16.36 Communication Systems Engineering
Spring 2009

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16.36 Communication Systems Engineering
Quiz – 2
April 23, 2009

<u>Part 1: Quick Questions (30 points; 5 points each)</u>

Please provide brief explanations for your answers in order to receive full credit.

1. In a binary PAM modulation system, the length of time of a pulse is reduced from 1 second to 0.25 seconds. How much should the amplitude be increased to maintain the same probability of error?

2. In a satellite communication system, there is an opportunity to use a new parabolic antenna with twice the diameter of the old antenna. What is the expected increase of the data rate? Assume free space loss.

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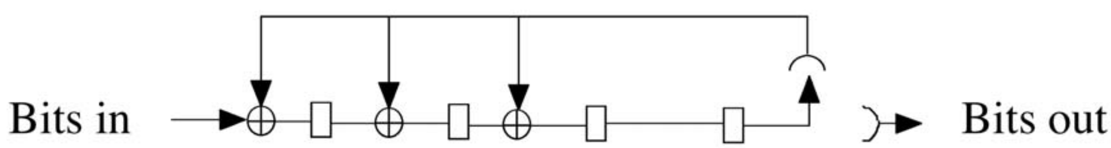
3. What is the minimum distance (d_{min}) of the (7,3) code defined by the following generator matrix?

$$G = \begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

4. What is generator matrix corresponding to the following CRC feedback shift register implementation?



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5. Suppose a cyclic code with generator string 11101 is used to generate a CRC.

   a. (5 pts) The data sequence is 101111, what should the CRC be?

   b. (5 pts) The received sequence is 10111011, did any errors occur?

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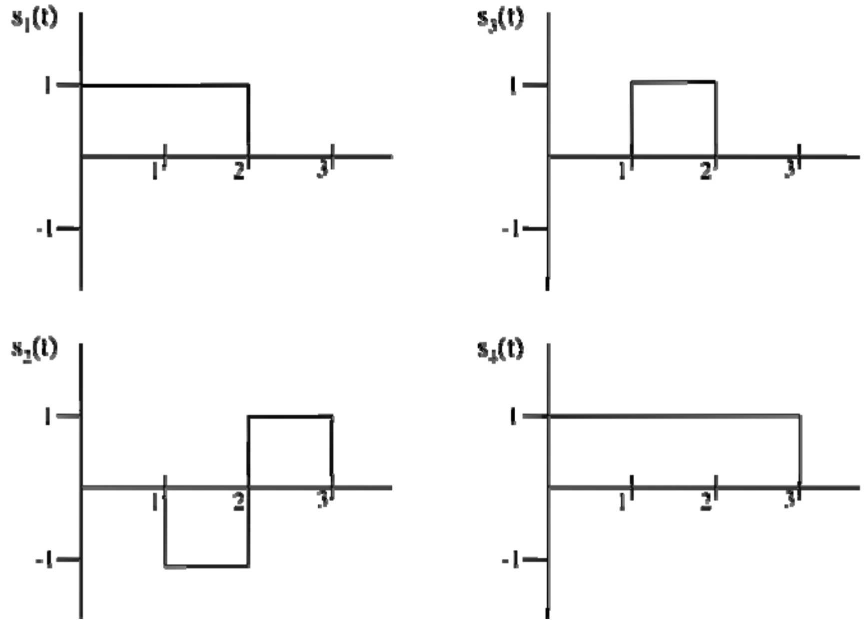
<u>Question 2: 20 points</u>

Consider the following set of four waveforms:



a) (10 pts) What is the dimensionality of the set of waveforms?

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b) (10 pts) Determine a set of basis functions for the set of waveforms.

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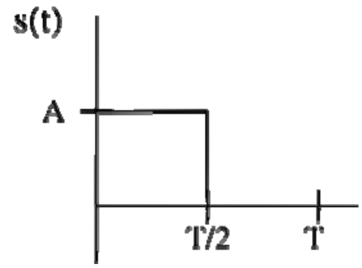
Question 3: 30 points

A binary communication system employs antipodal signals. The system operates over an AWGN channel with power spectral density $N_0/2$ W/Hz. The received signal is given by:

$$r(t) = \pm s(t) + n(t)$$

where s(t) is the transmit signal and n(t) is the noise signal. The sender uses signal s(t) to represent a 1 and –s(t) to represent a 0. The symbol duration is T.



a) (5 pts) What is the impulse response h(t) of the matched filter for s(t)? (sketch your answer)

b) (10 pts) What is the output of the matched filter to the input s(t)? (sketch your answer)

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The receiver uses this matched filter and samples the output at time T. Call the sampled value **r**. Under AWGN, the conditional distributions of **r** are Gaussian:

$$f(\mathbf{r} \mid 0 \text{ sent}) \sim \mathcal{N}(\mu_0, N_0/2)$$
$$f(\mathbf{r} \mid 1 \text{ sent}) \sim \mathcal{N}(\mu_1, N_0/2)$$

With $\mu_0 = +\sqrt{E_S}$ and $\mu_1 = -\sqrt{E_S}$.

The prior probabilities of sending a 0 or 1 are P_0 and P_1 respectively.

c) (10 pts) What is the MAP decoding rule for the received value **r**, when $P_0 = P_1 = 0.5$?

d) (5 pts) What is the MAP decoding rule for the received value **r**, when $P_0 = 0.4$ and $P_1 = 0.6$?

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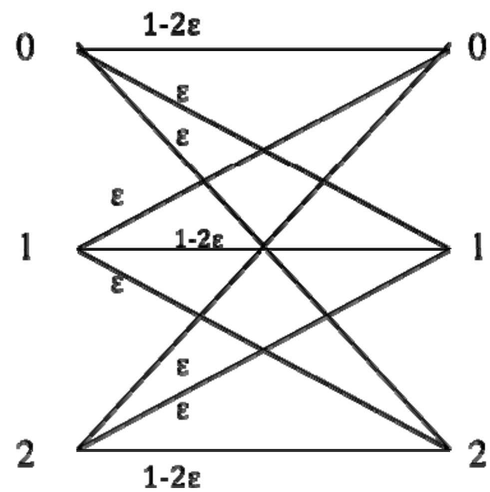
<u>Question 4: 20 points</u>

Consider the discrete memoryless symmetric ternary channel below with channel error ε and source alphabet {0,1,2}.



a) (10 pts) Find the capacity of the channel when $\varepsilon = 0$

b) (10 pts) Find the capacity of the channel when $\varepsilon = ⅓$