Introduction to Communication Systems

Columbia University
Spring Semester 2008

ELEN E3701

2 February 2008
Professor I. Kalet

This course is an introduction to analog and digital communications. We begin the course with a discussion of analog communications, including well-know modulations such as, AM, DSB, SSB VSB and FM. Then we introduce the concept of the Nyquist Sampling Theorem. The Nyquist Theorem allows us to convert analog signals into digital signals, and provides a bridge between analog and digital communications. We then describe the digital modulation and coding techniques, which are gradually replacing analog communications, throughout the world. We will conclude the course with a discussion of Shannon's Information Theory, which is the basis for almost all of the advancements in communications in the second half of the twentieth century and the beginning of the twenty-first century.

Course Website:
http://www.ee.columbia.edu/~kyee/ELENE3701/

Class: Tu and Th- 4:10-5:25 PM
Room:1127 Mudd

Instructor:Professor I. Kalet

Assistant: Kai Yang

Course Outline

	References	**Problems**
• **Introduction- A "Bit" of History**		**Problem Set #1**
• **Review of Fourier Transform**	**H715-720**	
• **Linear Systems**	**H718-720**	
-Impulse Response		
-Filters		
-Causality		
-Distortion-Linear		
-Harmonics		
• **Definitions of Analog and Digital Communications**		
• **Multiple Access Techniques**		
-FDMA and TDMA	**H105-107**	
-Introduction to CDMA	**H211-217**	

Analog Communications

• Linear Modulation and Demodulation

Topic	Reading	Problem Set
-Double Sideband	H93-98	
-Quadrature Modulation		
-Amplitude Modulation	H90-93	
-Envelope Detection		Problem Set #2
-Hilbert Transform	H723-725	
-Analytic Signal	H725-734	
-Single- Sideband (SSB)	H98-100	Problem Set #3
-Vestigial Sideband	H100-103	
-Superheterodyne Receiver	H103-105	Problem Set #4

• Angle Modulation- PM and FM

Topic	Reading	Problem Set
Angle Modulation- PM and FM	H107-109	
-Frequency Modulation	H109-111	Problem Set #5
-Narrowband Signals	H111-113	
-Bessel Functions	H113-120	
-Carson's Rule- Bandwidth	H117-120	
-Demodulation	H121-124	
	H142-143	
-Phase Lock Loop-PLL –(not covered)	H157-162	
-Capture Effect-(not covered)	H148-149	
-Single Sideband FM		

• Interference (Single-Tone)

- -Linear Modulation-DSB, SSB, AM
- -Angle Modulation-FM

Digital Communications

• **Nyquist Sampling Theorem**	**H183-188**	
• **Pulse Amplitude Modulation**	**H188-194**	
• **Pulse Code Modulation**	**H201-218**	**Problem Set #6**
-Quantization Noise	**H193-210**	
-Delta Modulation	**H217-227**	
-Delta-Sigma Modulation(not covered)		
-Differential PCM (DCPM)(not covered)	**H227-229**	
-Adaptive DCPM (not covered)	**H229-234**	
• **Definition of Digital Communications**		
-Bits and Symbols		
• **Pulse Shaping**		
-Nyquist Signals	**H259-264**	
-Eye Pattern		
-Nyquist I Theorem	**H259-264**	
-Nyquist Signals with	**H264-267**	
Raised Cosine Filtering		**Problem Set #7**
-Duobinary Signaling	**H267-275**	

• **Multiple Access Techniques**		
-FDMA and TDMA	H105-107	
-Introduction to CDMA	H211-217	
• **Random Signals and Noise**	H Chapter 1	
	H31-77	
-An Introduction	H31-35	
-Autocorrelation Function (Mentioned)	H35-44	
-Ergodic Processes (Mentioned)	H41-42	
-Power Spectral Density	H44-54	
-Gaussian Processes	H54-58	
-White Gaussian Noise	H58-79	
• **Introduction to Digital Communications**		
• **Detection of Nyquist Signals in White Gaussian Noise Channels**		
-Nyquist Signals	H261-264	
-Probability of Error		
-The Q-Function		
-Optimum Filtering		Problem Set #8
-Intersymbol Interference		
-Linear Equalization		
• **Optimum Detection of Binary Signals**		
-Time-Limited Signals		
-Optimum Detection of Binary Signals		
-Definition of Distance between signals		
-Probability of Error	H253-259	
-Antipodal and Orthogonal Signals		

- **Introduction to Digital Modulation and Signal Space**

-Signal Space-What is it?	**H309-322**	**Problem Set #9**
-Orthonormal Basis		
Definition of Classic Modulations		
-BPSK	**H349-354**	
-QPSK	**H354-361**	
-MPSK	**H365-368**	
-QAM	**H368-373**	
-BFSK and MFSK	**H380-386**	
• Optimum Detection of Binary Signals		
-Optimum Detection in Signal Space		
-Minimum Probability of Error		
-Correlation Detection		
• Introduction to Coding		
-What is a Code?		
-Block Code-Introduction	**H632-635**	
-Hamming (7,4) Code		
-Coding Gain		
• Matched Filtering	**H247-259**	
• Introduction to Information Theory	**H567-568**	
-Review of Some of Shannon's Results	**H597-599**	
-Why code?	**H601-607**	
-Bandwidth Efficiency vs Power Efficiency		

- **Summary**

The Course Textbook

S. Haykin, "Communication Systems", J. Wiley and Sons, New York, Fourth Edition, 2001. (H)

Recommended Books and References:

[1] S. Haykin, "Communication Systems", J. Wiley and Sons, New York, Fourth Edition, 2001. (H)

[2] J. G. Proakis, "Digital Communications", Fourth Edition, McGraw-Hill, New York, 2001. (P)

[3] J. G. Proakis, "Digital Communications", Fifth Edition, McGraw-Hill, New York, 2007. (P5)

[4] B. Sklar, "Digital Communications: Fundamentals and Applications-Second Edition", Englewood Cliffs, N.J., Prentice-Hall, 2001. (S)

[5] J. G. Proakis and M. Salehi, "Communication Systems Engineering", Second Edition, Prentice-Hall, New York, 2001. (PS)

[6] L. W. Couch, II, Digital and Analog Communication Systems, Sixth Edition, Prentice-Hall, New York, 2001. (C)

[7] L. W. Couch, II, Digital and Analog Communication Systems, Seventh Edition, Prentice-Hall, New York, 2006. (C7)

[8] M. Schwartz, "Information, Transmission, Modulation and Noise", Fourth Edition, McGraw-Hill, New York, 1990 (MS).

[9] J.B. Anderson, "Digital Transmission Engineering", Second Edition, John Wiley and Sons, New York, 2005.(A)

Final Mark will be based on

1-Midterm-	**30%**
(Will only count, if it helps your final grade)	
2-Homeworks (Required)	**10%**
3-Final Exam	**60%**

Course Website:

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