16.543 Communication Theory I

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This course presents a general analysis of modern digital and analog communications systems at the first year graduate level. We start with fundamentals of analog modulation because digital modulation is just a special case of generalized analog modulation, especially in how the waveforms look in time and frequency. Next we cover digital modulation ASK, PSK, FSK and QAM plus some commonly used variants, CPFSK and MSK. The last section covers basics of spread spectrum and OFDM. Homework is mandatory for students taking class for credit. Solutions are posted each week and discussed at the beginning of each class. The exams are based on the homework. Note that the more you put into the course in terms of homework and projects, the more you will get out of it.

Grading: Midterm Exam 40%, Final Exam 45%. There are 3 mini-projects (Project 0: Demonstrate Central Limit Theorem, Project 1: AM, Project 2: FM, Project 3 Three matched filter bears.

Prerequisites: Linear Systems including Fourier Transform Theory, A course in probability and random processes. (A must for this course) (e.g. 16.362 and 16.363) Please do not take this course if you do not have both of these courses or equivalent.

Textbook: *Communication Systems Engineering*, by Proakis and Salehi, plus Class notes

Course Schedule (subject to change)

Thurs Sep 4: Amplitude modulation and its variants: AM-SC, AM-LC, heterodyning, coherent and non-coherent detection of AM, single sideband, vestigial sideband.

Thurs Sep 11: Amplitude Modulation II.

Thurs Sept 18: Angle and frequency modulation, representation, generation, and spectral characteristics of FM and PM. Discriminators and PLL implementation of demodulators.

Thurs Sept 25: Angle Modulation II

Thurs Oct 2: Applications of analog modulation, AM radio, FM broadcast, TV signals, FDM, Performance of AM, FM and PM in the presence of Noise

Thurs Oct 9: Review of Probability and catch-up if we need it.

Thurs Oct 16: Mid Term Exam 3 Hours in Class,

Thurs Oct 23: Introduction to Digital Communication. Geometric representation of pulse modulation signals, Optimum receiver for pulse modulated signals in AWGN. The matched filter, maximum likelihood detection. The Shannon bound.

Thurs Oct 30: Modulation via carrier modulation I. (ASK, PSK, FSK), and hybrid QAM modulation systems. Performance of digital signals in noise. When do different modulation techniques work best. Demodulation and detection of signals.

Thurs Nov 06: Digital modulation via carrier modulation II. Spectral Characteristics of Digital modulation systems, CPFSK and MSK, special cases with unique spectral properties. Spectral shaping for band limited channels.

Thurs Nov 13: Effects of filtering, band limiting, multipath, and Intersymbol interference on performance of digital communication systems. Bit and carrier Synchronization

Thurs Nov 20: Introduction to Spread Spectrum and CDMA. Direct sequence spreading and how it can be used to deal with multipath, interference, and jamming. Extending spread spectrum to CDMA.

Thurs Nov 27: Thanksgiving Recess: No Class, take home project

Thurs Dec 4: Introduction to Orthogonal Frequency Division Multiplexing OFDM

Thurs Dec 11: Final Exam, 3 hours in class