:MODULATION:

MODULATION – In the process of modulation, some characteristics of a high frequency sine wave (carrier) is varied in accordance with the instantaneous value of some modulating signal. The characteristics may be amplitude, frequency or phase. In this process we transmitte audio frequency signal by superimposing radio frequency signal (carrier) on it. High frequency wave is called the carrier wave. Audio signal is called modulating signal. After superposition resultant wave is called modulated wave.

Need for Modulation – A signal is send with out modulation then there are several difficulties are arise.

(1) The greatest difficultie is that for efficient radiation and reception the transmitting and receiving antenna would have to high comparable comparable to a quater wave length of frequency used. Which is 7.5 meter for 1MHz and 5000m for 15KHz – So a vertical antenna of this size is unthinkable for audio signal (below 20KHz).

(2) Sound is concentrated with in range (20Hz – 20KHz). So all signal comming from different sources are mixed up. In order to seperate the various signals, it is necessary to translate them all to different portions of the frequency spectrum. This also over come the difficulties of poor radiation at low frequency. we apply a tuned circuit in front end of the reciver to get the desired spectrum and reject rest portion.

(3) Since message consist of variable quantities (in speech ω and Am variable) So it is not possible to represent these massage by a constant modulating signal (Am, ω, φm are constant). Speech is made up variation in Amplitude (volume) and frequency (pitch).

Let the carrier voltage may be expressed as

$$e_c = A_c \cos(\omega_c t + \theta)$$

where A_c is amplitude, ω_c is angular frequency of carrier wave and θ is the phase angle. are varied according modulating signal.

Then three case arises –

(i) when A_c is varied in accordance with modulating wave, then process is known as AM ; ω_c and θ remain constant.

(ii) when ω_c varied in accordance with modulating wave, then process is know as FM. while A_c and θ constant.

(iii) when θ is varied in accordance with modulating wave, which A_c and ω_c is constant, the process is known as Phase modulation (PM).

Amplitude Modulation (AM) -

AM is defined as a System of modulation in which the amplitude of carrier is made proportional to the instantaneous amplitude of the modulating voltage.

Let the modulating voltage be represented as $e_m = A_m \cos \omega_m t$ and unmodulated carrier may be written as

$$e_c = A_c \cos(\omega_c t + \theta)$$

here $\omega_c >> \omega_m$, ~~and the phase $\theta = 0$ taken zero~~

Take $\theta = 0$, Since it does not play any part in this process.

So $e_c = A_c \cos \omega_c t$

From def^n of AM the resulting modulated wave has

$$e = (A_c + k_a A_m \cos \omega_m t) \cos \omega_c t$$

Since A_m is not 100% added hence a proportionality factor k_a is used. k_a determines the max variation in amplitude for a given modulating signal e_m.

$$\text{So } e = A_c \left(1 + k_a \frac{A_m}{A_c} \cos \omega_m t\right) \cos \omega_c t$$

$$= A_c (1 + m_a \cos \omega_m t) \cos \omega_c t$$

where $m_a = k_a \frac{A_m}{A_c}$ is defined as modulation index. Also 100 m_a gives percentage of modulation. m_a lying bet^n 0 and 1.

* If $k_a = 1$ and $A_m = A_c$ then modulation is 100%. m_a is small gives weak modulation.

Frequency Spectrum of AM wave -

$$e = A_c \cos \omega_c t + m_a A_c \cos \omega_m t \cos \omega_c t$$

$$= A_c \cos \omega_c t + \frac{m_a A_c}{2} \left[\cos(\omega_c + \omega_m) t + \cos(\omega_c - \omega_m) t \right]$$

$$= A_c \cos \omega_c t + \frac{m_a A_c}{2} \cos(\omega_c + \omega_m) t + \frac{m_a A_c}{2} \cos(\omega_c - \omega_m) t$$

So AM wave contains three terms

(i) $A_c \cos \omega_c t$ represent original carrier wave

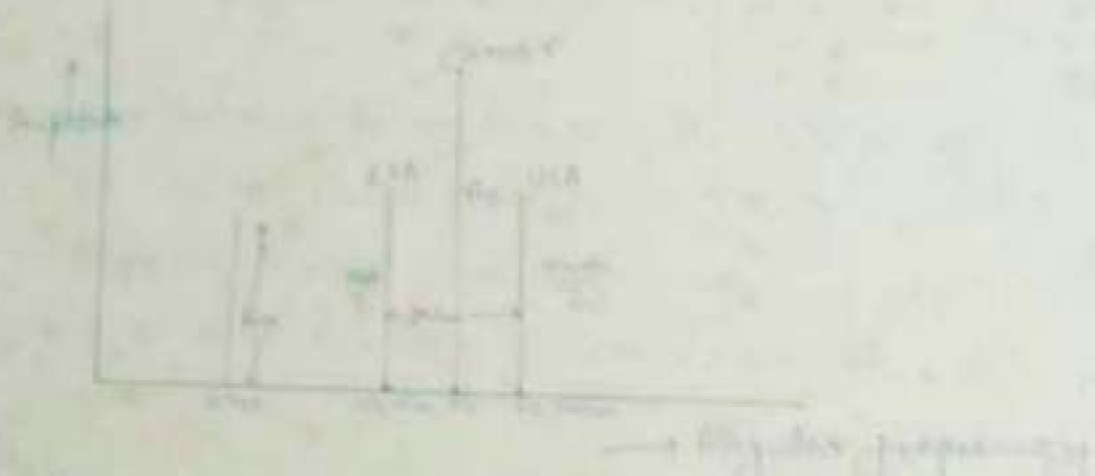
(ii) $\frac{m_a E_c}{2}\cos(\omega_c+\omega_m)t$ represent upper side band

(iii) $\frac{m_a E_c}{2}\cos(\omega_c-\omega_m)t$ represents lower side band (LSB)

Modulated wave has three frequency components one are carrier (ω_c), LSB ($\omega_c-\omega_m$), USB ($\omega_c+\omega_m$). So As in AM broadcasting service, the band width required is twice the highest modulating frequency.

① The carrier voltage component transmits no information while each of two side bands complete intelligence.

Frequency spectrum of AM wave is shown below.



Prob: A tuned ckt. of oscillator in simple AM transmitter employs a 50 µH coil and 1 nF capacitor. If o/p of oscillator is modulated by audio frequency of 10 kHz. What is the frequency range occupied by the side bands.

Soln

$f_m = 10\,kHz$, $L = 50\times10^{-6}$, $C = 1\,nF$

$f_c = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\times3.14\sqrt{50\times10^{-6}\times1\times10^{-9}}} = 712\times10^3$

$= 712\,kHz$

range of side bands $= f_c - f_m$ to $f_c + f_m$

$= (702$ to $722)$