

## ETT\_3005 DIGITAALISET TIETOLIIKENNEJÄRJESTELMÄT

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Note: Use of calculator is allowed, the necessary equations and q-table are given 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) Advantages of spread spectrum communication **(1p)**
  - c) Hamming distance and hamming weight of a codeword **(1p)**
  - d) Intersymbol interference and the three techniques to tackle the effect of intersymbol interference **(1p)**
  - e) Entropy of an information source **(1p)**
  - f) Three digital binary modulation techniques and their features. **(2p)**
2. Suppose that QPSK is used for transmitting information over an AWGN with a power spectral density of  $0.5N_0 = 10^{-10}$  W/Hz. The transmitted signal energy is  $E_b = 0.5A^2T$ , where T is the bit interval and A is the signal amplitude. Determine the signal amplitude required to achieve an error probability of  $10^{-6}$  when the data rate is 100kbits/s and 300kbits/s. **(4p)**
3. The generator matrix of a (6, 3) systematic linear block code is given as follows

$$G = \begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

- a) What is the code rate and parity-check matrix for this code? **(1p)**
  - b) Determine the minimum hamming distance. **(1p)**
  - c) Determine which of the following vectors are codewords in the code { 110110, 111010, 000011, 110001}? **(2p)**
  - d) How many bits error within a given codeword can be corrected in this coding? **(1p)**
4. A discrete memoryless source outputs letters from the alphabet A, B, C, and D with respective probabilities 0.15, 0.25, 0.3, 0.3.
    - a) What is the average information content of the source output? **(1p)**
    - b) If this source outputs 400 alphabets per second, what is the bit rate of the source output?  
**(1p)**
    - c) Use Huffman encoding procedure to determine binary code for the source output alphabets? **(2p)**

5. Consider a communication system which has an information source that emits 1500 symbols/second and uses rectangular M-ary QAM with  $M = 16$  modulation and the noise in the channel is only AWGN.
- a) If the information content of each source output symbol is 3 bits, what is the required signal bandwidth? **(2p)**
  - b) What channel capacity is achievable if the SNR ( $E_b/N_0$ ) is 40dB? **(1p)**
  - c) If the system uses a rectangular 32-QAM modulation, what will be the required  $E_b/N_0$  for achieving bit error rate of  $P_b = 4 \times 10^{-5}$ ? **(1p)**