S-72.2505 Digital Transmission Methods

Exam 16.12.2009

This is a closed book exam

1. Compare the performance of two constellations. Errorless QAM constellation (plot a in figure 1) and QAM constellation with an IQ error (plot b in figure 1). All symbols are used equally often.

   a) Compute symbol error probability for both constellations.

   b) Compute bit error probability for Gray mapping shown in the figure.

   Express the peformane in terms of $\frac{d}{\sigma}$

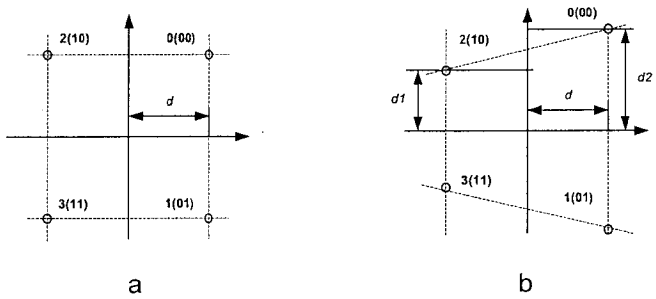

Figure 1. Signal constellation in quesiton 1. a) errorless constellation. b) costellation with IQ imbalance. In the figure $d = 1$, $d_1 = 0.8d$ $d_2 = 1.2d$.

2. The system is using 4 orthogonal basis functions for transmitting 1 bit of information (2 symbols). The vector representation of the symbols corresponding to the bits are

$$s_1 = [3A \;\; 2A \;\; 1A \;\; 0A]; \;\; s_2 = [0A \;\; 1A \;\; 2A \;\; 0A].$$

   Where A is the scaling amplitude of the signal. The signal is transmitted over an AWGN channel with noise power spectral density N_0.

   a) Express the equation that the optimal receiver is implementing.

   b) Draw the block diagram of the receiver that implements the equation of the optimal receiver. (Include also the matched filters to the basis functions).

   c) Express the BER performance as a function of $\frac{A}{N_0}$.

3. Calculate how many bit A/D is required if:

   (a) The receiver noise floor is 75 dBm. (This noise power contains the noise due to thermal noise and front end noise).

   (b) The noise added by A/D can not exceed 1 dB.

   (c) The maximum received signal power is -55 dBm.

   (d) For coping with the signal peak to average ratio and implementation losses the system reserves 15 dB margin.

4. Answer shortly to the following questions.

   a) What is the pulse shaping?

   b) Why do we need pulse shaping?

c) Why the Sinc pulse is not good for pulse shaping?

d) Why we use raised root cosine (RRC) pulse shaping?

e) What tradeoff is being made if the RRC pulse is used?

5. Assume a discrete channel model $h = [1 \;\; 0.5 \;\; 0.2]$

a) Express the received signal model after this channel and with additive white Gaussian noise.

b) Write out separately the parts of the model that represents the useful symbol and the part that represents the inter-symbol interference.

c) How would the transmitted signal power spectrum look like ? How would the signal power spectrum look like after the channel? Illustrate the spectrum by drawing examples.

d) How would the spectrum look like after linear zero forcing (ZF) equalizer?

e) Why is the minimum mean square error (MMSE) preferable to the ZF equalizer?