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1) A sinusoidal Carrier 20v, 2Mhz is frequency modulat-ed by a sinusoidal message signal of 10v, 50KHz 50KHz. Given k_f = 25KHz/v.

i) Find deviation, modulation index, bandwidth and Power

ii) Repeat above if message signal amplitude is doubled.

Sol: Given A_c = 20v, f_c = 2Mhz, A_m = 10v, f_m = 50KHz

$\quad\quad k_f$ = 25KHz/v

i) Deviation $\Delta f = k_f A_m$

$$= 25KHz/v \times 10v$$

$$= 250 Hz$$

modulation index $\beta = \dfrac{\Delta f}{f_m}$

$$= \dfrac{250KHz}{50KHz} = 5$$

Bandwidth B.w = $(\Delta f + f_m)$

$$= (250 + 50)$$

$$= 2 \times 330 KHz = 660KHz$$

Power = $\dfrac{A_c^2}{2} = \dfrac{(20)^2}{2} = \dfrac{400}{2} = 200w$

ii) when message signal amplitude is doubled A_m = 20v

Deviation $\Delta f = k_f A_m$

$$= 25KHz/v \times 20v$$

$$= 500KHz.$$

modulation index $\beta = \dfrac{\Delta f}{fm}$

$= \dfrac{500 KHz}{50 KHz} = 10$

Bandwidth $B.w = 2(\Delta f + fm)$

$= 2(500KHz + 50KHz)$

$= 2(550KHz) = 1,100KHz$

Power $= \dfrac{Ac^2}{2} = \dfrac{(20)^2}{2} = 200w$

2) → An Fm signal is given by $s(t) = 10\cos[2\pi10t + 8\sin u\pi10^3 t]$ find deviation, modulation index, bandwidth and power.

Sol) Given $s(t) = 10\cos(2\pi10^6 t + 8\sin u\pi10^3 t)$

$s(t)$ Fm $= Ac\cos(2\pi fc t + \beta\sin2\pi fm t)$

By comparing both we get

$Ac = 10$, $fc = 10^6$, $\beta = 8$ $fm = 2\times10^3$

Deviation $\Delta f = \beta fm = 8\times2\times10^3 = 16\times10^3 Hz = 16KHz$

modulation index $\beta = 8$

Bandwidth $B.w = 2fm(\beta+1)$

$= 2\times2\times10^3(8+1)$

$= 4\times9\times10^3 = 36KH3$

Power $= \dfrac{Ac^2}{2} = (100)/2 = 50w$

3) → 93.2Mhz carrier is modulated by a 5Khz sinewave the resultant fm signal has a frequency deviation of 40Khz. find.

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i) Carrier swing

ii) Highest and lowest frequency obtained by the Fm wave

iii) modulated index.

Sol: Given $f_c = 93.2 mhz$, $f_m = 5KHz$, $\Delta f = 40KHz$

i) Carrier Swing $= 2\Delta f_m$

$= 2 \times \overset{40}{\cancel{5}} KHz$

$= 80 KHz$

ii) Highest frequency $= f_c + \Delta f = 93.2 MHz + 40 KHz$

$= 93.2 \times 10^6 + 4 \times 10^4$

$= 932 \times 10^5 + 4 \times 10^4$

$= 9324 \times 10^4 Hz$

Lowest frequency $= 93.2 mHz - 40 KHz$

$= 9320 \times 10^4 - 4 \times 10^4$

$= 9316 \times 10^4$

iii) modulation index $\beta = \dfrac{\Delta f}{f_m} = \dfrac{40 KHz}{5 KHz} = 8$

