Date: 22/10/2021

**Q1.** A TV tower has a height of 71 m. What is the maximum distance upto which TV transmission can be received? Given that, the radius of the earth = $6.4 \times 10^6$ m.

**Q2.** What is the purpose of modulating a signal in transmission?

**Q3.** Why do we need a higher band width for transmission of music compared to that for commercial telephone communication?

**Q4.** Name any two types of transmission media that are commonly used for transmission of signals? Write the range of frequencies of the signals for which these transmission media are used.

**Q5.** A message signal of frequency 10 kHz and peak voltage of 10 volts is used to modulate a carrier of frequency 1 MHz and peak voltage of 20 volts. Determine (a) modulation index, (b) the side bands produced.

**Q6.** What is the length of a dipole antenna to transmit signals of frequency 200 MHz?

**Q7.** What should be the length of dipole antenna for a carrier wave of frequency $5 \times 10^8$ Hz?

**Q8.** What would be the length of the quarter-wave dipole antenna for the carrier wave of frequency of (a) $3 \times 10^4$ Hz; (b) $6 \times 10^6$ Hz and (c) $5 \times 10^7$ Hz? What do you infer from the result?.

**Q9.** Why is communication using line of sight mode limited to frequencies above 40 MHz?

**Q10.** A microwave telephone link operating at the central frequency of 12 GHz has been established and only 2% of this is available for microwave communication channel. How many telephone channels can be simultaneously granted, if each telephone is allotted a bandwidth of 8 kHz?

**Q11.** Consider an optical communication system operating at a wavelength of 800 nm and only 1% of the optical source frequency is the available channel bandwidth for communication. How many channels can be accommodated for transmitting audio signals requiring a bandwidth of 8 kHz?

**Q12.** In standard AM broadcast, what mode of propagation is used for transmitting a signal? Why is this mode of propagation limited to frequencies upto a few MHz?

**Q13.** What is the range of frequencies used in satellite communication? What is common between these waves and light waves?

**Q14.** Distinguish between 'Analog and Digital signals'.

**Q15.** What is the bandwidth required for speech signal transmission?

**Q16.** A TV tower has a height of 80 m at a given place. Calculate the coverage range, assuming the radius of the earth to be 6400 km.

**Q17.** A message signal of frequency 10 kHz and peak voltage of 10 V is used to modulated frequency of 1 MHz and peak voltage of 20 V. Determine (a) modulation index, (b) the side bands produced.

**Q18.** Write two factors justifying the need of modulation for transmission of a signal.

**Q19.** Name any two types of transmission media that are commonly used for transmission of signals. Write the range of frequencies of signals for which these transmission media are used.

**Q20.** Optical communication system having an operating wavelength $\lambda$ (in meters) can use only x% of its source frequency as its channel bandwidth. The system is to be used for transmitting TV signals requiring a band width of $F$ hertz. How many channels can this system transmit simultaneously? Assuming all other factors to remain constant, show graphically the dependence of the number of channels that can be transmitted simultaneously on the operating wavelength of the system.

**Q21.** An audio signal of 3.2 kHz modulates a carrier of frequency 84 MHz and produces a frequency deviation of 96 kHz. Find (a) frequency modulates index and (b) frequency range of the frequency modulated wave.

**Q22.** In an amplitude modulator, the tank circuit consists of a coil of inductance 3.6 mH and a capacitor of capacitance 2.5 pF. If an audio signal of frequency 15 kHz modulates the carrier generated by the tank circuit, find the frequencies of the sidebands.

**Q23.** Assume that light of frequency $4.5 \times 10^{14}$ Hz is used in an optical communication system. If 2% of this frequency bandwidth is used, how many TV channels can be accommodated in this bandwidth? The bandwidth needed for TV transmission is $4.5 \times 10^{6}$ Hz per channel.

**Q24.** (a) Why is communication using line of sight mode limited to frequencies above 40 MHz?

(b) 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 line of sight mode?

**Q25.** Give reasons for the following:

(a) For ground wave transmission, size of antenna ($l$) should be comparable to wavelength ($\lambda$) of signal *i.e.*, $l \simeq \lambda / 4$.

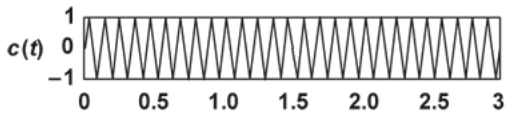
(b) Audio signals, converted into an electromagnetic wave, are not directly transmitted.

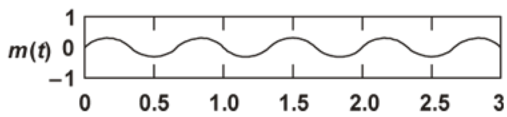
(c) The amplitude of a modulating signal is kept less than the amplitude of carrier wave.

**Q26.** Define the term critical frequency, in relation to sky wave propagation of electromagnetic waves.

**Q27.** Define the term modulation. Name three different types of modulation used for a message signal using a sinusoidal continuous carrier wave. Explain the meaning of any one of these.

**Q28.** State the two main reasons explaining the need of modulation for transmission of audio signals.




The diagrams, given above show a carrier wave $c(t)$, that is to be (amplitude) modulated by a modulating signal $m(t)$. Draw the general shape of the resulting AM wave. Define its modulation index.

Date: 22/10/2021

**S1.** Maximum distance,

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

$$= \sqrt{2 \times 6.4 \times 10^6 \times 71}$$

$$= 37.68 \times 8 \times 10^2$$

$$= 3.0 \times 10^4 = 30 \text{ km.}$$

**S2.** Purpose of modulating a signal to reduce antenna-length, effective power of transmission and frequency multiplexing.

**S3.** As compared to speech signals in telephone communication, the music signals are more complex and correspond to higher frequency range.

**S4.** (a) Coaxial cables. They are used for transmission of signals of frequencies upto 18 GHz.

(b) Free space. It is used for transmission of signals of frequencies from 540 kHz to 4.2 GHz.

**S5.** (a) Modulation index =10/20 = 0.5

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

**S6.** Length of dipole antenna = $\frac{\lambda}{2}$

Here, $$\lambda = \frac{c}{\nu} = \frac{3 \times 10^8 \text{ m/s}}{200 \text{ MHz}}$$

$$= \frac{3 \times 10^8 \text{ m/s}}{200 \times 10^6 \text{ Hz}} = 1.5 \text{ m}$$

∴ Length of dipole antenna = $\frac{1.5}{2}$

$$= 0.75 \text{ m}$$

= **75 cm**.

**S7.** Length of dipole antenna = $\frac{\lambda}{2}$

Here $$\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{5 \times 10^8} = 0.6 \text{ m}$$

[where, $c$ = speed of light and $v$ = frequency]

$\therefore$ Length of dipole antenna $= \frac{0.6}{2} = 0.3$ m

$=$ **30 cm**.

**S8.** We know that speed of radiowaves,

$$c = 3 \times 10^8 \text{ ms}^{-1}.$$

(a) Given: $f = 3 \times 10^4$ Hz

Therefore, length of the quarter-wave dipole antenna,

$$L = \frac{\lambda}{4} = \frac{c}{4f} = \frac{3 \times 10^8}{4 \times 3 \times 10^4} = 2.5 \text{ x } 10^3 \text{ m.}$$

(b) Given: $f = 6 \times 10^6$ Hz

Therefore, length of the quarter-wave dipole antenna,

$$L = \frac{\lambda}{4} = \frac{c}{4f} = \frac{3 \times 10^8}{4 \times 6 \times 10^6} = 12.5 \text{ m.}$$

(c) Given: $f = 5 \times 10^7$ Hz

Therefore, length of the quarter-wave dipole antennas,

$$L = \frac{\lambda}{4} = \frac{c}{4f} = \frac{3 \times 10^8}{4 \times 5 \times 10^7} = 1.2 \text{ m.}$$

If follows that as the carrier frequency increases, the length of the antenna decreases.

**S9.** The transmission of signals of frequencies above 40 MHz cannot be done through ground wave propagation, as such signals get absorbed by ground due to their high frequency. On the other hand, such signals cannot be transmitted via sky wave propagation, as ionosphere is unable to reflect radio waves of frequencies greater than 40 MHz. Therefore, transmission of signals of frequencies above 40 MHz is achieved through space wave propagation. Space wave communication is essentially limited to line of sight. However, because of line of sight nature of space wave propagation, the waves travelling directly from the transmitting antenna to the receiving antenna get blocked due to curvature of the earth.

**S10.** Given: $f = 12$ GHz $= 12 \times 10^{12}$ Hz

Available bandwidth = 2% of operating frequency

$$= \frac{12 \times 10^{12} \times 2}{100} = 2.4 \times 10^{11}$$

Bandwidth per channel = 8 kHz = $8 \times 10^3$ Hz

Now the no. of audio signal that can transmitted

$$= \frac{2.4 \times 10^{11}}{8 \times 10^3} = 3.0 \times 10^7.$$

**S11.** Given: $\lambda = 800\,\text{nm} = 800 \times 10^{-9}\,\text{m}$.

Therefore, operating frequency,

$$f = \frac{3 \times 10^8}{800 \times 10^{-9}} = 3.75 \times 10^{14}\,\text{Hz}.$$

Available bandwidth = 1% of the operating frequency

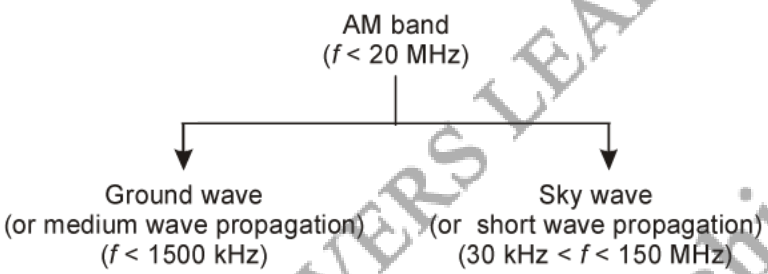
$$= \frac{1 \times 3.75 \times 10^{14}}{100} = 3.75 \times 10^{12}\,\text{Hz}.$$

Bandwidth per channel = 8 kHz = $8 \times 10^3$ Hz,

Therefore, number of audio signals that can be transmitted

$$= \frac{3.75 \times 10^{12}}{8 \times 10^3} = \mathbf{4.7 \times 10^8}.$$

**S12.** In standard AM broadcast, surface wave propagation is used for transmitting the signals. Attenuation of surface wave increases very rapidly with increase in frequency that is why it is limited to frequencies upto a few MHz. In AM broadcast, range of frequencies are limited to 30 MHz.




