GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING
Quiz II - Fall 2015
ECE 4601: Communication Systems

Aids Allowed: 8 1/2"X11" crib sheet (2 sides), calculator
Attempt all questions
Questions are of equal value

DATE: Thursday November 12, 2015.
TIME: 12:05pm - 1:25pm
INSTRUCTOR: Prof. G.L. Stüber

Math tables are attached at the end of this exam
You do not need to turn them in

1) ISI Channels Consider a binary communication system that transmits binary data bits, x_n, where $x_n \in \{-1, +1\}$ with equal probability. The overall pulse response $p(t)$ is such that the sample pulse is

$$p_k = p(kT) = \begin{cases} 1, & k = 0 \\ 0.25, & k = 1,\ 2 \\ 0, & \text{elsewhere} \end{cases}$$

The samples at the output of the receiver matched filter are

$$y_n = p_0 x_n + \sum_{k \neq n} x_k p_{n-k} + n_n$$

where the n_n are independent zero-mean Gaussian random variables with variance σ^2. Data decisions are made such that

$$\hat{x}_n = \begin{cases} -1 & , \quad \text{if } y_n < 0 \\ +1 & , \quad \text{if } y_n > 0 \end{cases}$$

a) 4 marks: What are the possible values for the ISI term and their probabilities?

b) 6 marks: Derive an expression for the probability of bit error, $P[\hat{x}_n \neq x_n]$.

Extra sheet

2) Signal Constellations: Suppose that the following set of bi-orthogonal signal vectors are used on an AWGN channel with two-sided noise power spectral density of $N_o/2$ watts/Hz.

$$\mathbf{s}_i = \begin{cases} \sqrt{E}\mathbf{e}_i & , \quad i = 1, \ldots, M/2 \\ -\mathbf{s}_{i-M/2} & , \quad i = M/2+1, \ldots, M \end{cases}$$

where the unit basis vectors $\mathbf{e}_i$ have length $M/2$, and $\mathbf{e}_i$ is a vector containing all 0's except for a 1 in the ith coordinate.

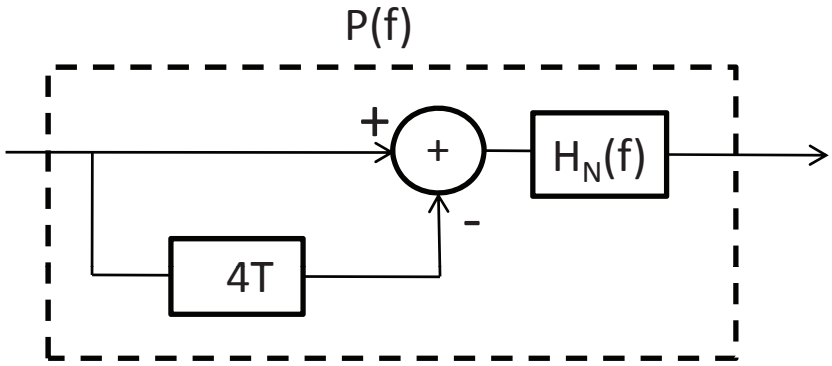
a) 5 marks: Obtain a union bound on the probability of *symbol* error as a function of the received bit energy-to-noise ratio E_b/N_o.

b) 3 marks: For the case $M = 4$, obtain an exact expression for the probability of *symbol* error as a function of the received bit energy-to-noise ratio E_b/N_o.

c) 2 marks: Assuming a baud period of T seconds and $M = 8$, specify and/or sketch one possible set of bi-orthogonal waveforms $\{s_i(t)\}_{i=1}^{8}$. *The solution is not unique but any one will do.*

Extra sheet

3) Partial Response: The overall pulse response $P(f)$ of a partial response system is generated by the figure below, where $H_N(f)$ is an ideal Nyquist (low-pass) filter with a cutoff frequency of $W = 1/(2T)$ Hz.



a) 5 marks: What is the overall pulse response $P(f)$? Sketch the magnitude and phase response of $P(f)$, on a properly labeled graph.

b) 3 marks: What is the corresponding time domain pulse $p(t)$? Sketch it, on a properly labeled graph.

c) 2 marks: Using $P(f)$ from part a) obtain the frequency responses of the corresponding transmit filter, $G(f)$, and receiver matched filter, $H(f)$.

Extra sheet