ECE 335 - Systems, Signals and Noise

2005-06 Catalog Data: ECE 335: Systems, Signals and Noise. Signal models, systems analysis, random variables and random processes. Analog communication systems, baseband analog signal transmission, and continuous wave modulation techniques for analog transmission. Digital transmission for analog signals, sampling, quantizing, encoding of analog signals for transmission over digital systems. Analysis and design of digital communications systems, information theory, discrete pulse and carrier wave modulation schemes. Written reports are required for each of the three design projects. Prerequisites: ECE 222 and MATH 309. Offered in the Spring semester. *One semester; three credits.*

Textbook: Communication Systems, Simon Haykin, 4^{th} ed., John Wiley & Sons, 2001.

Coordinator: Dr. Juan Carlos Olabe-Basogain, Professor of Electrical Engineering.

Goals: This course is designed to give juniors in Electrical Engineering basic tools in frequency domain analysis of signals and noise, information theory and analysis, and design of digital and analog communication systems.

Prerequisites by Topic:

1. Sinusoidal steady state analysis of linear systems.
2. Fourier series, and Fourier transform.
3. Probability.

Topics:		**Classes**	**Design**
1.	Signals representation and analysis.	3	(-)
2.	Systems response and analysis. Mod-Demodulation.	4	(1)
3.	Noise representation and analysis.	6	(2)
4.	Analog communication systems: Linear modulation (DSB, SSB, VSB, AM,) angle modulation (PM, FM,) and baseband.	5	(2)
5.	Noise in analog communication systems.	5	(2)
6.	Information theory.	4	(2)
7.	Digital communication systems. Baseband and digital carrier modulation (ASK, PSK, FSK,) error, and error control coding.	6	(2)
8.	Digital transmission of analog signals: sampling, quantizing, coding (PCM, DM). Noise (PCM, DM).	6	(2)
9.	Test.	3	(1)
		42	(14)

Computer Usage:

The students use MathCAD to simulate, test, and evaluate the two design projects.

1. Design of an analog communication system.
2. Design of a digital communication system.

Estimated ABET Category Content: Engineering Science: 2 credits or 67%
Engineering Design: 1 credit or 33%

Prepared by: Dr. Juan Carlos Olabe Date: October 2005

1. **Signals representation and analysis. (3 classes)**
   Classification of signals. Periodic and aperiodic signals. Signal representation using Fourier series. Signal representation using Fourier transforms. Properties of the Fourier series and transforms. Power spectral density function.

2. **Systems response and analysis. Mod-Demodulation. (4 classes)**
   Classification of systems. System response and Filters. Study of the impulse response and step response. Transfer function of and frequency domain analysis. Effect of transfer function on spectral densities. Real and ideal filters. Modulation and demodulation operations. Spectral measurements and computations.

   <u>Design Content</u>: (1 class, 25%)
   Students execute a performance analysis of a general communication system. Differences between an ideal communication system component and a real one, and its implications on the global system performance and cost. Consequences of limited resources (bandwidth and equipment). Modulation/demodulation process versus time-domain multiplexing, a cost-complexity-performance analysis.

3. **Noise representation and analysis. (6 classes)**
   Introduction to probabilities. Discrete random variables. Continuous random variables. Random processes. Systems and random signals. Noise in communication systems. Thermal noise. Signal-to-Noise ratio and probability of error. Noise Equivalent Bandwidth. Effective Noise Temperature. Noise Figure.

   <u>Design Content</u>: (2 classes, 33%)
   The students analyze the implications of the presence of noise in a communication system. They study the relationship between the techniques used to minimize the effect of noise and their complexity and cost. The students are given a selection of communication equipment parts and a fixed budget, and they have to determine the topology of the final communication system, performing under specifications, maximizing the parameter quality (defined as signal-to-noise ratio, effective noise temperature, or noise figure).