**S13.** The range of frequencies used in satellite communication is 3.7 GHz to 6.4 GHz.

(a) Radio wave and light waves are also travel with same speed ($c = 3 \times 10^8$ m/s).

(b) It occurs and also get affected by ground terrain, atmosphere and other objects.

**S14.** ***Analog:*** **Continuously with time** at any time, the value of signal is represented by its amplitude.

In an analog communications system, the retrieved message is not an exact copy of the original message, as the message suffers distortions over the medium and during its detection process.

***Digital signals:*** In digital signal the amplitudes are not continuous with time. Amplitude of a signal has only its two levels (*i.e.*, low or high).

In digital communication, the retrieved message is always an exact copy of the original message.

**S15.** As speech signal transmission requires frequency range 300 Hz to 3100 Hz, bandwidth of 2800 Hz is used.

**S16.** Given: height of the tower $h$ = 80 m

$$R = 6400 \times 10^3 \text{ m}$$

Range of the TV tower = $\sqrt{2Rh}$

$$= \sqrt{2 \times 6400 \times 10^3 \times 80}$$
$$= 32 \times 10^3 \text{ m} = 32 \text{ km}$$

**S17.** (a) Peak voltage of modulating signal

$$A_m = 10 \text{ V}$$

Peak voltage of carrier signal = $A_c$ = 20 V

$\therefore$ Modulation index, $\mu = \frac{A_m}{A_c} = \frac{10}{20} = \frac{1}{2}$

(b) USB (Upper Side Band) $= f_c + f_m$ = 1 MHz + 10 kHz

$$= 1\text{MHz} + \frac{1}{100}\text{MHz}$$
$$= 1 \text{ MHz} + 0.01 \text{ MHz}$$

= **1.01 MHz**.

LSB (Lower Side Band) $= f_c - f_m$

= 1 MHz – 10 kHz

= **0.99 MHz**.

**S18.** The needs of modulation for transmission of a signal are given below:

(a) The transmission of low frequency signal needs antenna of height 4-5 km which is impossible to construct. So, there is need to modulate the wave in order to reduce the height of antenna to a reasonable height.

(b) Effective power radiated by antenna for low wavelength or high frequency wave as

$$P \propto \frac{1}{\lambda^2}$$

So, for the effective radiation by antenna, there is need to modulate the wave.

**S19.** For the transmission of signals following two types of transmission media are used.

(a) Sky wave propagation or short wave propagation.

(b) Space wave communication or line of sight communication.

***Range of frequencies:***

(a) ***Sky wave propagation*** is 30 MHz > f > 1500 kHz.

(b) ***Space wave communication*** is 220 MHz > f > 100 MHz.

**S20.** Here, the wavelength of signal = $\lambda$.

Therefore, frequency of the signal,

$$\nu = \frac{c}{\lambda}$$

Since $x$% of the source frequency can be used as the bandwidth,

$$\text{available bandwidth} = \frac{\nu \times x}{100} = \frac{cx}{\lambda \times 100}.$$

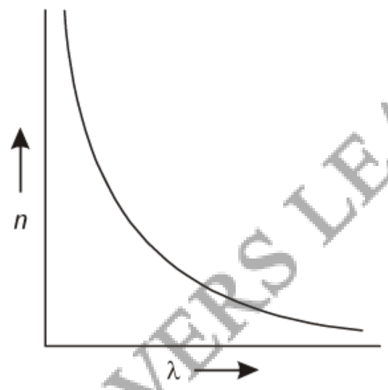
The bandwidth of the TV signal to be transmitted = $F$.

Therefore, number of channels, the system can transmit,

$$n = \frac{\text{available bandwidth}}{\text{bandwidth of TV singnal}}$$

$$= \frac{cx/\lambda \times 100}{F} = \frac{cx}{100\lambda F}$$

As $n \propto 1/\lambda$, the dependence of number of channels on the operating wavelength of the system will be as shown in figure below




**S21.** Given: $f_m = 3.2\,\text{kHz}$; $f_c = 84\,\text{MHz} = 84 \times 10^3\,\text{kHz}$; frequency deviation, $\delta = 96\,\text{kHz}$

(a) Now, frequency modulation index,

$$\mu_f = \frac{\delta}{f_m} = \frac{96}{3.2} = \mathbf{30}.$$

(b) Frequency range of the modulated wave

$$= f_c \pm f_m = 84 \times 10^3 \pm 3.2\,\text{kHz}$$

$$= 83.997 \times 10^3\,\text{kHz} \text{ to } 84.003 \times 10^3\,\text{kHz}$$

$$= \mathbf{83.997\,MHz \text{ to } 84.003\,MHz}.$$

**S22.** Given: $L = 3.6\,\text{mH} = 3.6 \times 10^{-3}\,\text{H}$; $C = 2.5\,\text{pF} = 2.5 \times 10^{-12}\,\text{F}$; $f_m = 15\,\text{kHz}$.

The frequency of carrier generated by the tank circuit,

$$f_c = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{3.6\times10^{-3}\times2.5\times10^{-12}}}$$

$$= 1.678\times10^{6}\text{ Hz} = 1{,}678\text{ kHz.}$$

Frequency of the upper sideband,

$$f_c + f_m = 1678 + 15 = \mathbf{1{,}693\ kHz}$$

and frequency of the lower sideband,

$$f_c - f_m = 1678 - 15 = \mathbf{1{,}663\ kHz}.$$

**S23.** Given $f = 4.5\times10^{14}$ Hz

Now, Available bandwidth = 2% of operating frequency

$$= \frac{4.5\times10^{14}\times2}{100} = 9\times10^{12}$$

Bandwidth per channel = $4.5\times10^{6}$ Hz

Now, number of audio signals that can be transmitted = $\frac{9\times10^{12}}{4.5\times10^{6}} = 2\times10^{6}$

**S24.** (a) At these frequencies, the antenna are relatively smaller and can be placed at a height of many wave length above the ground.

(b) Given, $h_T = 32$, $h_R = 50$ m and $R = 6.4\times10^{6}$ m

$$d = \sqrt{2h_T R} + \sqrt{2h_R R}$$

$$d = \sqrt{2\times32\times6.4\times10^{6}} + \sqrt{2\times50\times6.4\times10^{6}}$$

$\therefore$ $d = \mathbf{45.5\ km}.$

**S25.** (a) For efficient transmission and reception, the length of the antenna should be at least equal to the quarter wavelength of frequency used. It is not possible to send a signal of frequency 15 kHz because the length of the antenna will be about 5000 m which is very large. Hence, there is a need of converting the information contained in original low frequency base band into high frequency before it is transmitted.

(b) If a number of transmitters are transmitting base band signals simultaneously, then all these signals cover the same frequency range (20 Hz to 20 kHz) and will get mixed up. If the transmission is being done at a high frequency, different users may use adequate bandwidth for that given high frequency.

(c) The amplitude of the modulating signal is kept less than the amplitude of the carrier waves.

We know,

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

If $A_m > A_c$, then over modulation will take place resulting in distortion of the signal.

**S26.** ***Critical frequency:*** The critical frequency ($f_C$) of modulated wave for which refraction or bending of the beam of sky wave by ionosphere, reaches at the critical angle after which it gets reflected back is known as critical frequency. The relationship between critical frequency and maximum electron density of ionosphere ($N_{max}$) is given by

$$f_C = 9\,(N_{max})^{1/2}$$

Let, $N_1$ and $N_2$ are maximum electron densities of the ionosphere on first and second days corresponding to 10 MHz and 8 MHz respectively.

$$\therefore \quad \left(\frac{N_1}{N_2}\right)^{1/2} = \frac{f_{C_1}}{f_{C_2}} = \frac{10\text{ MHz}}{8\text{ MHz}}$$

$$\left(\frac{N_1}{N_2}\right)^{1/2} = \frac{5}{4}$$

$$\Rightarrow \quad \frac{N_1}{N_2} = \frac{25}{16}$$

$$\therefore \quad N_1 : N_2 = 25 : 16.$$

**S27.** ***Modulation:*** The phenomenon of variation of some characteristics *viz.*, amplitude, frequency of phase angle of high frequency carrier wave in accordance with the instantaneous value of low frequency modulating signal, is called modulation.

Types of modulation used for a message signal:

(a) Amplitude modulation

(b) Frequency modulation

(c) Pulse modulation

***Pulse modulation:*** The phenomenon of variation of parameters of pulses is varies in accordance with the message signal or modulating signals.

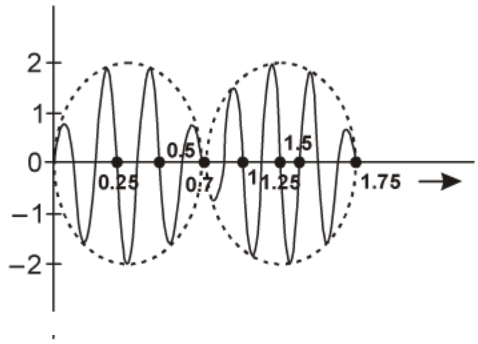
**S28.** The needs of modulation for transmission of a signal are given below:

(a) The transmission of low frequency signal needs antenna of height 4-5 km which is impossible to construct. So, there is need to modulate the wave in order to reduce the height of antenna to a reasonable height.

(b) Effective power radiated by antenna for low wavelength or high frequency wave as

$$P \propto \frac{1}{\lambda^2}$$

So, for the effective radiation by antenna, there is need to modulate the wave.




**Modulation index:** The degree of modulation is defined by the term modulation index. It is also called modulation factor or depth of modulation and given by

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

where, $A_m$ is the amplitude of modulating signal and $A_c$ is the amplified of carrier wave.

Date: 22/10/2021

**Q1.** What is a ground wave propagation?

**Q2.** Digital signals

(i) Do not provide a continuous set of values, (ii) Represent values as discrete steps,

(iii) Can utilize decimal as well as binary systems. (iv) Can utilize binary system, and

Which of the above statements are true?

(a) (i) and (ii) only (b) (ii) and (iv) only

(c) (i), (ii) and (iii) but not (iv) (d) All of (i), (ii), (iii) and (iv).

**Q3.** What is the range of frequencies used for TV transmission? What is common between these waves and light waves?

**Q4.** Define the term critical frequency in relation to sky wave propagation of electromagnetic waves.

**Q5.** Why ground wave propagation is not suitable for high frequency?

**Q6.** Write an expression for the maximum line of sight distance between the two antennas having heights $H_1$ and $H_2$ above the surface of the earth.

