1. **Course Description**

Basic principles of point-to-point communication link design and analysis, introduction to the theory and principles of modern communication systems, overview of the currently used analog and digital communication techniques and their relative advantages and disadvantages, analog modulation and demodulation, component parts used in analog and digital transceivers.

Prerequisite: GNE 331, ELE 430 and COE 321.

2. **Course Objectives**

The objective of the course is to provide students with an overview of currently used analog and digital communication methods and their relative advantages and disadvantages.

Course learning Outcomes:

A student who has successfully completed this course should be able to:

1. understand the basics of point-to-point communications.
2. be familiar with the objectives and constraints related to the design of communication systems.
3. understand the impact of communication channels on the achievable system performance.
4. understand the fundamentals of baseband signaling.
5. understand the basics of analog-to-digital conversion.
6. understand the basic principles of analog modulation and demodulation.
7. understand the basic principles of digital modulation and demodulation.
8. choose the system parameters to achieve a target signal-to-noise ratio with analog modulations.
9. compare different modulation schemes in terms of complexity, occupied bandwidth and performance.
10. be familiar with the main building blocks of a communication transceiver.

3. **Contribution of course to meeting the requirements of ABET Criterion 5**

<table>
<thead>
<tr>
<th>Professional Component</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics and Basic Sciences</td>
<td>0</td>
</tr>
<tr>
<td>Engineering Topic</td>
<td>3</td>
</tr>
<tr>
<td>General Education</td>
<td>0</td>
</tr>
</tbody>
</table>

4. **Relationship of course to program outcomes**

PO (c): ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

- Expresses unambiguous needs and identifies objectives and requirements
- Identifies realistic constraints related to the design effort
- Performs design or solve problems using knowledge and alternatives when applicable

PO (e): an ability to define, formulate, and solve engineering problems

Demonstrates an ability to formulate engineering problems, to recognize and identify the basic governing theories and principles in the following areas

- signal processing

5. **Course Outline**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Lecture -- Duration* -- Covered Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1 0.5 weeks</td>
</tr>
<tr>
<td></td>
<td>• Main building blocks of a communication system</td>
</tr>
<tr>
<td></td>
<td>• Baseband vs. passband signals</td>
</tr>
<tr>
<td></td>
<td>• Some types of communication channels</td>
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<tr>
<td></td>
<td>• High-level introduction to modulation</td>
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<tr>
<td></td>
<td>• Quality and quantity measures</td>
</tr>
<tr>
<td></td>
<td>• Main design constraints of a communication system</td>
</tr>
<tr>
<td>Time (weeks)</td>
<td>Duration</td>
</tr>
<tr>
<td>-------------</td>
<td>----------</td>
</tr>
</tbody>
</table>
| 2           | 0.5      | Signals and spectra | Power spectral density (PSD)  
Energy signals vs. power signals  
Time-average operator  
Brief revision on the Fourier transform  
PSD calculation (example)  
Autocorrelation function  
Properties of the autocorrelation function |
| 3           | 0.5      | Orthogonal representation of signals | Orthogonal functions  
The Fourier series as a special case of the orthogonal series representation  
Spectrum of periodic signals  
PSD of periodic signals  
Power transfer function  
Distortion less channels (definition) |
| 4           | 0.5      | Sampling theorem | Band-limited vs. time-limited signals  
Parseval’s theorem  
Relationship between the orthogonal series coefficients and the signal samples  
Dimensionality theorem  
Impulse sampling  
Aliasing and pre-filtering  
Absolute, null-to-null, 3-dB and equivalent-noise bandwidths (definitions) |
| 5           | 0.75     | Baseband Pulse and Digital Signaling | Pulse Amplitude Modulation (PAM)  
Natural sampling: spectrum, generation and signal reconstruction  
Instantaneous sampling: spectrum, generation, signal reconstruction and equalization  
Advantages and disadvantages of PAM |
| 6           | 1.5      | Pulse code modulation (PCM) | Block diagram of wired digital communication systems deploying PCM  
Uniform quantization  
Gray codes  
Bandwidth of PCM signals  
Channel noise and quantization noise  
Signal to quantizing noise ratio  
Non-uniform quantization  
A-law and µ-law companding  
Chording and codeword generation  
Shannon’s theorem and capacity |
| 7           | 0.5      | Digital signaling | Baud rate and bit rate  
Bandwidth estimation  
Digital signal reconstruction  
Binary signaling with rectangular and sinc-type waveforms: signal reconstruction and bandwidth  
Multilevel signaling with rectangular and sinc-type waveforms: signal reconstruction and bandwidth |
| 8           | 0.25     | Differential codes and regenerative repeaters | Differential encoding and decoding  
Amplification vs. regeneration  
Serial cascade of regenerative repeaters |
| 9           | 1.5      | Line codes and spectra | Binary line codes  
Unipolar signaling  
Polar signaling  
Bipolar signaling  
Manchester signaling  
Desirable properties of line codes  
Power spectra of line codes  
PSD of unipolar-NRZ, polar-NRZ, unipolar-RZ, bipolar-RZ and Manchester-NRZ  
PSD of multilevel polar NRZ signals  
Spectral efficiency |
| 10          | 0.75     | Inter Symbol Interference (ISI) | Nyquist’s first method for eliminating ISI  
Raised cosine-rolloff Nyquist filter: impact of rolloff factor, transfer function, baud rates and effect of |
<table>
<thead>
<tr>
<th>Week</th>
<th>Duration</th>
<th>Topics and Details</th>
</tr>
</thead>
</table>
| 11   | 0.75 weeks | Time-Division Multiplexing (TDM)  
- Inaccurate synchronization  
- Nyquist filter  
- Square root raised cosine-rolloff Nyquist filters  

