Suomenkieliset kysymykset toisella puolella. Basic calculator allowed. Prepared by M. Valkama.

1. Explain and characterize (in both time and frequency domains) distortionless transmission? What kind of distortions are typically encountered in transmission systems, and how do they affect the signal spectrum? Given that a system is excited by two sinusoidals (frequencies f_1 and f_2, amplitudes A_1 and A_2, phases ϕ_1 and ϕ_2), how are these different distortion types seen in the corresponding quantities (frequencies, amplitudes, phases) of the output signal?

2. What is meant by the concept random signal ? Why one usually needs to consider such random signals in analyzing and modeling communication systems? In this context, explain briefly what is meant by the following terms or concepts (a) stationarity (strict-sense vs. wide-sense), (b) autocorrelation, (c) power spectrum, (d) white noise, (e) probability density / distribution.

3. (a) A general bandpass signal can be expressed mathematically as

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

Sketch an example waveform and the corresponding spectrum of this kind of signal. In the above expression, what do the quantities or functions $A(t)$, $\phi(t)$ and ω_C (or f_C) represent physically? Sketch also the spectrum of the corresponding lowpass equivalent signal. What's the time domain expression for this lowpass equivalent signal and how does it describe the waveform characteristics of the original bandpass signal?

(b) Compare AM, DSB, and FM modulations concerning (*i*) transmission bandwidth and (*ii*) operation in noisy channels. Which modulation would you choose to your own transmission application and why?

4. Describe the basic idea of synchronous detection. Illustrate the principle by sketching the essential signal spectra at different stages of the detector. What are the main practical difficulties in using synchronous detection and why? What types of modulated signals can be detected in general using the synchronous detection principle? Why?

5. (a) Explain shortly what is meant by (*i*) information and (*ii*) entropy. Explain also what is meant in this context by channel capacity. (Here it is sufficient to keep the description at a conceptual level.)

(b) Let's consider a carrier-modulated digital PAM/PSK/QAM system where the target bit rate is 12 Mbits/s and the available transmission bandwidth around the center-frequency is 5 MHz. Design the system at waveform level, i.e., determine reasonable values for the key parameters (symbol rate, alphabet size, excess bandwidth, etc.). Explain the thinking behind your design. How about the corresponding design in case of baseband PAM system with the same target bit rate of 12 Mbits/s and similar physical transmission bandwidth of 5 MHz?

Maximum points: 5 x 6 = 30p.

Reminder: Extra lectures for 7cr people in January, stay tuned at the website!

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