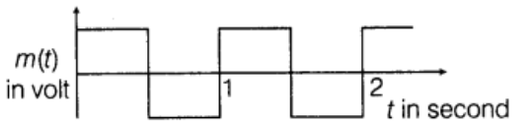
Modulation

1. The carrier wave of a signal is given by

$$c(t) = 3\sin(8\pi t) \text{ volt}$$

The modulating signal is a square wave as shown. Find modulation index. **[Delhi 2014]**



Ans.

According to the diagram,

Amplitude of modulating signal $A_m = 1\text{V}$

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

Modulation index, $\mu = \frac{A_m}{A_c} = \frac{1}{2} = 0.5$ **(1)**

2.Why do we need a higher bandwidth for transmission of music compared to that for commercial telephonic communication? [Delhi 2009]

Ans. The range of frequencies of music is higher than commercial telephone conversation and therefore, greater bandwidth is needed for music. Also, it is free from noise.

3.Identify the part X and Y in the following block diagram of a generalised communication system. [Delhi 2008C]

Ans. According to question figure,

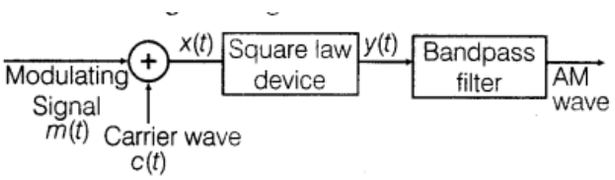
X: Information source.

Y: Communication channel

2 Marks Questions

4.Define the term modulation. Draw a block diagram of a simple modulator for obtaining AM signal. [Foreign 2014]

Ans. Modulation is the process in which low frequency message signal is superimposed on high frequency carrier wave so that they can be trasmitted over long distances. The block diagram for a simple modulator for obtaining AM signal is shown as below:



5.A message signal of frequency 10 kHz and peak voltage 10 V is used to modulate a carrier of frequency 1 MHz and peak voltage 20 V. Determine

- the modulation index
- the side bands produced. [Delhi 2013C]

Ans.

(*i*) Modulation index, $\frac{E_m}{E_c} = \frac{10}{20} = 0.5$ **(1)**

(*ii*) Side band frequencies $= f_c \pm f_m$

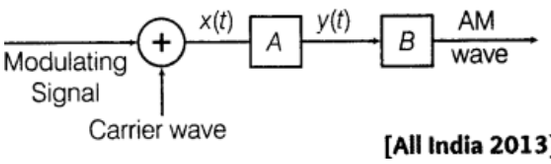
$f_m = 10$ kHz

$f_c = 1\text{MHz} = 1000$ kHz

$\therefore$ Side band frequencies $= 1000 \pm 10$

$= 1010$ kHz, 990 kHz **(1)**

6.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.



[All India 2013]

Ans.

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

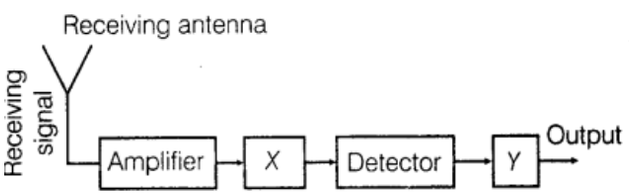
Bandpass filter rejects low and high frequencies and allows a band of frequencies to pass thorough. **(1)**

Square law device 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 $(A_c \sin \omega_c t)$ **(1)**

7. Block diagram of a receiver is shown in the figure below:



(*i*) Identify X and Y.

(*ii*) Write their functions.

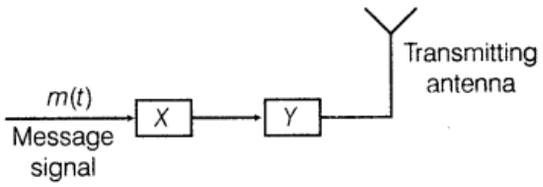
[Delhi 2013; All India 2012]

Ans. From the given block diagram of demodulation of a typical receiver, we can conclude the following,

(i) X represents Intermediate Frequency (IF) stage while Y represents an amplifier.

