

Spring 2010
EE 4601: Assignment 4

- Date Assigned: February 16, 2010.
 - Date Due: February 23, 2010.
1. In a binary PAM system (like binary antipodal modulation considered in Lecture 9), the clock that specifies the sampling of the correlator (or matched filter) output is offset from the optimum sampling time by 10%. The transmitted pulse shape, $g(t)$, is rectangular, i.e.,

$$g(t) = \begin{cases} A & , \quad 0 \leq t \leq T \\ 0 & , \quad \text{elsewhere} \end{cases}$$

The channel is an AWGN channel (ideal channel).

- a) What is the overall pulse shape $p(t) = g(t) * h(t)$, where $h(t)$ is the matched filter.
 - b) Determine the loss in "effective" received bit energy, E_b , at the output of the matched filter due to the mistiming.
 - c) Obtain an expression for the probability of bit error, and compare with the case when no timing error is present.
2. A wireline channel of length 1000 km is used to transmit data by means of binary PAM (like binary antipodal modulation considered in Lecture 9). Regenerative repeaters are spaced at 50-km apart along the system. Each segment of the channel has an ideal (constant) frequency response over the frequency band $0 \leq f \leq 1200$, and an attenuation of 1 dB/km. The channel noise is AWGN.
 - (a) what is the highest bit rate that can be transmitted without ISI?
 - (b) determine the required E_b/N_o to achieve a bit error of $P_b = 10^{-7}$ for each repeater.
 - (c) determine the transmitted power at each repeater to achieve the desired E_b/N_o , where $N_o = 4.1 \times 10^{-21}$ Watts/Hz.
 3. In a binary pulse amplitude modulated (PAM) system, the input to the decision device is

$$y_m = a_m + n_m + i_m$$

where $a_m = \pm 1$ is the desired signal, n_m is a zero-mean Gaussian random variable with variance σ_n^2 , and i_m represents the ISI due to channel distortion. The ISI term is a random variable which takes the values $-1/2, 0, 1/2$ with probabilities $1/4, 1/2, 1/4$, respectively. Determine the average probability of error as a function of σ_n^2 .

4. The frequency response of a channel can be approximated by

$$C(f) = \begin{cases} 1 + \alpha \cos 2\pi f t_o, & |\alpha| < 1, \quad |f| \leq W \\ 0, & \text{otherwise} \end{cases}$$

where W is the channel bandwidth. An input signal $s(t)$ whose spectrum is bandlimited to W Hz is passed through the channel, yielding the output $y(t)$.

- (a) Show that

$$y(t) = s(t) + \frac{\alpha}{2}[s(t - t_o) + s(t + t_o)]$$

Thus the channel produces a pair of echoes.

- (b) Suppose the received signal $y(t)$ is passed through a filter matched to $s(t)$. Determine the output of the matched filter at $t = kT$, $k = 0, \pm 1, \pm 2, \dots$ where T is the symbol duration.
- (c) What is the ISI pattern resulting from the channel if $t_o = T$?
5. A computer puts out binary data at the rate of 56 kb/s. The computer output is transmitted using a baseband binary PAM system (like binary antipodal modulation considered in Lecture 9) that is designed to have a raised-cosine spectrum. Determine the transmission bandwidth required for each of the following rolloff factors: $\alpha = 0.25, 0.5, 0.75, 1$.