EEGR4123 **FINAL EXAM** **FALL 1997**

Do NOT begin until told to do so
Make sure that you have all pages before starting
You may not leave the room during the exam
No calculators, open book, 2 page notes

ACADEMIC INTEGRITY:
Students have the responsibility to know and observe the requirements of The UNCC Code of Student Academic Integrity (1997-99 Catalog page 336). This code forbids cheating, fabrication or falsification of information, multiple submission of academic work, plagiarism, abuse of academic materials, and complicity in academic dishonesty.

Name: _____

Student Number: _____

Unless otherwise noted:

Show all work, even for multiple choice
Multiple choice answers should be within 5% of correct value
$\mathcal{F}\{\}$ denotes either continuous Fourier transform
$\mathcal{F}^{-1}\{\}$ denotes inverse Fourier transform
$m_h(t)$ denotes the Hilbert transform of $m(t)$
ω denotes the continuous-time frequency variable
$*$ denotes linear convolution
$x^*(t)$ denotes the conjugate of x(t)

Useful constants, etc:

$$\begin{array}{cccc} e \approx 2.72 & \pi \approx 3.14 & 1/e \approx 0.37 & \sqrt{2} \approx 1.41 \\ \sqrt{3} \approx 1.73 & \sqrt{5} \approx 2.22 & \sqrt{7} \approx 2.64 & \sqrt{10} \approx 3.16 \\ ln[2] \approx 0.69 & ln[4] \approx 1.38 & ln[55] \approx 4.0 & ln[256] \approx 5.6 \\ log_{10}[2] \approx 0.30 & log_{10}[3] \approx 0.48 & log_{10}[55] \approx 4.0 & log_{10}[10] \approx 1.0 \\ log_{10}[0.1] \approx -1.0 & log_{10}[0.5] \approx -0.3 & log_{10}[e] \approx 0.43 & cos(\pi/4) \approx 0.79 \end{array} \quad (1)$$

$cos(A)cos(B) = \frac{1}{2}cos(A-B) + \frac{1}{2}cos(A+B)$
$e^{j\theta} = cos(\theta) + jsin(\theta)$
$cos^2(A) = \frac{1}{2} + \frac{1}{2}cos(2A)$

5 Points Each (Circle the best answer)

1. The bandwidth of $y(t) = cos(2\pi t)cos(10000\pi t)$ is

   (a) 1 Hz (b) 2 Hz (c) $4\pi Hz$ (d) None above

2. The signal $y(t) = [3 + cos(2\pi t)]cos(10000\pi t)$ is best described as

   (a) AM (b) FM (c) Bessel (d) None above

3. The Hilbert transform produces a phase shift of π at all frequencies.

   (a) True (b) False

4. Zero crossings of Nyquist second criterion pulses must be at $t = n\ T_0$ where $n = \ldots -2, -1, 0, 1, 2 \ldots$

   (a) True (b) False

5. The information transmitted by an 8-ary symbol is

   (a) 1 bit (b) 3 bits (c) 8 bits (d) None above

5 Points Each (Circle the best answer)

6. The signal $m(t)cos(\omega_c t) + m_h(t)sin(\omega_c t)$ is best described as

   (a) VSB (b) SSB-LC modulation (c) LSB (d) None above

7. In general, bandlimited pulses are not realizable.

   (a) True (b) False

8. The modulation index μ of $y(t) = [2 + cos(30\pi t)]cos(10000\pi t)$ is

   (a) 1/3 (b) 1/2 (c) 3 (d) None above

9. The power efficiency η of $y(t) = [2 + cos(30\pi t)]cos(10000\pi t)$ is

   (a) 11 % (b) 33 % (c) 66 % (d) None above

10. If a 2-bit ADC has a voltage step size of $\Delta v = 4$ Volts, the quantization noise is

    (a) 1/48 Vrms (b) 1 Vrms (c) $\sqrt{4/3}$ Vrms (d) None above

5 Points Each (Circle the best answer)

11. Which one of the following is used as an FM demodulator.

(a) Square law detector (b) Envelope detector (c) Slope detector

12. The bandwidth of the signal $y(t) = cos(1000\pi t + 2cos(4\pi t))$ is

(a) 2π Hz (b) 12 Hz (c) 8π Hz (d) None above

13. Assuming $y(t)$ is the voltage across a 1Ω resistor, the power P_y of the signal $y(t) = cos(2t)cos(1000t)$ is

(a) 1/4 W (b) 1/2 W (c) 1 W (d) None above

14. The peak phase deviation $\Delta\phi$ of the PM signal $y(t) = cos(1000\pi t + 2cos(4\pi t))$ is

(a) 2 radians (b) 8π radians (c) 1004π radians (d) None above

15. Baseband data is transmitted at a rate of 1000 symbols per second using a sinusoidal roll-off filter with r = 0.2 . The bandwidth of the transmission is

