EECS 562
Homework #4

1. Drill Problem 4.1 (pp 156)
2. Let the RF signal

$$s(t) = A_c \cos(\theta_i(t))$$

where

$$\theta_i(t) = 2\pi f_c t + k_p m(t) \quad m(t) = A_m \sin(2\pi f_m t)$$

Here the phase sensitivity factor=k_p=0.2radians/V and A_m=1.0V and f_c=100MHz and f_m=2kHz and A_c=20V

a. Find the frequency deviation.
b. Plot the amplitude spectrum of *s(t).* State any approximations.
c. Is the phase or frequency modulation?

3. Let the RF signal

$$s(t) = A_c \cos(\theta_i(t))$$

where

$$\theta_i(t) = 2\pi f_c t + \beta \sin(2\pi f_m t) \quad m(t) = A_m \cos(2\pi f_m t)$$

Here β =0.2 and A_m=2.0V and f_c=100MHz and f_m=2kHz and A_c=10V
a. Is the phase or frequency modulation?
b. What is the modulation index?
c. Find the frequency deviation.
d. Find the frequency sensitivity factor in Hz/V.
e. Plot the amplitude spectrum of *s(t).* State any approximations.
f. What is the total power in s(t)?
g. How much power is at f_c=100MHz?
h. What is the RF bandwidth?

4. Let the RF signal

$$s(t) = A_c \cos(\theta_i(t))$$

where

$$\theta_i(t) = 2\pi f_c t + \beta \sin(2\pi f_m t) \quad m(t) = A_m \cos(2\pi f_m t)$$

Here β =6 and A_m=2.0V and f_c=100MHz and f_m=4kHz and A_c=10V
a. What is the modulation index?
b. Find the frequency deviation.
c. Find the frequency sensitivity factor in Hz/V.
d. Plot the power spectrum of *s(t).* State any approximations.
e. Is the phase or frequency modulation?
f. What is the RF bandwidth?
g. What is the total power in s(t)?
h. How much power is at 100.008MHz?

Hint: use
http://demonstrations.wolfram.com/PowerContentOfFrequencyModulationAndPhaseModulation/
To confirm some of the above answers.

5. For each case below use using Carson's rule to find the bandwidth of the frequency modulated signal. Validate your results using http://demonstrations.wolfram.com/PowerContentOfFrequencyModulationAndPhaseModulation/

a. A_c=1V, f_m=1 Hz, f_c=8 Hz, message amplitude =A_m=1.5V, deviation constant = 2 Hz/volt
b. A_c=1V, f_m=0.4 Hz, f_c=8 Hz, message amplitude =A_m=1.0V, deviation constant= 2Hz/volt
c. A_c=1V, f_m=1 Hz, f_c=8 Hz, message amplitude =A_m=1.0V, deviation constant = 2 Hz/volt
d. A_c=1V, f_m=1 Hz, f_c=8 Hz, message amplitude =A_m=0.5, deviation constant = 2 Hz/volt

6. A tone signal is input to an frequency modulator with a carrier of (f_{c1}) to produce a signal $y_1(t)$. The signal $y_1(t)$ in input to an 3rd order nonlinearity with in input voltage/output voltage relationship of $v_{out} = a_3 v_{in}^3$ to produce a signal $y_2(t) = a_3(y_1(t))^3$
Show that with a proper BPF, you can process $y_2(t)$ to get an FM signal with carrier frequency and modulation index 3 times as large as the corresponding input values. YOU MUST specify the center frequency and bandwidth of the BPF in terms of the original (input) carrier frequency (f_{c1}) and modulation index (β_1). You may assume the BPF is ideal.

7. Let the message signal *m(t)* given below be the input to an FM modulator with k_f=10Hz/V and f_c=1000 Hz and A_c=1. Plot the RF signal, $y_{FM}(t)$.

$m(t) = 0$ for $t < 0$

$m(t) = 5$ for $0 < t < 10\text{ms}$

$m(t) = 15$ for $10\text{ms} < t < 30\text{ms}$

$m(t) = 5$ for $30\text{ms} < t < 40\text{ms}$

$m(t) = 0$ for $t > 40\text{ms}$