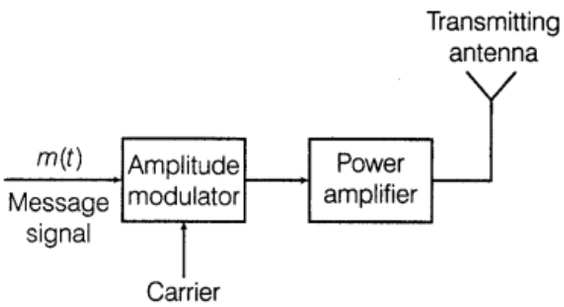
(ii) At IF stage, the carrier frequency is changed to a lower frequency and in this process, the modulated signal is detected while the function of amplifier is to amplify the detected signal which may not be strong enough to be made use of and hence is required.

8.Figure shows a block diagram of a transmitter identify the boxes X and Y and write their functions. [Foreign 2012]



Ans.

Block diagram of a transmitter



Modulator Since, the frequency range of signal is quite low and it is associated with very small amount of energy. It dies out very soon if transmitted as such.

So, it is modulated by mixing with very high frequency waves called carrier waves. This is done by modulator power. **Amplifier** Since, the signal gets weaken after travelling through long distances it cannot be transmitted as such.

Thus, we use a power amplifier to provide it necessary power before feeding the signal to the transmitting antenna.

9.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%. [Delhi 2012]

Ans.

Here, $A_c = 18\text{V}, A_m = ?$

Modulation index

$$\mu_c = 50\% = 0.50$$

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

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

$$\therefore \quad A_m = 9\text{ V}$$

10.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? [Foreign 2011]

Ans.

For AM wave,

Maximum amplitude,

$$A_{max} = 10 \text{ V}$$

Minimum amplitude,

$$A_{min} = 2 \text{ V}$$

$\therefore$ Modulation index,

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

$$\mu = \frac{10 - 2}{10 + 2} = \frac{8}{12} = \frac{2}{3} \qquad \textbf{(1/2)}$$

$$\mu = \frac{2}{3} \qquad \textbf{(1/2)}$$

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

11. For an amplitude modulated wave, the maximum amplitude is found to be 12 V while minimum amplitude is 2 V the modulation index. Why is modulation index generally kept less than One? [Foreign 2011]

Ans. Refer to ans .10

12.(i) Define modulation index.

(ii) Why is the amplitude of modulating signal kept less than the amplitude of carrier wave? [Delhi 2011]

Ans.

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

$$\therefore \mu = \frac{\text{Change in amplitude of carrier wave}}{\text{Amplitude of carrier wave}} \quad \textbf{(1/2)}$$

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

$$\therefore \quad \mu = \frac{A_m}{A_c} = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} \quad \textbf{(1/2)}$$

where, A_{max} and A_{min} are maximum and minimum voltage of AM wave, respectively. **(2)**

(*ii*) Refer to ans. 10. **(1)**

13.Write two factors justifying the need of modulating a signal. A carrier wave of peak voltage 12 V is used to transmit a message signal. What should be the peak voltage of the modulating signal in order to have a modulation index of 75%? [Ail India 2010]

Ans.

Need for modulation

(*i*) To reduce the length of antenna from 15 km to reasonable height.

(*ii*) Effective power radiated by antenna takes place for high frequency or low wavelength range. ($\frac{1}{2} \times 2 = 1$)

$$\%\text{Modulation index, } \mu = \frac{A_m}{A_c} \times 100 \quad \textbf{(1/2)}$$

where, A_m and A_c are peak voltage of modulating signal and carrier wave voltage.

Here, $A_m = ?, A_c = 12\text{ V}, \mu = 75\%$

$$\because \quad 75 = \frac{A_m}{12} \times 100 \implies A_m = \frac{12 \times 75}{100}$$

$$A_m = 9\text{ V} \quad \textbf{(1/2)}$$

14. 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. **[Delhi 2010C]**

Ans.

Here, maximum amplitude, $A_{max} = 16$ V

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

$\because$ Modulation index, $\mu = \frac{A_m}{A_c}$

$$= \frac{A_{max} - A_{min}}{A_{max} + A_{min}} \quad (1)$$

$$\therefore \quad \mu = \frac{16-4}{16+4} = \frac{12}{20} = \frac{3}{5} = \frac{3}{5} \quad (1)$$

15. Write two factors justifying the need of modulation for transmission of a signal. [All India 2009]

Ans. The needs of modulation for transmission of a signal are given as below:

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

(*ii*) 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 a need to modulate the wave.

16.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 the

- **modulation index**
- **the sidebands produced [All India 2009C]**

Ans.

