Name_____ **USF ID#**_____

EEL 4512 – Introduction to Communication Systems

Fall 2006

Test 2 – December 6, 2006

Open Book/Open Notes

1 hour and 15 minutes

1. The exam is open-book/open-notes.

2. A calculator may be used to assist with the test. No laptops or PDAs are allowed. No cellular phones may be used in any way during the test. Unauthorized cellular phone use during the test will result in disqualification.

3. You must circle or box your answers to get full credit.

4. All work and steps toward a solution must be clearly shown to obtain credit.

5. Partial credit may be given provided that the grader can clearly follow your work to the extent that an understanding of the problem is demonstrated.

6. No collaboration is allowed on this examination. Only Charles Baylis may be consulted for clarification.

7. You may attach extra sheets to the exam if necessary. Each page should contain your name, the problem number, and the page number for that problem.

Please sign the statement below. YOU MUST SIGN THE STATEMENT OR YOU WILL GET A ZERO FOR THIS EXAMINATION!!!

I hereby testify that I have neither provided or received information during the test and that this test is the sole product of my effort.

Signed _____ Date_____

PROBLEM 1 (20 points): A modulating signal is given by

$$m(t) = \cos 200t + 3\cos 400t\,.$$

Single-sideband (upper-sideband) AM is used to modulate a cosine carrier with ω_c = 1000 rad/s.

(a) Find $m_h(t)$, the Hilbert transform of m(t) (5 points).

(b) Find the time-domain representation $\varphi_{USB}(t)$ of the AM upper-sideband signal (5 points)

(c) Sketch the amplitude spectrum of m(t), that is, M(ω). Include all frequencies and amplitudes in your plot and sketch for positive and negative values of ω. (5 points)

(d) Sketch the amplitude spectrum of $\varphi_{USB}(t)$, that is, $\Phi_{USB}(\omega)$. Include all frequencies and amplitudes in your plot and sketch for positive and negative values of ω. (5 points)

PROBLEM 2 (20 points): Consider an AM superheterodyne receiver for which the intermediate frequency (IF) is f_{IF} = 455 kHz.

(a) If the local oscillator (LO) has a higher frequency than the incoming carrier frequency f_c and the incoming carrier frequency of the modulated message to be received is f_c = 1530 kHz, then what is the necessary local oscillator frequency f_{LO} (8 points)?

(b) What is the image frequency (6 points)?

(c) For what incoming carrier frequency will 1530 kHz be the undesired image frequency? (6 points)

PROBLEM 3 (20 points): Over an interval $|t| \leq 1$, an angle modulated signal is given by

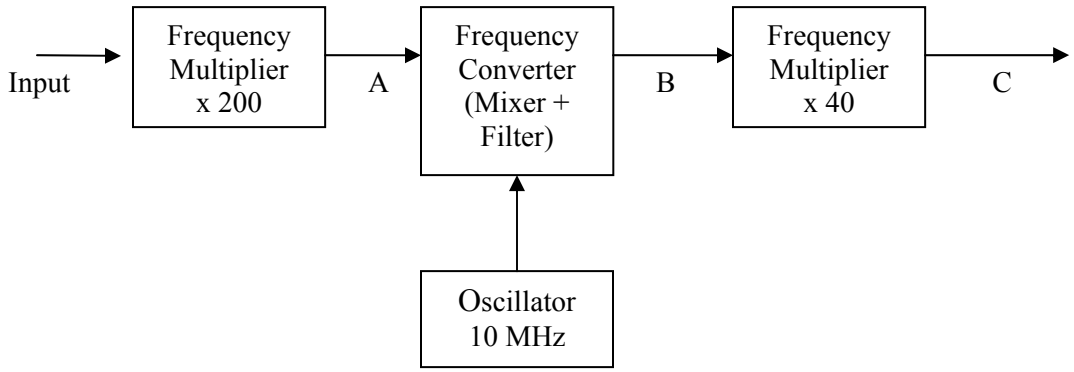
$$\varphi_{EM}(t) = 4\cos(33000t + 7000\sin 5t).$$

It is known that the carrier frequency is $\omega_c = 30{,}000$ radians per second.

(a) If this is assumed to be a phase-modulated (PM) signal with $k_p = 1000$, find an expression for m(t) over the interval $|t| \leq 1$ (10 points).

(b) If this is assumed to be a frequency-modulated (FM) signal with $k_f = 1000$, find an expression for m(t) over the interval $|t| \leq 1$ (10 points).

PROBLEM 4 (15 points): Consider the following indirect FM generator. The input to the generator is a narrowband FM signal with $f_c = 100$ kHz and $\Delta f = 20$ Hz.



Give both f_c and Δf at the following points in the circuit:

(a) Point A (5 points)

(b) Point B (assuming f_c is converted downward in frequency by the mixer and filter) (5 points)

(c) Point C (5 points)

PROBLEM 5 (25 points): A message signal

$$m(t) = 5\cos(2000\pi t)$$

must be sampled, quantized, and encoded for transmission in a digital communication system.

(a) What is the Nyquist rate (do not forget to use f instead of ω) (4 points)?

(b) Let f_s, the sampling frequency, be equal to the Nyquist rate. Consider only the first two samples; the first sample will be taken at $t = T_s$, and the second sample will be taken at $t = 2T_s$, where $T_s = 1/f_s$. Give the values of the signal that are sampled (use a calculator to calculate the decimal representation by using the appropriate time values in the expression for m(t)). Write the answers in the spaces below (4 points).

m[1] = _____

m[2] = _____

(c) Assume the number of quantization levels is L = 4. Use $m_p = 5$ and determine the quantization level values required for m[1] and m[2] in pulse code modulation (PCM). The level number must be 0, 1, 2, or 3. Show your work clearly (5 points).

Quantization Level Number for m[1] = _____

Quantization Level Number for m[2] = _____

(d) Give the bitstream representing the first two samples. Each sample is encoded in 2-bit format; your answer should be a vector with four numbers, each of which is either 1 or 0. The first two bits represent m[1], the second two bits represent m[2] (4 points).

Bitstream Vector = _____

(e) What is the binary pulse rate (bits per second) of the binary-coded bitstream (2 bits per sample) (4 points)?

(f) Using the knowledge that 2 bits can be transmitted per second over a 1 Hz bandwidth, determine the minimum transmission bandwidth B_T that can be used to successfully transmit this bitstream (4 points).