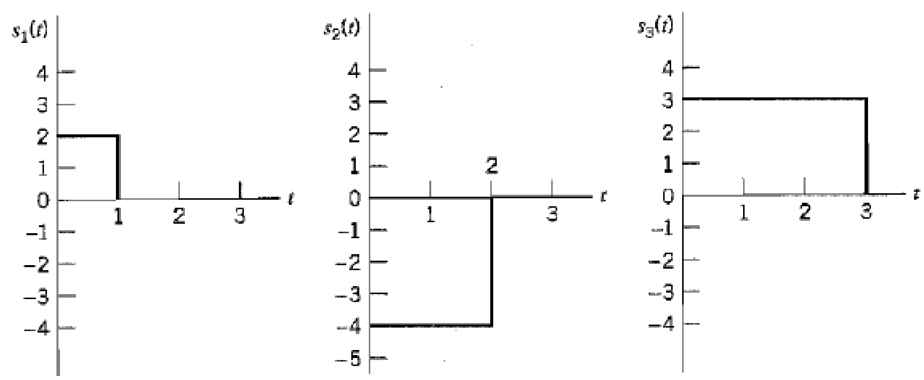
Question list is from Proakis V2 and Haykin V4:

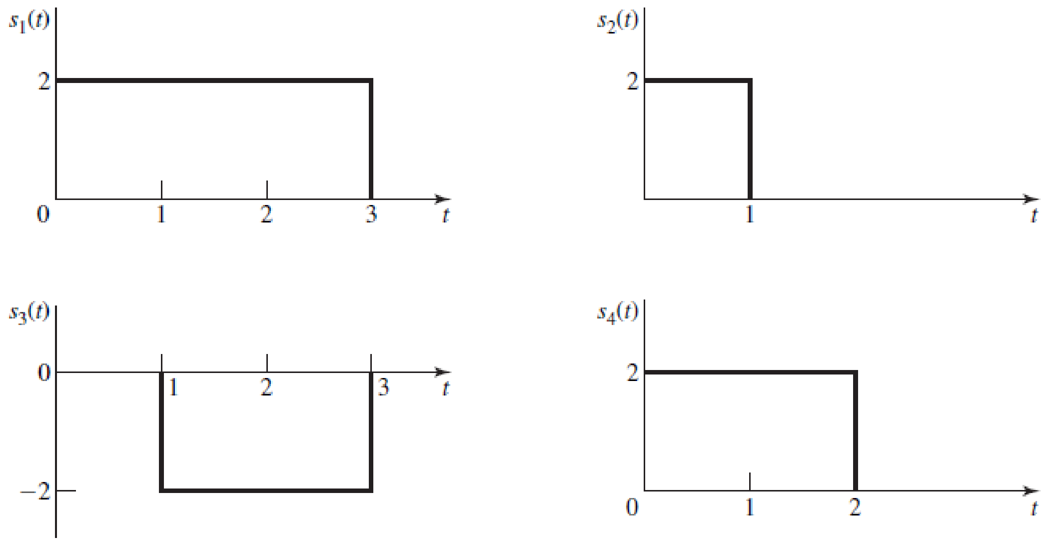
Q1: Communication Systems (Haykin Q-5.4)
Q2: Communication Systems Engineering (Proakis Q-7.6)
Q3: Communication Systems Engineering (Proakis Q-7.9)
Q4: Communication Systems Engineering (Proakis Q-7.13)
Q5: Digital Communications (Proakis Q-4.5)
Q6: Communication Systems Engineering (Proakis Q-7.21)
Q7: Digital Communications (Proakis Q-4.14)
Q8. Communication Systems (Haykin Q-5.12)
Q9: Communication Systems (Haykin Q-5.11)
Q10: Communication Systems Engineering (Proakis Q-7.18)
Q11: Communication Systems Engineering (Proakis Q-7.22)
Q.12: Communication Systems Engineering (Proakis Q-7.23)

Questions

1. (a) Using the Gram-Schmidt orthogonalization procedure, find a set of orthonormal basis functions to represent the three signals $s_1(t)$, $s_2(t)$ and $s_3(t)$ shown in figure.
   (b) Express each of the signals in terms of basis functions found in part (a).



2. Determine a set of orthonormal functions for the four signals shown in figure.



(a) Express each of the signals in terms of found basis functions.
(b) Determine minimum distance.

