ECE 403 (405) - Digital & Data Communications (with Laboratory)

2012 Catalog Data: ECE 403: Digital & Data Communications. Credit 3. Introduction to Amplitude, Phase, and Frequency modulation systems. Multiplexing and Multi-Access Schemes; Spectral design considerations. Sampling theorem. Channel capacity, entropy; Quantization, wave shaping, and Inter-Symbol Interference (ISI), Matched filters, Digital source encoding, Pulse Modulation systems. Design for spectral efficiency and interference control. Probability of error analysis, Analysis and design of digital modulators and detectors. Prerequisite(s): [(ECE 308 and MATH 474)] (3-0-3) (P)

ECE 405: Digital & Data Communications with Laboratory. Credit 4. Introduction to Amplitude, Phase, and Frequency modulation systems. Multiplexing and Multi-Access Schemes; Spectral design considerations. Sampling theorem. Channel capacity, entropy; Quantization, wave shaping, and Inter-Symbol Interference (ISI), Matched filters, Digital source encoding, Pulse Modulation systems. Design for spectral efficiency and interference control. Probability of error analysis, Analysis and design of digital modulators and detectors. Prerequisite(s): [(ECE 308* and MATH 474)] An asterisk (*) designates a course which may be taken concurrently. (3-3-4) (C)(P)

Enrollment: Elective course for CPE and EE majors.


Coordinator: G. Atkin, Associate Professor of ECE

Course goals:
After completing ECE 403, the student should be able to do the following:
1. Determine the frequency spectrum and bandwidth of AM and FM signals.
2. Perform noise analysis of AM and FM receivers with power spectral densities.
3. Apply the sampling theorem to analog signals.
4. Design uniform and non-uniform quantizers for Gaussian sources.
5. Represent digital signal using orthonormal functions.
6. Design a receiver for baseband digital modulation formats.
7. Recover digital signals using distance and correlation metrics.
8. Understand coding and decoding using block and convolutional codes.

After completing ECE 405, the student should be able to do the following:
1. Determine the frequency spectrum and bandwidth of AM and FM signals.
2. Perform noise analysis of AM and FM receivers with power spectral densities.
3. Analyze frequency and time division multiplexing systems.
4. Apply the sampling theorem in pulse amplitude modulated systems.
5. Compute channel bit rate and bandwidth needed for pulse code modulated systems.
6. Complete an engineering design incorporating engineering standards and realistic constraints.
7. Prepare an informative and organized design project report.

Prerequisites by topic:
1. Basic probability theory
2. System transfer functions
3. Spectral analysis
4. Analog communication systems

Lecture schedule: Two 75-minute sessions per week
Laboratory schedule: One 150-minute session per week. (ECE 405 only)

Topics:
1. Introduction to Digital Communications (1 week)
2. Information, Entropy, Capacity, Huffman Source Coding (2 weeks)
3. Review of Probability Theory, pdf, cdf, Statistical Averages (1 week)
4. Digital Communication Systems, Sampling Review, Bandpass Sampling, TDM, PCM, Quantization Noise, DPCM, Companding, DM, ADM, ADPCM, LPC, CELP, Binary Codes, Parity Channel Coding (2 weeks)
5. Digital Modulation and Detection, DPSK, Multisymbol, QAM, Modems, MSK (3 weeks)
6. Performance of Digital Systems, Bit Error Rate, Random Noise Processes, Matched Filters, Binary Detection (3 weeks)
7. Block and convolutional codes (2 week)
8. Exams (1 week)

Computer usage:
Three computer simulation assignments using the language of their choice: a) Generation Gaussian Random Variables, b) Effect of noise on SSB-SC-AM and FM c) Quantization using Matlab and Simulink, d) Simulation of Binary Orthogonal signal. Use of MATLAB is encouraged. Theory is compared to simulated “experimental” results and a written mini-report is required for each assignment.

Laboratory topics (ECE 405 only):
1. Determine the frequency spectrum and bandwidth of AM and FM signals (1 weeks)
2. Perform noise analysis of AM and FM receivers with power spectral densities (2 weeks)
3. Analyze frequency and time division multiplexing systems (2 weeks)
4. Apply the sampling theorem in pulse amplitude modulated systems (2 weeks)
5. Compute channel bit rate and bandwidth needed for pulse code modulated systems (2 week)
6. Complete an engineering design incorporating engineering standards and realistic constraints (4 week)
7. Prepare an informative and organized design project report (1 weeks)
8. Project presentation, demonstration, and report (1 week)
### Relationship of ECE 403/405 Course Goals to ABET Student Outcomes:

<table>
<thead>
<tr>
<th>Student Outcomes</th>
<th>ECE 403 Goals</th>
<th>ECE 405 Goals</th>
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<tbody>
<tr>
<td>a Apply knowledge of math, engineering, science</td>
<td>1, 2, 3, 4, 5, 6, 7, 8</td>
<td>1, 2, 3, 4, 5, 6</td>
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<tr>
<td>b Design and conduct experiments / Analyze and interpret data</td>
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<td>1, 2, 3, 4, 5</td>
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<td>c Design system, component, or process to meet needs</td>
<td>4, 6</td>
<td>5, 6</td>
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<td>d Function on multi-disciplinary teams</td>
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<tr>
<td>e Identify, formulate, and solve engineering problems</td>
<td>1, 2, 3, 4, 5, 6, 7, 8</td>
<td>1, 2, 3, 4, 5, 6</td>
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<td>f Understand professional and ethical responsibility</td>
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<td>g Communicate effectively (written / oral)</td>
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<td>h Broad education</td>
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<td>i Recognize need for life-long learning</td>
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<td>j Knowledge of contemporary issues</td>
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<td>k Use techniques, skills, and tools in engineering practice</td>
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<td>6</td>
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**Prepared by:** G. E. Atkin  
**Date:** October 18, 2013