(*i*) Peak voltage of modulating signal,

$A_m = 10$ V

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

$\therefore$ Modulation index,

$$\mu = \frac{A_m}{A_c} = \frac{10}{20} = \frac{1}{2} \quad (1)$$

(*ii*) USB (Upper Side Band)

$$= f_c + f_m = 1\text{MHz} + 10\text{ kHz}$$

$$= 1\text{MHz} + \frac{10^4}{10^6}\text{ MHz}$$

$$= 1\text{MHz} + 0.01 = 1.01\text{ MHz}$$

LSB (Lower Side Band)

$$= f_c - f_m = 1\text{MHz} - 10\text{ kHz}$$

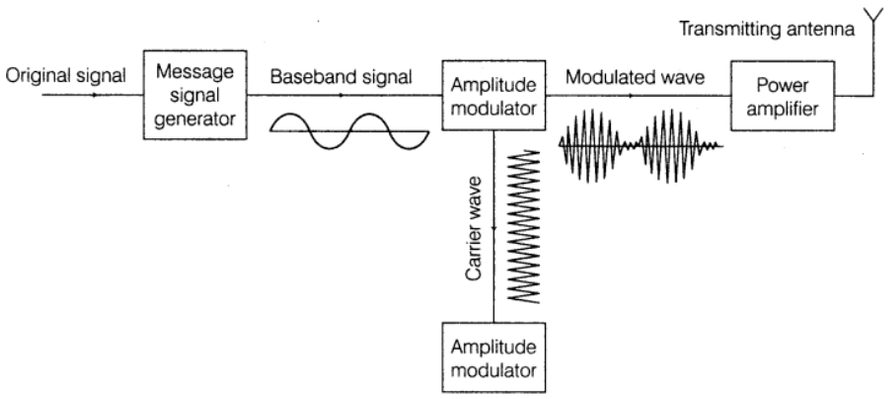
$$= 0.99\text{ MHz} \quad (1)$$

17.Draw a block diagram of a simple amplitude modulation. Explain briefly how amplitude modulation is achieved? [HOTS; All India 2008]

Ans.

When we are drawing block diagram for AM, we should have focus on the transmitter as well as receiver and super imposing of carrier wave and modulating signal should also be kept in mind.

Block diagram of a simple amplitude modulation



Block diagram of a transmitter of AM wave

(1)

The amplitude of an AM carrier waves changes in accordance to the values of modulating signal. Low frequency modulating signals are superimposed on high frequency carrier wave at the input of transistor as CE amplifier. The output voltage as carrier signal varying in amplitude in accordance with biasing modulation voltage. Thus, AM wave is produced. **(1)**

3 Marks Questions

18.Write two basic modes of communication. Explain the process of amplitude modulation.

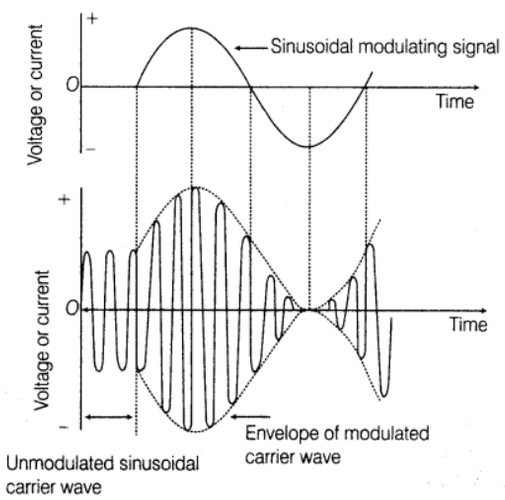
Draw a schematic sketch showing how amplitude modulated signal is obtained by superposing a modulating signal over a sinusoidal carrier wave. [All India 2014]

Ans.

The two basic modes of communication are given as below:

(*i*) Point-to-point (*ii*) Broadcast **(1)**

The process of amplitude modulation is the process of varying the amplitude of the sinusoidal carrier wave by the amplitude of the modulating signal.



(2)

19. Arnab was talking on his mobile to his friend for a long time. After his conversation was over, his sister Anita advised him that if his conversation was of such a long duration, it would be better to talk through a land line.

- Why is it considered harmful to use a mobile phone for a long duration?
- Which values are reflected in the advice of his sister Anita?
- A message signal of frequency 10 kHz is superimposed to modulate a carrier wave of frequency 1 MHz. Determine the sidebands produced. [All India 2014c]

Ans.