**Q7.** Name the type of radiowave propagation involved, when TV signals broadcast by a tall antenna are intercepted directly by the receiver antenna.

**Q8.** What is the range of frequencies used for satellite communication? What is common between these waves and light waves?

**Q9.** What is the sky wave propagation?

**Q10.** What is space wave propagation?

**Q11.** What is the ground wave propagation?

**Q12.** Why Sky-wave propagation of electromagnetic wave can't be used for TV transmission?

**Q13.** What does the term 'attenuation' used in communication system mean?

**Q14.** Why high frequency carrier waves are employed for transmission of signals?

**Q15.** Discuss the significance of green house effect in the atmosphere.

**O16.** What is the need for modulation?

**Q17.** What is space wave propagation? Give two examples of communication system, Which use space wave mode.

**Q18.** What is space wave propagation? Why is it limited upto small distance over earth's surface?

**Q19.** What do you mean by the following?

(a) Ground waves (b) Sky wave.

**Q20.** An audio signal in frequency range 370 Hz to 2.5 kHz modulates a carrier of frequency 80 kHz. Find the range of (a) upper sideband and (b) lower sideband.

**Q21.** A message signal of 12 kHz and peak voltage 20 V is used to modulate a carrier wave of frequency 12 MHz and peak voltage 30 V. Calculate the (a) modulation index and (b) sidebands frequencies.

**Q22.** An audio signal of 2.8 kHz modulates a carrier of frequency 90 MHz producing a frequency deviation of 84 kHz. Find (a) frequency modulation index and (b) frequency range of the modulated wave.

**Q23.** What is the role of band pass filter in modulation circuit?

**Q24.** Which mode of wave propagation is suitable for television broadcast and satellite communication and why? Draw a suitable diagram depicting this mode of propagation of wave.

**Q25.** (a) A TV tower has height of 80 m. Find the radius of the circle within which the transmission can be observed, if radius of earth is $6.4 \times 10^6$ m.

(b) How much population is covered by the TV broadcast, if the average population density around the tower is 800 $km^{-2}$?

**Q26.** Explain, why high frequency carrier waves are needed for effective transmission off signals.

A message signal of 12 kHz and peak voltage 20 V is used to modulate a carrier wave of frequency 12 MHz and peak voltage 30 V. Calculate the (a) modulation index (ii) side-band frequencies.

**Q27.** Name the three different modes of propagation of electromagnetic waves. Explain, using a proper diagram the mode of propagation used in the frequency range above 40 MHz.

**Q28.** By what percentage will the transmission range of a TV tower be affected, when the height of the tower is increased by 21%?

**Q29.** Calculate the length of half wave dipole at

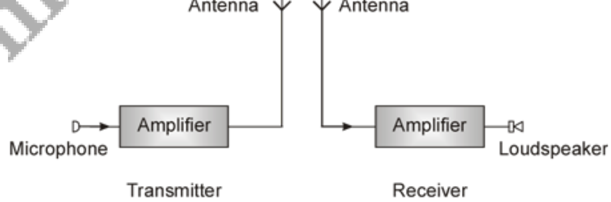
(a) 30 MHz; (b) 300 MHz and (c) 3000 MHz

What inference do you draw from these results?

**Q30.** A schematic arrangement for transmitting a message signal (20 Hz to 20 kHz) is given below:

Give two drawbacks from which this arrangement suffers.

Describe briefly with the help of a block diagram the alternative arrangement for the transmission and reception of the message signal.




**Q31.** An audio signal of amplitude one half the carrier amplitude is employed in amplitude modulation. What is the modulation index?

**Q32.** Write the acronym LASER in expanded form. State any four reasons for preferring diode lasers as light sources for optical communication links.

**Q33.** An audio signal is modulated by a carrier wave of 20 MHz such that the bandwidth required for modulation is 3 kHz. Could this wave be demodulated by a diode detector which has the values of $R$ and $C$ as

(a) $R = 1\ k\Omega$, $C = 0.01\ \mu F$. (b) $R = 10\ k\Omega$, $C = 0.01\ \mu F$. (c) $R = 10\ k\Omega$, $C = 0.1\ \mu F$.

**Q34.** A TV transmission tower antenna is at a height of 20 m. How much service area can it cover if the receiving antenna is (a) at ground level, (b) at a height of 25 m? Calculate the percentage increase in area covered in case (ii) relative to case (i).

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**S1.** A radiowave signal propagation from one point to another following the surface of earth is called a surface or ground wave.

**S2.** **(c) Answer**

A digital signal uses the binary (0 and 1) system for transferring message signals. Such a system cannot utilise the decimal system (which corresponds to analogue signals). Digital signals represent discontinuous values.

**S3.** The radiowaves are used for TV transmission and their frequencies are in the range 54 MHz to 80 MHz.

Both the radiowaves and light waves are electromagnetic waves.

**S4.** The highest value of the frequency of radiowaves, which on being radiated towards the ionosphere at some angle are reflected back to the earth is called critical frequency.

**S5.** In ground wave propagation, the energy of the signal is absorbed by the earth. The loss of energy increases with the increase in the frequency of the signal. For this reason, ground waves are restricted upto a frequency of 1,500 kHz.

**S6.** The expression is

$$d = \sqrt{2H_1R} + \sqrt{2H_2R}\ .$$

where $R$ is radius of the earth.

**S7.** Space wave propagation.

It may be pointed out that in space wave propagation, the radiowaves from the transmitting antenna can also reach the receiving antenna after reflection from ground or troposphere.

**S8.** The microwaves are used for satellite communication and their frequencies are in the range 3.7 GHz to 6.4 GHz

Both the radiowaves and light waves are electromagnetic waves.

**S9.** ***Sky wave propagation:*** When radio wave propagates from one place of earth to other after reflection by ionosphere, the range of frequencies from few MHz to 30 MHz gets reflected back

by ionosphere. This range also reflected as short wave band. This mode of propagation is used by short wave broad cast service.

**S10.** ***Space wave propagation:*** It is also known as Line Of Sight propagation (LOS). The radiowave transmitted by antenna directly reaches the receiving antenna travelling along a straight line. TV waves (80 MHz-200 MHz) propagate through space wave propagation.

**S11.** ***Ground wave propagation:*** The radiowaves, whose frequencies ranged upto 1500 kHz, propagate from one place of earth to other following its transmission along the surface of earth.

These waves get attenuated and hence, cannot travel over long distances. This range of frequencies also referred an amplitude modulated band (AM band).

**S12.** The sky-wave propagation deals with amplitude modulated radiowave which can reflected by ionosphere of earth's atmosphere and the frequency of these radio wave is more than 1500 kHz. The TV transmission deals with frequency range 80 MHz to 200 MHz. The communication via sky wave is not possible. Since they are not reflected back by earth's ionosphere.

**S13.** 'Attenuation' is loss of intensity of the signal flux in a medium.

**S14.** If an audio signal (low frequency) is transmitted as such, it dies out after traversing some distance. Do that it can reach up to a large distance, it is superimposed on high frequency waves, called carrier waves.

**S15.** The behaviour of atmosphere is different towards different types of radiations. Whereas the ultra violet radiation and other low wavelength waves are absorbed by the ozone layer, a large part of the infra-red radiation is not allowed by the atmosphere to pass through it. As the earth's atmosphere is transparent to visible light, only visible light and a part of infra-red radiations reach the earth's surface. On the other hand, the earth gets heated to only a low temperature due to the solar energy emitted from the earth lies mostly in the infra-red region. Since earth's atmosphere is not transparent to infra-red radiations, these radiations are reflected back. Due to this, the earth's atmosphere becomes richer in infra-red radiation. These radiations keep the earth's surface warm even at night.

**S16.** The sound waves cannot be transmitted from a radio transmitter by converting them into electrical waves (audio signal) directly for the following reasons:

(a) For efficient transmission and reception, the transmitting and receiving antennas must have a length equal to quarter wavelength of the audio signal. For a frequency of 15 kHz of audio signal, the length of the antenna comes out to be of the order of 5,000 m. To set up a vertical antennas of this size is practically impossible.

(b) The energy radiated from an antenna is practically zero, when the frequency of the signal to be transmitted is below 15 kHz. It also makes the direct transmission of audio signal as impracticable.

(c) Due to the fact that all audio signals from different sources possess frequencies in the same range *i.e.*, 20 Hz to 20 kHz, an audio signal cannot be transmitted directly. It is because, the audio signal from different transmitting stations will get hopelessly and inseparably mixed up.

The above said difficulties faced during the transmission of audio signal (if transmitted directly) are overcome by the process of modulation.

**S17.** **Space wave propagation:** When the radiowaves from the transmitting antenna reach the receiving antenna either directly or after reflection from the ground or in troposphere, the wave propagation is called *space wave propagation*.

**Examples:** 1. TV transmission.

2. Satellite communication.

**S18.** **Space wave propagation:** When the radiowaves from the transmitting antenna reach the receiving antenna either directly or after reflection from the ground or in troposphere, the wave propagation is called *space wave propagation*.

Space wave communication is essentially limited to the transmission of signal directly from the transmitting antenna to receiving antenna, called line of sight communication. The waves travelling directly from the transmitting antenna to the receiving antenna get blocked due to curvature of the earth. As such, it limits both the maximum line of sight distance between the two antennas and also the maximum distance upto which transmission can be received.

**S19.** (a) **Ground wave:** The radiowaves from the transmitting antenna reaching the receiving antenna either directly or after reflection from the ground are called **ground waves**.

(b) **Sky waves:** The radiowaves from the transmitting antenna reaching the receiving antenna after reflection in the ionosphere are called **Sky waves**.

