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TLT-5206 COMMUNICATION THEORY Final Exam 20.12.2012

Prepared by M.Valkama, no materials, no calculators

(*Suomenkieliset kysymykset paperin toisella puolella*)

1. Explain the concept of distortionless transmission. Given the transmit signal is $x(t)$, and the system is distortionless, how does the received signal $y(t)$ depend on the transmit signal and the properties of the system? Based on this, what kind of transfer function, and thereon amplitude- and phase responses, does a distortionless system have? What kind of distortions are typically encountered in transmission systems, and how do they affect the signal spectrum?

2. Explain what is meant by a Hilbert transformer and how is it related to SSB modulation. Explain also how a real-valued signal can be transformed into an analytic signal (i.e., into a signal which consists of only the positive frequency components of the original signal) using a Hilbert transformer. How is this related to SSB modulation?

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 shape and 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) Explain shortly the basic idea of frequency modulation (FM). Sketch also the essential waveform shape and spectrum of the modulated signal (at principal levels) when the modulating signal is a single sine-wave (frequency f_M). Explain the basic pros and cons of FM compared to linear modulations.

4. Present the time domain mathematical model for ideal sampling process. Given the spectrum of a continuous-time signal, sketch (i.e., draw) also the corresponding spectrum after ideal sampling. Based on that, formulate the basic requirement in order to avoid aliasing. Explain also the basic idea of reconstruction both in time and frequency domains. Finally, tell the basic idea of sub-sampling principle in bandpass signal context.

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 18 Mbits/s and the available transmission bandwidth around the center-frequency is 8 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 18 Mbits/s and similar physical transmission bandwidth of 8 MHz?

Maximum points: 5 x 6 = 30p.