3. A binary digital communication system employs the signals

$$s_0(t) = 0,\ 0 \le t \le T$$

$$s_1(t) = A,\ 0 \le t \le T$$

for transmitting the information. This is called *on-off signaling*. The demodulator crosscorrelates the received signal $r(t)$ with $s_1(t)$ and samples the output of the correlator at $t = T$.

a. Determine the optimum detector for an AWGN channel and the optimum threshold, assuming that the signals are equally probable.

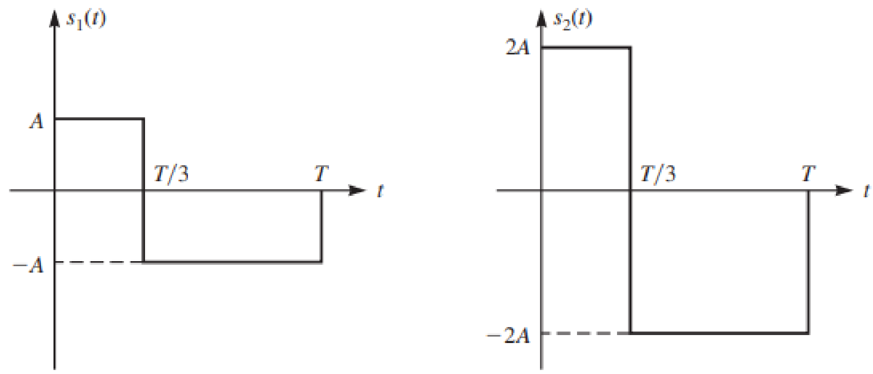
b. Determine the probability of error as a function of the SNR. How does on-off signaling compare with antipodal signaling?

antipodal demek birisi A ise birisi -A

4. Binary antipodal signals are used to transmit information over an AWGN channel. The prior probabilities for the two input symbols (bits) are 1/3 and 2/3.

   a. Determine the optimum maximum-likelihood decision rule for the detector.
   b. Determine the average probability of error as a function of Eb/N0.

5. A communication system transmits one of the three messages m1, m2, and m3 using signals s1(t), s2(t), and s3(t). The signal s3(t) = 0, and s1(t) and s2(t) are shown in the figure. The channel is an additive white Gaussian noise channel with noise power spectral density equal to N0/2.



a. Determine an orthonormal basis for this signal set, and depict the signal constellation.
b. If the three messages are equiprobable, what are the optimal decision rules for this system? Show the optimal decision regions on the signal constellation you plotted in part 1.
c. If the signals are equiprobable, express the error probability of the optimal detector in terms of the average SNR per bit.
d. Assuming this system transmits 3000 symbols per second, what is the resulting transmission rate (in bits per second)?

[illegible] binary antipodal signalling scheme the signals are given by

$$s_1(t) = -s_2(t) = \begin{cases} \frac{2At}{T} & 0 \le t \le \frac{T}{2} \\ 2A\left(1 - \frac{t}{T}\right) & \frac{T}{2} \le t \le T \\ 0, & \text{otherwise} \end{cases}$$

The channel is AWGN and Sn (f) = N0/2. The two signals have prior probabilities p_1 and p_2=1- p_1

a. Determine the structure of the optimal receiver.

b. Determine an expression for the error probability.

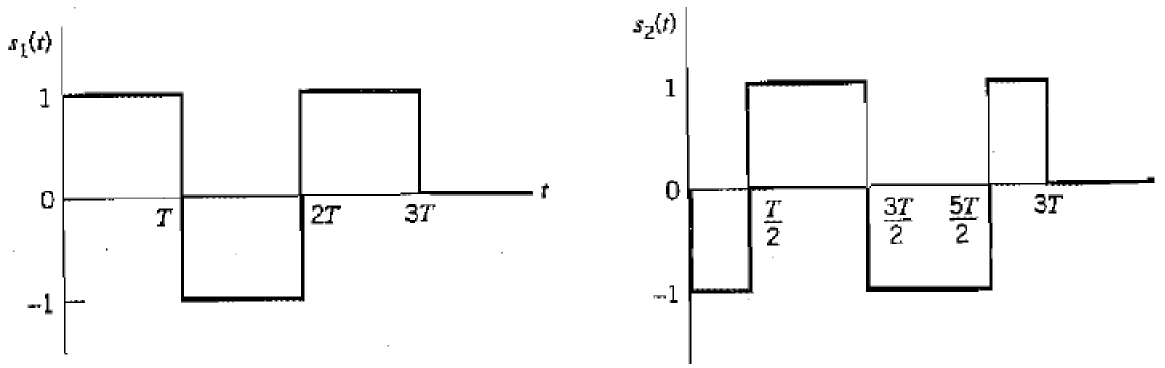
[illegible]inary communication system uses two equiprobable messages s1(t) = p(t) and s2(t) = −p(t). The channel noise is additive white Gaussian with power spectral density N0/2. Assume that we have designed an optimal receiver for this channel, and let the error probability for the optimal receiver be Pe.

