

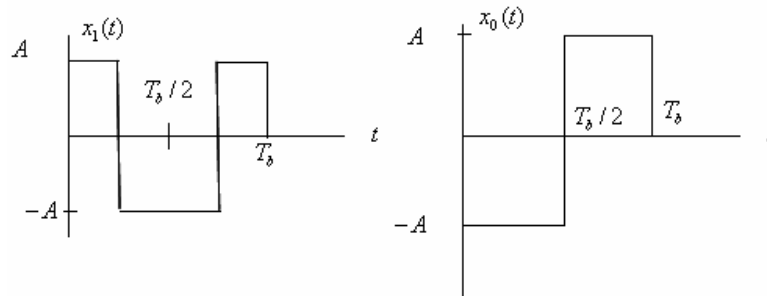
## Chapter 11 MATLAB PROBLEMS

### Introduction

The below set of problems will have you simulate the transmission of digital information over a noisy channel using orthogonal and antipodal signaling. The digital message bits will be encoded onto orthogonal or antipodal waveforms. They will then be corrupted by AWGN and then decoded using a correlation detector. Performance will be measured based on comparisons between the theoretical and simulated probability of bit error. The signals from the various output stages of the system will also be plotted in order to develop an understanding of the workings of the various stages of the correlation detector function.

The correlation detector for orthogonal signals is given in Fig. 14.2-3(b), and the correlation detector for antipodal signals is given in Figs 14.2-4 or Fig. 11.2-8

11.1 Given the following orthogonal pulses:



- a. Write a program to plot a graph of the theoretical probability of error,  $P_e$  versus  $10\log_{10}(E_b/N_o)$  ranging from 0 to 12 dB in increments of 1 for orthogonal signals. This will be used to evaluate your simulations.
- b. Write a simulation program to estimate and plot  $P_{be}$  for a binary communication system that uses an orthogonal correlation detector. The specifics are as follows:
  - (i) Generate a random  $m = 0, 1$  message stream where the bits are equiprobable.
  - (ii) Encode the 0, 1 message stream into one of the above orthogonal waveforms below with "0"  $\rightarrow x_0(t)$  and "1"  $\rightarrow x_1(t)$  :
  - (iii) Let  $x_0(t)$  and  $x_1(t)$  consist of 24 samples each. Therefore,  $x_0(0 \rightarrow T_b) \Rightarrow x_0(0 \rightarrow 23)$  and  $x_1(0 \rightarrow T_b) \Rightarrow x_1(0 \rightarrow 23)$ .

(iv) Add various amount of random noise to your message stream to create signals with  $E_b / N_0$ 's from 0 to 12 dB in increments of 1. You can adjust the signal's  $E_b / N_0$  by changing the noise generator's variance  $\sigma^2 = N_0 / 2$ .

(v) Construct a correlation receiver to detect the noisy signals. As noted elsewhere, the correlation receiver should consist of multipliers, integrators (or summers) and a comparator. The output of the comparator will be the message  $\hat{m}$

(vi) Compare the values of  $m$  and  $\hat{m}$ . Have an error counter in your correlation detector count the number of errors in order that you can calculate the  $P_{be}$ .

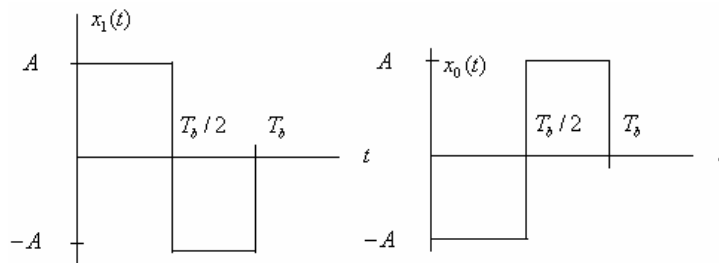
(vii) For each value of  $E_b / N_0$ , calculate a  $P_{be}$  based on the 10,000 generated and received data bits, and then overlay with an "x" on the plot generated in above step (a).

(viii) Repeat the above so that you have  $P_{be}$  for each value of  $10 \log E_b / N_0$  from 0 to 12 dB in increments of 1 dB.

(ix) Note the degree of closeness the simulated points are to the theoretical plot. You might also note that as  $E_b / N_0$  increases it takes more samples to reach the theoretical value of  $P_{be}$ . Why?

c. Plot the signals from the various detector stages. The outputs should conform to what is expected. Make any observations and state any conclusions.

11.2 Repeat 11.1 except use the following antipodal pulses.



11.3 Repeat 11.1 except use orthogonal sinusoidal waveforms. Assume the waveforms are a single period with 24 samples.

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