Angle Modulation

Modulation process is anolog modulation process but non linear modulation process. In this we change the total phase angle of $c(t)$ according to $m(t)$ by keeping amplitude constant.

§ Advantages of angle modulation over amplitude modulation:

i) S/N Ratio at R_x S: Signal Power , N: Noise Power.

ii) Higher B_T.

Angle modulation can be classified as:

i) Frequency modulation

ii) Phase modulation

$$\omega_i = \frac{d}{dt}\theta(t)$$

$$\omega_i = \omega_c + \frac{d}{dt}\phi(t) \quad = \text{Frequency deviation}$$

Frequency modulation is a process in which we change the instantaneous frequency of carrier signal according to the amplitude of the message signal.

The amount by which frequency of $c(t)$ is varied to it's unmodulated value is called frequency deviation.

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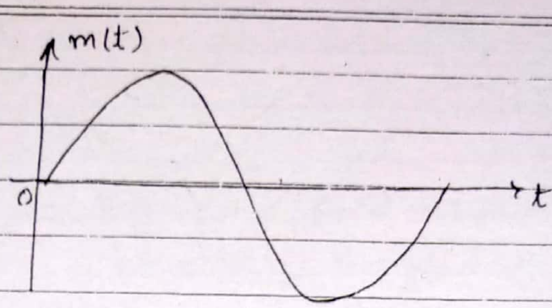

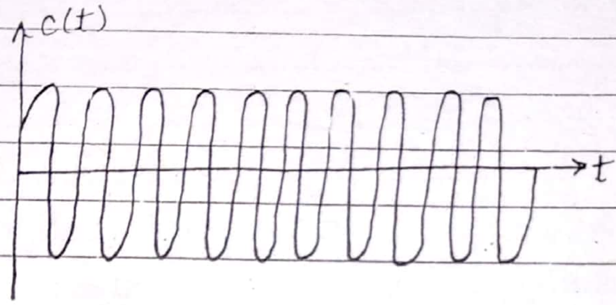

The frequency deviation (δ) :

$$\boxed{\delta = K V_m f_c}$$

where,

V_m = amplitude of m(t)

f_c = frequency of carrier signal.

The instantaneous frequency of F.M :

$$f_i = f_c (1 \pm K V_m \cos \omega_m t)$$

$$m(t) = V_m \cos \omega_m t$$
$$c(t) = V_c \cos \omega_c t$$

If $\cos \omega_m t = 1$ then,

$$f_i = f_c (1 \pm k V_m)$$

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$f_i = f_c \pm kV_m f_c$

If we consider the +ve side :

$f_H = f_{max} = f_c + kV_m f_c$
$= f_c + \delta$

δ = allowed deviation

If we consider the -ve side :

$f_L = f_{min} = f_c - kV_m f_c$
$= f_c - \delta$

$\therefore \delta = \frac{f_H - f_L}{2}$

Modulation Index for F.M. Wave :

$m_f = \frac{\delta}{f_m} = \frac{\text{Frequency deviation}}{\text{Highest freq. component present in } m(t)}$

Physical significance of m : How much frequency changes according to amplitude of message signal.

Wave eq^n of F.M. :

$S(t) = A_c \sin \theta$

$\theta = \int \omega_i \, dt$

$\theta = \int \omega_c (1 \pm kV_m \cos \omega_m t) \, dt$

$$\theta = \omega_c t \pm \omega_c k V_m \frac{\sin \omega_m t}{\omega_m}$$

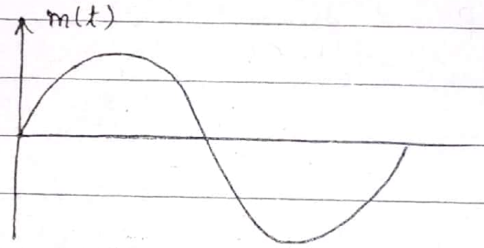
$$= \omega_c t \pm \frac{2\pi f_c \cancel{t}\, k V_m \sin \omega_m t}{\omega_m\, 2\pi f_m}$$

