Exercise 5

Task 1. A digital communication system requires a bitrate R_b = 1 Mbps. Consider the following possible choices of base Nyquist pulses used for baseband PAM modulation: rectangular NRZ, sinc-shaped, and raised cosine with 20% roll-off.

a) **Estimate the transmission bandwidth required by binary PAM in the three cases.**
b) **Find the minimum *m*-ary PAM size required to transmit the signal with a bandwidth of only W = 350 kHz, and the maximum usable roll-off in this case.**
c) **Explain how does the required transmission bandwidth changes between a baseband PAM and radio frequency (carrier-modulated) PAM.**

Task 2. Consider the following possible radio frequency modulations: BPSK, QPSK, and 16-QAM.

a) **Assuming the bitrate is fixed R_b = 1 Mbps, for each of these modulations calculate the symbol rate, the minimum required transmission bandwidth, and the maximum achievable spectral efficiency.**
b) **Explain how spectral efficiency is affected by the roll-off when using raised cosine or root raised cosine pulses, and calculate the effect on the spectral efficiency with a roll-off of 10%, 25% or 50%.**
c) **Compare the minimum Euclidian distances of these modulations, when the average transmission power is the same for all of them.**

Task 3. A digital video broadcasting system uses ODFM with 2048 QPSK subcarriers within a system bandwidth of 8.2 MHz. A guard band of 4 kHz on both sides of the spectrum.

a) Find the length of the OFDM symbol duration.

b) Calculate the maximum bitrate provided when all subcarriers are active.

c) If one subcarrier every 8 is unused, find how many of the active subcarriers should be changed to 16-QAM in order to maintain the same total bitrate.

d) Explain how the total bitrate changes if a guard interval of 25% is used.

Task 4. Explain shortly how signals separation is achieved by the different multiplexing principles of FDM, TDM, CDM and SDM. List the most important advantages and drawbacks of each method.

Task 5. A digital communication system uses DS-CDMA with spreading codes of length 4.

a) **Find the maximum number of users that can be granted simultaneous access for transmission using orthogonal spreading codes, and choose a set of possible codes.**
b) **Calculate the sequence s_{11} obtained by encoding a source bit sequence b_1=[-1 1] using the spreading code s_1 = [-1 1 1 -1].**
c) **Calculate the cross-correlation between the sequence s_{11} and the spreading code s_1, and compare it with the cross-correlation between the sequence s_{11} and a different spreading code s_2 = [1 -1 1 -1].**