

# **ECE 440 – Spring 2019**

## **Syllabus**

1. Block diagram of a communications system
2. Signals and systems
  - 2.1. Important signals
  - 2.2. Energy and power signals
  - 2.3. Convolution
3. Spectral analysis of continuous time signals
  - 3.1. Fourier series
  - 3.2. Continuous time Fourier Transform (CTFT) and inverse
  - 3.3. Transform theorems (linearity, superposition, shifting, modulation, convolution, etc.)
  - 3.4. Parseval's theorem.
4. Time-average correlation and power spectral density (PSD) for deterministic signals.
5. Linear time-invariant systems
6. Sampling and reconstruction. Aliasing and Nyquist frequency.
7. Linear Modulations
  - 7.1. Double sideband modulation.
  - 7.2. Amplitude modulation.
  - 7.3. Single sideband modulation.
  - 7.4. Vestigial sideband modulation.
8. Superheterodyne receiver
9. Angle modulations
  - 9.1. Phase modulation (PM) and Frequency modulation (FM).
  - 9.2. Narrowband angle modulation
  - 9.3. Spectrum and power of angle modulated signals. Carson's rule.
  - 9.4. Demodulation: frequency discriminator
  - 9.5. Demodulation: PLL

10. Review of basic probability and statistics
  - 10.1. Theorems (Total probability, Bayes, etc.)
  - 10.2. Random variables (pdf, cdf, expectation, variance, correlation, independence, etc.)
  - 10.3. Important statistical distributions
  - 10.4. Central limit theorem.
  - 10.5. Multivariate Gaussian distribution.
11. Random processes
  - 11.1. Definitions
  - 11.2. Stationarity
  - 11.3. Ergodicity
  - 11.4. Gaussian random processes.
  - 11.5. Mean, variance, auto-, cross-correlation, and power spectral densities.
  - 11.6. Effect of LTI systems
12. Noise in modulation systems
  - 12.1. Additive White Gaussian Noise
  - 12.2. Signal to Noise Ratios (SNR)
  - 12.3. Threshold effect in FM demodulation
13. Multiplexing
14. Digital modulations
  - 14.1. Pulse Modulations (PAM, Delta, PCM, PWM, PPM).
  - 14.2. Quantization noise
  - 14.3. Inter-Symbol-Interference (ISI) and Nyquist criterion
  - 14.4. Equalization
15. Matched filters
16. Vector space representation of signals
  - 16.1. Norm, inner product, orthonormal functions
  - 16.2. Schwartz inequality
  - 16.3. Symbol constellations
  - 16.4. Gray coding
17. M-ary modulations
  - 17.1. PAM, ASK, PSK and FSK signaling schemes.
  - 17.2. Energy, Bandwidth and error rates
18. Introduction to Spread spectrum communications: DSSS and CDMA
19. Introduction to multi-carrier modulation: OFDM
20. Cellular radio: Historical overview of 1G through 5G.

- 21. Introduction to Multiple-Input-Multiple-Output (MIMO) communications
- 22. Information theory
  - 22.1. Entropy
  - 22.2. Discrete channel models
  - 22.3. Channel capacity
  - 22.4. Source coding: Huffman
  - 22.5. Channel coding: Hamming
  - 22.6. Minimum distance, MAP and ML decoding
  - 22.7. Burst error correction: interleaving and non-binary codes