EE 320 Communications Principles

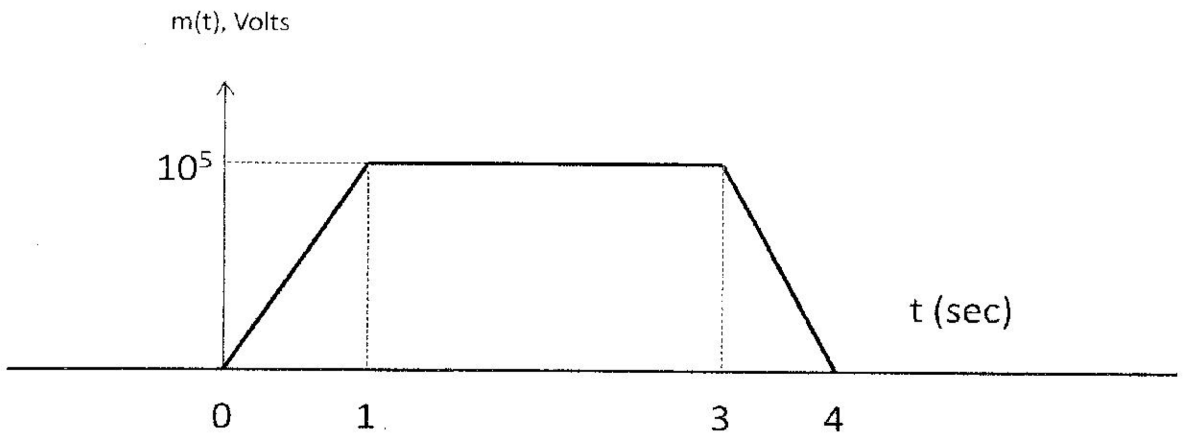
Midterm# # 2 (1st Semester 1433/34) *Name:*________________________

Monday, December 10, 2012 *Student-ID:*________________________

Total Marks=60 Total Time = 90 Minutes

Question#1(15 *marks*):

Consider a message signal m(t) sketched below:



(a) [5] Suppose the message signal is frequency modulated (FM) using a carrier signal of frequency 1 MHz and k_f = 5 Hz/Volt. What is the maximum instantaneous frequency of this FM signal?

(b) [6] Suppose the message signal is phase modulated (PM) using a carrier signal of frequency 1 MHz and k_p= 4π radian/Volt. What is the maximum instantaneous frequency of this PM signal? What is the minimum instantaneous frequency of this PM signal? What is the frequency deviation in this case?

(c) [4] Using the Carson' rule determine the BW for PM signal from part (b). Assume the bandwidth of the message signal W=1 KHz.

Question#2(10 *marks*):

(a) [4] Suppose you have a FM modulator. Using a block diagram explain how a PM signal can be generated using this FM modulator.

(b) [4] Suppose you have a PM modulator. Using a block diagram explain how a FM signal can be generated using this PM modulator.

(c) [2] Give two main applications of a Phase Lock Loop (PLL) circuit in communication systems.

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Question#3(20 *marks*):

Consider a message signal given by $m(t)=\cos(200\pi t)+2\cos(400\pi t)$ and a carrier signal given by $c(t)=\cos(2000\pi t)$.

(a) [4] Write down time-domain equation of USSB (upper single side-band).

(b) [4] Write down time-domain equation of LSSB (lower single side-band).

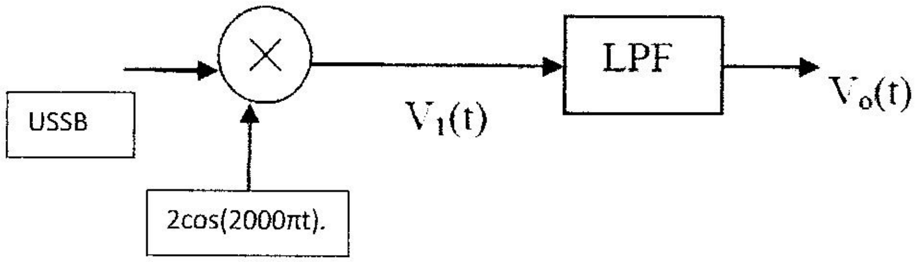
(c) [2] Sketch the frequency spectrum of USSB from part (a), label both the axis clearly.

(d) [2] Sketch the frequency spectrum of LSSB from part(b) , label both the axis clearly.