(a) 200 Hz (b) 600 Hz (c) 1200 Hz (d) None above

5 Points Each (Circle the best answer)

16. Given identical noise at their inputs, the power spectral densities of the noise at the outputs of an FM and a PM receiver are the same.

    (a) True (b) False

17. The CDF $F_x(x)$ of a random variable x can never be greater than 1.

    (a) True (b) False

18. The modulation index β of $y(t) = cos(1000\pi t + 8cos(4\pi t))$ is

    (a) 1/2 (b) 8 (c) 32 (d) None above

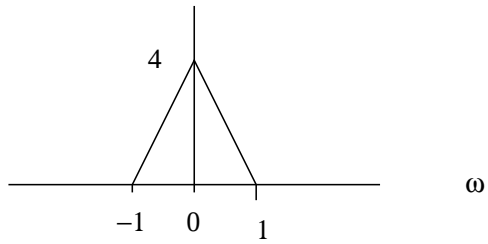
19. A random voltage has a Gaussian distribution with mean 2 and variance 4. The probability that the voltage is greater than 3 volts is

    (a) 0.136 (b) 0.242 (c) 0.5 (d) None above

20. $y(t) = [2 + 4cos(30\pi t)]cos(10000\pi t)$ is overmodulated.

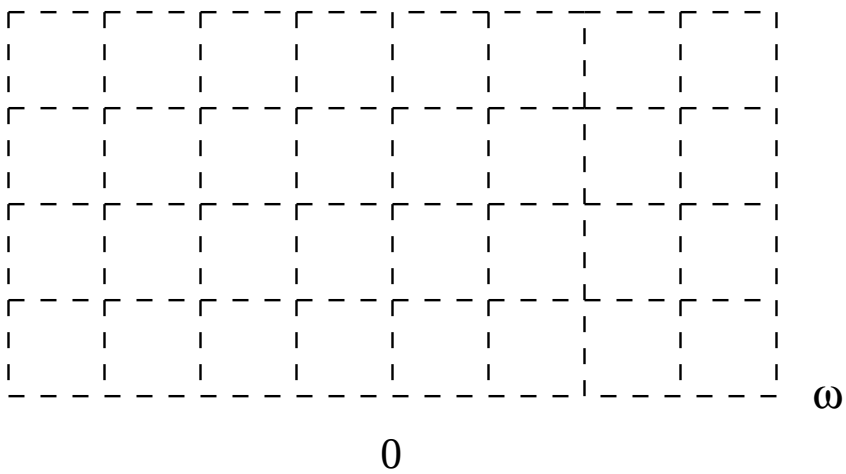
    (a) True (b) False

21. The frequency spectrum $M(\omega)$ of a signal $m(t)$ is shown below, and the pre-envelope for negative frequency is $m_-(t)$.



10 points

Sketch $Y(\omega) = M_-(\omega - \omega_c) + M_-(\omega + \omega_c)$ below, where $M_-(\omega) = \mathcal{F}\{m_-(t)\}$ and where $\omega_c = 2$ rad/s.



5 points

Is $Y(\omega)$ (as defined above) the frequency spectrum of a real-valued function? Explain.

22. The power spectral density of noise at the input to a receiver is 0.0001 Watts/Hz, and the modulating signal is $m(t) = cos(20\pi t)$. Assume that the received signal power S_i is 1 Watt. The following questions investigate the relative performance of various possible modulations. You may assume that the bandwidth is determined by the bandwidth of $m(t)$.

5 points

If DBS-SC modulation is used, what is the signal to noise ratio S_o/N_o at the output of the DSB-SC receiver?

5 points

If SSB modulation is used, what is the signal to noise ratio S_o/N_o at the output of the SSB receiver?

