Q1: Proakis - Communication Systems Engineering (2nd Ed) 7.11
Q2: Proakis - Communication Systems Engineering (2nd Ed) 7.25
Q3: Proakis - Communication Systems Engineering (2nd Ed) 7.14
Q4: Proakis - Communication Systems Engineering (2nd Ed) 7.15
Q5: Proakis - Digital Communications (5th Ed) 9.14
Q6: Proakis - Digital Communications (5th Ed) 9.19
Q7: Proakis - Digital Communications (5th Ed) 9.23
Q8: Proakis - Digital Communications (5th Ed) 9.32
Q9: Proakis - Digital Communications (5th Ed) 9.41
Q10: Proakis - Digital Communications (5th Ed) 9.44
Q11: Haykin - Communication Systems (4th Ed) 4.19
Q12: Haykin - Introduction to Analog & Digital Communications (2nd Ed) 6.18

Matched Filter & Correlator & Error Probability

Q1. In a binary PAM system for which the two signals occur with unequal probabilities (p and $1-p$), the optimum detector is specified by

$$\sqrt{\mathcal{E}_b}\,r \underset{s_2}{\overset{s_1}{\gtrless}} \frac{\sigma_n^2}{2} \ln \frac{1-p}{p} = \frac{N_0}{4} \ln \frac{1-p}{p}$$

a. Determine the average probability of error as a function of $(\mathcal{E}_b/N_0)$ and p.

b. Evaluate the probability of error for $p = 0.3$ and $p = 0.5$, with $\mathcal{E}_b/N_0 = 10$.

Q2. A three-level PAM system is used to transmit the output of a memoryless ternary source whose rate is 2000 symbols/sec. The signal constellation is shown in Figure 1. Determine the input to the detector, the optimum threshold that minimizes the average probability of error, and the average probability of error.

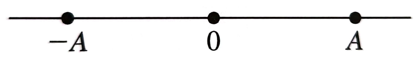

Figure 1: PAM signal constellation

Q3. The received signal in a binary communication system that employs antipodal signals is

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

where $s(t)$ is shown in Figure 2 and $n(t)$ is AWGN with power-spectral density $N_0/2$ W/Hz.

a. Sketch the impulse response of the filter matched to $s(t)$.

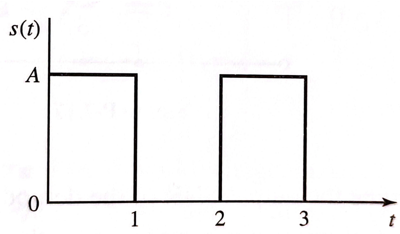

Figure 2: Signal $s(t)$

b. Sketch the output of the matched filter to the input $s(t)$.

c. Determine the variance of the noise of the output of the matched filter at $t = 3$.

d. Determine the probability of error as a function of A and N_0.

Q4. A matched filter has the frequency response

$$H(f) = \frac{1 - e^{-j2\pi fT}}{j2\pi f}$$

a. Determine the impulse response $h(t)$ corresponding to $H(f)$.

b. Determine the signal waveform to which the filter characteristic is matched.

ISI & Raised Cosine & Equalizers

Q5. A voice-band telephone channel passes the frequencies in the band from 300 to 3300 Hz. It is desired to design a modem that transmits at a symbol rate of 2400 symbols/s, with the objective of achieving 9600 bits/s. Select an appropriate QAM signal constellation, carrier frequency, and the roll-off factor of a pulse with a raised cosine spectrum that utilizes the entire frequency band. Sketch the spectrum of the transmitted signal pulse and indicate the important frequencies.

Q6. A voice-band telephone channel has a passband characteristic in the frequency range $300 < f < 3000$Hz.

a. Select a symbol rate and a power efficient constellation size to achieve 9600 bits/s signal transmission.

b. If a square-root raised cosine pulse is used for the transmitter pulse $g(t)$, select the roll-off factor. Assume that the channel has an ideal frequency-response characteristic.

Q7. Consider the transmission of data via PAM over a voice-band telephone channel that has a bandwidth of 3000 Hz. Show how the symbol rate varies as a function of the excess bandwidth. In particular, determine the symbol rate for an excess bandwidth of 25, 33, 50, 67, 75 and 100 percent.

Q8. In a binary PAM system, the input to the detector is

$$y_m = a_m + n_m + i_m$$

where $a_m = \pm 1$ is the desired signal, n_m is a zero-mean Gaussian random variable with variance σ_n^2, and i_m represents the ISI due to channel distortion. The ISI term is a random variable that takes the values $-1/2$, 0, 1/2 with probabilities 1/4, 1/2, and 1/4, respectively. Determine the average probability of error as a function of σ_n^2.

Q9. Binary PAM is used to transmit information over an unequalized linear filter channel. When a = 1 is transmitted, the noise-free output of the demodulator is

$$x_m = \begin{cases} 0.3 & m = 1 \\ 0.9 & m = 0 \\ 0.3 & m = -1 \\ 0 & \text{otherwise} \end{cases}$$

a. Design a three-tap zero-forcing linear equalizer so that the output is

$$q_m = \begin{cases} 1 & m = 0 \\ 0 & m = \pm 1 \end{cases}$$

b. Determine q_m for $m = \pm 2, \pm 3$, by convolving the impulse response of the equalizer with the channel response.

Q10. Determine the tap weight coefficients of a three-tap zero-forcing equalizer if the ISI spans three symbols and is characterized by the values $x(0) = 1$, $x(-1) = 0.3$, $x(1) = 0.2$. Also determine the residual ISI at the output of the equalizer for the optimum tap coefficients.

Q11. A binary PAM wave is to be transmitted over a baseband channel with an absolute maximum bandwidth of 75 kHz. The bit duration is $10\mu s$. Find a raised-cosine spectrum that satisfies these requirements.

Q12. The sampled impulse response of a data-transmission system (encompassing the transmit filter and channel) is defined by

$$c_m = \{0.0, 0.15, 0.68, -0.22, 0.08\}$$

For zero-forcing equalization of the system, it is proposed to use a three-tap transversal filter.

a. Calculate the adjustable weights of the equalizer.

b. Using the equalizer determined in part (a), calculate the residual intersymbol interference at the equalizer output.

c. Identify the magnitude of the sample making the largest contribution to the residual intersymbol interference.