**S20.** Frequency range of upper sideband

$$f_m = 370 \text{ Hz to } 2.5 \text{ kHz}$$
$$= 0.37 \text{ kHz to } 2.5 \text{ kHz}$$

Carrier frequency, $f_c = 80$ kHz

(a) Frequency range of upper sideband

$$= 80 + 0.37 \text{ to } 80 + 2.5$$
$$= \mathbf{80.37 \text{ kHz to } 82.5 \text{ kHz}}$$

(b) Frequency range of lower sideband

$$= 80 - 2.5 \text{ to } 80 - 0.37$$
$$= \mathbf{77.5 \text{ kHz to } 79.63 \text{ kHz}}$$

**S21.** Given: $E_m = 20$ V; $E_c = 30$ V; $f_m = 12$ kHz; $f_c = 12$ MHz = 12,000 kHz.

(a) Here, modulation index,

$$\mu = \frac{E_m}{E_c} = \frac{20}{30} = \mathbf{0.67}.$$

(b) Frequency of the upper sideband,

$$f_c + f_m = 12{,}000 + 12 = \mathbf{12{,}012 \text{ kHz}}$$

and frequency of the lower sideband,

$$f_c - f_m = 12{,}000 - 12 = \mathbf{11{,}988 \text{ kHz}}.$$

**S22.** Given: $f_m = 2.8\,\text{kHz}$: $f_c = 90\,\text{MHz} = 90 \times 10^3\,\text{kHz}$; $\delta = 84\,\text{kHz}$.

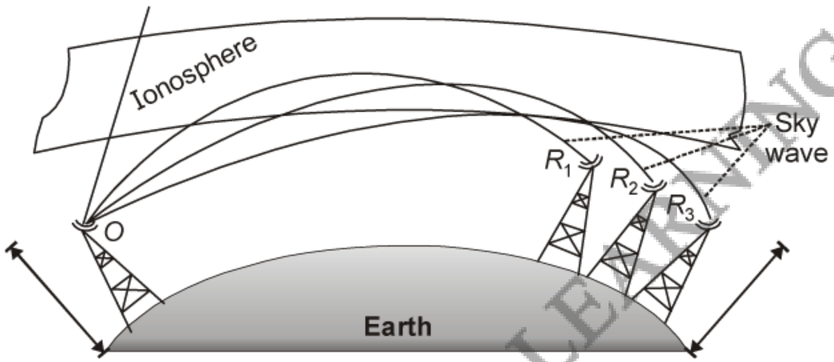
(a) Now,
$$\mu_f = \frac{\delta}{f_m} = \frac{84}{2.8} = \mathbf{30}.$$

(b) Frequency range of modulated wave
$$= f_c + f_m = 90 \times 10^3 \pm 2.8\,\text{kHz}$$
$$= 89.997 \times 10^3\,\text{kHz} \text{ to } 90.003 \times 10^3\,\text{kHz}$$
$$= \mathbf{89.997\ MHz\ \ to\ \ 90.003\ \ MHz}.$$

**S23.** A band pass filter rejects low and high frequencies and allows a band of frequencies ($\omega_c - \omega_n$ to $\omega_c + \omega_n$) to pass through.

**S24.** Sky wave propagation is suitable for television broadcast and satellite communication.

Television → 1710 kHz to 40 MHz




As, signals of these frequency range are reflected back by ionosphere upto the receiver end after travelling a large distance.

**S25.** (a) Given: $h = 80\,\text{m}$; $R = 6.4 \times 10^6\,\text{m}$.

If $d$ is the radius of the circle within which the transmission can be observed, then
$$d = \sqrt{2hR}$$
$$= \sqrt{2 \times 80 \times 6.4 \times 10^6} = \mathbf{3.2 \times 10^4\,m}.$$

(b) Area in which transmission can be viewed,
$$A = \pi d^2 = \pi \times (3.2 \times 10^4)^2$$
$$= 3.217 \times 10^9\,\text{m}^2 = 3.217 \times 10^3\,\text{km}^2.$$

Now, the average population density,
$$\sigma = 800\,\text{km}^{-2}.$$

Therefore, the population covered by the transmission

$$= A \times \sigma$$

$$= 3.217 \times 10^3 \times 800 = \mathbf{2.574 \times 10^6}.$$

**S26.** (a) With high frequency carrier waves

(i) Transmission can take place with reasonable antenna length.

(ii) As power radiated is proportional to $\frac{1}{\lambda^2}$, poser radiation increases.

(b) (i) Modulation index

$$\mu = \frac{A_m}{A_c} = \frac{20}{30} = 0.67$$

(ii)

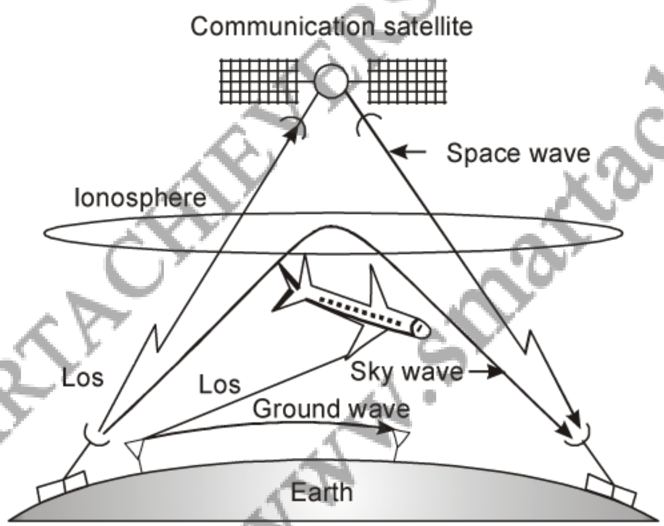
$$\text{U.S.B.} = f_c + f_m$$
$$= (12 \times 10^6 + 12 \times 10^3)\ \text{Hz}$$
$$= 1.20 \times 10^7\ \text{Hz}$$

$$\text{L.S.B.} = f_c - f_m$$
$$= (12 \times 10^6 - 12 \times 10^3)\ \text{Hz}$$
$$= 1.19 \times 10^7\ \text{Hz.}$$

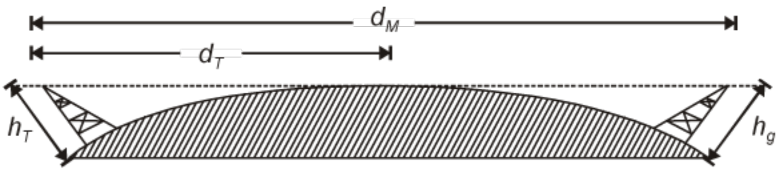
**S27.** Three modes of propagation of electromagnetic waves are:

(a) Ground waves (b) Sky waves (c) Space waves

In the frequency range above 40 MHz space wave propagation is used.




Space waves travel in a straight line from transmitter to receiver.




Space waves are used for Line of Sight (LOS) communication as well as satellite communication.

**S28.** Initially, let the height of the tower be $h_1$ and the radius of the circle within which, the transmission can be observed be $d_1$. If $R$ is radius of the earth, then

$$d_1 = \sqrt{2h_1R}$$

On increasing the height of the tower by 21%, the height of the tower becomes,

$$h_2 = \frac{121}{100}h_1$$

If $d_2$ is the radius of the circle within which, the transmission can be observed now, then

$$d_2 = \sqrt{2h_2R} = \sqrt{2\times\frac{121}{100}h_1\times R} = \frac{11}{10}\sqrt{2h_1R} = \frac{11}{10}d_1$$

$\therefore$ $$d_2 - d_1 = \frac{11}{10}d_1 - d_1 = \frac{1}{10}d_1$$

Therefore, the percentage increase in the transmission range of the TV tower,

$$\frac{d_2-d_1}{d_1}\times 100 = \frac{d_1/10}{d_1}\times 100 = \mathbf{10\%}.$$

**S29.** (a) When $f = 30\,\text{MHz}$:

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{30\times10^6} = 10 \text{ m}$$

Therefore, length of half wave dipole,

$$l = \frac{\lambda}{2} = \frac{10}{2} = \mathbf{5\ cm}.$$

(b) When $f = 300\,\text{MHz}$:

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{300\times10^6} = 1 \text{ m}$$

Therefore, length of half wave dipole,

$$l = \frac{\lambda}{2} = \frac{1}{2} = \mathbf{0.5\ m} = \mathbf{50\ cm}.$$

(c) When $f$ = 3000 MHz:

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{3000 \times 10^6} = 0.1 \text{ m}$$

Therefore, length of half wave dipole,

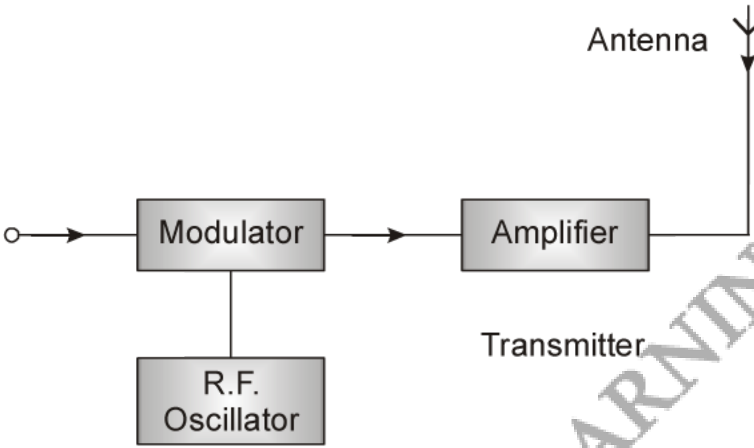
$$l = \frac{\lambda}{2} = \frac{0.1}{2} = \mathbf{0.05\ m = 5\ cm}.$$

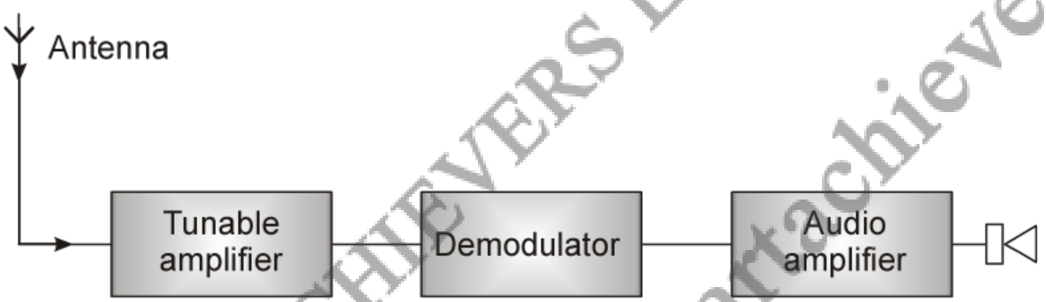
If follows that as the frequency of the carrier increases, the length of the half wave dipole decreases.

**S30.** Two drawbacks from which given arrangement suffers are :

(a) Signals cannot be sent very far without employing large amount of power.

(b) Bandwidth is very short.




