Name: Solutions
Student ID: _____

ECE 457 EXAM 1
February 27, 2004

- 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. [30] Answer the following questions briefly.

   a) The effect of a small, constant phase error between the incoming carrier and the local oscillator in the coherent demodulation of SSB is

   Overmodulation (Shape Distortion) Amplitude Distortion

   b) Arrange VSB, SSB, DSB, AM and wideband FM in the decreasing order of bandwidth required for transmission.

   Wideband FM > AM = DSB > VSB > SSB

   c) What's the highest power efficiency that an AM system, transmitting a single tone message, can achieve such that the message can be demodulated using envelope detection?

   33.3%

   d) Which one of the following modulation schemes is easiest to demodulate?

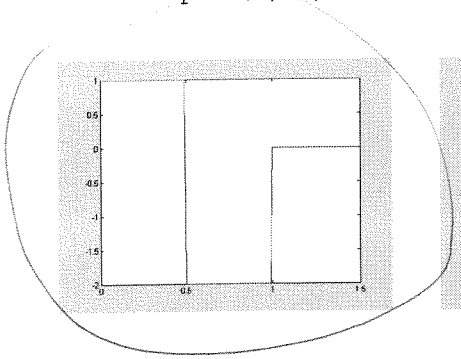
   DSB (AM) VSB

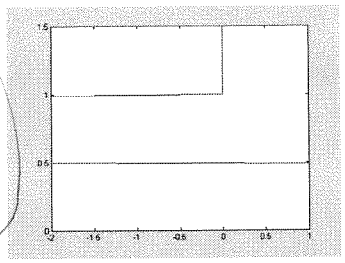
   e) A PM system with $k_p = \frac{\pi}{2}$ is used to transmit the message signal $m(t) = u(t)$. What is the modulated signal for $t > 0$?

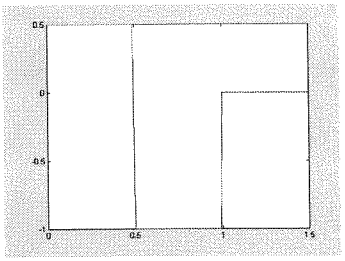
   $x_c(t) = A_c \cos(2\pi f_c t)$ $x_c(t) = A_c \sin(2\pi f_c t)$ $(x_c(t) = -A_c \sin(2\pi f_c t))$

f) Which one of the outputs would you get for the following MATLAB program:

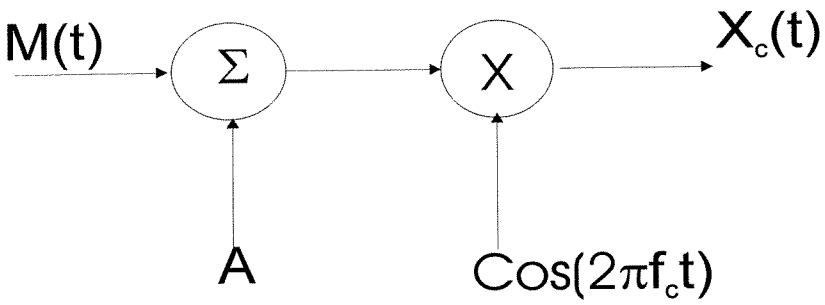
```
t=[0:0.01:1.5];
m=[ones(1,1.5/(0.03)),-2*ones(1,1.5/(0.03)),zeros(1,1.5/(0.03)+1)];
plot(t,m);
```







2. [35] Consider the following modulation system:



Assume that a tone message, $m(t) = 2\cos(20\pi t)$ is transmitted using this modulation system with $f_c = 500$ Hz.

a) [10] Assume that A=2.
   2 i. What type of modulation does this correspond to?
   2 ii. What is the power efficiency of this system?
   3 iii. Sketch the output signal.
   3 iv. Sketch the spectrum of the output signal.

b) [10] Assume that A=0.
   2 i. What type of modulation does this correspond to?
   2 ii. What is the power efficiency of this system?
   3 iii. Sketch the output signal.
   3 iv. Sketch the spectrum of the output signal.

c) [15] Assume that A=0.
   5 i. How would you modify the given modulation system such that the output signal is $x_c(t) = \cos(980\pi t)$?

