King Fahd University of Petroleum & Minerals
Electrical Engineering Department
EE370: Communications Engineering I (091)
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Quiz 4: Frequency Modulation

Serial # 0

-1 for not writing your serial number

Name: KEY

ver. 1.0

A single-tone modulating signal cos ($15\pi\ 10^3 t$) frequency modulates a carrier of 10 MHz and produces a frequency deviation of 75 kHz. ← $(2\pi(7.5 \times 10^3)t)$ f_m

1) Find the modulation index. **(2 points)**

$$\beta = \frac{\Delta\omega}{\omega_m} = \frac{\Delta f}{f_m} = \frac{75 \times 10^3}{7.5 \times 10^3} = 10$$

2) Estimate the bandwidth of the FM signal. **(2 points)**

$$B \simeq 2(\Delta f + B_m) \simeq 2(75 + 7.5) \times 10^3 = 2(82.5k)$$

$$= 165\ KHz$$

3) Find the phase deviation produced in the FM wave. **(3 points)**

$$\varphi_{FM}(t) = A\cos\left(\omega_c t + \frac{K_f}{\omega_m}\sin\omega_m t\right)$$

K_f in rad/volt

instantaneous total phase $\omega_c t + \frac{K_f}{\omega_m}\sin\omega_m t$

instantaneous total freq $\omega_c t + K_f \cos \omega_m t \Rightarrow \Delta f = K_f \Rightarrow$

$$\Delta\theta = \frac{K_f}{\omega_m} = \frac{75k}{7.5k} = 10\ \frac{rad}{sec}$$

note that $\int_{-\infty}^{t} \cos(\omega_m t)\,dt = \frac{\sin(\omega_m t)}{\omega_m}$

4) If another single-tone modulating signal produces a modulation index of 100 while maintaining the same deviation, find the frequency and amplitude of the modulating signal, assume k_f=15 k Hz per volt. **(3 points)** A & f_m

$$A\cos(\omega_m t) = A\cos(2\pi f_m t)$$

$$\beta_{=100} = \frac{75 \times 10^3}{f_m} \Rightarrow \boxed{f_m = 750\ Hz}$$

$$\beta = \frac{\Delta f}{f_m}$$

$$A\cos\left(\omega_c t + \frac{K_f A}{\omega_m}\sin\omega_m t\right)$$

$$\Delta f = (15\,kHz)(A) = 75k$$

$$\Rightarrow A = \frac{75k}{15k} = 5\ V$$

Note: the unit of K_f it is given in Hz/volt. K_f can also be represented in rad/volt

Good Luck, **Dr. Ali Muqaibel**