(e) To demodulate the upper sideband SSB signal (from part(a)), we multiply it by $2\cos(2000\pi t)$ and then apply an ideal low pass filter (LPF) as shown below.

  a. [4] Write down $V_1(t)$ and then sketch $V_1(f)$, label both the axis clearly.

  b. [4] What should be the gain and cut-off frequency of ideal LPF so that $V_o(t)$ is equal to original message signal



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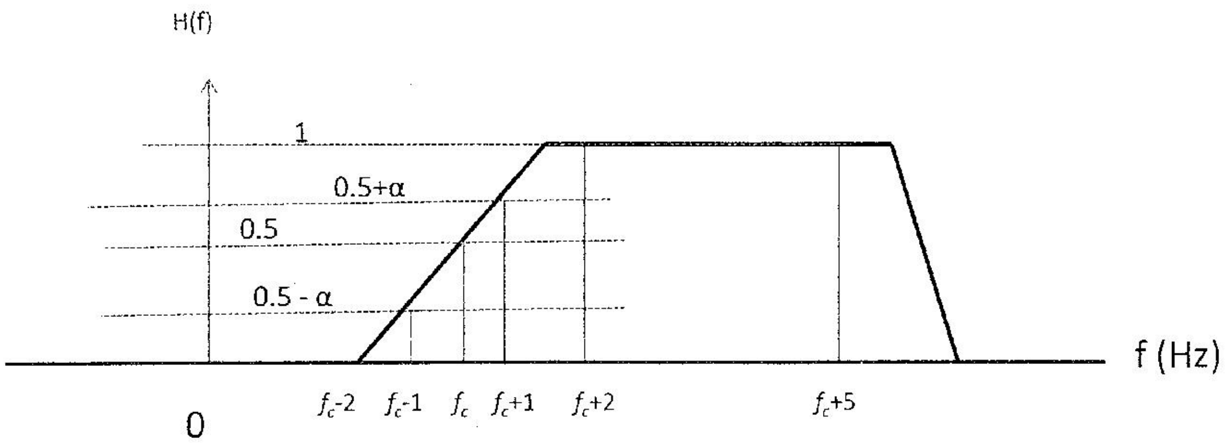
Question#4 (15 *marks*):

Consider a carrier given by $c(t)=2\cos(2\pi f_c t)$ and a message signal given by $m(t)= 8+4\cos(2\pi t) + 8\sin(10\pi t)$. The VSB shaping filter, H(f) used to form VSB signal is sketched below (exactly symmetric in the negative frequency range), assume $\alpha=0.2$.

a. [8] Write down the time-domain equation for VSB signal.

b. [7] Sketch the frequency spectrum of VSB signal. label both the axis clearly.