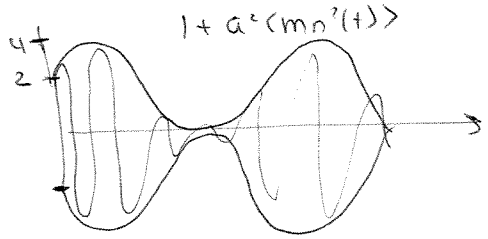
   Hint: You might need to add an additional component to the given system.

   4 ii. What type of modulation does this correspond to?
   6 iii. State one advantage and one disadvantage of this modulation system compared to the one in part a).

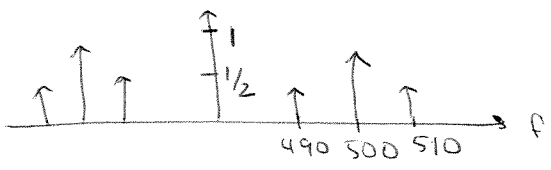
a) i. AM

ii. $\text{Eff} = \dfrac{a^2\langle m_n^2(t)\rangle}{1 + a^2\langle m_n^2(t)\rangle} = \dfrac{1/2}{3/2} = 1/3$ 33.3%

iii.



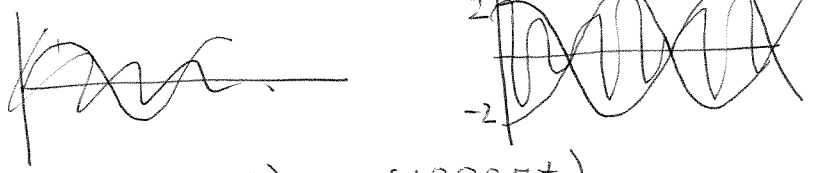
iv.



Extra Page for Question 2:

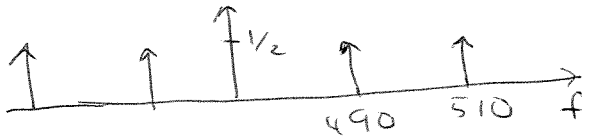
b) i) DSB

ii) 100 %

iii) 

iv) $2\cos(20\pi t)\cos(1000\pi t)$

$= \cos(980\pi t) + \cos(1020\pi t)$



c) -Add LPF with cutoff 500Hz

- SSB
- less bandwidth than AM.
  Harder to implement (harder to demodulate)

3. [35] A FM modulator is used to transmit a tone message with amplitude of 4 Volts and frequency of 20 Hz. The frequency deviation constant for the modulator is 25Hz/V, and the carrier wave has amplitude 10 Volts and frequency 2000 Hz.

a) [5] What's the power of the FM modulated signal?
b) [5] What's the approximate bandwidth of the FM modulated signal using Carson's rule?
c) [15] The output of the FM modulator is passed through a bandpass filter centered at 2000Hz. What should be the bandwidth of the filter such that 90% of the power in the modulated signal passes through?
d) [5] How would your answer to part b) change if the amplitude of the message is doubled?
e) [5] How would your answer to part b) change if the frequency of the carrier is doubled?

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

b) $\beta = \frac{A_m f_d}{f_m} = \frac{(4)(25)}{20} = 5$

$BW = 2(5+1)\,20 = 240Hz$

c) $\sum_{n=-k}^{k} J_n^2(5) \geq 90 \Rightarrow k = 5$

$BW = 2kf_m = (10)(20) = 200Hz$

d) If A_m is doubled, $\beta = 10$

$BW = 2(11)(20) = 440Hz$

e) wouldn't change.