| 12   | 1 week | Delta Modulation (DM) and Pulse Time Modulation (PTM)  
- Redundancy in information sources  
- DM transmitter and receiver  
- Slope overload noise and granular noise  
- Signal-to-noise ratio of DM with audio signals  
- DM vs. PCM  
- Adaptive delta modulation  
- PTM: pulse width modulation and pulse position modulation  
- PTM generation and detection  

| 13   | 0.75 weeks | Complex envelope  
- Complex envelope representation of bandpass waveforms  
- Representation of modulated signals  
- Spectrum of bandpass signals  
- PSD of bandpass signals  
- Average power of bandpass signals  
- Peak envelope power  

| 14   | 0.25 weeks | Building blocks of bandpass receivers  
- Limiters  
- Mixers  
- Frequency multipliers  

| 15   | 0.25 weeks | Detector circuits  
- Envelope detector  
- Product detector  
- Frequency modulation detector  
- Coherent vs. noncoherent detectors  

| 16   | 0.5 weeks | Phase Locked Loops (PLL) and super-heterodyne receivers  
- PLL: circuit, input-output relation, linearization, steady-state operation and stability  
- Super-heterodyne receivers: block diagram  
- RF vs. IF filtering  
- Image frequency  

| 17   | 0.5 weeks | Amplitude Modulation (AM)  
- AM signals: modulation percentage, modulation efficiency, spectrum and power  
- Double sideband suppressed carrier (DSB-SC) amplitude modulation  
- Upper single sideband (USSB) and lower single sideband (LSSB) amplitude modulation  

| 18   | 0.75 weeks | Angle Modulation  
- Phase modulation (PM) and frequency modulation (FM)  
- Instantaneous frequency and frequency deviation  
- Peak phase deviation and phase modulation index  
- Peak frequency deviation and frequency modulation index  
- Spectra of angle modulated signals  
- Carson’s rule  
- Frequency division multiplexing (FDM)  
- FM stereo broadcasting  

*: Please note the following:  
- The duration is approximate.  
- It excludes the time dedicated for the examination.  
- It excludes the time spent in solving selected problems from assignments.

6. **Required tools / software / skills**  
Software: Matlab.
7. **Textbook[s]**


8. **Additional References**


9. **Schedule of Exams & Grading Percentage**

<table>
<thead>
<tr>
<th>Exam</th>
<th>Grading Weight</th>
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</thead>
<tbody>
<tr>
<td>Exam 1</td>
<td>(20% or 25%)*</td>
</tr>
<tr>
<td>Exam 2</td>
<td>(20% or 25%)*</td>
</tr>
<tr>
<td>Exam 3</td>
<td>(20% or 25%)*</td>
</tr>
<tr>
<td>Final Exam</td>
<td>35%</td>
</tr>
</tbody>
</table>

- *: 25% on max(Exam 1, Exam 2, Exam 3) and 20% on each of the remaining exams.
- The dates of the mid-terms will be announced at least two weeks in advance.

10. **Course Policies**

- Failure to take a test or the final exam during the assigned class period will result in a grade of zero being recorded for that test unless the student has personally contacted me and received permission to be absent from the test.
- No makeup exams will be given for the three midterms. In case a student fails to take an exam, the 20% of the final grade assigned for this midterm will be redistributed in the following manner: 10% for the other midterms (that will now count for 30% and 25% of the final grade, respectively) and 10% for the final exam (that will now count for 45% of the final grade).
- Makeup exams will be given for students who fail to attend the final exam.
- The student is responsible for all business conducted and announcements made during any scheduled class period. LAU attendance policies are enforced.

11. **General Comments**

Homework sets will be given on a regular basis and their solutions will be posted on the course website. Most of the homeworks will be solved in class. Even though homeworks will not be graded, they are critical to learning the material and to doing well on the midterms and final exam. Homework questions will appear regularly in quizzes and they may also appear in the tests. You are encouraged to discuss the homework with your colleagues.

In order to get the most out of the course, try to stay ahead. Before attending a lecture, make sure you have reviewed the material covered in the previous lectures. Read the assigned material, but at a minimum, make sure to review the slides posted on the course website. This way, lectures will be much more informative and meaningful.

It is intended that the overall work required be approximately six hours per week, including three hours of lecture. Students who find themselves spending substantially more than six hours any week should question whether they are stuck and might make more rapid progress if they asked the course instructor for some hints or advice. I am available at these office hours:

Office Hours: TR 09:30 - 11:00, TR 12:15-02:00 or by appointment.
Office: Bassil 102.
Email: chadi.abourjeily@lau.edu.lb
Course Website: [http://services.sea.lau.edu.lb/academia/courses/ele537/](http://services.sea.lau.edu.lb/academia/courses/ele537/)

12. **General Rules & Regulations**

- A student can miss no more than 4 sessions of instruction. By the 5th session, the instructor may ask the student to drop the course.
- Plagiarism: students caught cheating on an exam receive a grade of zero on the exam in the first cheating attempt and a warning. Students caught cheating for the second time in the same course receive an F grade in the course and a second warning. A grade of zero on an exam resulting from cheating must be counted in the student’s course grade. The zero cannot be dropped in computing the final grade in case the instructor has a policy of allowing students to drop their worst exam grade.
- Any student who receives 3 warnings will be suspended.

13. **Person(s) who prepared this description and date of preparation**

Chadi Abou-Rjeily, September 19, 2013