EE 320 Communications Principles

Midterm# # 2 (2nd Semester 1432/33) *Name:*____

Saturday, April 28, 2012 *Student-ID:*____________________________________

Total Marks=60 Total Time = 90 Minutes

Question#1(15 *marks*)**:**

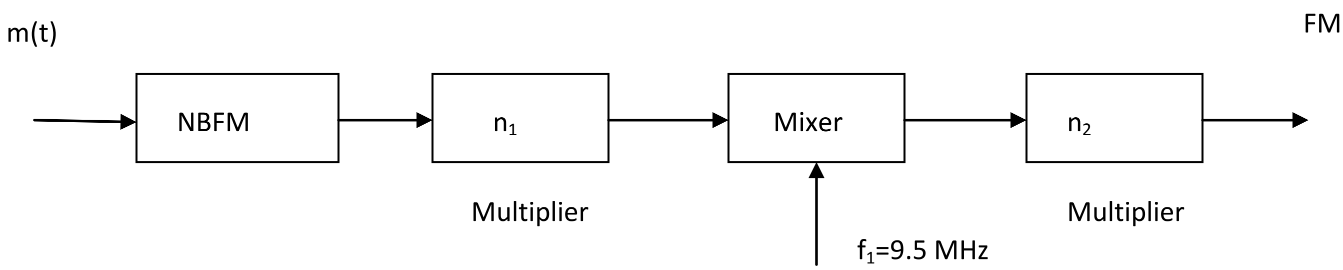
An angle-modulated signal has the following form: $s(t)=100\cos(2\pi f_c t+4\sin 2000\pi t)$

(a) [2] Determine the transmitted power.
(b) [4] Determine the Frequency deviation Δf, and modulation index β.
(c) [4] Determine the signal BW using Carson's Rule.
(d) [5] Assume s(t) is a FM signal . Then determine the message signal m(t) (assume message signal amplitude =1).

Question#2(10 *marks*)**:**

Consider the block diagram for Indirect FM generation shown below. The output of NBFM is at the carrier frequency of 0.1 MHz and frequency deviation of 20 Hz. The mixer oscillator frequency f_1 is 9.5 MHz. The final FM signal carrier frequency is 100 MHz with a frequency deviation of 75 KHz.

(a) [5] What is the product of the two integer frequency multiplication ratios: n_1 and n_2
(b) [5] Find the values of n_1 and n_2



Question#3(15 *marks*)**:**

(a) Consider a message signal $m(t)=A_m\sin(2\pi f_m t)$ and the carrier signal $c(t)=A_c\sin(2\pi f_c t)$. Suppose we want to transmit this message signal using VSB modulation. The VSB shaping filter has the frequency response as given by: $H(f_c-f_m) = 1-a$ and $H(f_c+f_m)= a$ where $0 \le a \le 1$ is a constant.
   a. [5] Write down the time-domain equation for final VSB signal.
   b. [5] Write down the frequency-domain equation for final VSB signal.

(b) [5] Draw the block diagram of Phase-Lock Loop (PLL) circuit that can be used in FM demodulation.

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Question#4 (20 *marks*)**:**

This question deals with **SSB signal**. Consider the message signal m(t) whose Fourier transform M(f) is sketched below.

(a) [2] **Determine** and **sketch** the signal Y(f), where $y(t)=m(t)\cos(2\pi f_c t)$

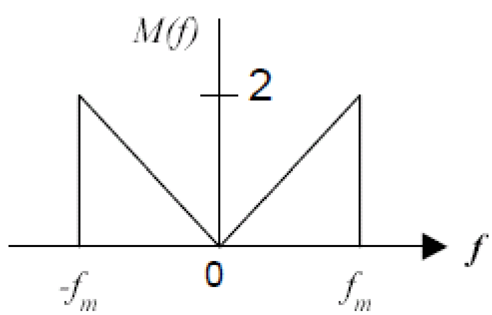
(b) [4] **Determine** and **sketch** the signal Z(f), where $z(t)=\hat{m}(t)\sin(2\pi f_c t)$, where $\hat{m}(t)$ is the Hilbert transform of the message signal m(t). Make sure to convert the $\hat{M}(f)$ to M(f).

