TLT-5406 DIGITAL TRANSMISSION
Exam 19.11. 2012/M. Renfors

No calculator needed/allowed!

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1. (a) Assume that a source produces r binary symbols per second and the probability of binary 1 is p. Further, it is assumed that the source symbols are statistically independent of each other. What is theoretically the lowest bit-rate (as a function of p and r) which can be used for transmitting the information provided by the source? In which case this rate is maximized for given r and what is the corresponding bit-rate?
   (b) Assume that the rate of the source is 100 kbit/s. What is theoretically the smallest bandwidth which can be used in passband transmission of the bit sequence using *(i)* QPSK modulation, *(ii)* 64-QAM modulation?

2. In a QAM system, the transfer function of the transmit filter is $G(f)$ and the channel transfer function is $B(f)$.
   (a) What is the transfer function of the matched filter in the receiver?
   (b) What is the transfer function of the sampled matched filter system model (including the effects of transmit filter, channel, receiver matched filter, and symbol-rate sampling).
   (c) Under which conditions, there is no intersymbol interference (ISI) at the sampled matched filter output?
   (d) Which additional block is needed in the receiver to reach zero/small ISI with practical frequency-selective channels?

3. Describe the principle of maximum likelihood sequence detection. Explain (e.g., through an example) how Viterbi algorithm can be used to implement efficiently maximum likelihood sequence detection. For which different purposes Viterbi algorithm can be used in digital transmission systems? In which cases Euclidian distance and Hamming distance are used as path metrics?

4. Describe the principles and structures of linear equalizer (LE) and decision-feedback equalizer (DFE). Which are the advantages and disadvantages of LE and DFE?

5. Explain briefly the following terms:
   - Systematic code
   - Soft decision decoding
   - Hamming distance
   - Euclidian distance
   - Puncturing