

Name: _____
Student ID: _____

ECE 457 EXAM 1
February 28, 2005

- No textbooks, notes or HW solutions.
- One page of hand-written notes.
- Calculators are allowed.
- Exam is 50 minutes.
- To maximize your score on this exam, read the questions carefully and write legibly. For those problems that allow partial credit, show your work clearly.
- Good luck.

1. [25] Answer the following questions briefly.

i) For a video signal with bandwidth 4MHz and a transmission channel with bandwidth 6MHz, which one of the following statements is true?

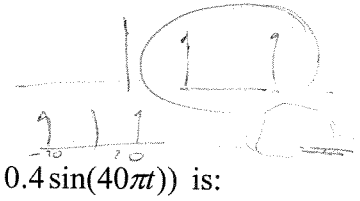
- a) The video signal is modulated using SSB and the bandwidth is 4MHz.
- b) The video signal is modulated using VSB and the bandwidth is 5.25MHz.
- c) The video signal is modulated using DSB and the bandwidth is 8MHz.
- d) The video signal is modulated using VSB and the bandwidth is 4MHz.

ii) Assume that the efficiency of an AM modulation system is E. If we double the amplitude of the message, the efficiency will be:

4E

E

E/2



iii) The bandwidth of PM modulated signal, $x_c(t) = A_c \cos(2000\pi t + 0.4 \sin(40\pi t))$ is:

40Hz

80Hz

2000Hz

iv) For which one of the following modulated signals, the original message, up to a scaling factor, can be recovered using envelope detection?

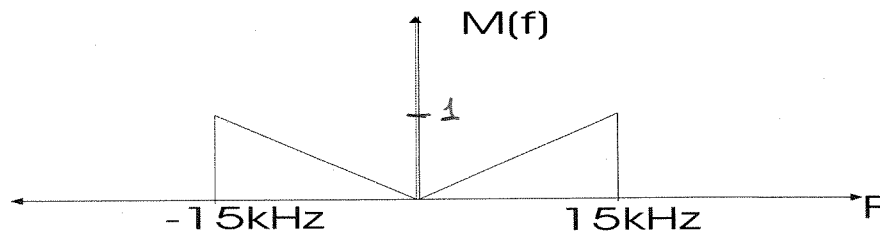
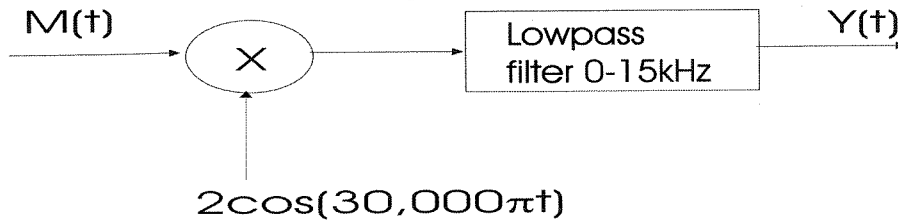
- a) $20 \cos(200\pi t) + 30m(t) \cos(200\pi t)$
- b) $20 \cos(200\pi t) + 16m(t) \cos(200\pi t)$
- c) $10m(t) \cos(400\pi t)$
- d) None of the above.

v) What will the following MATLAB code display?

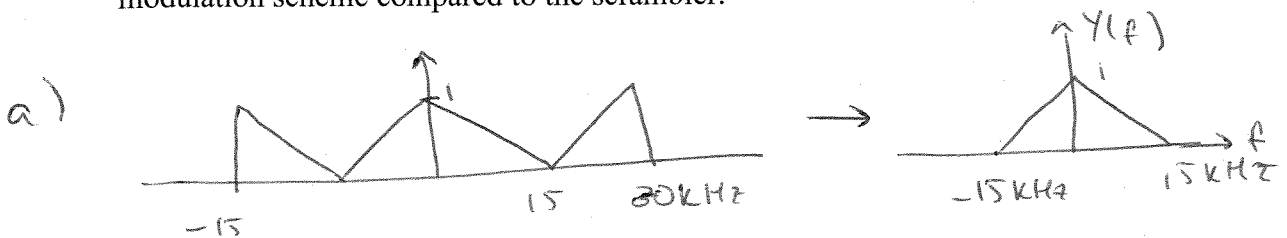
```
t0=0.15;
ts=0.001;
%carrier frequency;
fc=250;
fs=1/ts; % sampling frequency;
t=[0:ts:t0];
m=[ones(1,t0/(3*ts)), -2*ones(1,t0/(3*ts)), zeros(1,t0/(3*ts)+1)];
c=cos(2*pi*fc.*t);
u=m.*c;
M=fftshift(fft(m));
U=fftshift(fft(u));
C=fftshift(fft(c));
plot([-fs/2:fs/(length(M)-1):fs/2], abs(U));
```