We attach modulator in the transmitter. It superimposes baseband signals on carrier waves generated by radio frequency oscillator. It is done so because audio signals cannot cover a large distance. Signals get attenuated before they reach the receiving end. Carrier waves have high frequency. They can cover large distance without being attenuated. They act as a means to transport baseband signals over a large distance. On the receiving side demodulator takes out audio signals back from modulated signals. Antenna is used on both sides to radiate and pick up signals respectively.

**S31.** Given: $E_m = \frac{E_c}{2} = 0.5\,E_c$

Modulation index,

$$\mu = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}$$

$$E_{max} = E_c + 0.5\,E_c = 1.5\,E_c$$
$$E_{min} = E_c - 0.5\,E_c = 0.5\,E_c$$

Thus, $$\mu = \frac{1.5\,E_c - 0.5\,E_c}{1.5\,E_c + 0.5\,E_c} = \frac{E_c}{2E_c} = \mathbf{0.5}.$$

**S32.** Laser-light amplification by stimulated emission of radiation.

Diode laser is used as light source for optical communication links because.

(a) It gives adequate power.

(b) Diode laser is monochromatic and coherent.

(c) It is dimensionally compatible with optical fibre.

(d) Light from diode laser can be varied or modulated by varying the applied voltage or current.

**S33.** $f_m =$ 1.5 kHz, $\frac{1}{f_m} = 0.7 \times 10^{-3}$ s

$f_c =$ 20 MHz, $\frac{1}{f_c} = 0.5 \times 10^{-7}$ s

(a) $RC = 10^3 \times 10^{-8} = 10^{-5}$ s

So, $\frac{1}{f_c} \ll RC < \frac{1}{f_m}$ is satisfied

So, it can be demodulated

(b) $RC = 10^4 \times 10^{-8} = 10^{-4}$ s

Here, too $\frac{1}{f_c} \ll RC < \frac{1}{f_m}$

So, this too can be demodulated

(c) $RC = 10^4 \times 10^{-7} = 10^{-3}$ s

Here, $\frac{1}{f_c} > RC$, so this cannot be demodulated.

**S34.** (a) Range = $\sqrt{2 \times 6.4 \times 10^6 \times 20} = 16$ km

Area covered = 803.84 km$^2$

(b) Range = $\sqrt{2\times 6.4\times 10^6\times 20}+\sqrt{2\times 6.4\times 10^6\times 25}$

$= (16 + 17.9)$ km $= 33.9$ km

Area covered = $3608.52\ km^2$

$\therefore$ Percentage increase in area = $\frac{(3608.52-803.84)}{803.84}\times 100$

$= 348.9\%$.

Date: 22/10/2021

**Q1.** **A carrier wave of peak voltage 12 V is used to transmit a message signal. What should be the peak voltage of the modulating signal in order to have a modulation index of 75%?**

**Q2.** **Define modulation index.**

**Q3.** **Why is the amplitude of modulating signal kept less than the amplitude of carrier wave?**

**Q4.** **Draw a diagram showing the amplitude modulated wave by superposing a modulating signal over a sinusoidal carrier wave.**

**Q5.** **State two factors by which the range of transmission of signals by a TV tower can be increase.**

**Q6.** **Why is frequency modulation preferred over amplitude modulation for transmission of music?**

**Q7.** **Distinguish between sinusoidal and pulse shaped signals**

**Q8.** **Is it necessary for a transmitting antenna to be at the same height as that of the receiving antenna for line-of-sight communication? A TV transmitting antenna is 81 m tall. How much service area can it cover if the receiving antenna is at the ground level?**

**Q9.** **For an amplitude modulated wave, the maximum amplitude is found to be 10 V while the minimum amplitude is found to be 2 V. Determine the modulation index μ. What would be the value of μ if the minimum amplitude is zero volt?**

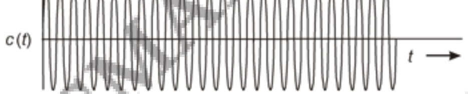
**Q10.** **For an amplitude modulated wave, the maximum amplitude is found to be 10 V while the minimum amplitude is 2 V. Calculate the modulation index. Why is modulation index generally kept less than one?**

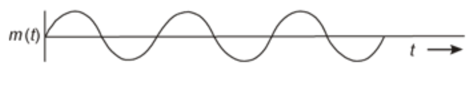
**Q11.** **Why are high frequency carrier waves used for transmission?**

**Q12.** **In standard AM broadcast, what mode of propagation is used for transmitting a signal? Why is this mode of propagation limited to frequencies upto a few MHz?**

**Q13.** **Why is FM signal less susceptible to noise than an AM signal?**

**Q14.** **Figure given below shows a carrier wave $c\,(f)$ that is to be amplitude modulated by a modulating signal $m\,(f)$.**




**Draw the general shape of the resulting amplitude modulated wave. Define its modulation index.**

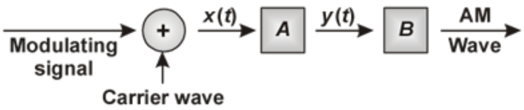
**Q15.** **A transmitting antenna at the top of a tower has a height 32 m and the height of the receiving antenna is 50 m. What is the maximum distance between them for satisfactory communication in LOS mode? Given radius of earth $6.4 \times 10^6$ m.**

**Q16.** (a) Define modulation index.

(b) Why is the amplitude of modulating signal kept less than the amplitude of carrier wave?

**Q17.** A carrier wave, $c(t) = A_c \sin \omega_c t$, is amplitude modulated by a modulating signal, $m(t) = A_m \sin \omega_m t$. The maximum and minimum amplitudes of the resulting AM wave are found to be 16 V and 4 V respectively. Calculate the modulation index.

**Q18.** In the block diagram of a simple modulator for obtaining an AM signal, shown in the figure, identify the boxes *A* and *B*. Write their function.




**Q19.** A carrier wave of peak voltage 18 V is used to transmit a message signal. Calculate the peak voltage of the modulating signal in order to have a modulation index of 50%.

**Q20.** Due to economic reasons, only the upper sideband of an AM wave is transmitted, but at the receiving station, there is a facility for generating the carrier. Show that if a device is available which can multiply two signals, then it is possible to recover the modulating signal at the receiver station.

**Q21.** An AM wave is represented by $C_m(t) = 6(1 + 0.5 \cos 12560\, t) \cos 22 \times 10^5\, t$.
Calculate

(a) amplitude and frequency of carrier (b) frequency of the modulating signal

(c) modulation index (d) maximum and minimum amplitude of the AM wave.

**Q22.** What is 'amplitude modulation'? Represent the process graphically. Write its two advantages and disadvantages?

**Q23.** (a) Write any two factors which justify the need for modulating a signal.

(b) Draw a diagram showing an amplitude modulated wave by superposing a modulating signal over a sinusoidal carrier wave.

**Q24.** What is the role of a band-pass filter in amplitude modulation?
Draw a block diagram of a detector of A.M. signal and briefly explain how the original signal is obtained from the modulated wave.

**Q25.** An audio signal of amplitude (a) equal to (b) 1.5 times the carrier amplitude is employed in amplitude modulation. Find the modulation index in each case.

**Q26.** (a) Draw the plot of amplitude versus $\omega$ for an amplitude modulated wave whose carrier wave ($\omega_c$) is carrying two modulating signals, $\omega_1$ and $\omega_2$ ($\omega_1 > \omega_2$).

(b) Is the plot symmetrical about $\omega_c$? Comment especially about plot in region $\omega < \omega_c$.

(c) Extrapolate and predict the problems one can expect if more waves are to be modulated.

(d) Suggest solutions to the above problem. In the process can one understand another advantage of modulation in terms of bandwidth?

Date: 22/10/2021

**S1.** Here, $\mu_a = 75\% = 0.75$ and $E_c = 12\,V$.

Now, $\mu_a = \dfrac{E_m}{E_c}$

or, $E_m = \mu_a \times E_c = 0.75 \times 12 = \mathbf{9\ V}$.

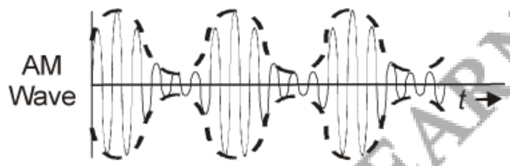
**S2.** The degree, to which the carrier wave is modulated, is called modulation index.

**S3.** The modulation index is given by

$$\mu_a = \frac{E_m}{E_c} = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}$$

In case, $E_m > E_c$, $E_{min}$ (= $E_c - E_m$) will be negative and it will lead to distortion.

**S4.**

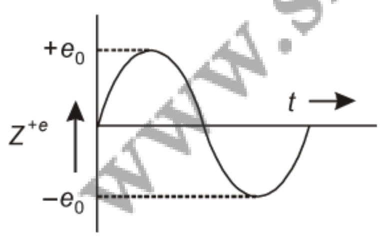



**S5.** (a) By increasing the height of the tower.

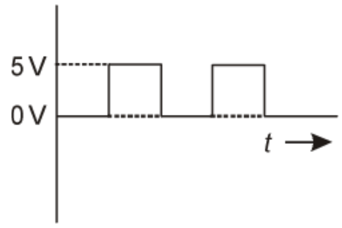
(b) By increasing the height of the receiving antenna, so that it may directly intercept the signal from the transmitting antenna.

**S6.** FM transmission is quite immune to noise as compared to AM transmission.

**S7.** A signal in which current or voltage change continuously with time, sinusoidally is known as sinusoidal signal.




A signal in which current or voltage can take only two discrete values for it is called pulse shaped signals.




**S8.** Line-of-sight communication means that there is no physical obstruction between the transmitter and the receiver. In such communications it is not necessary for the transmitting and receiving antennas to be at the same height.

Height of the given antenna, $h = 81$ m

Radius of Earth, $R = 6.4 \times 10^6$ m

For range, $d = 2Rh$, the service area of the antenna is given by the relation:

$$A = \pi d^2$$
$$= \pi (2Rh)$$
$$= 3.14 \times 2 \times 6.4 \times 10^6 \times 81$$
$$= 3255.55 \times 10^6 \, m^2$$
$$= 3255.55$$
$$\sim 3256 \, km^2.$$

**S9.** Maximum amplitude, $A_{max} = 10$ V

Minimum amplitude, $A_{min} = 2$ V

Modulation index μ, is given by the relation:

$$\mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$$
$$= \frac{10-2}{10+2} = \frac{8}{12} = 0.67$$

If $A_{min} = 0$

Then $\mu = \frac{A_{max}}{A_{min}} = \frac{10}{10} = 1$

**S10.** For AM wave,

Maximum amplitude, $A_{max} = 10$ V

Minimum amplitude, $A_{min} = 2$ V

∴ Modulation index, $\mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} = \frac{10-2}{10+2} = \frac{8}{12} = \frac{2}{3}$

$$\mu = \frac{2}{3}.$$

If the modulation index ($\mu$) is greater than 1, the carrier wave is send to be over modulate and distortion will occur during reception as negative peak of modulating signal will be missing, Therefore, $\mu$ is kept less than one.

