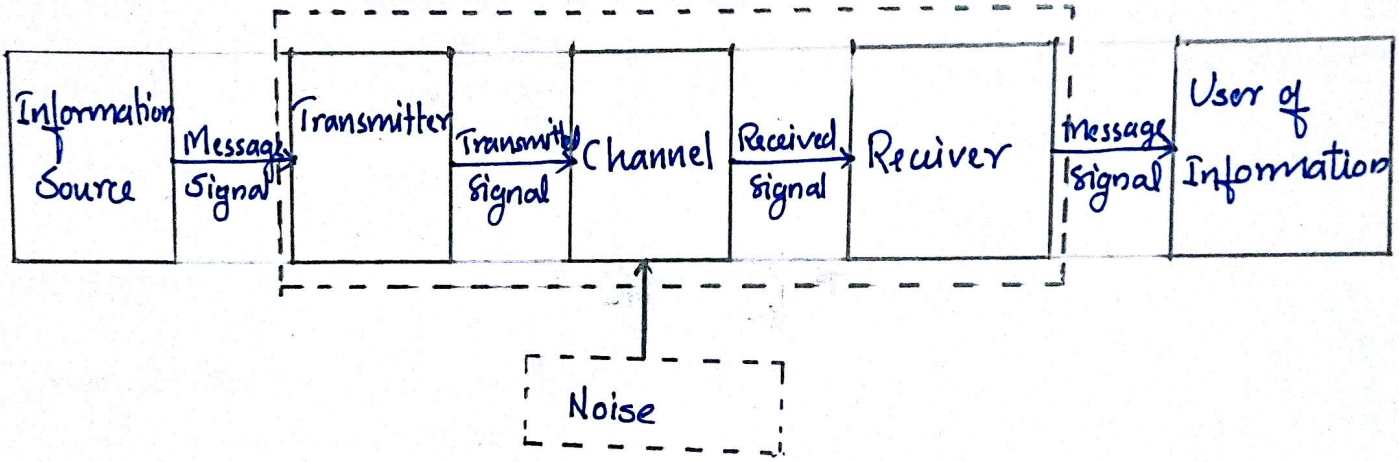
COMMUNICATION SYSTEMS

Communication is the act of transmission or information. It is the transfer of ideas from one point to another.

Communicaton system - Block diagram



Basic terminology used in electronic communication Systems

i) Transducer :- Any device that converts one form of energy in to another can be termed as a transducer

ii) Signal :- A single valued function of time suitable for transmission is called a signal

iii) Noise :- Any unwanted signal that interrupts proper communication is called noise.

iv) Transmitter :- Device which converts a signal suitable for transmission through a channel is called transmitter

v) Receiver :- A receiver extracts the destred message signal from the received signal.

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

vii) Amplification :- The process of increasing the strength of a signal is called amplification.

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 :- The range of frequency over which an equipment operates is called the bandwidth.

x) Modulation

xi) Demodulation

xii) Repeater :- A combination of a transmitter and a receiver is called a repeater.

Modulation and its necessity

Needs of modulation

i) To reduce the height of the antenna :-

The minimum height required for an antenna to transmit a signal of wavelength λ is,

$$h = \lambda/4$$

∴ If the frequency of signal is low, the height of the antenna required is very high.

(ii) To increase the radiating power of the antenna.

The effective radiating power of an antenna of length l is proportional to $(\frac{l}{\lambda})^2$.

so the power can be increased by using a high frequency signal.

Modulation

The process of changing some characteristics like amplitude, frequency or phase of the carrier wave in accordance with the intensity of the low frequency signal is called modulation.

Amplitude modulation (AM)

The process of changing the amplitude of the carrier (high frequency signal) in accordance with the intensity of the low frequency signal is called amplitude modulation.

Let $c(t) = A_c \sin \omega_c t$ represent carrier wave and

$m(t) = A_m \sin \omega_m t$ represent the modulating signal.

Where $\omega_m = 2\pi f_m$, is the angular frequency of the message signal.