(c) [8] Suppose s(t)=y(t)+z(t). Write down the equation for S(f). Make sure to convert the $\hat{M}(f)$ to M(f). Then write down the simplified equations of S(f) for following four frequency ranges:

$$S(f) = \begin{cases} f \geq f_c \\ 0 \leq f \leq f_c \\ f \leq -f_c \\ -f_c \leq f \leq 0 \end{cases}$$

(d) [3] Using (c) , **Sketch** the signal S(f)

(e) [3] Using (a) and (b) , **Sketch** the signal R(f), where r(t)=y(t)-z(t).



Q#1 $s(t) = 100 \cos(2\pi f_c t + 4 \sin 2000\pi t)$

(a) $P_T = \frac{1}{2} A_c^2 = \frac{1}{2} \times (100)^2 = 5000$ Watt

(b) $\Delta f = \max \left| \frac{1}{2\pi} \times \frac{d}{dt} (4 \sin 2000\pi t) \right|$

$= \max \left| \frac{1}{2\pi} \times 4 \times 2000 \times \pi \times \cos 2000\pi t \right|$

$\Delta f = 4000$ Hz

$\beta = \frac{\Delta f}{f_m} = \frac{4000}{1000} = 4$ $f_m = 1000$ Hz

(c) $BW = 2(\Delta f + f_m) = 2(4000 + 1000)$

$BW = 10{,}000$ Hz

(d) $A_m = 1$ $\Delta f = k_f \times A_m = 4000$

if FM $\boxed{k_f = 4000}$

then $2\pi k_f \int_0^t m(\tau)\, d\tau = 4 \sin 2000\pi t$

~~So~~ solve for $m(t)$ by taking $\frac{d}{dt}$ of both sides

$m(t) = \frac{1}{2\pi \times k_f} \times 4 \times \cos(2000\pi t) \times 2000\pi$ $k_f = 4000$

$m(t) = \frac{4000}{k_f} \cos(2000\pi t)$

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

With this $m(t)$ and $k_f = 4000$ we get given $s(t)$

~~not possible with AM~~

Q #2

NBFM output $f_{c_1} = 0.1\ MHz$

$\Delta f_1 = 20\ Hz$

(a) Find $\Delta f = 75\ KHz$

$$\Delta f_1 \times n_1 \times n_2 = 75 \times 10^3$$

$$\boxed{n_1 \times n_2 = 3750.} \longrightarrow \text{eq \#1}$$

(b) Find $f_c = 100\ MHz$

use $$(n_1 f_{c_1} - f_1) \times n_2 = 100 \times 10^6$$

$$n_2 n_1 f_{c_1} - f_1 n_2 = 100 \times 10^6$$

use $n_1 n_2 = 3750.$

$$3750 \times 0.1 \times 10^6 - 9.5 \times 10^6 n_2 = 100 \times 10^6$$

$$375 - 9.5 \times n_2 = 100$$

$$n_2 = 28.9474$$

$$\boxed{n_1 = 129.5453}$$

Q #3 : (a)

$$m(t) = A_m \sin(2\pi f_m t) \qquad c(t) = A_c \sin(2\pi f_c t)$$

DSB _ SC $\quad m(t)\times c(t) = A_m A_c \sin(2\pi f_c t)\sin(2\pi f_m t)$

$$= \frac{A_m A_c}{2}\left[\cos(2\pi(f_c - f_m)t) - \cos(2\pi(f_c + f_m)t)\right]$$

after going through VSB shaping Filter.