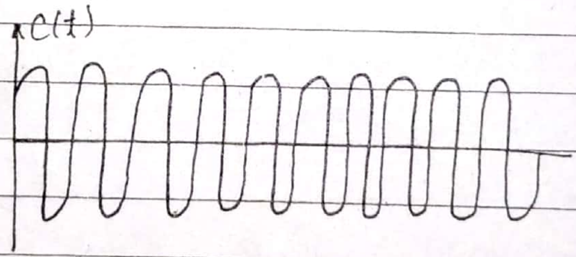
$$= \omega_c t \pm \frac{k V_m f_c \sin \omega_m t}{f_m}$$

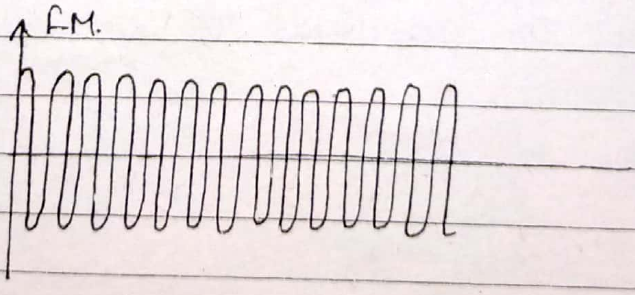
$$= \omega_c t \pm \left(\frac{\delta}{f_m}\right) \sin \omega_m t$$

$$= \omega_c t \pm m_f \sin \omega_m t$$

$$s(t) = A_c \sin\left[\omega_c t \pm m_f \sin \omega_m t\right]$$







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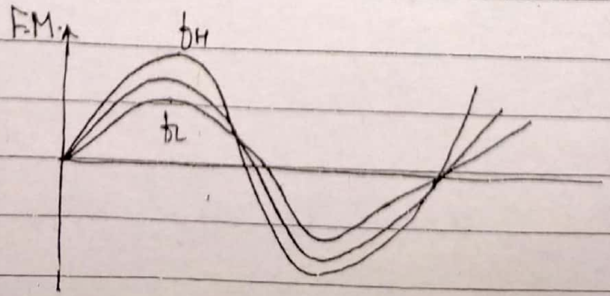

Practical

$$\delta = \frac{f_H - f_L}{2}$$

Properties of F.M:

i) In amplitude modulation we get two sidebands but in the F.M. we get infinite sideband.

ii) In frequency modulation process the modulation index (m_f) is given by:

$$m_f = \frac{\delta}{f_m}$$

i.e. $m_f \propto \frac{1}{f_m}$, so in the frequency modulation process if frequency of $m(t)$ increases then value of modulation index decreases.

iii) The total transmitted power contained only by the sideband.

R = Load resistor

Transmitted power $(P) = \frac{A_c^2}{2R}$ A_c = Amp. of FM wave

iv) Bandwidth - Theoretically, the FM wave consists of infinite sidebands so the bandwidth of FM is infinite but practically it is not possible. The bandwidth of FM wave is practically given by Carson's Rule.

$$B_T = 2\delta + 2f_m$$

$$B_T = 2\delta + 2\left(\frac{\delta}{m_f}\right)$$

$$B_T = 2\delta\left(1 + \frac{1}{m_f}\right)$$

Classification of F.M. waves

i) Wideband F.M. waves (WBFM)
ii) Narrowband F.M. waves (NBFM)

	WBFM	NBFM
1.	Modulation index $m_f >> 1$	Modulation index $m_f < 1$
2.	Maximum frequency deviation $\delta_{max} = 75\,kHz$	Maximum frequency deviation $\delta_{max} = 5\,kHz$ to $15\,kHz$ (10kHz American standard)
3.	Bandwidth of WBFM $B_T = 2\delta + 2f_m$	Bandwidth of NBFM $B_T = 2f_m$ i.e. Bandwidth of NBFM just equa the conventional A.M wave
4.	WBFM signals are used in transmission of T.V. signals	NBFM signals are used in mobile communication.
5.	The bandwidth of WBFM is about 15 times higher than the bandwidth of NBFM.	The bandwidth of NBFM signals are just equal to the bandwidth of amplitude modulated waves.