ETT_3005 DIGITAALISET TIETOLIIKENNEJÄRJESTELMÄT

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Note: Use of calculator is allowed, the necessary equations and Q-function table are appended in the last three pages.

1. Explain the following:
   a) The purpose and tasks of digital communication system components. Draw the overall structure and name the components. **(2p)**
   b) The need for time synchronization and its components **(1p)**
   c) Orthogonal frequency division multiplexing (OFDM) **(1p)**
   d) Entropy of an information source. **(1p)**
   e) The three automatic repeat request systems **(1p)**
   f) The features of three digital M-ary modulation techniques and comparison of their spectrum efficiency. **(1p)**
   g) Direct sequence spread spectrum communication scheme and its advantages **(1p)**

2. Consider a communication system, which has an information source that emits 1000 symbols/second and uses rectangular M-ary QAM with M = 32 modulation and the noise in the channel is only AWGN.
   a) If the information content of each source output symbol is 6 bits, what is the required signal bandwidth? **(1p)**
   b) What channel capacity is achievable if the SNR (E_b/N_0) is 40dB? **(1p)**
   c) If the system uses a rectangular 64-QAM modulation, what will be the required E_b/N_0 for achieving bit error rate of $P_b = 4*10^{-5}$? **(2p)**

3. Consider the (7,4) cyclic code generated by $g(x) = 1 + X + X^3$
   a) What is the generator matrix of this code? **(2p)**
   b) Determine the code rate and parity check matrix. **(1p)**
   c) Which of the following codewords belong to this code 1010001, 1110010, 1011101? **(1p)**

4. A CDMA system consists of 32 equal-power users that transmit information at a rate of 20 kbits/s, each using a DS spread spectrum signal operating at a chip rate of 4MHz. The modulation is binary PSK.
   a) Determine the E_b/J_0, where J_o is the spectral density of the combined interference. **(2p)**
   b) How much the processing gain should be increased to allow for doubling the number of users without affecting the output SNR? **(2p)**

5. Consider the two 16-QAM signal constellations shown in Figure 1.
   a) The constellation in Figure 1(a) is an international standard for telephone-line modems. Ignoring the four corner points at ($\pm 1.5\Delta$, $\pm 1.5\Delta$), specify a Gray mapping of the constellation in Figure 1(a). **(1p)**
   b) Assume that all the 16 signal points are equally likely, sketch the optimum decision boundaries of the minimum-distance receiver for both constellations. **(1p)**

c) Calculate the average energy of both constellation and determine which of the constellation is more energy-efficient? **(2p)**

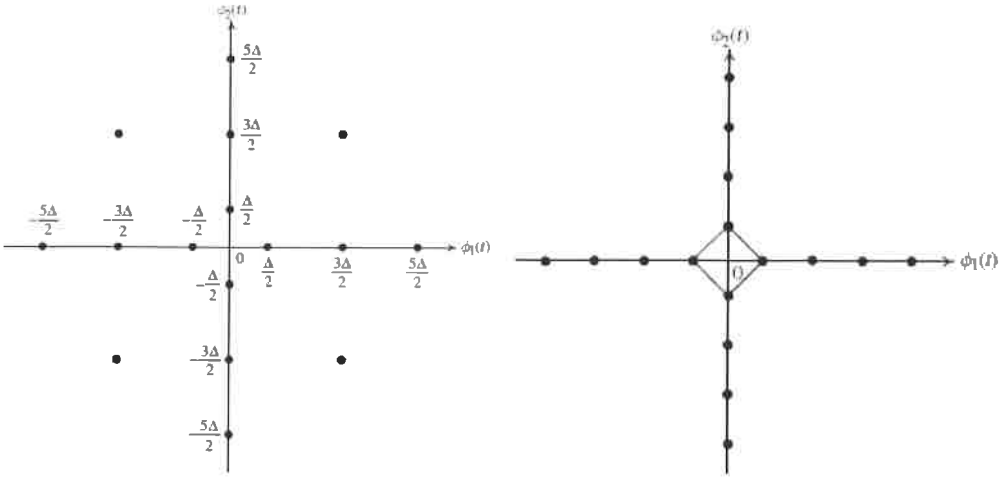

Figure 1 16-QAM Constellations