Then, the modulated signal can be written as

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

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

$$= A_c \sin \omega_c t + \mu A_c \sin \omega_m t \sin \omega_c t$$

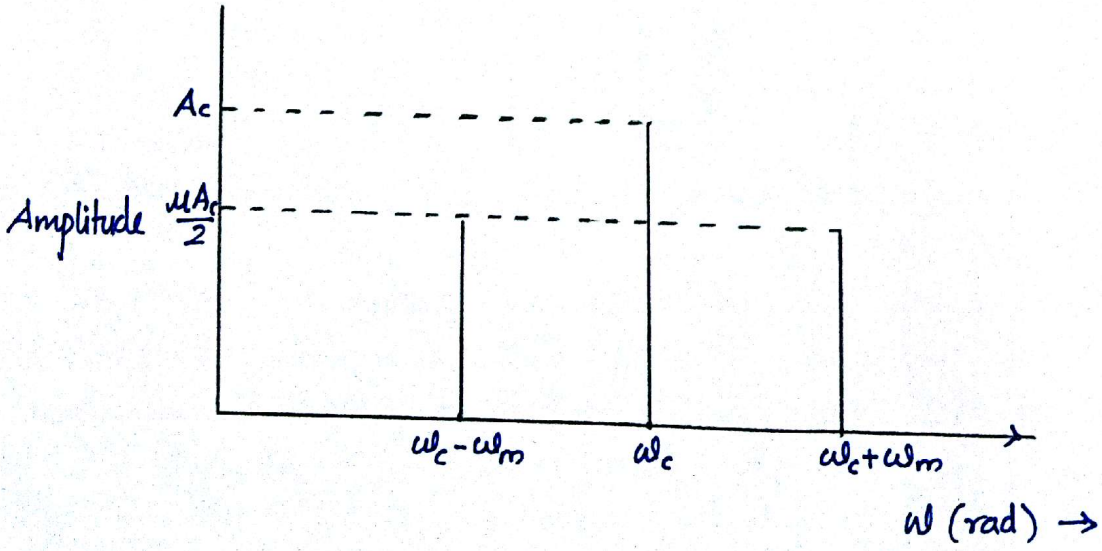
Where $\mu = \frac{A_m}{A_c}$, called the modulation index.

Note:- To avoid distortion, $\mu \leq 1$

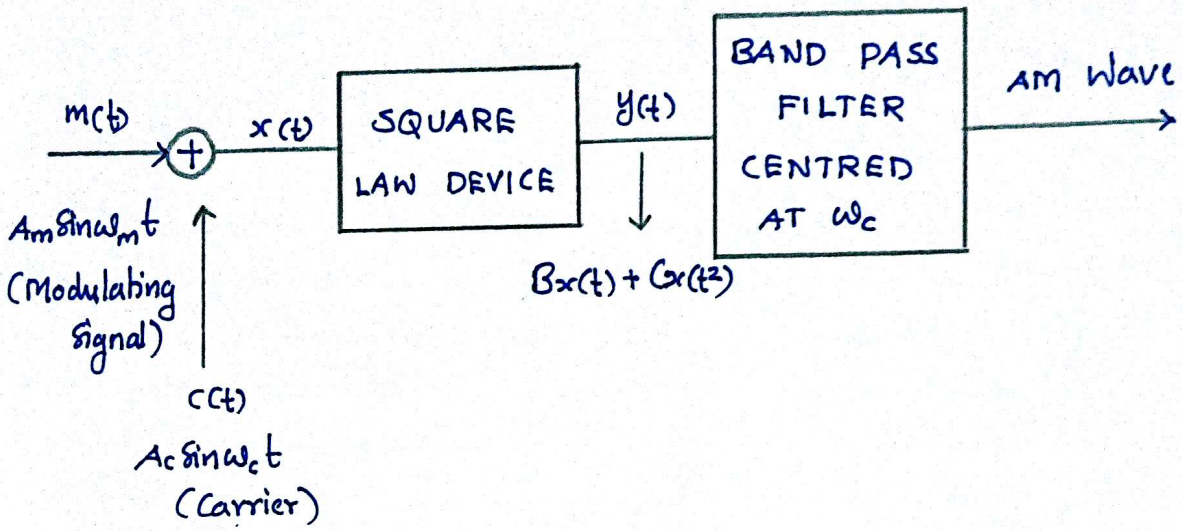
Using trigonometric relation, $2 \sin A \sin B = \cos(A-B) - \cos(A+B)$