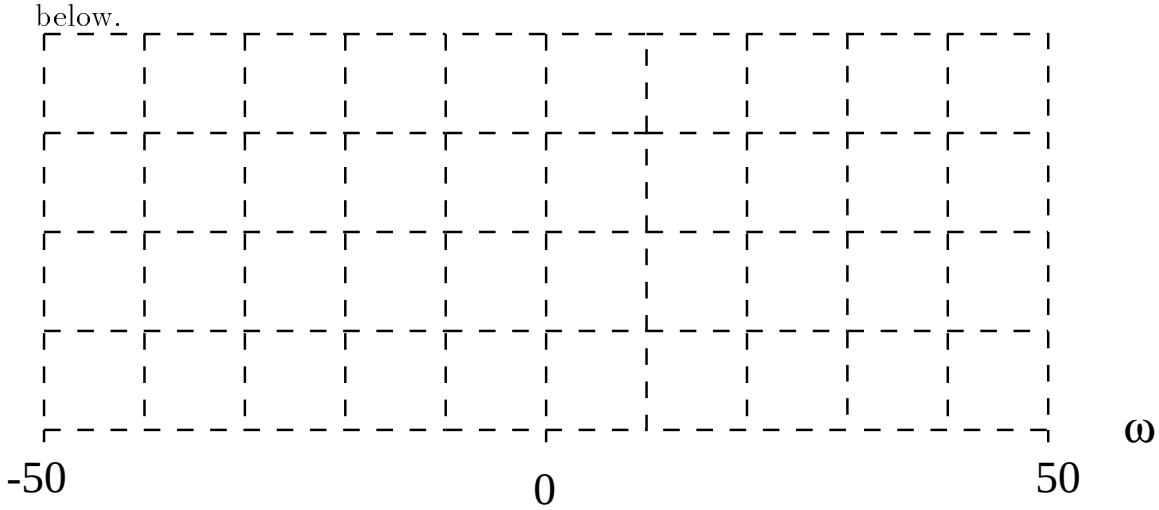
5 points

If FM modulation is used with a peak deviation of 100 Hz, what is the signal to noise ratio S_o/N_o at the output of the FM receiver?

23. A modulating signal is $m(t) = cos(10t)$. The following questions ask for the frequency spectrum when different modulations are used. In each question you may assume that the amplitude of the *unmodulated* carrier is $A = 10$ at a carrier frequency of $\omega_c = 30$ radian/second.

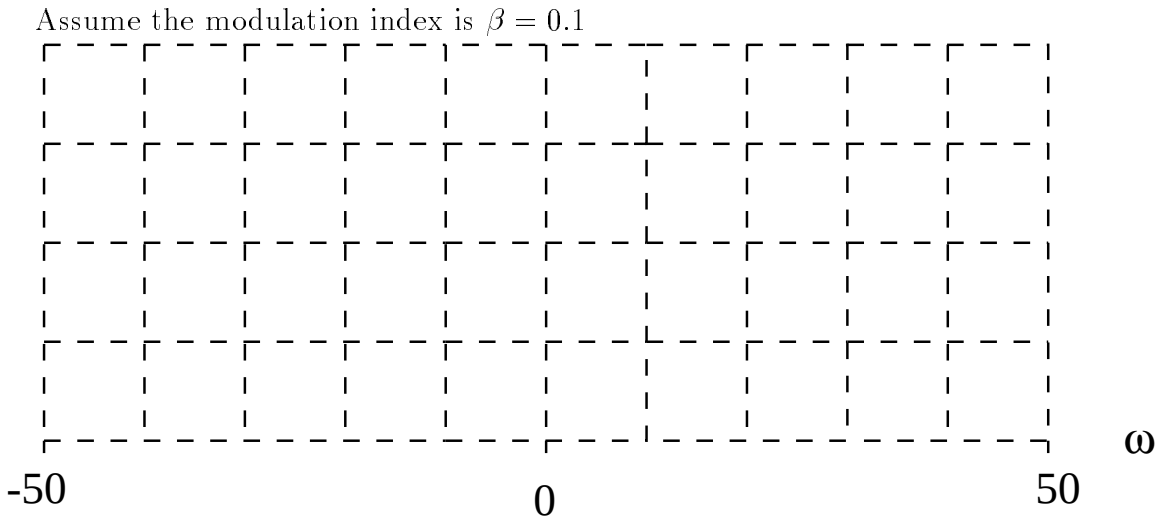
10 points

If DBS-SC modulation is used,sketch the magnitude of the DSB-SC frequency spectrum below.

