EECS 562

Homework 9

1. Determine the instantaneous phase and frequency for the following signals.

a. $\cos(2\pi 1000000t+1000t^2)$

b. $\cos(2\pi 1000000t+1000\sqrt{t})$

2. Given a set of information bits b_i = {1, 0 ,0, 1}. Let x(t) = 0 for 1 ms for a bit = 0 and x(t) = 1 for 1ms for a bit = 1.

A modulated RF signal is y_{RF} (t) = $10\cos(2\pi($ x(t)*10000 + $f_c)t)$ where f_c=10kHz. Plot y(t) for 0<t<4ms.

3. A transmitted RF signal is given by $y_{RF}(t) = 10\cos(2\pi f_c t + \beta\sin(2\pi f_m t))$, where f_c=100MHz, β=4, and f_m= 10kHz. The message signal is $x(t)= \cos(2\pi f_m t)$.

a. Is the RF modulation:

i. PM

ii. FM

iii. VSB

iv. SSB

v. DSB-LC

b. What is the instantaneous frequency?

c. What is the total power in dB_W?

d. What is the frequency deviation, Δf?

e. What is the RF bandwidth of $y_{RF}(t)$?

f. How much power is at 100 MHz?

g. How much power is at 100.03 MHz?

4. Let the RF signal be

$y_{RF}(t) = A_c\cos(\theta_i(t))$ where

$\theta_i(t) = 2\pi f_c t + \beta\sin(2\pi f_m t)$ with $x_{bb}(t) = A_m\cos(2\pi f_m t)$

Here A_m=1.0V and f_c=109MHz, f_m=1kHz, A_c=10V, β=0.3

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 $y_{RF}(t)$.

State any approximations.

f. What is the total power in $y_{RF}(t)$ in dB_W?

g. What is the RF bandwidth?

5. Let the RF signal be

$y_{RF}(t) = A_c\cos(\theta_i(t))$ where

$\theta_i(t) = 2\pi f_c t + \beta\sin(2\pi f_m t)$ with $x_{bb}(t) = A_m\cos(2\pi f_m t)$

Here A_m=1.0V and f_c=109MHz, f_m=1kHz, A_c=10V, β=3.

a. Find the frequency deviation, Δf.

b. Find the frequency sensitivity factor in Hz/V.

c. Plot the amplitude spectrum of $y_{RF}(t)$.

d. What is the RF bandwidth?

6. For each case below use using Carson's rule to find the bandwidth of the frequency modulated signal. The deviation constant = 0.75 Hz/volt.

a. A_c=1.5V, f_m=2 Hz, f_c=8 Hz, message amplitude = A_m=0.5V,

b. A_c =1.5V, f_m =2 Hz, f_c=8 Hz, message amplitude = A_m =1.5V

c. A_c =1.5V, f_m =0.5 Hz, f_c=8 Hz, message amplitude = A_m =1.5V

d. Define a bandwidth expansion factor as $B_{\text{RF}} / B_{\text{bb}}$. Calculate the bandwidth expansion factor the systems defined in parts a)-c).

7. Let the message signal m(t) given below be the input to an FM modulator with k_f=20Hz/V and f_c=200 Hz and A_c=1.0. v = {2.5, 5, 7.5}, the symbol time=20ms.

$m(t)=\sum_{i=1}^{3} v_i \, \text{rect}\left(\frac{t-(i-1)T_s-0.5\,T_s}{T_s}\right)$

a. Plot m(t).

b. Plot the RF signal, y_{RF}(t).

c. Suggest a detector architecture detect each symbol

Measure power around each frequency for a symbol time and pick the largest.

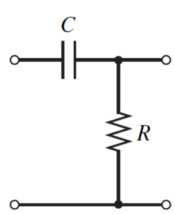
8. In a stream of bits each pair of bits (2 bits) is mapped into one voltage level to form the baseband signal, e.g. m(t) = v_i for 20 ms, where v_i=0, 2.5, 7.5, 10. The message signal is input to an FM modulator with k_f=20Hz/V and f_c=2000 Hz and A_c=1.

a. What is the bit rate for this signal?

b. During a symbol time of 20ms are the 4 possible transmitted RF signals, are these orthogonal to each other?

9. A DC blocking capacitor is not needed when a balanced discriminator is used to demodulate FM signals, why?

10. A HPF shown below has a transfer function of H(f) = $\frac{j2\pi fRC}{1+j2\pi fRC}$, the 3dB cutoff frequency = $\frac{1}{2\pi RC}$.



a. Plot |H(f)| and find and mark the 3dB cutoff = $f_{3\,\text{dB}}$.

b. The input to H(f) is $x_{\text{RF}}(t)$ =cos(2 πf_ct +βsin(2 πf_mt)). The output $y(t) \approx H(f_i(t))$. For R=800Ω, $C = 10^{-9}$ f, β=1, f_m=1000Hz, and f_c=100kHz. Find |y(t)|; note here $f_c \ll f_{3\,\text{dB}}$ H(f) is approximately linear.