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

NB 1: 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.

NB 2: A maximum of two full response sheets is allowed.

1. Explain shortly the following concepts in the context of electrical or electromagnetic communications: a) spectrum, b) nonlinear distortion, c) correlation function, d) spectral density, e) white noise, f) signal-to-noise ratio (SNR). No need to dwell on finest details, rough explanations which show your understanding are enough.
2. Explain the basic principles of Nyquist pulse-shape filtering based baseband pulse amplitude modulation (PAM) and I/Q modulated single-carrier PAM/QAM/PSK techniques, in the context of digital communication. How are the bandwidth and bit-rate calculated in the two techniques (baseband system and I/Q modulated system)? Give also a feasible numerical example. What does intersymbol interference (ISI) mean?
3. Explain the basic principle of frequency shift keying (FSK). How is the physical-layer bit-rate calculated for FSK-based systems? What are the most fundamental aspects in designing an FSK-based system and the associated frequencies? Finally, explain shortly the concept of minimum shift keying (MSK).
4. Explain briefly the basic ideas of multicarrier modulation / OFDM and multi-antenna / MIMO communications. Discuss also shortly the benefits of OFDM compared to single-carrier PAM/QAM/PSK and the corresponding benefits of multi-antenna/MIMO compared to single-antenna systems.
5. Explain shortly what is meant by (i) information, (ii) entropy and (iii) mutual information, in the context of electrical or electromagnetic communications. Explain also what is meant in this context by channel capacity. Assuming a bandlimited additive white Gaussian noise (AWGN) channel, what factors are determining the channel capacity? Give also a numerical example.

Maximum points: $5 \times 6 = 30$ p