**S11.** Radiation loss at low frequencies is more length of receiver antenna becomes very high for low frequency.

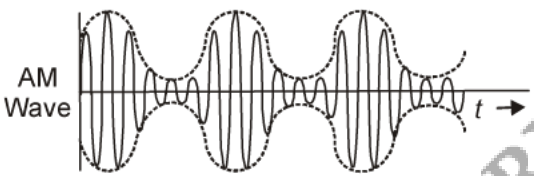
So, we use high frequency carrier waves for transmission.

**S12.** Surface wave propagation.

Attenuation of surface waves increases very rapidly with increase in frequency that is why it is limited to frequencies upto a few MHz.

**S13.** In FM transmission, the message signal is in the form of frequency variations of carrier waves. During modulation process, the noise gets amplitude modulated. Since it brings about variations only in the amplitude of carrier waves, it does no harm to the message signal. For this reason, FM signal is less susceptible to noise than an AM signal.

**S14.** The shape of the resulting amplitude modulated wave is as shown in the figure below




**Modulation index:** The degree, to which the carrier wave is modulated, is called modulation index.

**S15.**
$$d_m = \sqrt{2 \times 64 \times 10^5 \times 32} + \sqrt{2 \times 64 \times 10^5 \times 50} \text{ m}$$
$$= 64 \times 10^2 \times \sqrt{10} + 8 \times 10^3 \times \sqrt{10} \text{ m}$$
$$= 144 \times 10^2 \times \sqrt{10} \text{ m} = 45.5 \text{ km.}$$

**S16.** (a) ***Modulation Index:*** The modulation index is defined as the ratio of change in the amplitude of carrier wave to the amplitude of carrier wave.

$$\therefore \qquad \mu = \frac{\text{Change in amplitude of carrier wave}}{\text{Amplitude of carrier wave}}$$

But change in amplitude of carrier wave = Amplitude of modulating wave ($A_m$)

$$\therefore \qquad \mu = \frac{A_m}{A_c} = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$$

where, $A_{max}$ and $A_{min}$ are maximum and minimum voltage of AM wave, respectively

(b) If the modulation index ($\mu$) is greater than 1, the carrier wave is send to be over modulate and distortion will occur during reception as negative peak of modulating signal will be missing, Therefore, $\mu$ is kept less than one.

**S17.** Here, Maximum amplitude, $A_{max} = 16\,V$

Minimum amplitude, $A_{min} = 4\,V$

$\because$ Modulation index, $(\mu) = \frac{A_m}{A_c} = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$

$\therefore$ $\mu = \frac{16-4}{16+4} = \frac{12}{20} = \frac{3}{5}$

$\mu = \frac{3}{5}$.

**S18.** In the block diagram of modulator, *a* is square law device and *b* is band pass filter.

***Band pass filter:*** It rejects low and high frequencies and allows a band of frequencies to pass through.

***Square law device:*** It is a non-linear device. It produces a non-linear output of message and carrier signals. The output from square law device is,

$$y(t) = Bx(t) + Cx^2(t)$$

where, *B* and *C* are constants and $x(t)$ = message signal ($A_m \sin \omega_m t$) + carrier signal ( ).

**S19.** Here, $A_c = 18\,V$,

$A_m = ?$

Modulation index, $\mu_c = 50\% = 0.50$

Since, $\mu_a = \frac{A_m}{A_c}$

$0.50 = \frac{A_m}{18}$

$\therefore$ $A_m = 9\,V$.

**S20.** Let $\omega_c$ and $\omega_s$ be the respective frequencies of the carrier and signal waves.

Signal received at the receiving station,

$$V = V_1 \cos(\omega_c + \omega_s)t$$

Instantaneous voltage of the carrier wave,

$$V_{in} = V_c \cos \omega_c t$$

$$\therefore \quad VV_{in} = V_1 \cos (\omega_c + \omega_s) t . (V_c \cos \omega_c t)$$

$$= V_1 V_c [\cos (\omega_c + \omega_s) t . \cos \omega_c t]$$

$$= \frac{V_1 V_c}{2} [2 \cos (\omega_c + \omega_s) t . \cos \omega_c t]$$

$$= \frac{V_1 V_c}{2} [\cos \{(\omega_c + \omega_s) t + \omega_c t\} + \cos \{(\omega_c + \omega_s) t - \omega_c t\}]$$

$$= \frac{V_1 V_c}{2} [\cos \{(2\omega_c + \omega_s) t + \cos \omega_s t\}]$$

At the receiving station, the low-pass filter allows only high frequency signals to pass through it. It obstructs the low frequency signal $\omega_s$.

Thus, at the receiving station, one can record the modulating signal $\frac{V_1 V_c}{2} \cos \omega_s t$, which is the signal frequency.

**S21.** Standard equation of AM wave is

$$C_m(t) = A_c (1 + \mu \cos \omega_m t) \cos \omega_c t \quad \text{... (i)}$$

Given equation is

$$C_m(t) = 6 (1 + 0.5 \cos 12560 t) \cos 22 \times 10^5 t \quad \text{... (ii)}$$

Comparing equation (ii) w.r.t. (i), we get

(a) Amplitude of carrier wave, $A_c$ = 6 volt

$$\omega_c = 22 \times 10^5$$

$$\nu_c = \frac{22 \times 10^5}{2\pi} = \textbf{350.32 kHz}.$$

(b) Frequency of modulating signal

$$\omega_m = 12560$$

$$\nu_m = \frac{12560}{2\pi}$$

$$= 2000 \text{ Hz} = \textbf{2 kHz}.$$

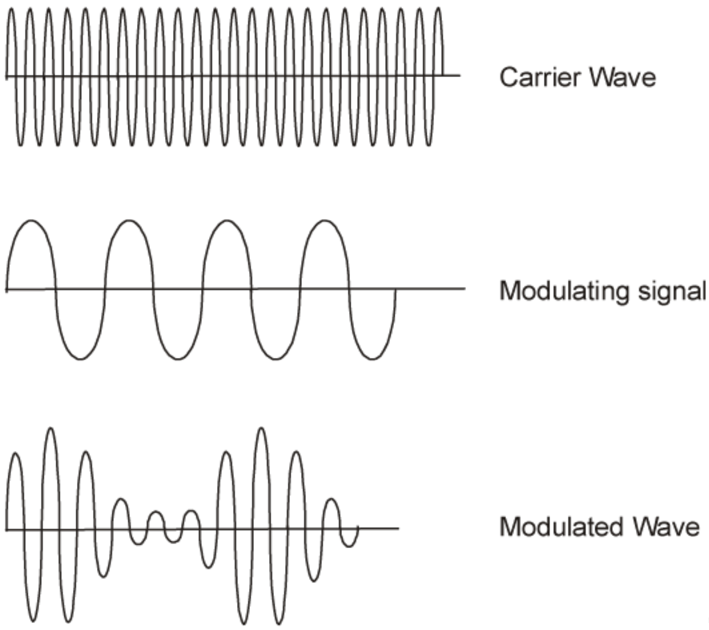
(c) Modulation index,

$$\mu = \frac{A_m}{A_c} = \textbf{0.5}$$

(d) Maximum amplitude, $A_{max} = A_c - \mu A_c = 6 + 0.5 \times 6 = 9\,V$

Minimum amplitude, $A_{min} = A_c - \mu A_c = 6 - 0.5 \times 6 = 3\,V$

**S22.** Amplitude modulation: The amplitude of the carrier wave is varied about a mean value, linearly with the base band signal, the angular frequency remains constant.




### Advantage:

(a) Area of reception is larger.

(b) Equipment used is simple and cheaper.

### Disadvantages:

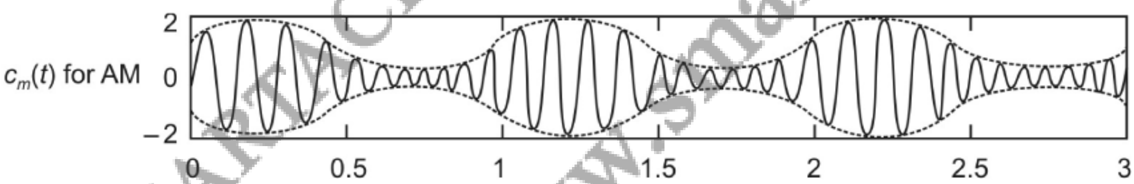
(a) Efficiency is low.

(b) Reception is noisy.

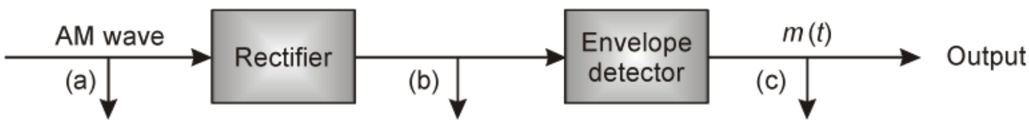
**S23.** (a) (i) Antenna size becomes practically variable.

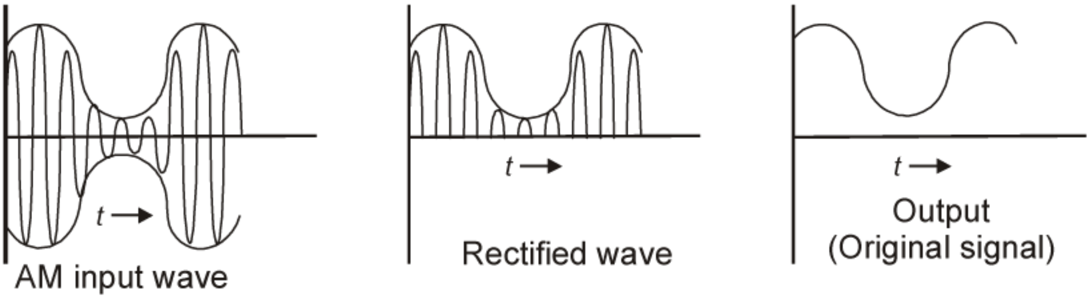
(ii) Antenna can radiate out power more effectively.

