3 Labwork

a. Set the sampling frequency and the time duration as 3kHz and 0.4s, respectively.

b. Choose $N = 4$ as the number of symbols to be transmitted. Be careful that you will use N in the item "d".

c. Let $s_0(t)$ and $s_1(t)$ given in Figure 1 be the symbol waveforms and they represent 0 and 1 bits, respectively. Let $T_b = 100ms$. Generate and plot $s_0(t)$ and $s_1(t)$ in a one figure with *subplot(2xx)*.

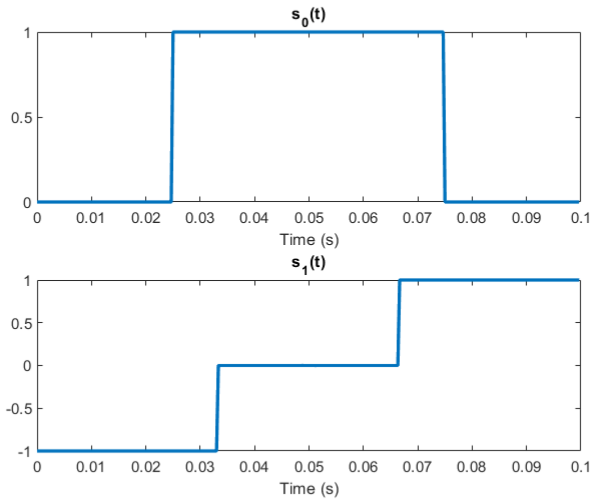

Figure 1: Signal waveforms for a binary communication system

d. Construct and plot the transmitted signal $s(t)$ depending on the binary sequence $b = [1, 0, 1, 0]$ (When your symbol is 0 $s_0(t)$ is transmitted and when your symbol is 1 s_1 is transmitted.). Make sure that the number of symbols in the transmitted signal is N. You can use concatenation operation to combine the signals which correspond to bit 0 or 1.

e. Compute (by MATLAB) the average transmit power of the transmit signal P. You should take the sum of the square of all elements' absolute value and divide it by length of the transmitted signal array as in the below formula (**Note that** you can use *abs(.)*,*length(.)* and *sum(.)*:

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P=sum(abs(st).^2)/length(st);
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f. $s(t)$ is transmitted over additive white Gaussian noise (AWGN) channel by the following equation.

$$r(t) = s(t) + n(t) \tag{1}$$

where $n(t)$ is AWGN with zero mean and σ^2 variance.

g. Obtain and plot $r(t)$ for 15 dB signal to noise ratio (SNR).

- In this part, it is not allowed to use MATLAB built in function *awgn(.)*. You should create a random noise vector $\mathrm{n}_i = \mathrm{sqrt}(\mathrm{var}_i)\mathrm{randn}(1, \mathrm{length}(\mathrm{st}))$, $i \in \{1, 2\}$, 1 for 15dB 2 for 0dB. To get the received signal array r_i, $i \in \{1, 2\}$ you can add the corresponding noise array n_i and the transmitted signal array $s(t)$.

- When computing (by MATLAB) the variance of the corresponding noise, firstly you should calculate linear value of the corresponding SNR by,

$$\mathrm{SNRlin}_i = 10^{(0.1\times \mathrm{SNRdB}_i)}, \quad i \in \{1, 2\} \tag{2}$$

Then the corresponding variance of the noise var_i is computed (by MATLAB) by,

$$\mathrm{var}_i = \frac{\mathrm{P}}{\mathrm{SNRlin}_i}, \quad i \in \{1, 2\} \tag{3}$$

where P is the average power of the transmitted signal array.

h. Design a correlation receiver which is given in the following figure that finds the correlation between

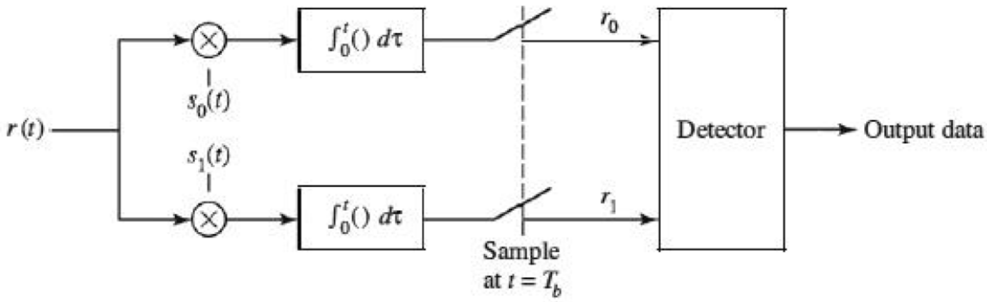

Figure 2: Correlation Receiver

transmit symbol ($s_0(t)$ and $s_1(t)$) and the received signal (r(t)). Use the equations given below;

$$r_0[k] = \sum_{n=(k-1)W_b+1}^{kW_b} r(nT_s)s_0((n-(k-1)W_b)T_s), \quad k = 1, 2, ..., N$$

$$r_1[k] = \sum_{n=(k-1)W_b+1}^{kW_b} r(nT_s)s_1((n-(k-1)W_b)T_s), \quad k = 1, 2, ..., N$$

i. where k is the sample at $t = T_b$, Ts is the sampling period and $W_b = T_b/T_s$ is the pulse width in these equations.

j. Plot the correlator outputs $r_0[k]$ and $r_1[k]$ with respect to each symbol $k = 1, 2, .., N$ which is sampled at $t = T_b$. Use *scatter()* to plot the outputs with respect to each sample. Use *hold on* command to plot $r_0[k]$ and $r_1[k]$ together. Plot $r_0[k]$ and $r_1[k]$ with different colors.

k. Change the SNR to 0 dB and repeat (g) and (j). **Report** Do your correlators work well? Why?

Make your plot consistent with the given directions. Please add title, legend and labels to get full credit.

3.1 Remaining Questions for Report

- What is the AWGN channel, and why is it considered a fundamental model in communication systems?
- Explain the concept of the optimum receiver for AWGN channels. How does it maximize the Signal-to-Noise Ratio (SNR)?
- Explain the steps involved in designing a correlator for a specific communication system application.
- What are the advantages of using correlators in the presence of noise, and how do they contribute to improving the overall system performance?