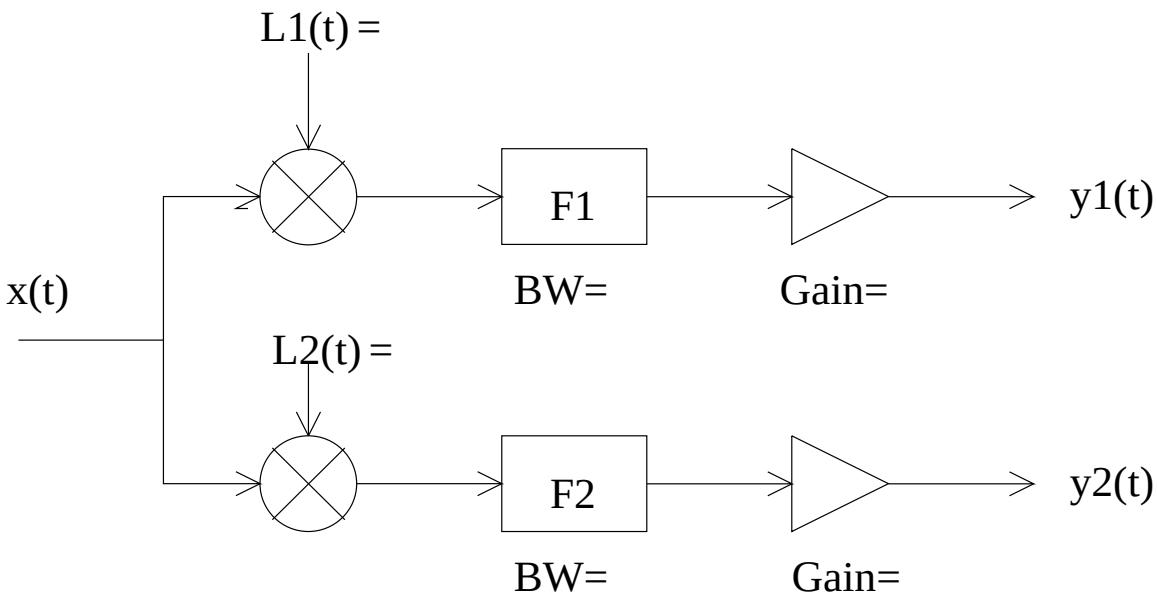


10 points

If FM modulation is used, sketch the magnitude of the FM frequency spectrum below. Assume the modulation index is $\beta = 0.1$



24. Let
$x(t) = m_1(t)cos(5000\pi t) + m_2(t)sin(5000\pi t) + m_3(t)sin(10000\pi t)$,
where the bandwidths of $m_1(t)$, $m_2(t)$ and $m_3(t)$ are 10 Hz. The block diagram of the receiver is shown below.



15 points

Specify $L1(t)$, $L2(t)$, the bandwidths of the ideal lowpass filters F1 and F2, and the gains of the amplifiers such that outputs are $y_1(t) = m_1(t)$ and $y_2(t) = m_2(t)$.

Indicate $L1(t)$, $L2(t)$, the bandwidths of F1 and F2, and the Gains of the amplifiers directly on the block diagram.

5 points

If white noise with power spectral density N was also present at the input of the above receiver, how would the signal to noise ratio at the output $y_1(t)$ be affected if the bandwidth of filter F1 were doubled?
Explain.

25. A baseband bipolar signal plus noise is received. The signal rate is 1000 symbols per second with a peak amplitude of +/- 4 volts. The noise amplitude is 2 V rms.

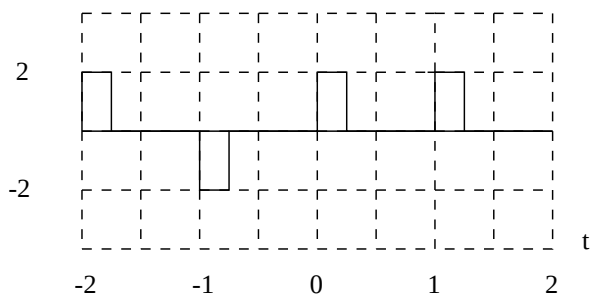
5 points

Find the threshold or thresholds for properly detecting the received pulses.

10 points

Find the predicted error rate $P(\epsilon)$.

26. A short time segment of a polar line code $y(t)$ is shown below. Assume the data is random. For the time interval shown below, the four data bits transmitted are 1, 0, 1, 1.



10 points

Find the power spectral density $S_y(\omega)$.