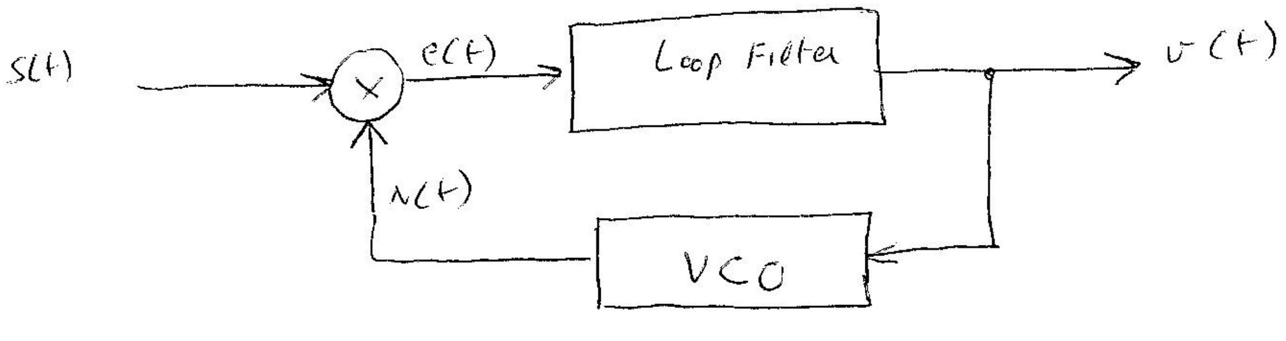
assume $\boxed{A_m A_c = 1}$

(a) $s(t) = \left[\frac{1-a}{2}\right]\cos\left(2\pi(f_c - f_m)t\right) - \left[\frac{a}{2}\right]\cos\left(2\pi(f_c + f_m)t\right)$

(b) $S(f) = \left[\frac{1-a}{4}\right]\left[\delta(f - (f_c - f_m)) + \delta(f + (f_c - f_m))\right]$

$$- \left[\frac{a}{4}\right]\left[\delta(f - (f_c + f_m)) + \delta(f + (f_c + f_m))\right]$$

