ECE-300-B: Communication Theory

Professor: Brian Frost

Fall 2020

References

The most important reference for this course will be my website: brianlfrost.com. I will post assignments here, along with helpful documents.

The text followed in this class is "Fundamentals of Communication Systems" Second Edition by John Proakis. The book is helpful, and I suggest securing a copy, but I will not assign homework directly from it.

Grading Breakdown

- **Homework (50%)** – There will be about seven equally weighted homework assignments. Homework will contain handwritten problems and short MATLAB problems. You will be given one week to complete homeworks. You are expected to turn in the MATLAB code through email as a part of your assignment as a .m file (not a livescript or a published version). The handwritten questions will be graded based on correctness and completeness, while the MATLAB questions will be graded on style as well. Good style, as you should know, includes appropriate use of comments, vectorization where possible, and intuitive variable names. The lowest homework grade will be dropped.
- **Analog Simulation Project (15%)** – You will receive three weeks to perform a series of MATLAB-based experiments exploring amplitude modulation, frequency modulation and phase modulation. You will perform parameter analyses and efficiency comparisons, and simulate the transmission of your own chosen audio signal. You will write a short report containing your results and a substantive discussion.
- **Digital Simulation Project (15%)** – You will receive two weeks to perform a series of MATLAB-based experiments exploring a number of techniques for digital modulation. You will perform noise analyses and efficiency comparisons, and simulate the transmission of very large randomly generated data sets. You will write a short report containing a description of your MATLAB code, your results and a substantive discussion.
- **Coding Theory Project (10%)** – You will receive two weeks to perform a series of MATLAB-based experiments exploring methods of error-detecting and error-correcting encoding and decoding. You will write a report containing a description of your MATLAB code and the encoding schemes you have implemented, your results and a substantive discussion.
- **Participation (10%)** – Due to the online class format, I believe it is important to mandate some form of participation. There will be many points at which you may ask and answer questions during lecture, and I will ask students to go over homework problems during each class. More participation will make the online experience better for everyone!

Outside of Class

I am generally responsive by email at b.frost@columbia.edu. Office hours will be held in a video conference format on request, and open office hours will be announced during the first week of class. Please let me know if you will be absent, and we can coordinate make-up material.

Course Material

- **Signals and Systems Context** – Fourier series; Fourier transforms; baseband and bandpass signals; the Hilbert transform.
- **Probability Context** – Review of probability concepts; conditional expectation; random processes; random vectors; stationarity; additive white Gaussian noise.
- **Analog Communications** – Amplitude modulation; phase modulation; frequency modulation; RF, IF and baseband systems; time-domain and frequency-domain multiplexing; SNR calculations .
- **Decision Theory** – Maximum likelihood; maximum *a posteriori*; least squares; correlation receiver; matched filter.
- **Digital Communications** – Constellations; a survey of modulation formats; digital communications receivers; bit-error rate calculations; coherent, noncoherent and differential detection strategies; power/bandwidth tradeoff; pulse-shaping; equalization and ISI.
- **Information Theory** – Information; entropy; channel capacity; entropic coding; rate-distortion theory.
- **Error-Control Coding** – Linear block, cyclic and convolutional codes; Soft- and hard-decision decoding; Trellis diagrams; Viterbi algorithm and applications; finite state machines and maximum likelihood sequence estimation.
- **Orthogonal Frequency Division Multiplexing** – OFDM theory and performance; FFT implementation of OFDM.