(*i*) The ultra high frequency of EM radiations continuously emitted by a mobile phone, may harm the system of the human body.

(*ii*) Anita shows the following values.

(*a*) Concern about her brother.

(*b*) Awareness about the likely effects of electromagnetic radiations on human body.

(*c*) Given, $f_c = 1000$ kHz, $f_m = 10$ kHz

The sidebands are

$(f_c + f_m)$ and $(f_c - f_m)$

or $(1000 + 10)$ and $(1000 - 10)$ kHz

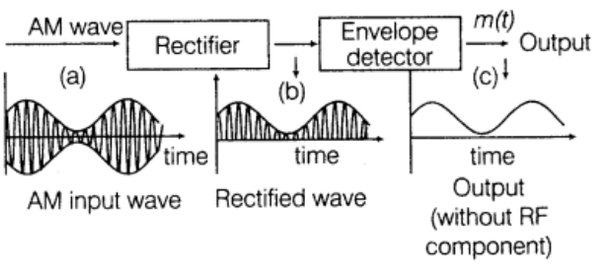
$= 1010$ and 990 kHz

20.What is meant by detection of a modulated signal? Draw block diagram of a detector for AM waves and state briefly showing the waveforms, how the original message signal is obtained. [Delhi 2013c]

Ans.

The transmitted messages get attenuated in propagating through the channel. The receiving antenna is to be followed by an amplifiers and a detector. Detection is the process of recovering the modulating signal from the modulated carrier wave. **(1)**

The block diagram of a detector for AM waves are shown as below:



The modulated signal of the form given in Fig. (a) is passed through a rectifier to produce the output shown in Fig. (b). This envelope of signal Fig. (c) is the message signal. In order to retrieve $m(t)$, the signal is passed through an envelope detector. **(1)**

21.Write three important factors which justify the need of modulating a message signal. Show diagrammatically how an amplitude modulated wave is obtained when a modulating signal is superimposed on a carrier wave. [Delhi 2013]

Ans.

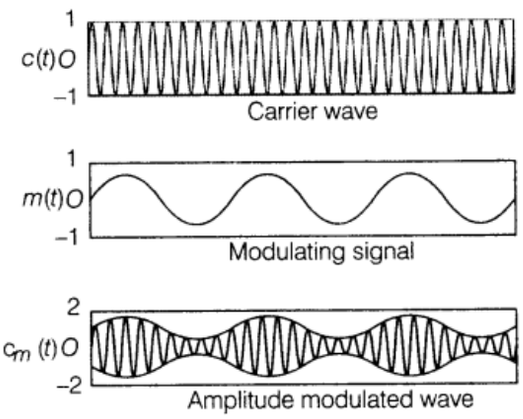
Three important factors which justify the need of modulating a message signal **(1)**

(*i*) Size of effective power radiated by antenna

(*ii*) Theoretical studies reveal that power P radiated from a linear antenna of length l is proportional to $(l/\lambda)^2$, i.e. $P \propto (l/\lambda)^2$
As high powers are needed for good transmission, therefore, for given antenna length, wavelength λ should be small or frequency ν should be high.

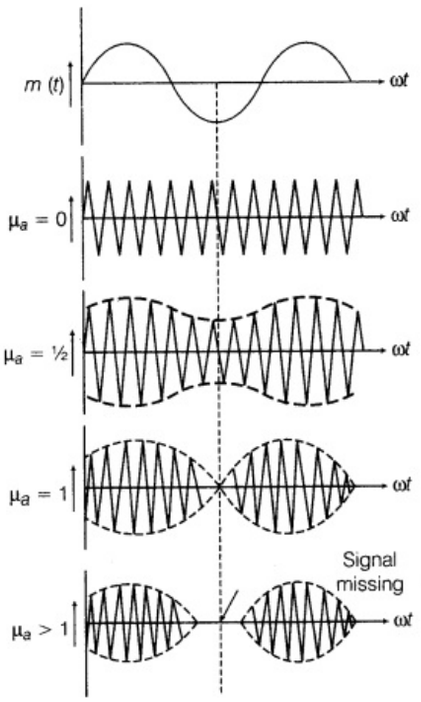
Thus, this factor also points out to need of using high frequency transmission. **(1)**

(*iii*) The interference of signals from different transmitters. To avoid the interference of the signals, there is a need of high frequency which can be achieved by the modulation. **(1)**



22.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 2 V. Determine the modulation index p. [Foriegn 2012]

Ans.