Q #1

(a) FM $f_i(t) = f_c + k_f\, m(t)$

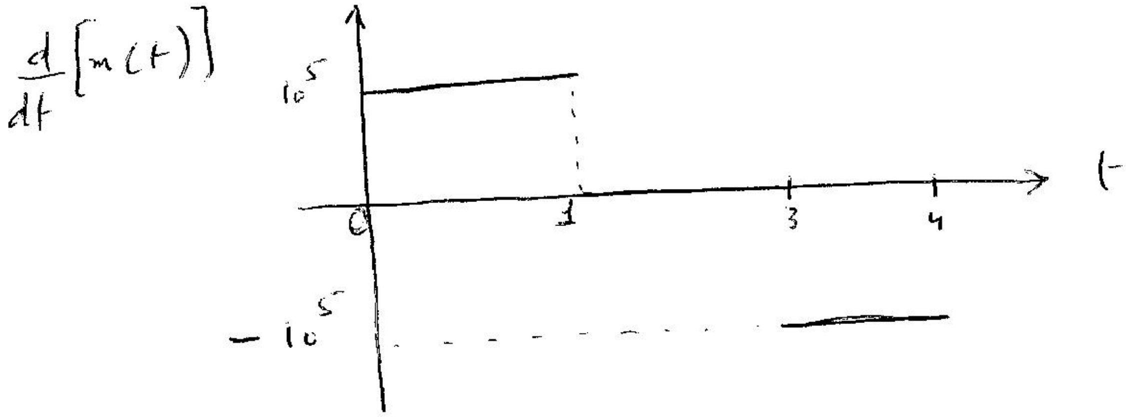
$k_f = 5$ Hz/volt $\quad f_c = 10^6$

$\max|m(t)| = 10^5$

$f_i(t)\big|_{max} = 10^6 + 5\times 10^5 = 1.5$ MHz

(b) $f_c = 1$ MHz $\quad k_p = 4\pi$ rad/volt

PM: $f_i(t) = f_c + \frac{k_p}{2\pi}\frac{d}{dt}m(t)$



$f_i(t)\big|_{max} = 10^6 + 2\times 10^5 = 1.2$ MHz

$f_i(t)\big|_{min} = 10^6 - 2\times 10^5 = 0.8$ MHz

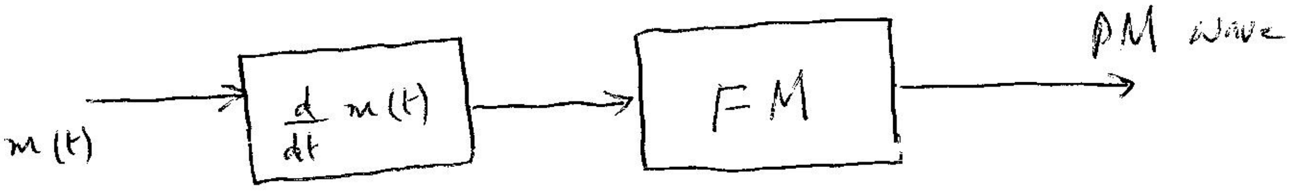
$\Delta f = 2\times 10^5 = 0.2$ MHz

(c) $BW = 2(\Delta f + W) = 0.402$ MHz

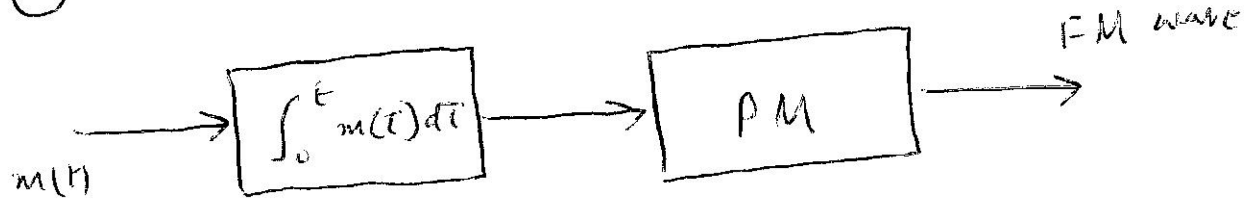
$= 402$ KHz

Q # 2

(a)



(b)



(c) PLL application

1. FM Demodulation
2. Carrier Synchronization.

Q #3

$$m(t) = \cos(200\pi t) + 2\cos(400\pi t)$$

$$c(t) = \cos(2000\pi t)$$

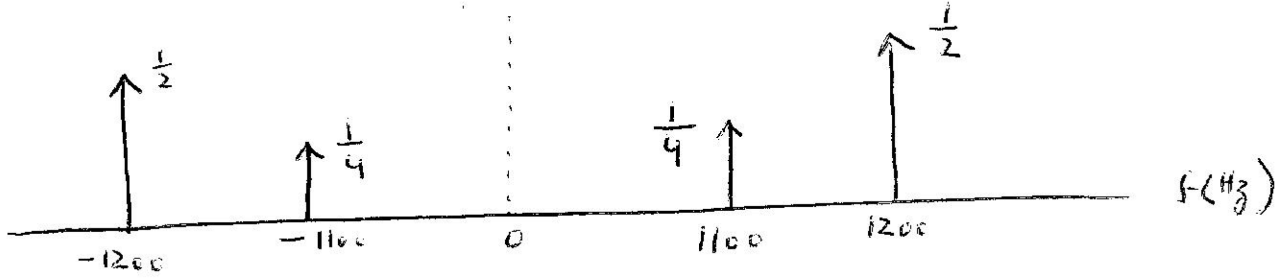
$$m(t)\,c(t) = \cos(2000\pi t)\cos(200\pi t) + 2\cos(2000\pi t)\cos(400\pi t)$$

$$= \frac{1}{2}\cos(2200\pi t) + \frac{1}{2}\cos(1800\pi t) + \cos(2400\pi t) + \cos(1600\pi t)$$

(a) USSB : $\frac{1}{2}\cos(2200\pi t) + \cos(2400\pi t)$

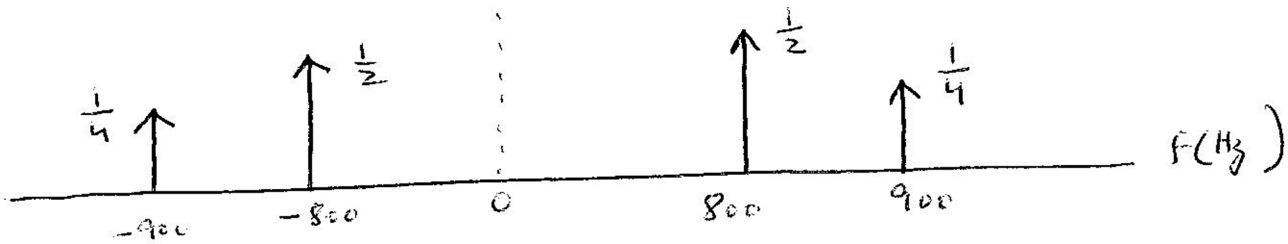
(b) LSSB : $\frac{1}{2}\cos(1800\pi t) + \cos(1600\pi t)$

