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: Please 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) phase spectrum, c) wide-sense stationary random signal, d) spectral density, e) white noise. No need to dwell on details, rough explanations which show your understanding are enough. (5p)

2. Explain and characterize (in both time and frequency domains) the concept of distortionless (distortion-free) transmission? What kind of different distortions are commonly encountered in communication systems ? As an example, consider a system where the transmitted signal $x(t)$ is received as $y(t) = x(t) + ax(t-\tau)$. Determine the impulse and frequency responses of this system and illustrate them graphically. What kind of distortions does this system cause (if any) ? How do these distortions depend on the values of a and τ and on the input signal bandwidth ? (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 ? How are the bandwidth and bit-rate calculated in baseband PAM systems ? (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 128 Mbit/s, and that you have 20 MHz bandwidth available around a center-frequency of 2600 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. Draw also an elementary block-diagram of the transmitter, starting from the transmit bit sequence towards the I/Q modulated waveform. (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 a bandlimited 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