(b) It avoids mixing up of signals from different transmitters.




**S24.** **Role of band-pass filter in Amplitude modulation:** A band-pass filter rejects low and high frequencies and allows a band of frequencies to pass through. It rejects d.c. and the sinusoids of frequencies $\omega_m$, $2\omega_m$ and $2\omega_c$ and retains the frequencies $\omega_c$, $\omega_c - \omega_m$ and $\omega_c + \omega_m$.






In order to obtain original signal from the modulated wave it is passed through a rectifier first. Rectified wave then passed through an envelope detector which filters out rectified waves and signal is retrieved.

**S25.** (a) Given, $E_m = E_c$

$\therefore$ $$E_{max} = E_m + E_c = E_c + E_c = 2E_c \quad \text{and} \quad E_{min} = E_m - E_c = E_c - E_c = 0$$

Now, $$\mu_a = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} = \frac{2E_c - 0}{2E_c + 0} = \mathbf{1}.$$

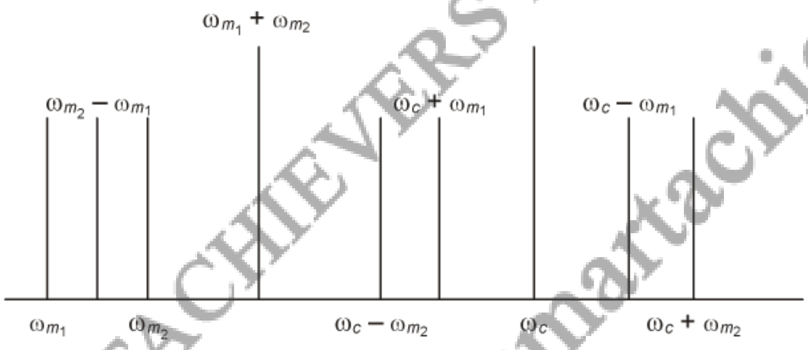
(b) $E_m = 1.5\,E_c$

$\therefore$ $$E_{max} = E_c + 1.5\,E_c = 2.5\,E_c$$

and $$E_{min} = E_c - 1.5\,E_c = -0.5\,E_c$$

Now, $$\mu_a = \frac{2.5E_c - (-0.5E_c)}{2.5E_c - 0.5E_c} = \mathbf{1.5}.$$

**S26.** (a) Plot of amplitude versus ω is shown in the figure.




(b) As can be seen frequency spectrum is not symmetrical about $\omega_c$. Crowding of spectrum is present for $\omega < \omega_c$.

(c) Adding more modulating signals lead to more crowiding in $\omega < \omega_c$ and more chances of mixing of signals.

(d) Increase bandwidth and $\omega_c$ to accommodate more signals. This show that large carrier frequency enables to carry more information (more $\omega_m$) and which will inturn increase bandwidth.

Date: 22/10/2021

**Q1.** What is the basic function of demodulation?

**Q2.** What is demodulation?

**Q3.** Name the type of communication in which the signal is a discrete and binary coded version of the message or information.

**Q4.** Name the mode of propagation of radio waves which travel in a straight line, from the transmitting antenna to the receiving antenna.

**Q5.** Why is short wave band used for long distance radio broadcast.

**Q6.** What will be the effect of scratches on optical fibre cable?

**Q7.** What is a demodulator?

**Q8.** A carrier wave of peak voltage 12 V is used to transmit a message signal. What should be the peak voltage of the modulating signal in order to have a modulation index of 75%?

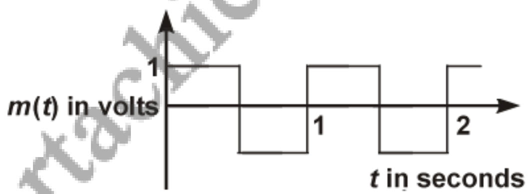
**Q9.** Draw a labelled circuit diagram for detection of amplitude modulated wave.

**Q10.** Mention the function of the following used in communication system:
(a) Transducer (b) Repeater (c) Transmitter (d) Bandpass filter.

**Q11.** "A communication satellite is essentially a repeater station is space". Justify this statement by analyzing the function of a repeater.

**Q12.** With the help of diagrams, differentiate between PAM and PDM.

**Q13.** A modulating signal is a square wave, as shown in figure.
The carrier wave is given by
$c(t) = 2 \sin(8\pi t)$ volts.
(a) Sketch the amplitude modulated waveform
(b) What is the modulation index?




**Q14.** What is meant by detection of a signal in a communication system? With the help of a block diagram explain the detection of A.M. signal.

**Q15.** A photo detector is made from a semiconductor. In $_{053}Ga_{047}As$ with $E_g$ = 0.73 eV. What is the maximum wavelength, which it can detect?

**Q16.** Define modulation index. Give its physical significance.
For an amplitude modulated wave, the maximum amplitude is found to be 10 V while the minimum amplitude is 3V. Determine the modulation index $\mu$.

**Q17.** Write briefly, any two factors which demonstrate the need for modulating a signal. Draw a suitable diagram to show amplitude modulation, using sinusoidal signal as the modulating signal.

Date: 22/10/2021

**S1.** To extract the audio signal from the modulated signal .

**S2.** The process of separating out the audio signal from the modulated signal is known as demodulation.

It is inverse of the modulation process.

**S3.** In digital communication, the signal is a discrete and binary coded version of the massage or information.

**S4.** Space wave propagation is that mode of wave propagation in which the radiowaves emitted from the transmitter antenna reaches the receiving antenna through space.

**S5.** Short waves are reflected by ionosphere and are received at large distance from the place of transmission with very low attention. Thus, they are used in long distance broadcast.

**S6.** If there are any scratches on the optical fibre cable, the light signal can escape at such points. It is because, a ray of light can meet the surface of the scratch at an angle of incidence less than the critical angle. To ensure that the core of the cable stays smooth, the outer coating of the fibre cable has to be made tougher.

**S7.** A device for separating out the audio signal from the modulated signal is known as demodulator.

**S8.** Amplitude of the carrier wave, $A_c = 12$ V

Modulation index, $m = 75\% = 0.75$

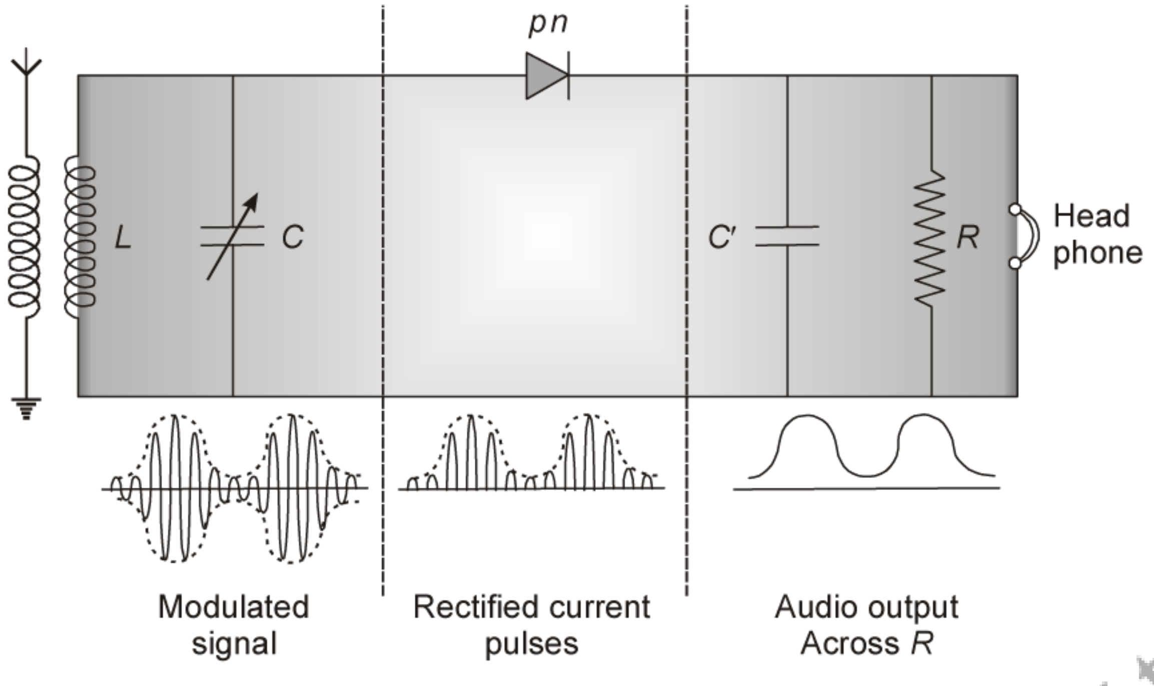
Amplitude of the modulating wave $= A_m$

Using the relation for modulation index:

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

$$\therefore \quad A_m = m A_c = 0.75 \times 12 = 9 \text{ V}.$$

**S9.**




**S10.** (a) **Transducer:** A device, which converts one form of energy into another.

(b) **Repeater:** A repeater is a combination of receiver and transmitter placed along the path of signal so as to extend the range of the communication system.

(c) **Transmitter:** A device that converts the signal in to an electrical signal, mixes it with carrier wave and then transmits it into the medium is called a transmitter.

(d) **Bandpass filter:** A device that allows frequencies in a certain range to pass through it and rejects those outside that range.