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

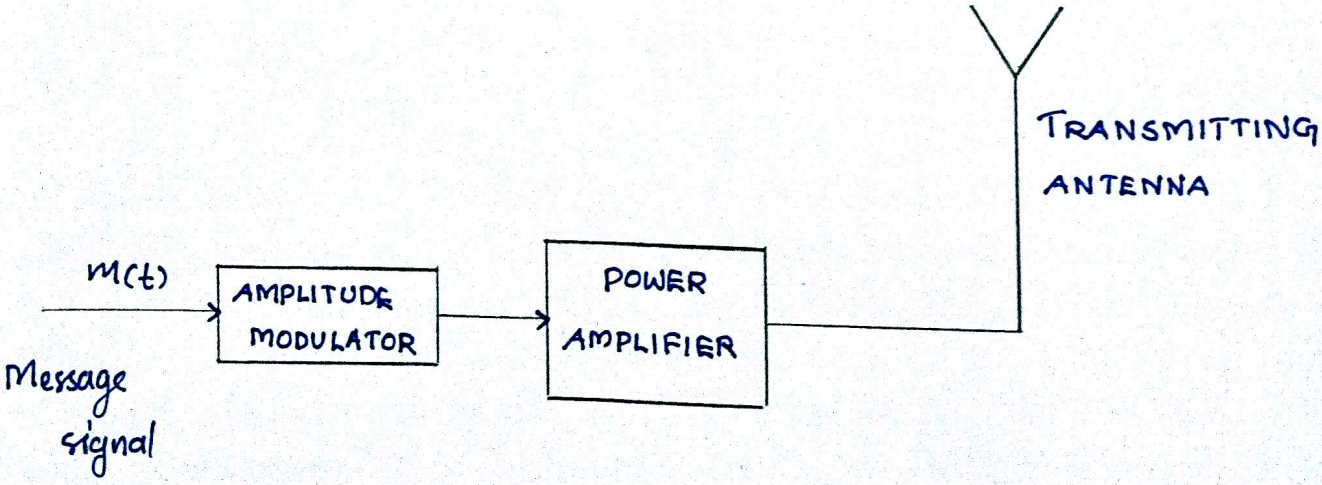
Here $\omega_c - \omega_m$ and $\omega_c + \omega_m$ are respectively called the lower side and upper side frequencies. The frequency spectrum of the amplitude modulated signal is shown in the figure.



Production of Amplitude modulated wave - Block diagram

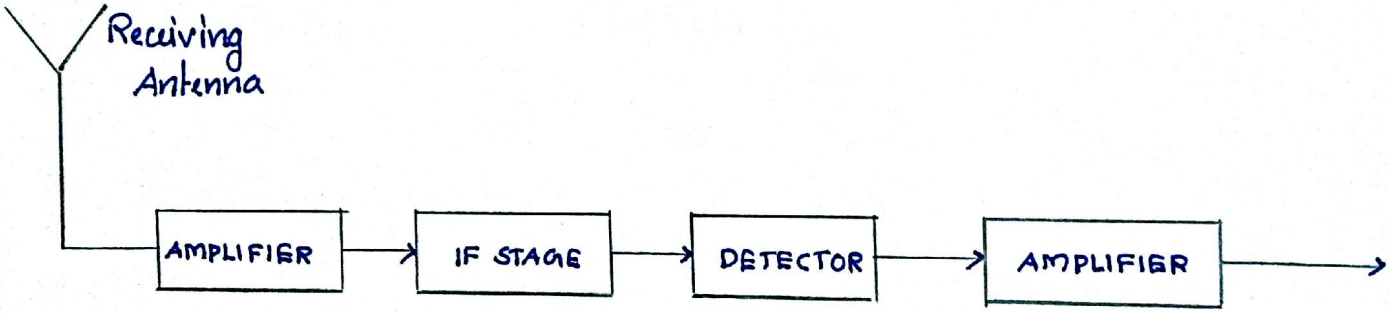


The modulator has to be followed by a power amplifier which provides the necessary power and then the modulated signal is fed to an antenna of appropriate size for radiation as shown in the figure.