- a) DSB modulated signal in the time domain
- b) The amplitude spectrum of the DSB modulated signal
- c) The amplitude spectrum of the original message
- d) The original message signal in the time domain

2. [35] The system shown below is used for scrambling audio signals. The output $y(t)$ is the scrambled version of the input $m(t)$.



- [8] Find the spectrum of the scrambled signal, $y(t)$. Label the frequency and the amplitude axes.
- [5] If the power of the message is 10W, what is the power of the scrambled signal, $y(t)$?
- [6] What type of modulation does this system correspond to? Explain the type of signals that this modulation scheme is suitable for and discuss whether the given signal falls into this category.
Hint: You need to describe the characteristics of the signals in the frequency domain.
- [8] Suggest a method of descrambling $y(t)$ to obtain $m(t)$. Draw the block diagram and specify all the parameters of each block. Show that you can actually recover back the original message.
- [8] Now assume that the lowpass filter is removed, what type of modulation does this correspond to? State one disadvantage and one advantage of this new modulation scheme compared to the scrambler.



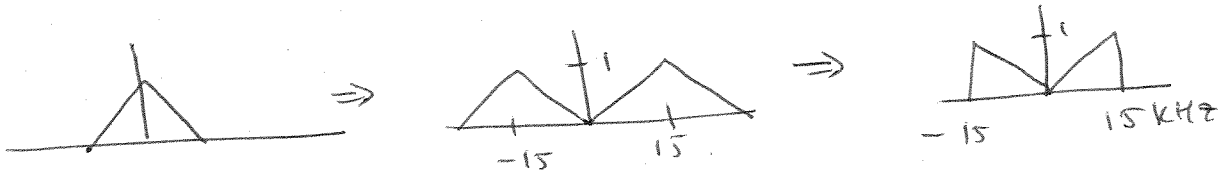
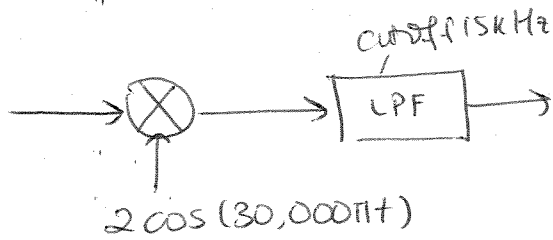
b) $P_T = 10W$

c) SSB - LSB

Signals with small low freq. content like audio signals.
This signal falls into that category.

Extra Sheet for Question 2:

d) Descrambling:



e) DSB

Advantage: Easier to implement, no need for sharp filter design

Disadvantage: Double BW.

3. [40] An angle modulated signal is described by the equation

$$x_c(t) = 10 \cos(2\pi f_c t + a_1 \sin(4000\pi t) + a_2 \sin(2000\pi t))$$

a) [5] Find the power of this angle modulated signal.

b) [5] Is this PM or FM modulation? Explain.

c) Let $a_1 = 10, a_2 = 5$:

i) [6] Find the peak frequency deviation.

Hint: The maximum of $A \cos(4000\pi t) + B \cos(2000\pi t)$ is $A + B$.

ii) [5] Find the deviation ratio, D .

iii) [5] What's the bandwidth of this angle modulated signal?

d) Now assume that $a_1 = 10, a_2 = 0$:

i) [4] Is this a narrowband or wideband signal?

ii) [10] Assume that $x_c(t)$ is passed through a bandpass filter centered at f_c with bandwidth of 10kHz. What percentage of the total power passes through the filter? Sketch the amplitude and phase spectra at the output of the bandpass filter. Clearly label the axes.

