York University

Department of Electrical Engineering and Computer Science

EECS 4214

Lab #6 Baseband Demodulation/Detection,

Optimal Design, Simulation, and Analysis

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1. Purpose

In this lab, you will be introduced to modeling and simulation of the receiving filter and detector blocks in a receiver. Using a computer, you will learn how to analyze the operation and performance of such blocks according to the results achieved during the operation of a digital communication system.

2. Objectives

By the end of this project, you will be able to: 1) Study the behavior of a receiving filter realized using a correlator detector in the case of both noise-less and noisy inputs, 2) Statistically analyze the operation of a detector decision-making block when the input is influenced by noise. 3) Characterize the performance of the detector as a function of the input signal-to-noise ratio.

3. References

1) Handouts available on the course homepage on Moodle.

2) Bernard Sklar text: Chapter 3.

Problem 1 Design of a receiver for "Optimum Detection"

In MATLAB®,

1.1 Generate an NRZ-L baseband signal, $s(t)$, for the8-bit binary sequence of 10110001 with

- 0's represented by $s_1(t)$ = A = +5V,
- 1's represented by $s_2(t)$ = –A = –5V, and
- Bit time: T=1ms

Transition time for both 0→1 and 1→0 shouldn't be longer than 10μs.

1.2 Suppose that the waveform $s(t)$ in part 1.1 passes through a distortion-less and noise-less communication channel, and arrives at the receiver with 20% attenuation: $r(t)$ =0.8 $s(t)$. the received signal is to be detected using a *correlator detector* with the block diagram shown below:

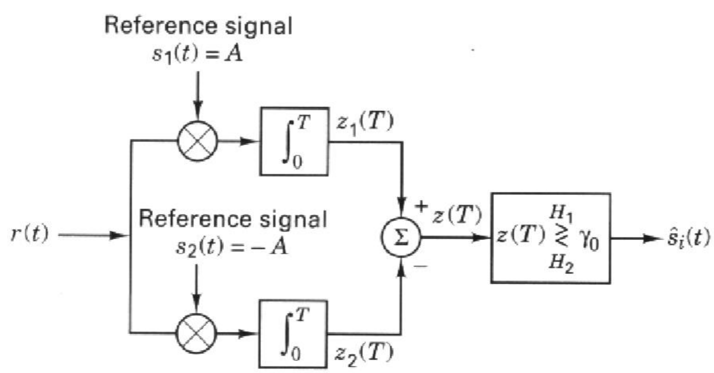

Fig. 6.1

Design the detector for <u>optimum detection</u>. Find the best comparison threshold level for the decision-making stage (γ_0).

1.3 Simulate the operation of the detector of Fig. 6.1 when it receives $r(t)$ as the input. Assume that an <u>ideal</u> sampler is used for the sampling of the outputs of the integral blocks. Plot the waveforms at the outputs of all the building blocks of the detector.

Problem 2 Detection of an NRZ-L code in the presence of noise

2.1 Suppose that some AWGN is superposed on the baseband signal when it passes through the channel. In this case, the signal receiving the input of the detector of Fig. 6.1 is modeled as $r(t)$ =0.8 $s(t)$ + $n(t)$, where $n(t)$ is the white Gaussian noise added to the signal.

a) With a very large *signal-to-noise ratio* (*SNR*), simulate the operation of the detector.

b) Explain how you calculate the SNR.

c) Find the number of errors occurred in the detection of the received bit sequence.

d) In the 8-bit binary sequence you are using, there are 4 zeros and 4 ones. As such, in part 2.1(a), you have observed 4 values for $z(T)|s_1$ and 4 values for $z(T)|s_2$. Repeat 2.1(a) for nine more times. In each trial, make a record of the values you obtain for $z(T)|s_1$ and $z(T)|s_2$. Overall, you have obtained 40 values for $z(T)|s_1$ and 40 values for $z(T)|s_2$. Calculate the average and standard deviation values for $z(T)|s_1$ and $z(T)|s_2$, and draw their histograms on the same plot.

e) On the plot drawn in part 2.1(e), specify where the decision-making threshold level (the value chosen for γ_0 in part 1.2) is located. Discuss on the number of detection errors according to the $z(T)$ distribution histograms.

2.2 Gradually lower the SNR by making the AWGN larger in amplitude in 5 steps, in such a way that the last step exhibits unacceptably-high bit errors. For each SNR value, repeat part 2.1(a),(c),(d)&(e).

Using the data collected in parts 2.1 and 2.2,

2.3 Verify whether the choice of the decision-making threshold level (the value chosen for γ_0 in part 1.2) has been the best value making your design optimal. Which SNR scenario(s) is appropriate for this verification? Explain why.

2.4 Plot the *average bit error frequency* (normalized to the total number of bits: 8) versus SNR. Do you see any resemblance between what you have just plotted and a similar (not the same) plot discussed in the class relating bit errors and signal-to-noise ratio? Explain the similarities and differences.