ECE 566 - Communication Systems I, Fall 1999 Final Exam

Overview

- The exam consists of five problems for 105 points. The points for each part of each problem are given in brackets - you should spend your **two hours** accordingly.
- The exam is closed book, but you are allowed **three page-sides** of notes. Calculators are **not** allowed. I will provide all necessary blank paper.

Testmanship

- **Full credit will be given only to fully justified answers.**
- Giving the steps along the way to the answer will not only earn full credit but also maximize the partial credit should you stumble or get stuck. If you get stuck, attempt to neatly define your approach to the problem and why you are stuck.
- If part of a problem depends on a previous part that you are unable to solve, explain the method for doing the current part, and, if possible, give the answer in terms of the quantities of the previous part that you are unable to obtain.
- Start each problem on a new page. Not only will this facilitate grading but also make it easier for you to jump back and forth between problems.
- If you get to the end of the problem and realize that your answer must be wrong, be sure to write "this must be wrong because . . . " so that I will know you recognized such a fact.
- Academic dishonesty **will** be dealt with **harshly** - the *minimum penalty* will be an "F" for the course.

Some potentially useful information

$$\begin{aligned}\cos(\theta) &= \tfrac{1}{2}\left(e^{j\theta} + e^{-j\theta}\right)\\ \sin(\theta) &= \tfrac{1}{2j}\left(e^{j\theta} - e^{-j\theta}\right)\end{aligned}$$

$$\begin{aligned}\sin(a \pm b) &= \sin(a)\cos(b) \pm \cos(a)\sin(b)\\ \cos(a \pm b) &= \cos(a)\cos(b) \mp \sin(a)\sin(b)\end{aligned}$$

$$\begin{aligned}\cos(a)\cos(b) &= \tfrac{1}{2}\left[\cos(a-b) + \cos(a+b)\right]\\ \sin(a)\sin(b) &= \tfrac{1}{2}\left[\cos(a-b) - \cos(a+b)\right]\\ \sin(a)\cos(b) &= \tfrac{1}{2}\left[\sin(a-b) + \sin(a+b)\right]\end{aligned}$$

Time Function	**Fourier Transform**
$x(at+b)$	$\frac{1}{\lvert a\rvert}X\left(\frac{f}{a}\right)e^{j2\pi\frac{b}{a}f}$
$p(t) = \begin{cases} 1 & \lvert t \rvert \le 1/2 \\ 0 & \lvert t \rvert > 1/2 \end{cases}$	$P(f) = \frac{\sin(\pi f)}{\pi f} = \mathrm{sinc}(f)$
$\cos(2\pi f_0 t)$	$\frac{1}{2}\left[\delta(f-f_0) + \delta(f+f_0)\right]$
$\sin(2\pi f_0 t)$	$\frac{1}{2j}\delta(f-f_0) - \frac{1}{2j}\delta(f+f_0)$
$x(t) = \begin{cases} 1-\lvert t\rvert & \lvert t\rvert \le 1 \\ 0 & \lvert t\rvert > 1 \end{cases}$	$X(f) = \mathrm{sinc}^2(f)$

Parseval's Relation: If $X(f)$ is the Fourier Transform of $x(t)$,

$$\int_{-\infty}^{\infty} |x(t)|^2 dt = \int_{-\infty}^{\infty} |X(f)|^2 df$$

1. We have considered a number of analog communication systems this semester, among them: DSB-SC, conventional AM, SSB, and FM. For the following applications, give *one* system from the above list that you might specify for the application. Only brief answers are required, but be sure to give the positives and negatives of the system you suggest for each application.

   [5] (a) A broadcast radio station in Pelham.

   [5] (b) A short wireless link in a laboratory, where a high data rate is the key consideration.

   [5] (c) A network of low-power hand-held two-way radios to be used on a construction site.

2. We are designing an analog quadrature amplitude modulation (QAM) system to carry two messages: $m_1(t) = \text{sinc}(10t)\cos(2\pi 100t)$ and $m_2(t) = \text{sinc}(20t)\cos(2\pi 100t)$.

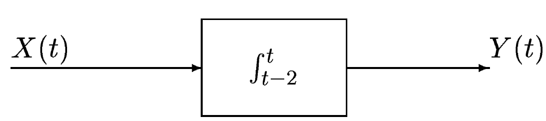
   [18] (a) The QAM signal is formed as:

$$x(t) = m_1(t)\cos(2\pi 10^6 t) + m_2(t)\sin(2\pi 10^6 t)$$

   and filtered with a bandpass filter $h(t) = \text{sinc}(200t)\sin(2\pi 10^6 t)$. Find the output $y(t) = h(t) * x(t)$ of the transmitter.

   [7] (b) Redesign the transmitter from part (a) such that the use of an RF bandpass filter is avoided. Be sure to give all oscillator frequencies and filter impulse responses. Your system should have $m_1(t)$ and $m_2(t)$ as input and $y(t)$ as output.

3. [15] Consider the received signal $X(t) = 2\sqrt{5}\cos(2\pi 0.25t) + W(t)$, where $2\sqrt{5}\cos(2\pi 0.25t)$ is the desired signal, and the noise process $W(t)$ is zero-mean white Gaussian noise with power spectral density $S_W(f) = 10^{-3}$. Let $Y(t) = \int_{t-2}^{t} X(\tau)d\tau$ as shown below:



   Find the output signal-to-noise ratio (in dB).