Digital Communication Systems Exam

January 23, 2017

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

1. Explain the following:
   a) Spread spectrum techniques and its advantage in digital communication (1p)
   b) Encryption and its advantages (1p)
   c) The three commonly used multiple access techniques (1p)
   d) additive white Gaussian noise (1p)
   e) The principle of one of the three automatic repeat request schemes (1p)
   f) Structure of a digital communication system and the purpose as well as tasks of each component (2p)
   g) discrete memoryless channel (1p)

2. Consider a communication system which has an information source that emits 1000 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 $P_b = 4*10^{-5}$? (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 communication system with a channel bandwidth of 10kHz and possible channel noise of 10^{-19} watts/Hz is implemented for a communication based application. The application requires a received signal power of 1picowatt.
   a) Determine the channel capacity? (2p)
   b) Is the channel capable to transmit data at a transmission rate of 60kbps? (1p)
   c) Is it possible to support the 60kbps transmission rate if the bandwidth of the channel decreases to 1kHz? (1p)

5. A DS spread-spectrum system transmits at a rate of 1500 bits/s in the presence of a tone jammer. The jammer power is 40dB greater than the desired signal and the required E_b/J_0 to achieve satisfactory performance is 30dB. Ignore the additive noise.

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

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 {0011000, 1010001, 1110100, 0101011}? (2p)
d) How many bits error within a given codeword can be corrected in this coding? (1p)

6. A discrete memoryless source outputs letters from the alphabet R, S, T, U, and V with respective probabilities 0.1, 0.15, 0.2, 0.25, 0.3.
   a) What is the average information content of the source output? (1p)
   b) If this source outputs 500 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)