(c)



USSB(f)

(d)

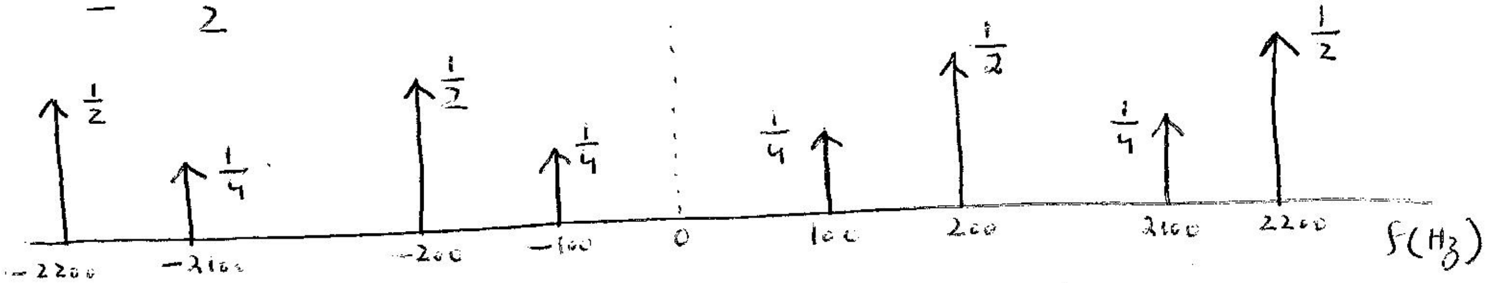


LSSB(f)

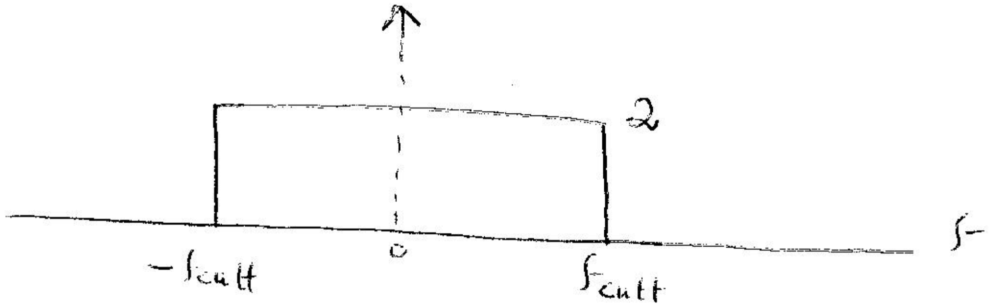
(e) (a) $v_1(t) = 2\cos(2000\pi t)\left[\frac{1}{2}\cos(2200\pi t) + \cos(2400\pi t)\right]$

$$= \cos(2000\pi t)\cos(2200\pi t) + 2\cos(2000\pi t)\cos(2400\pi t)$$

$$= \frac{1}{2}\cos(4200\pi t) + \frac{1}{2}\cos(200\pi t) + \cos(4400\pi t) + \cos(400\pi t)$$



(e) (b)



$$\boxed{200 < f_{cutt} < 2100}$$

Q # 4

$$c(t) = 2\cos(2\pi f_c t)$$

$$m(t) = 8 + 4\cos(2\pi t) + 8\sin(10\pi t)$$

$$m(t)\,c(t) = 16\cos(2\pi f_c t) + 8\cos(2\pi f_c t)\cos(2\pi t) + 16\cos(2\pi f_c t)\sin(10\pi t)$$

$$= 16\cos(2\pi f_c t) + 4\cos(2\pi(f_c+1)t) + 4\cos(2\pi(f_c-1)t)$$

$$+ 8\sin(2\pi(f_c+5)t) + \underline{8\sin(2\pi(5-f_c)t)}$$

Since $f_c >> 5$ $\quad - 8\sin(2\pi(f_c-5)t)$

$$= 16\cos(2\pi f_c t) + 4\cos(2\pi(f_c+1)t) + 4\cos(2\pi(f_c-1)t)$$

$$+ 8\sin(2\pi(f_c+5)t) - 8\sin(2\pi(f_c-5)t)$$

(a) at f_c $\quad H(f) = 0.5$ $\quad\quad \alpha = 0.2$

at $f_c + 1$ $\quad H(f) = 0.7$

at $f_c - 1$ $\quad H(f) = 0.3$

at $f_c + 5$ $\quad H(f) = 1$

at $f_c - 5$ $\quad H(f) = 0$

(a) Continue :

$$v_{SB}(t) = 8\cos(2\pi f_c t) + 2.8\cos(2\pi(f_c+1)t) + 1.2\cos(2\pi(f_c-1)t) + 8\sin(2\pi(f_c+5)t)$$

(b)