Date
Page

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

A_c = Amp. of FM wave

$$\text{Transmitted power } (P) = \frac{A_c^2}{2R}$$

iv) Bandwidth - Theoretically, the FM wave consists of infinite side bands 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.

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

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

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

Date
Page

Q. A carrier signal is frequency modulated by a sinusoidal modulating signal of frequency 2kHz and resulting in a frequency deviation 5 kHz. Determine B_T. If amplitude of modulating signal is increased by a factor 3 and frequency is lowered by 1 kHz. Calculate new bandwidth.

Soln: $f_m = 2\text{ kHz}$

$\delta = 5\text{ kHz}$

$$B_T = 2\delta + 2f_m$$
$$= 2\times5 + 2\times2$$
$$= 10+4 = 14\text{ kHz}$$

$$f_m' = 2\text{kHz} - 1\text{kHz} = 1\text{kHz}$$

$$\delta' = kV_m f_c$$
$$\delta \propto V_m$$
$$\delta' \propto V_m'$$

$$\delta' = 3\times5\times10^3 = 15\text{ kHz}$$

$$B_T = 2\delta' + 2f_m'$$
$$= 2\times15 + 2\times1$$
$$= 32\text{ kHz}$$

Q. A carrier signal is frequency modulated by a 4Hz sine wave resulting in a FM signal of maximum frequency 107.218 MHz and minimum frequency 107.196 MHz. Determine:

a) Carrier swing

b) Carrier frequency
c) Frequency deviation and modulation index.

Soln- a) Carrier swing $= 2\delta$

$f_m = 4Hz$
$f_H = 107.218\ MHz$
$f_L = 107.196\ MHz$

$$\delta = \frac{f_H - f_L}{2}$$
$$= \frac{107.218 - 107.196}{2}$$
$$= 0.011\ MHz$$

$$\therefore 2\delta = 0.022\ MHz$$

b) $f_{max} = f_H = f_c + \delta$

$$\therefore f_c = 107.218 - 0.011\ MHz$$
$$= 107.207\ MHz$$

c) $\delta = 0.011\ MHz$

$$m_f = \frac{\delta}{f_m}$$
$$= \frac{0.011 \times 10^6}{4}$$
$$= 2.75 \times 10^3$$

Date ____
Page ____

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.

§ Proof: NBFM signal = conventional A.M. wave

$$S(t) = V(t) = A_c \cos\left[\omega_c t + m_f \sin \omega_m t\right]$$

$$= A_c\left[\cos \omega_c t \cdot \cos(m_f \cdot \sin \omega_m t)\right] -$$
$$A_c\left[\sin \omega_c t \cdot \sin(m_f \cdot \sin \omega_m t)\right]$$