ECE 440 – Spring 2019
Review Midterm 1

Non-exhaustive list of concepts covered

All the questions will be on the material from the lectures, no questions from the lab. The exam will cover up to and including the material covered on Friday 02/15. Make sure to review the homeworks and past midterms posted on Blackboard.

This list could be updated depending on the progress of the class. Make sure to check again a few days before the midterm. Updates will be in red font.

The exam will be closed book and closed notes. A simple scientific calculator is allowed but not needed. You are free to leave your answers in any form that can be directly computed with a calculator (e.g. sin(30) instead of 0.5).

The following list of topics is indexed according to the 7th edition of the book. The same material should be in the 6th edition, but it could be in a different section or chapter.

1 Chapter 1

Block diagram of a communications system.

2 Chapter 2

- All definitions in section 2.1 and 2.2 (same sections in 6th edition of the book): types of signals, phasors, singularity functions, convolution, energy, power, rms value, etc.
- Understand AND be able to derive delta function properties.
- Definitions of Fourier series and continuous Fourier transform (CFT), and their inverses.
- Know AND be able to prove the transform theorems for CFT: linearity, superposition, duality, modulation, convolution, etc.
- Know AND be able to show the symmetries of the CFT for real x(t).
- Parseval's theorem.
- Time-average correlation and power spectral density (PSD) for deterministic signals.
- Linear time-invariant (LTI) systems characterization (impulse response and transfer function).
- LTI system response to periodic inputs.
- Know the definition and time scaling property of $\Delta(t)$.
- Sampling theorems (lowpass and bandpass) and Nyquist frequency.
- Reconstructing the sampled signal through interpolation.
- Computation of Fourier transform of the sampled signal. Aliasing.
- Time and frequency definition of the Hilbert transform.
- Know the definitions of analytic signal and complex envelope.
- Be able to derive the spectrum of $X_p(f)$, where $x_p(t)$ is the analytic signal of $x(t)$.
- Know how to derive the complex envelope $\tilde{x}(t)$ of an analytic signal.
- Know what inphase and quadrature components are.
- Be able to derive the Fourier transform of $X(f)$ in terms of the lowpass complex envelope $\tilde{X}(f)$.

3 Chapter 3 (Linear modulations)

- Know the basic problem we are trying to solve with analog communications. (i.e., centers on conveying a continuous time message m(t)).
- Know the formula and definition for linear modulation.
- Know and be able to draw the modulators and demodulators covered in class for the cases below. Understand how they work.
- Know what happens if the transmitter and receiver oscillators are not synchronized (i.e. there is a fixed or time-varying phase offset).
- Double sideband modulation.
- Amplitude modulation.
- Envelope detection.
- Single sideband modulation.
- Vestigial sideband modulation (frequency domain representation only).
- Benefits and problems of each modulation. These include transmission bandwidth, efficiency, and implementation issues.
- Frequency translation and mixing. Intermediate and image frequencies.
- Superheterodyne receiver, with low-side and high-side tuning.

4 Chapter 4

- Know the formula and definition for angle modulation.
- Know the definition of instantaneous phase and instantaneous frequency.
- Know the definition of phase deviation and frequency deviation.
- Phase modulation (PM) and Frequency modulation (FM).
- Be able to draw the time signals for PM and FM given a message. As well, be able to roughly sketch a message given a PM or FM signal.
- Equations for narrowband angle modulation. Know the power series of e^x.
- Be able to compute the spectrum of an angle modulation signal with $\phi(t) = \beta \sin(\omega_m t)$, if you are given the definition and value of the Bessel functions..
- What needs to happen for an FM/PM signal to be narrowband?
- Be able to compute the power of angle modulation, and the power ratio for a given bandwidth (and vice versa).
- Carson's Rule. If a cosine or sine is the message, it corresponds to a 0.98 power ratio.
- Demodulation of FM and PM using a frequency discriminator.
- Phase-Locked Loop (PLL). Understand what it is and its uses.

5 Chapter 6

- Basic probability theorems (Total probability, Bayes, etc.)
- Probability density function (PDF) and cumulative density function (CDF) for random variables and functions thereof.
- Expectation, variance, covariance, correlation coefficient, characteristic function of a random variable and combinations thereof.
- Independent and uncorrelated r.v.
- Important distributions: Bernouilli, Binomial, Uniform, Gaussian. Be able to derive means and variances.

- Central limit theorem.
- Multivariate Gaussian distribution.
- Jointly Gaussian random variables and combinations thereof. Relationship between independent and uncorrelated.

6 Chapter 7

- Descriptions of a random process (collection of r.v.s or function-valued r.v.).
- Understand the definitions of strict-sense stationary (sometimes just called stationary) and wide-sense stationary.
- Understand the definition of ergodic random process.
- Know the definition of Gaussian random process.
- Mean, variance, auto- and cross-correlation, and auto- and cross-covariance of random processes.
- Know and be able to derive the properties of the autocorrelation function.
- Know how to compute power spectral densities.
- Know the relations of correlation and PSD to variance.
- Average power of a random process.
- Know what happens to the power spectral density of a stationary random process passing through an LTI system. What happens if it is a Gaussian random process?
- Know the definition of white noise.
- Know what AWGN is.
- Know the definition of Noise-equivalent bandwidth.