Note: Label the frequency axis in terms of f_c .

a) $P = \frac{(10)^2}{2} = 50 \text{ W}$

b) Can't tell. you need to have the message to decide

c) $\phi(t) = 10 \sin(4000\pi t) + 5 \sin(2000\pi t)$

i) $\frac{1}{2\pi} \frac{d\phi(t)}{dt} = \frac{10(4000\pi)}{2\pi} \cos(4000\pi t) + \frac{5(2000\pi)}{2\pi} \cos(2000\pi t)$

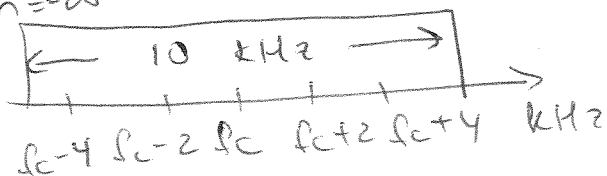
peak is = 25,000Hz / 25kHz

ii) $D = \frac{\text{max freq. dev.}}{\text{BW}} = \frac{25\text{kHz}}{2\text{kHz}} = 12.5$

iii) $\text{BW} = 2(D+1)W = 2(12.5+1)(2\text{kHz}) = 54\text{kHz}$

d) i) wideband $\beta = 10$

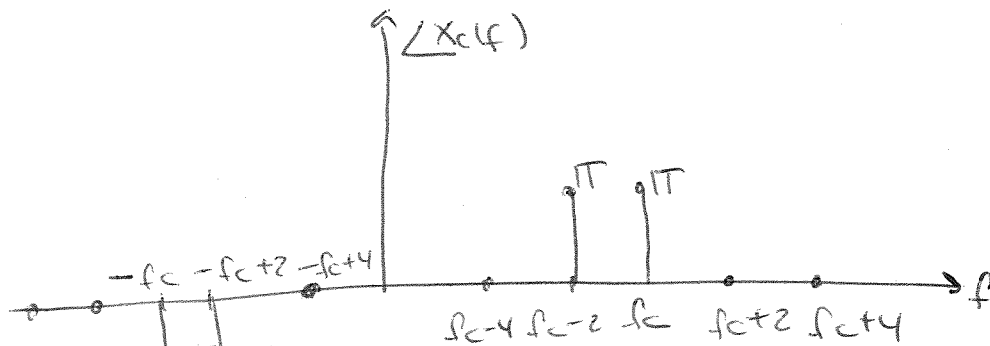
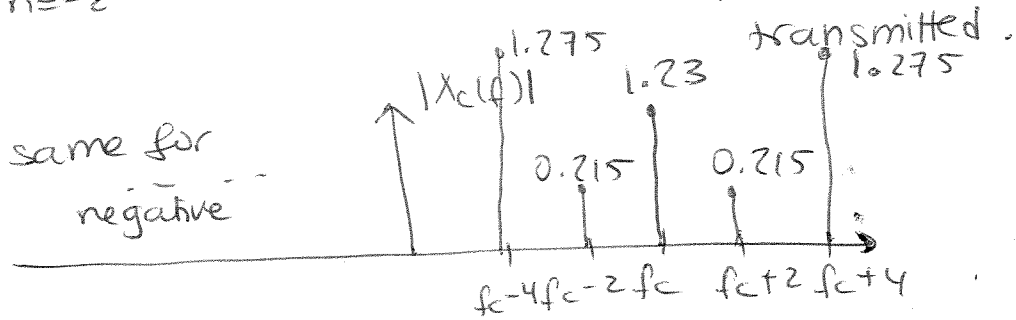
ii) $x_c(t) = 10 \sum_{n=-\infty}^{\infty} J_n(10) \cos(2\pi(f_c + n2000)t)$



you pass two harmonics.

Extra Sheet for Question 3:

$$P_r = \sum_{n=-2}^{\infty} J_n^2(\beta) = 0.194 \Rightarrow 19.4\% \text{ of total power is transmitted.}$$



$$J_0(\beta) = -0.246$$

$$J_1(10) = 0.043$$

$$J_2(10) = 0.255$$

$$\rightarrow J_{-1}(10) = 0.043$$

$$J_{-2}(10) = 0.255$$