a. Find an expression for Pe.
b. If this receiver is used on an AWGN channel using the same signals but with the noise power spectral density N1 > N0, find the resulting error probability P1 and explain how its value compares with Pe.
c. Let Pe1 denote the error probability in part 2 when an optimal receiver is designed for the new noise power spectral density N1. Find Pe1 and compare it with P1.
d. Answer parts 1 and 2 if the two signals are not equiprobable but have prior probabilities p and 1 − p.

8. Figure shows a pair of signals s_1(t) and s_2(t) that are orthogonal to each other over the observations interval 0≤t≤3T. The received signal is defined by

$$x(t) = s_k(t) + w(t), \quad \begin{matrix} 0 \le t \le 3T \\ k = 1, 2 \end{matrix}$$

Where w(t) is white Gaussian noise of zero mean and power spectral density $N_0/2$.



a. Design a receiver that decides in favor of signals $s_1(t)$ or $s_2(t)$, assuming that these two signals are equiprobable.
b. Calculate the average probability of symbol error incurred by this receiver for $E/N_0 = 4$, where E is the signal energy.

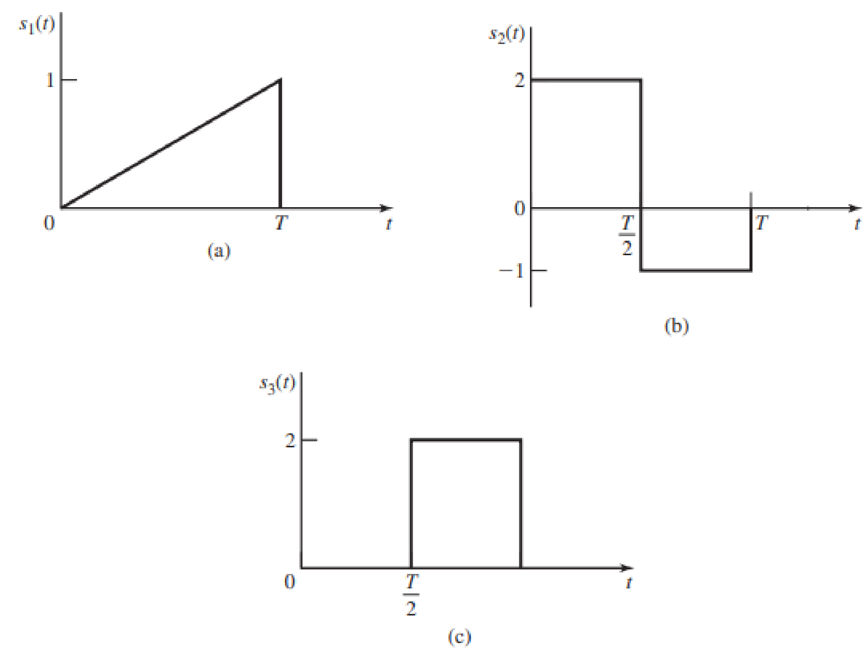
9. Consider the optimum detection of the sinusoidal signal

$$s(t) = \sin\left(\frac{8\pi t}{T}\right), \quad 0 \le t \le T$$

In additive Gaussian noise.

a. Determine the correlator output assuming a noiseless input.
b. Determine the corresponding matched filter output, assuming that the filter includes a delay T to make it causal.
c. Hence show that these two outputs are the same only at time instant t=T.

10. Sketch the impulse response of the filter matched to the pulses shown in the figure. Also determine and sketch the outputs of each of the matched filters.



11. In an additive white Gaussian noise channel with noise power-spectral density of $N_0/2$, two equiprobable messages are transmitted by

$$s_1(t) = \begin{cases} \frac{At}{T}, & 0 \le t \le T \\ 0, & \text{otherwise} \end{cases}$$

$$s_2(t) = \begin{cases} A\left(1 - \frac{t}{T}\right) & 0 \le t \le T \\ 0, & \text{otherwise} \end{cases}$$

a. Determine the structure of the optimal receiver.
b. Determine the probability of error

12. Consider a signal detector with an input

$$r = \pm A + n$$

where +A and −A occur with equal probability and the noise variable n is characterized by the Laplacian pdf. Determine the probability of error as a function of the parameters A and σ.