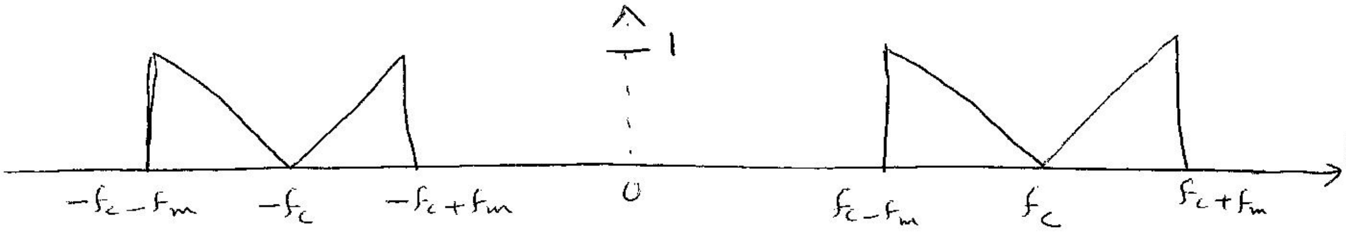
(I) PLL



Q #4

(a) $y(t) = m(t)\cos(2\pi f_c t)$

$$Y(f) = \frac{1}{2}\left[M(f-f_c) + M(f+f_c)\right]$$

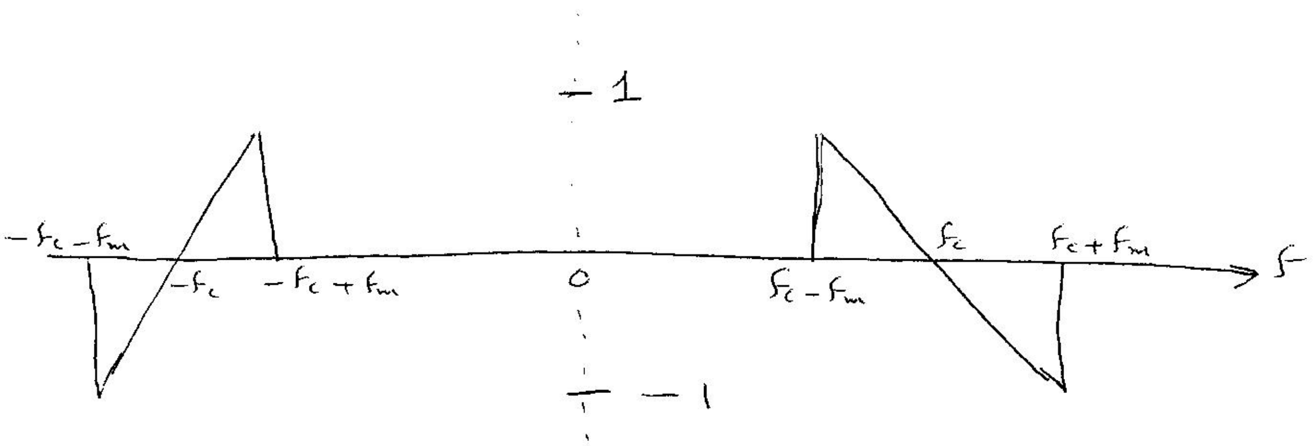


(b) $z(t) = \hat{m}(t)\sin(2\pi f_c t)$

$$Z(f) = \frac{1}{2j}\left[\hat{M}(f-f_c) - \hat{M}(f+f_c)\right]$$

$$Z(f) = \frac{1}{2j}\left[-j\,\mathrm{sgn}(f-f_c)M(f-f_c) + j\,\mathrm{sgn}(f+f_c)M(f+f_c)\right]$$

$$Z(f) = \frac{1}{2}\left[\mathrm{sgn}(f+f_c)M(f+f_c) - \mathrm{sgn}(f-f_c)M(f-f_c)\right]$$



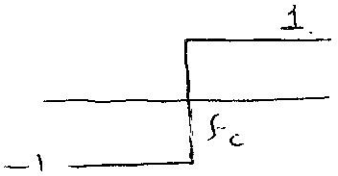
(c) $S(f) = Y(f) + Z(f)$

$$= \frac{1}{2}\left[M(f-f_c) + M(f+f_c)\right] + \frac{1}{2}\left[\operatorname{sgn}(f+f_c)M(f+f_c) - \operatorname{sgn}(f-f_c)M(f-f_c)\right]$$

for $\underline{f > 0}$

$$= \frac{1}{2}\left[M(f-f_c)\right] + \frac{1}{2}\left[-\operatorname{sgn}(f-f_c)M(f-f_c)\right]$$

$\operatorname{sgn}(f-f_c)$



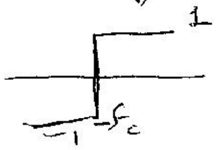
for $f > f_c$ $\quad = \frac{1}{2}\left[M(f-f_c) - M(f-f_c)\right] = 0$

$0 \le f \le f_c$ $\quad = \frac{1}{2}\left[M(f-f_c) + M(f-f_c)\right]$

$$= M(f-f_c)$$

for $f < 0$

$$S(f) = \frac{1}{2}\left[M(f+f_c)\right] + \frac{1}{2}\left[\operatorname{sgn}(f+f_c)M(f+f_c)\right]$$



$f \le -f_c$

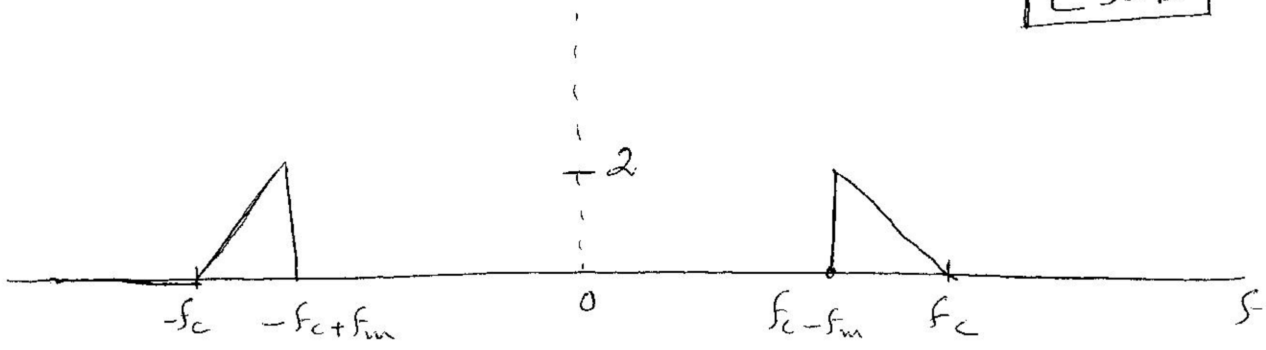
$$= \frac{1}{2}\left[M(f+f_c) - M(f+f_c)\right] = 0$$

$-f_c \le f \le 0$ $\quad = \frac{1}{2}\left[M(f+f_c) + M(f+f_c)\right]$

$$= M(f+f_c)$$

d Sketch: $S(f)$

$\boxed{LSSB}$



e $R(f) = Y(f) - Z(f)$