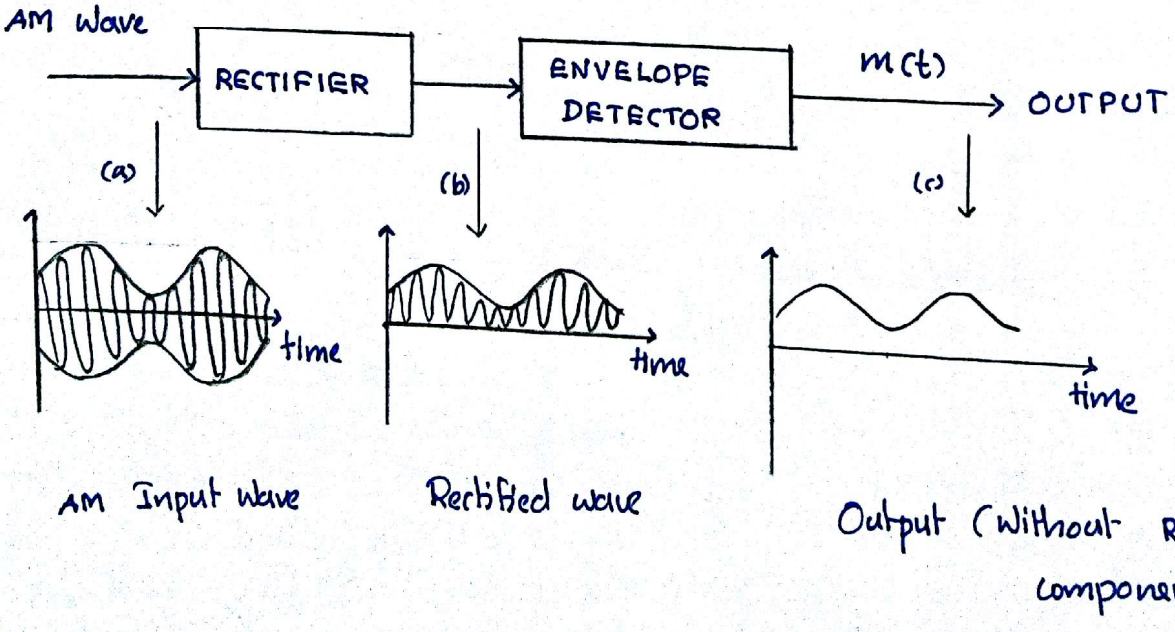


Detection of Amplitude Modulated wave

The transmitted message gets attenuated in propagating through the channel. The receiving antenna is therefore to be followed by an amplifier and a detector. In addition, to facilitate further processing, the carrier frequency is usually changed to a lower frequency by an intermediate frequency (IF) stage preceding the detection. A block diagram of a typical receiver is shown in figure.



Detection is the process of recovering the modulating signal from the modulated carrier wave. Block diagram is shown in fig



Limitations of AM

(i) Effect of noise is high

(ii) clarity is less.

(iii) Long range transmission is not possible.

Frequency Modulation (FM)

The process of changing frequency of the carrier wave in accordance with the intensity of the modulating signal is called frequency modulation.

Advantages of FM

(i) Effect of noise is less

(ii) High clarity

(iii) Long range transmission is possible.

Phase Modulation (PM)

The process of changing phase of the carrier wave in accordance with the intensity of modulating signal is called phase modulation

Note :- Refer figure 15.8 in the reader.

PROPAGATION OF ELECTROMAGNETIC WAVES

EM waves can be propagated through three different ways

I. Ground wave propagation.

Propagation of em waves just above the surface of the earth is called ground wave propagation. For this ground based vertical towers are used. In ground wave propagation, attenuation is very high due to the absorption of energy by 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 few MHz).

II. Sky Wave propagation

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 to earth. This mode of propagation is called skywave propagation. The ionospheric layer acts as a reflector for a certain range of frequencies (3 to 30 MHz). EM waves of frequencies higher than 30 MHz penetrate the ionosphere and escape. The frequency of radiation above which sky wave propagation is not possible is called the critical frequency (f_c) and is given by.

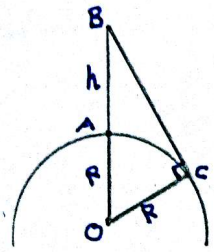
$f_c = 9\sqrt{N_{max}}$, where N_{max} – maximum ion density of the ionosphere

III. Space Wave propagation

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. 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.

Range of a tower (antenna)

The maximum distance up to which a signal can travel from a tower is called its range.



Consider a tower of height 'h' fixed at the point A on the surface of earth. Let R be the radius of earth.

In figure, $AC \simeq BC = d$,

the range of the tower

From, $\triangle OBC$,

$$OB^2 = OC^2 + BC^2 \quad \text{--- (1)}$$

But $OB = OA + AB = R + h$,

$OC = R$

& $BC = d$

$$\therefore (R+h)^2 = R^2 + d^2, \qquad R^2 + 2Rh + h^2 = R^2 + d^2$$

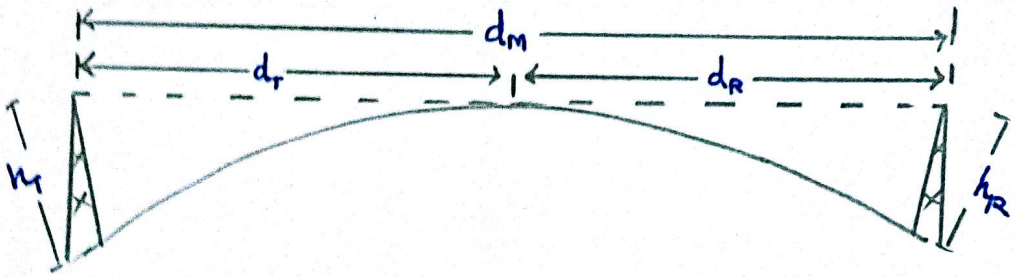
$$d^2 = 2Rh \quad (\because h^2 \text{ is very small})$$

∴ Range of the tower, $d = \sqrt{2Rh}$

Coverage area of the tower, $A = \pi d^2$

$$A = 2\pi Rh$$

A line of sight communication is illustrated in the figure.



$$d_T = \sqrt{2Rh_T} \quad \& \quad d_R = \sqrt{2Rh_R}$$

$$\therefore d_M = d_T + d_R$$

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

Television broadcast, microwave links and satellite communication are some examples of space wave propagation.

Note:- Refer Table 15.2 & 15.3 for additional information.