S-38.411 Signal Processing in Telecommunications I
Exercise #4: Nonlinear equalizers

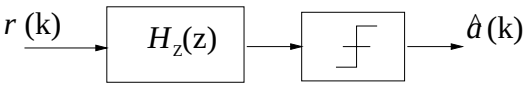
March 31, 2000

Exercise 1:

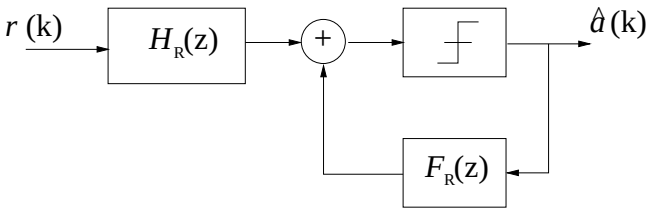
The output from a linear channel is given by $r(k) = a(k) + \alpha a(k-1) + n(k)$, where the $|\alpha| < 1$, $a(k) \in \pm 1$ is the transmitted signal sequence, and $n(k)$ is additive white noise with variance σ_n^2. In this exercise you will design a zero-forcing and a decision feedback equalizer for the given channel (see Figure 1 below).

a) Find the zero-forcing equalizer $H_Z(z)$ and draw the filter structure.

b) Find the decision feedback equalizer filters ($H_R(z)$, $F_R(z)$) so that the total MSE is minimized.



(a)



(b)

Figure 1: a) Zero-forcing equalizer (ZF-E) b) Decision feedback equalizer (DFE)

Exercise 2:

The binary sequence $\mathbf{x}$, $x_k \in \{0, 1\}$, is transmitted over a channel with additive white Gaussian noise. The channel impulse response is given by $c(k) = \delta(k) + 0.5\delta(k-1)$.

a) Model the system as a shift register process and draw the state transition diagram. Label the arcs with the input/output pairs (x_k, s_k)

b) Draw one stage of the trellis and label with the input/output pairs (x_k, s_k)

c) Assume $x_k = 0$ for $k \leq 0$. Draw the trellis diagram.

d) Suppose the noisy received sequence is $\mathbf{r} = (0.6, 0.9, 1.4, 0.3)$. Use the Viterbi algorithm to find the ML decision sequence.

Homework 4

The homework is to be returned to the course box *at latest* April 14, 15:00. The course box can be found near the course information board on the second floor in the G wing. Each set of homework can give up to 1 point on the final exam. Remember to motivate each step in your solution. Write your name and student number on each page.

1. Suppose the binary sequence $\mathbf{x}$, $x(k) \in \{\pm 1\}$, is transmitted over a channel with additive white Gaussian noise (AWGN). The channel is given by $C(z) = 1 + z^{-1} + z^{-2}$.

a) Model the system as a shift register process and draw the state transition diagram. Label the arcs with the input/output pairs (x_k, s_k)

b) Draw one stage of the trellis and label with the input/output pairs (x_k, s_k)

c) Assume the initial state to be $(x_0, s_0) = (-1, -1)$. Draw the trellis diagram.

d) Suppose the noisy received sequence is $\mathbf{r} = (-3.2,\ -1.1,\ ,0.9,\ 0.1,\ 1.2,\ 1.5,\ 0.7,\ -1.3)$. Use the Viterbi algorithm to find the ML decision sequence.

e) Assuming only an AWGN channel and symbol-by-symbol decision, what is the ML decision sequence of $\mathbf{r}$ above?