायें स्तम्भ में तरंगों के प्रकार दिये गये है।

A.	आप्टिकल फाइबर संचार	P.	पराध्वनि
B.	रेडार	Q.	अवरक्त प्रकाश
C.	सोनार	R.	सूक्ष्म तरंगें
D.	मोबाइल फोन	S.	रेडियों तरंगें

दिये गये विकल्पों में, दायें तथा बायें स्तम्भ की प्रविष्टियों का सर्वोचित मिलान क्या होगा ?

(1) A - Q, B-S, C-P, D-R (2) A-S, B-Q,C-R, D-P

(3) A-Q, B-S, C-R, D-P (4) A-R, B-P, C-S, D-Q

Ans. **(2)**

Sol. $(A \rightarrow Q)$; $(B \rightarrow S)$, $(C \rightarrow P)$, $(D \rightarrow R)$

21. A message signal of frequency 100 MHz and peak voltage 100 V is used to execute amplitude modulation on a carrier wave of frequency 300 GHz and peak voltage 400 V. The modulation index and difference between the two side band frequencies are :

100 MHz आवृत्ति तथा शिखर वोल्टता 100 V के एक सूचना सिग्नल का उपयोग 300 GHz आवृत्ति तथा शिखर वोल्टता 400 V की एक वाहक तरंग का आयाम मॉडुलन करने के लिये करते है। मॉडुलन सूचकांक तथा दोनों पार्श्व बैण्ड़ की आवृत्तियों का अन्तर होगा : **[JEE(Main)-2019_10-04-2019_Shift-1]**

(1) 4 ; 1×10^8 Hz (2) 0.25 ; 1×10^8 Hz (3*) 0.25 ; 2×10^8 Hz (4) 4 ; 2×10^8 Hz

Sol. Modulating index माडुलन सूचकांक $m = \frac{100}{400} = 0.25$

$f_{max.} - f_{min.} = (f_c + f_m) - (f_c - f_m)$

$= 2F_M = 2 \times 10^8$ Hz

Answers

EXERCISE # 1

PART-I

1.	(3)	**2.**	(1)	**3.**	(3)
4.	(2)	**5.**	(4)	**6.**	(3)
7.	(3)	**8.**	(3)	**9.**	(4)
10.	(2)	**11.**	(1)	**12.**	(3)
13.	(1)	**14.**	(2)	**15.**	(1)
16.	(3)	**17.**	(4)	**18.**	(1)
19.	(1)	**20.**	(1)	**21.**	(1)

PART-II

1.	(10.00)	**2.**	(9.72)	**3.**	(71.00)
4.	(15.00)	**5.**	(8.00)	**6.**	(1.28)
7.	(12.80	**8.**	(2.00)		

EXERCISE # 2

PART - I

	(2)	**5.**	(3)	**6.**	(3)	**7.**	(1)
8.	(3)	**9.**	(4)	**10.**	(2)		
		11.	(1)	**12.**	(3)		
		13.	(4)	**14.**	(4)		
15.	(2)	**16.**	(3)	**17.**	(2)		
		18.	(1)	**19.**	(2)		
		20.	(2)				
21.	(3)						