S-72.2505 Digital Transmission Methods

Exam 10.12. 2013

All five tasks are evaluated and taken into account in the grading. The exam can be written in Finnish, Swedish or English.

This is a closed book exam

1. Answer shortly the following questions.

   a) What is pulse shaping?

   b) Why is pulse shaping needed?

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

   d) What characteristics of Root Raised Cosine (RRC) pulses make them more attractive than sinc pulses?

   e) What tradeoff is controlled by the roll-off parameter in RRC pulse shaping?

2. The error probability of differential BPSK in the Additional White Gaussian Noise channel is $P_b(\gamma) = \frac{1}{2}e^{-\gamma}$, where γ is the instantaneous Signal-to-Noise Ratio (SNR).

   a) Derive the expression for average bit error probability of differential BSPK in a Rayleigh fading channel without diversity.

   b) Derive the expression for average bit error probability of differential BSPK in a Rayleigh fading channel with selection combining of two equally strong diversity branches.

   c) Calculate the **diversity gain** in dB (= the reduction in the average required SNR) for differential BPSK with two branch selection diversity at the bit error probability values 10^{-2} and 10^{-4}.

   Hint: If there are M diversity branches and $\bar{\gamma}$ is the SNR per branch, the CDF of post-combining SNR γ_c with selection diversity is $P(\gamma_c < \gamma) = \left(1 - e^{-\gamma/\bar{\gamma}}\right)^M$.

3. Consider a transmission using two signals in the interval $[0, T]$. One transmission has value 1 between 0 and $2T/3$ and is zero elsewhere and the other has value 1 between $T/3$ and T and is zero othewise:

$$s_1(t) = \begin{cases} 1 & t \in [0, \frac{2T}{3}] \\ 0 & t \in (\frac{2T}{3}, T] \end{cases} \quad s_2(t) = \begin{cases} 0 & t \in [0, \frac{T}{3}) \\ 1 & t \in [\frac{T}{3}, T] \end{cases}$$

   a) Use the Gram-Schmidt algorithm to derive a set of orthonormal basis functions for this signal set.

   b) Give the vectors of 2D coordinates representing these signals given the computed orthonormal basis functions.

   c) Show that the basis functions are orthogonal.

   d) Draw the constellation diagram of the signal set if $T = 1$.