**S11.** A communication satellite

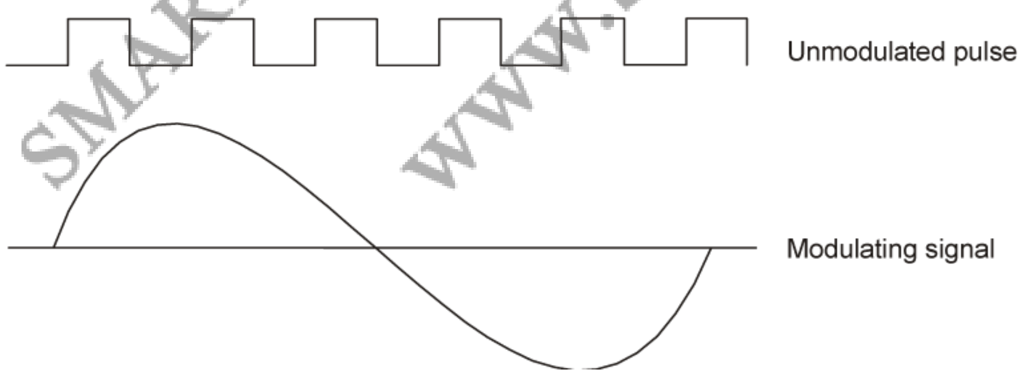
(a) pick up the signal transmitted by transmitter

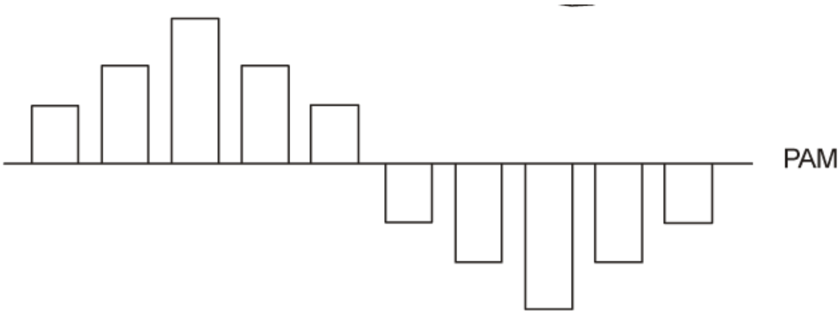
(b) amplifies it

(c) retransmit it towards information users. These all are also a function of repeater to receive, amplify and retransmission of signal.

**S12.** **PAM**

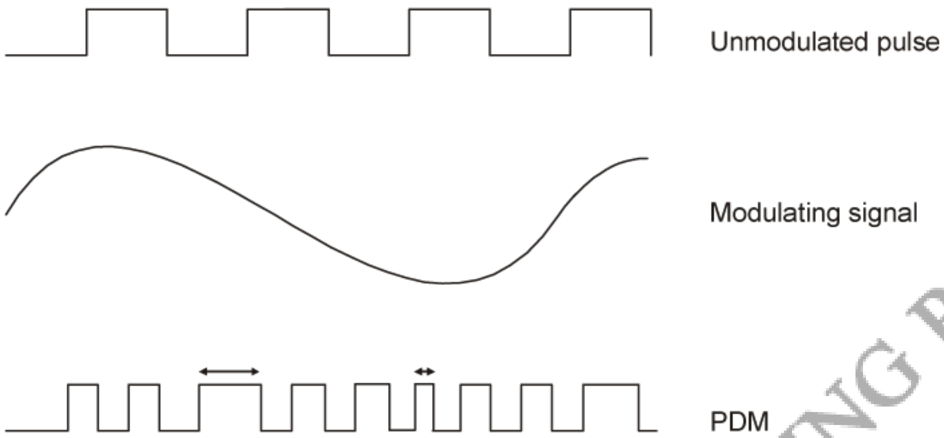
Amplitude of the pulse (carrier wave) varies according to modulating signal.






### PDM

Pulse duration varies in accordance with the modulating signal.




**S13.** (a) It can be observed from the given modulating signal that the amplitude of the modulating signal,

$$A_m = 1\ \text{V}$$

It is given that the carrier wave $c(t) = 2 \sin (8\pi t)$

Amplitude of the carrier wave, $A_c = 2\ \text{V}$

Time period of the modulating signal $T_m = 1\ \text{s}$

The angular frequency of the modulating signal is calculated as:

$$\omega_m = \frac{2\pi}{T_m} = 2\pi \text{ rad s}^{-1} \quad \text{... (i)}$$

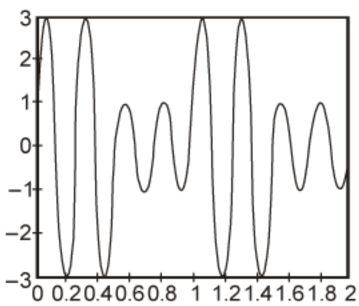
The angular frequency of the carrier signal is calculated as:

$$\omega_c = 8\pi \text{ rad s}^{-1} \quad \text{... (ii)}$$

From Eqs. (i) and (ii), we get:

$$\omega_c = 8\omega_m$$

The amplitude modulated waveform of the modulating signal is shown in the following figure.




(b) Modulation index, $m = \frac{A_m}{A_c} = \frac{1}{2} = 0.5$.

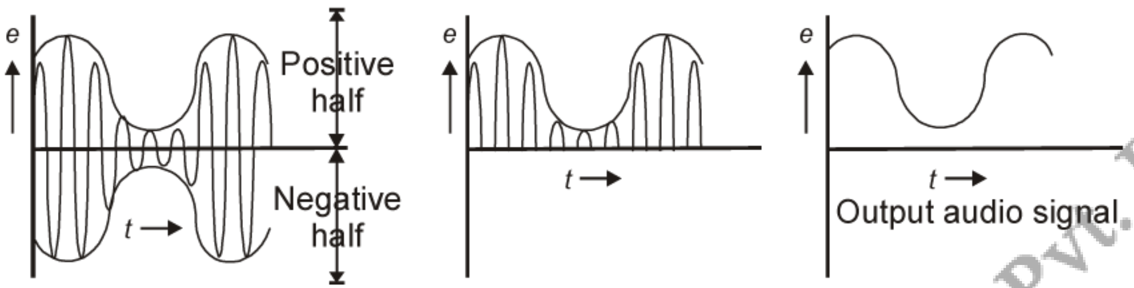
**S14.**


Detection or De-modulation is the process used to recover the original signal from the received signal which is a higher frequency signal.

**Step:** (a) It rectifies the modulated carrier wave

(b) It filters out the components, the carrier and the useful audio signal.

The waveforms at different stages can be shown as below:




**S15.** Limiting value of $h\nu$ is Eg, such that

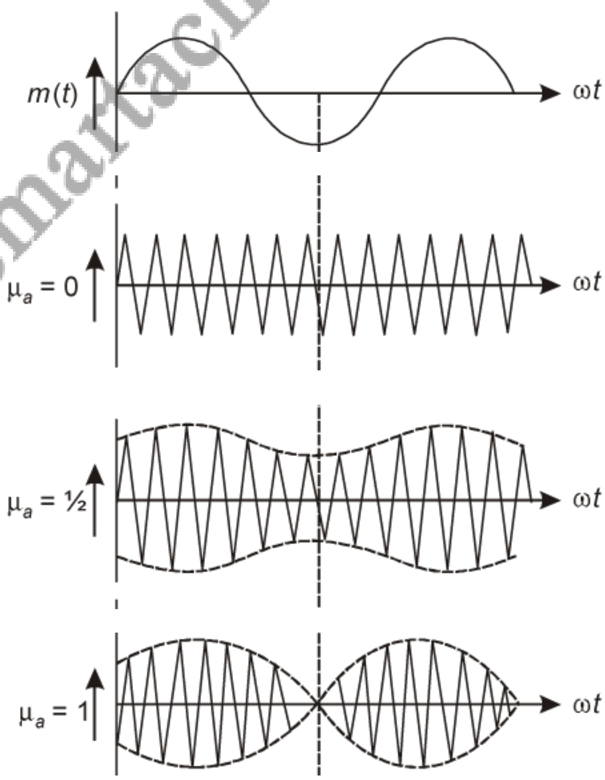
$$h\nu = \frac{hc}{\lambda} = E_g$$

$$\lambda = \frac{hc}{E_g} = \frac{6.63 \times 10^{-34}\ \text{Js} \times 3 \times 10^{8}\ \text{ms}^{-1}}{0.73 \times 1.6 \times 10^{-19}\ \text{J}}$$

$\therefore$ $\lambda$ = **1703 nm**.

**S16.** ***Modulation index:***

The degree of modulation is defined by the term modulation index. It is also called modulation factor or depth of modulation and given by

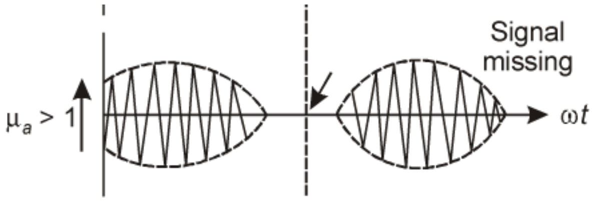



$$\mu = \frac{A_m}{A_c}$$

Where, $A_m$ is the amplitude of modulating signal and $A_c$ is the amplified of carrier wave.

***Physical significance of modulation index:***

It is used to determine the strength and quality of transmitted signal. If the modulation index is small, the amount of variation in the carrier amplitude is small. Thus, the audio signal transmitted will not be strong. The greater the degree of modulation, the stronger and clearer will be the audio signal during reception.




Maximum amplitude, $A_{max} = 10$ V,

Minimum amplitude, $A_{min} = 3$ V

Thus, modulating index, $\mu = \dfrac{A_{max} - A_{min}}{A_{max} + A_{min}}$

$$= \frac{10-3}{10+3} = \frac{7}{13}$$

$$= \mathbf{0.539}$$

**S17.** The needs of modulation for transmission of a signal are given below:

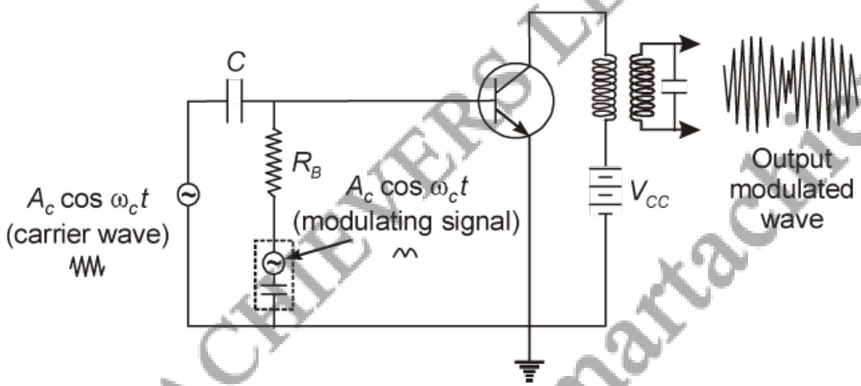
(a) The transmission of low frequency signal needs antenna of height 4-5 km which is impossible to construct. So, there is need to modulate the wave in order to reduce the height antenna to a reasonable height.

(b) Effective power radiated by antenna for low wavelength or high frequency wave as

$$P \propto \frac{1}{\lambda^2}$$

So, for effective radiation by antenna, there is need to modulate the wave.

Figure shows the amplitude modulation using a sinusoidal signal as the modulating signal.




Circuit for an amplitude modulator