ELT-41307 COMMUNICATION THEORY 12.12.2016

No materials, no calculator. Prepared by and return to: Mikko Valkama.

NB 1: If you wish to take the Full Exam, answer to all the questions 1-6. If you wish to take only the 2nd Midterm Exam, answer only to the questions 4-6.

NB 2: Pay special attention to clear handwriting. If I cannot read your text with reasonable effort, your paper cannot be unfortunately graded. So, please, try to write in a clear manner. Thank you.

1. Explain shortly the following concepts: a) amplitude spectrum, b) cross-correlation, c) wide-sense stationary random signal, d) spectral density, e) white noise. No need to dwell on details, rough explanation which shows your understanding is enough. (5p)

2. Assume $x(t)$ is a real-valued wide-sense stationary random signal. Suppose another random signal $y(t)$ is created as $y(t) = x(t) + a_1 x(t - T_1)$ where a_1 and T_1 are known constants. First, calculate the autocorrelation function of $y(t)$ and express it in terms of the autocorrelation function of $x(t)$. Suppose then that $x(t)$ is white noise. In that case, what are the autocorrelation function and spectral density of $y(t)$? (5p)

3. Explain the general concept of I/Q modulation. Illustrate the principle by drawing a block-diagram of an I/Q modulator, and some example spectral contents of the relevant signals in different stages. How does I/Q modulation utilize the structure of a general bandpass signal, sketched below, and how can the receiver recover the I and Q components ? (5p)

$$x_{BP}(t) = A(t)\cos(\omega_C t + \varphi(t)) = x_I(t)\cos(\omega_C t) - x_Q(t)\sin(\omega_C t)$$

4. Explain shortly the basic principle of Nyquist pulse-shaping filtering and pulse amplitude modulation (PAM), in the context of baseband digital communication. What does the concept of intersymbol interference mean ? (5p)

5. Suppose you are to design an I/Q modulated single-carrier M-QAM digital communication system where the target physical layer bit rate is 32 Mbit/s, and that you have 10 MHz bandwidth available around a center-frequency of 1800 MHz. Design the system in terms of the needed QAM symbol alphabet size, symbol rate and feasible nonzero excess bandwidth (rolloff) factor for a raised-cosine pulse. (5p)

6. Explain shortly the concepts of entropy, mutual information and channel capacity. What is the meaning of channel capacity for a communications engineer ? In an additive Gaussian noise channel, what is dictating or determining the channel capacity ? (5p)

Maximum points, Full Exam: 5+5+5+5+5+5 = 30p.

Maximum points, 2nd Midterm Exam: 5+5+5 = 15p.