4. **Analog communication systems: Linear modulation (DSB, SSB, VSB, AM,) angle modulation (PM, FM,) and baseband. (5 classes)**
   Analog baseband transmission. Linear CW modulation schemes. Double-Sideband modulation. Single-Sideband modulation. Vestigial-Sideband modulation. Amplitude modulation. Angle modulation. Frequency modulation. Phase modulation.

   <u>Design Content</u>: (2 classes, 40%)
   The student design, simulate, test, evaluate, and obtain the cost analysis of an analog communication system. They select the modulation scheme; parameters of the individual parts of the system; and its topology. The instructor provides them with the input signal to be transmitted. The final output signal needs to be under specifications, and the cost has to be maintained to a minimum.

5. **Noise in analog communication systems. (5 classes)**
   Noise in baseband systems. Noise in linear CW modulation systems. System model and parameters. Noise in DSB, SSB, and AM systems. Noise in angle modulation systems. Noise in FM. Noise in PM. Preemphasis and Deemphasis filtering.

   <u>Design Content</u>: (2 classes, 40%)
   The students analyze the effect of noise in each of the parts of the first design project, as well as the effect on the global system. They determine the combination that will lead to an optimum performance.

6. **Information theory. (4 classes)**
   Measure of information. Concept of Entropy of symbols. Markoff statistical model of information sources. Entropy of Markoff information sources. Shannon's encoding algorithm. Discrete communication channels. Rate of information transmission. Continuous channels. Shannon-Hartley theorem.

<u>Design Content</u>: (2 classes, 50%)
The second design project requires the design of a communication system based on the Markoff statistical model to transmit the output of an information source. The students determine the entropy of the source, encode the signal, transmit it and recover it at the other end of the system. The parameter to optimize are the complexity of encoding/decoding, and the channel requirements. The students design, simulate, test, evaluate, and obtain the cost analysis of the system.

7. **Digital communication systems. Baseband and digital carrier modulation (ASK, PSK, FSK,) error, and error control coding. (6 classes)**

Baseband binary PAM systems. M-ary baseband PAM systems. Equalization. Binary PSK, ASK, and FSK, coherent and non-coherent modulation systems.

<u>Design Content</u>: (2 classes, 33%)
The students design, simulate, test, evaluate, and obtain the cost analysis of digital communication system. They select the modulation scheme; parameters of the individual parts of the system; and its topology. The instructor provides them with the input signal to be transmitted. The final output signal needs to be under specifications, and the cost has to be maintained to a minimum.

8. **Digital transmission of analog signals: sampling, quantizing, coding (PCM, DM). Noise (PCM, DM). (6 classes)**

Sampling theory and practice. Quantizing of analog signals. Coded transmission of analog signals. The PCM system. Q-level differential PCM system. The DM system. Time-division multiplexing. Comparison of methods for analog signal transmission.

<u>Design Content</u>: (2 classes, 33%)
The students analyze the trade-offs between sampling rate, quantizing levels, coding algorithm, quality, complexity, and cost. They perform a comparative study of the PCM and DM systems for a real application (telephone quality voice transmission), and contrast their performance/cost ratios. Effect of noise in each of the parts of the third design project, as well as the effect on the global system. They must be at least at the levels specified. They determine the combination that will lead to an optimum performance.

9. **Test. (3 classes)**

<u>Design Content</u>: (1 class, 33%)

EE 335 Systems, Signals, and Noise
Grading and Attendance Policy

Grade Scale:

A:	90 - 100
B:	80 - 89
C:	65 - 79
D:	60 - 64
F:	. . - 59

Make-up Policy:

If there is a good reason (an excuse absence), the student may make up an examination.

Attendance:

Students are expected to attend class. They are held responsible for all the material and assignments covered in class. For CBU policy on class attendance, see the College catalog.

Late Assignments:

All the assignments should be turned in on time. Assignments can be accepted one class day late with a 25% grade deduction.

Grading:

Class Quizzes	10%
Three 50-minute tests	40%
Three design projects	25%
Final examination	25%