ELEC-C7230 Tietoliikenteen siirtomenetelmät

Midterm II, 10.4.2019

1. Answer shortly the following questions.

   a) What is pulse shaping?

   b) Why is pulse shaping needed?

   c) What problems may arise from using the time domain rectangular pulse?

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

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

   f) Which tradeoff is controlled by the roll-off parameter in RRC pulse shaping?

2. Consider 16-PAM and 16-QAM modulaation. One is real-valued, the other complex valued. Both transmit 4 bits per symbol. Noise energy per dimension is $N_0/2$.

   With real-valued modualtion, all power is used on the I-branch, leading to I-branch signal-to-noise ratio (SNR) $\gamma_I^{\mathrm{Re}} = \frac{E_s}{N_0/2}$ and $\gamma_Q^{\mathrm{Im}} = 0$. Here E_s is the symbol energy, power times symbol period. For complex-valued signaling, the power is divided among the dimensions, such that $\gamma_I^{\mathrm{Im}} = \gamma_Q^{\mathrm{Im}} = \frac{E_s/2}{N_0/2}$.

   We estimate the power needed for reliable communication from the maximal spectral efficiency given by Shannon's law. For a real-valued signal we have $C^{\mathbb{R}} = \frac{1}{2}\log_2(1+\gamma_I)$ while for a complex-valued one it is $C^{\mathbb{C}} = \frac{1}{2}\log_2(1+\gamma_I) + \frac{1}{2}\log_2(1+\gamma_Q)$.

   Compute the required signal energy from Shannon's law (in units of N_0), when we aim at spectral efficiency 4 bps/Hz, both for complex- and real-valued modulation. How much more power is needed, if 4 bits are transmitted with real, as opposed to complex-valued modulation? Give the solution in dB-scale.

3. We use a spreading factor 2 Walsh-Hadamard code to transmit two code multiplexed signals in parallell to a user during two transmission samples, or "chips". The spreading code matrix is

$$\mathbf{C} = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}.$$

   a) Two code multiplexed symbols s_1 and s_2 are transmitted during the two chips. Compute the transmitted discrete time signal. (2p)

   b) The following chip sequence is received: $0, \sqrt{2}, \sqrt{2}, 0, -\sqrt{2}, 0, 0, -\sqrt{2}$. BPSK modulation has been used, and there is no noise. What are the transmitted BPSK-symbols? (4p)

   Hint: The transmitted chip-sequence consists of four consecutive Walsh-Hadamard transformed vectors.