4) An FM wave is defined as $s(t) = 10\cos[10\pi t + \sin 14\pi t]$

Calculate instantaneous frequency

Sol: Given $s(t) = 10\cos[10\pi t + \sin 14\pi t]$

$s(t) = A_c \cos[2\pi f_c + \beta \sin 2\pi f_m t]$
       Fm

Comparing both the equations, we have

$A_c = 10$, $f_c = 5 Hz$, $\beta = 1$, $f_m = 7 Hz$

Instantaneous frequency $f_i = f_c + k_f m(t)$

$$\theta_i(t) = 2\pi \int f_i \, dt$$

$$\frac{d\theta_i}{dt} = 2\pi f_i$$

$$f_i = \frac{1}{2\pi} \frac{d\theta_i}{dt}$$

$$f_i = \frac{1}{2\pi} \frac{d}{dt} \underbrace{(2\pi f_c t + \beta \sin 2\pi f_m t)}_{s(t) \, pm}$$

$$= \frac{1}{2\pi} \frac{d}{dt} (10\pi t + \sin 14\pi t)$$

$$= \frac{1}{2\pi} \left[\frac{d}{dt} (10\pi t) + \frac{d}{dt} (\sin 14\pi t) \right]$$

$$= \frac{1}{2\pi} (10\pi) + \frac{14\pi}{2\pi} \cos 14\pi t$$

$$f_i = 5 + 7 \cos 14\pi t$$

5 Calculate the B·W of a Commercial FM transmission assuming deviation as 75khz, w = 15KHz

Sol: Given $\Delta f = 75KHz$, $w = 15KHz = f_m$

$$B·W = 2(\Delta f + f_m)$$
$$= 2(75 + 15)$$
$$= 2(90) KHz$$
$$= 180 KHz.$$

6 A carrier is frequency modulated by a sinusoidal modulating frequency signal of 2KHz, resulting in a frequency deviation of 5KHz. What is the B·W occupied by the modulated waveform. Now, the deviation of the sinusoid is increased by the factor of 3 and its frequency lower by 1kHz what is the new B·W?

A

Given $f_m = 2KHz$, $\Delta f = 5KHz$

$$B.w = 2(f_m + \Delta f)$$
$$= 2(2+5) = 2 \times 7 KHz$$
$$= 14 KHz$$

f_m new $= 2KHz - 1KHz = 1KHz$

Δf new $= 3f_m = 3 \times (5KHz) = 15KHz$

$$B.w \text{ new} = 2(\Delta f + f_m)$$
$$= 2(15+1)$$
$$= 2(16KHz)$$
$$= 32 KHz$$

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Determine the relative power of Carrier and sideband frequency when index $= 0.2$ for a 10kw FM transmitter

Sol: Given $\beta = 0.2$, $P_T = 10kw$

$$P_T = \frac{Ac^2}{2}\left[1 + \frac{\beta^2}{2}\right]$$

$$10kw = \frac{Ac^2}{2}\left[1 + \frac{(0.2)^2}{2}\right]$$

$$10kw = \frac{Ac^2}{2}\left[1 + \frac{0.04}{2}\right]$$

$$10kw = \frac{Ac^2}{2}\left[1 + 0.02\right]$$

$$\frac{20kw}{1.02} = Ac^2$$

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$$Ac^2 = 1.96 \times 10^4$$

$$AC = 1.4 \times 10^2$$

$$Pc = \frac{Ac^2}{2} = \frac{1.96 \times 10^4}{2} = 0.98 \times 10^4 w = 9.8 kw$$

$$PLSB = PUSB = \left(\frac{\beta Ac}{2\sqrt{2}}\right)^2 = \frac{\beta^2 Ac^2}{8}$$

$$= \frac{(0.2)^2 (1.96 \times 10^4)}{8}$$

$$= \frac{0.04 \times 1.96 \times 10^4}{8}$$

$$= \frac{0.0784 \times 10^4}{8} = 98 w$$

8 A 10mhz carrier has a peak voltage of 5v, the carrier is frequency modulated by a sinusoidal modulating waveform of f = 2khz such that the frequency deviation is 75KHZ. the modulated wave form passed through 0 and is increases at time t = 0, write the expression for the modulated carrier waveform.