(1)

Refer to ans.12 (*i*).

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, $A_{min} = 2$ V

Thus, modulating index,

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

$$= \frac{10 - 2}{10 + 2} = \frac{8}{12} = 0.66 \qquad \textbf{(1)}$$

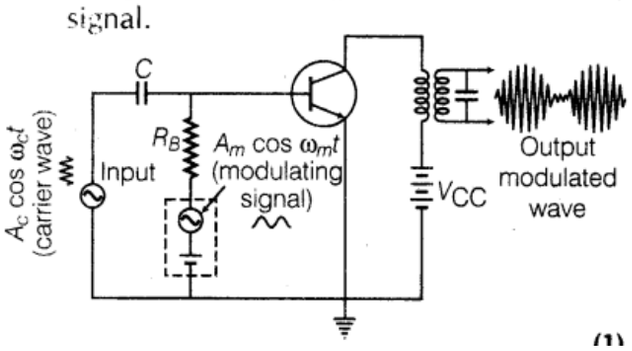
23.Write briefly any two factors which demonstrate the need for modulating signal. Draw a suitable diagram to show amplitude modulation using a sinusoidal signal as the modulating signal. [HOTS; Delhi 2012, All India 2011]

Ans.

The circuital arrangement for a modulator should be such that carrier wave should be mixed with the modulating signal. The output will be obtained through the LC filter.

Need for modulation Refer to ans.15. **(2)**

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



(1)

24.

Give reasons for the following.

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

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

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

Ans.

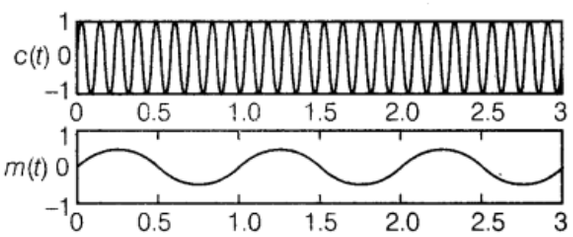
(*i*) To radiate the signals with high efficiency.

(*ii*) Because they are of large wavelength and power radiated by antenna is very small as

$$P \propto 1/\lambda^4.$$

(*iii*) It is so to avoid making over modulated carrier wave. In that situation, the negative half cycle of the modulating signal is dipped and distortion occurs in reception. **(1 × 3 = 3)**

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

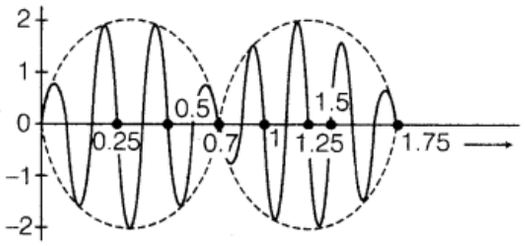


The diagrams given above show a carrier wave c (f), that is to be (amplitude) modulated by a modulating signal m{t). Draw the general shape of resulting AM wave. Define its modulation index. [All India 2010C]

Ans.

When are drawing wave form for AM wave the amplitude variation of carrier wave should be considerd and also that of modulating signal. **(1)**

Need for modulation Refer to ans.15. **(2)**

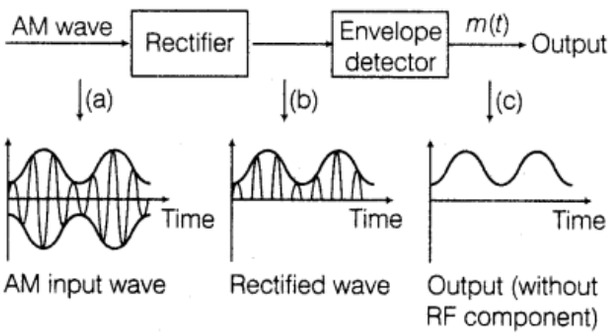


26.Draw a plot of the variation of amplitude versus co for an amplitude modulated wave. Define modulation index. State its importance for effective amplitude modulation. [Delhi 2008].

Ans. For importance of effective amplitude modulation Refer to ans. 15.

27.Draw a block diagram of a detector for an amplitude modulated signal explaining briefly the function of each of its components. [Delhi 2008C]

Ans.



The AM signals are allowed to pass through a rectifier which gives a series of positive half cycles of radio frequency pulse (rectified wave). These signals are allowed to pass through envelope detector (consisting of L - C circuit) which separates envelope (message signal) from rectified wave. **(1)**