EEEN 3336
HW # 4 **Due: Dec. 4, 2001**

1. Given the waveform $f(t) = 10\cos\left[90\times10^6 t + 200\cos 2000t\right]$

a) If $f(t)$ is a PM signal, what is the message signal if $k_p = 50\ rad/V$?

b) If $f(t)$ is a FM signal, what is the message signal if $k_f = 100\ KHz/V$?

. a) If $f(t)$ is a PM signal, then $k_p m(t) = 200\cos 2000t \quad \Rightarrow \quad 50m(t) = 200\cos 2000t$

$m(t) = 4\cos 2000t\ V$

b) If $f(t)$ is a FM signal, then $\omega_i = 90\times10^6 - 4\times10^5 \sin 2000t$

$$f_i = \frac{1}{2\pi}\left(90\times10^6 - 4\times10^5 \sin 2000t\right)$$

$$k_f m(t) = -\frac{4\times10^5 \sin 2000t}{2\pi} \quad \Rightarrow \quad m(t) = -\frac{4}{2\pi}\sin 2000t\ V.$$

2. Given the angle-modulated waveform $f(t) = 10\cos\left[90\times10^6 t + 200\cos 2000t\right]$

a) Determine the instantaneous frequency.

b) Whether $f(t)$ represents a PM or FM, the bandwidth can be found by using Carson's rule, determine the required bandwidth.

c) Determine β and identify whether it is NBFM or WBFM.

a) $f(t) = 10\cos\left[90\times10^6 t + 200\cos 2000t\right]$

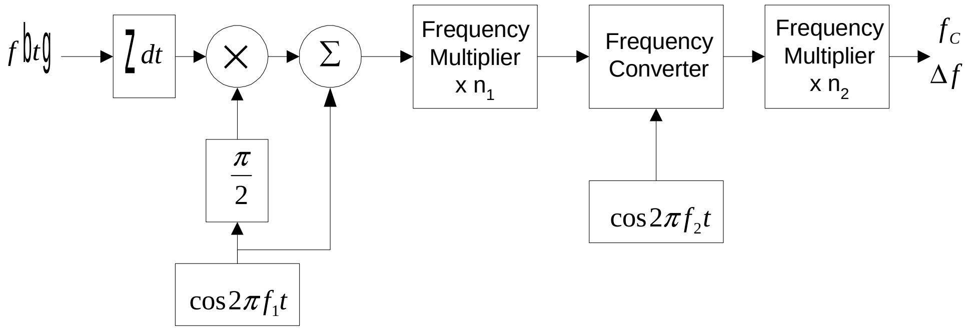
Note: $\omega_i = \dfrac{d\theta}{dt}$ *where* θ is the phase angle

The instantaneous frequency: $\omega_i = 90\times10^6 - 4\times10^5 \sin 2000t$

b) $f_m = 2000/2\pi \quad and \quad \Delta f = 4\times10^5/2\pi \quad \Rightarrow \quad BW = 2\left(f_m + \Delta f\right) = \dfrac{804}{2\pi}KHz$

c) Since $\beta = \dfrac{\Delta f}{f_m} = \dfrac{4\times10^5}{2\pi}\times\dfrac{2\pi}{2\times10^3} = 200 \quad \Rightarrow \quad WBFM \quad \Rightarrow \quad BW \cong 2\Delta f = \dfrac{800}{2\pi}KHz$

3. Compute the carrier frequency f_C, and the peak frequency deviation Δf of the output of the FM transmitter as shown below if $f_1 = 200\,,KHz,\ f_2 = 10.7\ MHz,\ \Delta f_1 = 25\,Hz,\ n_1 = 64$ and $n_2 = 48$.



$$f_C = (0.2\ MHz \times 64 \pm 10.7\ MHz)(48) = 1128\ MHz\ \ or\ \ 100.8\ MHz$$
$$\Delta f = 25 \times 64 \times 48 = 76.8\,KHz$$

4. A 1 GHz carrier is frequency modulated by a 10 KHz sinusoid so that the peak frequency deviation is 40 KHz. Use both Carson's rule and Bessel functions (significant up to 2 digits after the decimal) to determine the followings:

a) the approximate bandwidth of the FM signal
b) the bandwidth if the modulating signal amplitude were doubled
c) the bandwidth if the modulating signal frequency were doubled
d) the bandwidth if both the amplitude and the frequency of the modulating signal were doubled.

a) $\beta = \dfrac{\Delta f}{f_m} = \dfrac{40}{10} = 4$ Carson's rule: $BW = 2 f_m (1+\beta) = 2\times 10^4 \times 5 = 100\ KHz$

Bessel function: $BW = 2n f_m = 2\times 7\times 10^4 = 140\ KHz$

b) $\beta = \dfrac{\Delta f}{f_m} = \dfrac{80}{10} = 8$ Carson's rule: $BW = 2 f_m (1+\beta) = 2\times 10^4 \times 9 = 180\ KHz$

Bessel function: $BW = 2n f_m = 2\times 11\times 10^4 = 220\ KHz$

Note: double the amplitude will double the frequency deviation.

c) $\beta = \dfrac{\Delta f}{f_m} = \dfrac{40}{20} = 2$ Carson's rule: $BW = 2 f_m (1+\beta) = 2\left(2\times 10^4\right)3 = 120\ KHz$

Bessel function: $BW = 2n f_m = (2)(4)\left(2\times 10^4\right) = 160\ KHz$

d) $\beta = \dfrac{\Delta f}{f_m} = \dfrac{80}{20} = 4$ Carson's rule: $BW = 2 f_m (1+\beta) = (2)\left(2\times 10^4\right)(5) = 200\ KHz$

Bessel function: $BW = 2n f_m = (2)(7)\left(2\times 10^4\right) = 280\ KHz$