Tutorial No.4

Period 3 - 2006

Topic:ISI, Bandpass modulation/demodulation

Exercise 1

The 16-QAM signal constellation shown in Fig. 1 is an international standard for telephone-line modems (called V.29). Determine the optimum decision boundaries for the detector, assuming that the SNR is sufficiently high so that errors only occur between adjacent points.

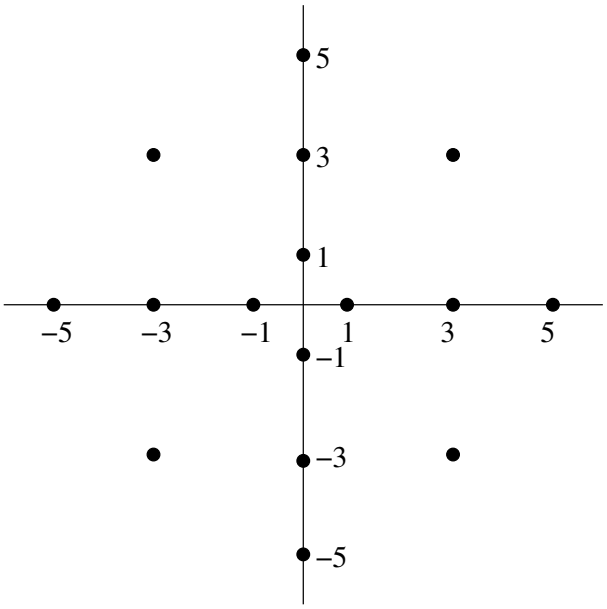

Figure 1: Signal constellation of V.29 modem

Exercise 2

Determine the bit rate that can be transmitted through a 4 KHz voice-band telephone (bandpass) channel if the following modulation methods are used:

1. Binary PSK
2. 4-PSK (QPSK)
3. 8-QAM
4. Binary orthogonal FSK with non-coherent detection
5. Orthogonal 8-FSK with non-coherent detection.

For parts 1-3 assume that the transmitter pulse shape has a raised cosine spectrum with a 50% roll-off.

Exercise 3

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

$$y_m = a_m + n_m + i_m \tag{1}$$

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 which takes the values -0.5, 0, 0.5 with probabilities 0.25, 0.5, 0.25, respectively. Determine the average probability of error as a function of σ_n^2.

Exercise 4

The frequency response characteristics of a lowpass channel can be approximated by

$$H(f) = \begin{cases} 1 + \alpha\cos(2\pi f t_0), & |\alpha| < 1, \quad |f| \le W; \\ 0, & \text{otherwise.} \end{cases} \tag{2}$$

where W is the channel bandwidth. An input signal $s(t)$ whose spectrum is bandlimited to W Hz is passed through the channel.

1. Show that

   $y(t) = s(t) + \frac{\alpha}{2}[s(t - t_0) + s(t + t_0)]$

   The channel produces a pair of echoes.

2. Suppose that the received signal $y(t)$ is passed through a filter matched to $s(t)$. Determine the output of the matched filter at $t = kT, k = 0, \pm 1, \pm 2, \cdots$, where T is the symbol duration.

3. What is the ISI pattern resulting from the channel if $t_0 = T$?