ECE 440 – Spring 2019
Review Midterm 2

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 focus on the topics studied after midterm 1, but it could also include concepts from the first midterm.

The exam will be closed book and closed notes, but a single sheet of paper, handwritten on both sides will be allowed. The exam will still include a formula sheet with Fourier Transforms, trigonometric identities, etc. so don't bother including those in your cheat sheet. 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). In the exam, you will be given partial credit for any progress in the right direction, even if you do not reach any final answer.

Make sure to review the homeworks.

At the end of each chapter in the book there is a summary with the main concepts covered. We have not covered all of them, but it is still a good idea for you to spend a few minutes reading them, skipping those related to topics not covered.

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 chapter. Per popular request, this list includes a list of the sections covered from each chapter. However, the book often describes topics in a lot more detail than covered in class. Other times, we have mentioned topics in class which are not in the book. Hence, I recommend using your own class notes as a guide, rather than studying all the indicated sections.

1 Chapter 3 (3.7 and 3.8)

- Pulse Amplitude Modulation (PAM). Understand the concept and be able to draw signal.
- Pulse Code Modulation (PCM). Know how a PCM system operates. equations that govern PCM.
- Understand the role of quantization noise in PCM.
- Understand why we would need multiplexing.
- Understand and draw time division multiplexing. Find bandwidth of TDM signal.

2 Chapter 4 (4.6)

- Understand and draw frequency division multiplexing. Find bandwidth of FDM signal.
- Understand and draw quadrature multiplexing.
- Comparison of different multiplexing schemes.

3 Chapter 5: (5.3 to 5.5, and 5.8)

- Understand the concept of inter-symbol-interference (ISI) and what causes it.

- In order for our transmissions to be band-limited, signals need to be infinite in time but we do not want adjacent pulses to interfere... how is this possible?
- Understand what equalization is and what it is used for.
- Carrier modulation of baseband digital signals.

4 Chapter 8: (8.1, 8.3, 8.4)

- Signal to Noise Ratio: Understand and be able to compute at the input and output of a filter.
- Pre- and Post- detection SNR for DSB and SSB. Signal and noise powers.
- Pre- and Post- detection SNR for AM with coherent and envelope demodulation. Signal and noise powers.
- Advantages and disadvantages of coherent and envelope demodulation for AM.
- Noise in angle modulation. Approximate expression for the phase noise for large input SNR ($\psi(t) = \phi(t) + \frac{n_s(t)}{A_c}$).
- Signal and noise power for PM demodulation.
- Signal and noise power for FM demodulation.
- PSD of noise at FM discriminator output.
- Trade-off between bandwidth and SNR in FM.
- Understand the threshold effect in FM (no need to know SNR below threshold, just understand the effect).
- SNR and Bandwidth comparisons among above modulations (see table 8.1 on P390).

5 Chapter 9: (9.1, 9.2, 9.4, 9.6, 9.7, 9.9)

- Definition of coherent and synchronous communication systems.
- Integrate and dump receiver (matched filter for baseband data). SNR and Probability of error.
- Understand the concept of binary signal transmission (i.e. either send $s_1(t)$ or $s_2(t)$).
- Know how to compute the energy of a signal.
- Understand receiver structure and be able to derive error probability for arbitrary signal shapes with AWGN noise.
- Understand and be able to derive matched filter for binary transmission.
- Understand the difference between maximum likelihood receiver (inputs assumed equally likely) and MAP (possibly assymetric distribution). See problem 9.10 from homework. No need to memorize formula, but understand that threshold shifts towards symbol with lower prior probability.
- Error probability with matched filter: understand effect of increasing signal energies and correlation between them. What is the minimum error rate possible? What is the error rate if signals are uncorrelated? What is the error rate if they are perfectly correlated?
- Understand and be able to draw ASK, PSK (concentrate on BPSK), and FSK signaling schemes.
- Error rates for binary ASK, PSK, and FSK.
- Be able to compute energies (average and for each symbol) for ASK, BPSK, and FSK.

- M-ary pulse amplitude modulation (M-PAM). Understand concept, how thresholds are chosen, and how probability of error is derived.
- Difference between symbol and bit in terms of power, probability of error, etc.
- Bandwidth of M-PAM.
- Compare M-PAM and BPSK in terms of bandwidth and error rate.
- Multipath interference. Concept.
- Multipath advantage: additional signal power received that can be used to improve SNR.
- Multipath drawback: distortion of the signal, unless equalized.

6 Chapter 10: (10.1, 10.4, 10.5)

- Know the definitions of norm and inner-product relating to the finite symbol period square integrable functions.
- Understand the concept of a set of orthonormal functions.
- Know how we can create an M-ary constellation given a set of orthonormal functions.
- Understand, analyze, and draw a receiver to recover the orthonormal function weights (or symbol) for an M-ary digital communication system.
- Understand that a sequence of $\log_2(M)$ bits maps to L weights (or a baseband symbol) that correspond to different orthonormal functions. Usually we consider $L = 2$ with $\phi_1(t) = \sqrt{\frac{2}{T_s}} \cos(\omega_c t)$ and $\phi_2(t) = \sqrt{\frac{2}{T_s}} \sin(\omega_c t)$ for $0 \leq t \leq Ts$, but we also mentioned FSK which can generalize to $L > 2$.
- Know the orthonormal function sets used with PAM, PSK, QAM and FSK. Be able to draw the constellations, detection regions, etc.
- Know how to compute the average energy per symbol and per bit for a given constellation.
- Understand QPSK, M-PSK, M-QAM and coherent M-FSK.
- Be able to compute the error probability for different constellations using the union bound. This generally assumes the symbols are equally likely, but you should be able to analyze systems where this is not the case.
- Be able to Gray code (or label) a constellation plot. This is where all equally distant nearest neighbor points differ in only one bit. PSK signal points have 2 nearest neighbors. QAM signal points have up to 4 nearest neighbors.
- FSK signal points have M-1 nearest neighbors and cannot be Gray coded.
- Comparison of M-ary modulations in terms of bit and symbol error rate. Consider limitations on the average power, maximum power (amplitude), power per bit, etc. No need to memorize all formulas, just be able to derive them when needed.
- Comparison of M-ary modulations in terms of bandwidth.
- Reasons to use spread spectrum modulation.
- Understand Direct Sequence Spread Spectrum (DSSS), just idea no need for equations.
- Using spread spectrum for multiple user access (CDMA)
- Advantages and drawbacks of CDMA over FDMA or TDMA.
- Orthogonal Frequency division multiplexing (OFDM). Understand advantages and disadvantages (no need to know equations)