EE 448L: Communication Electronics (4 units)  Spring 2014
Department of Electrical Engineering
University of Southern California

Lecturer: Hossein Hashemi
Office: Powel Hall of Engineering (PHE) 616, x03596
Email: hosseinh@usc.edu
Office Hours: Mondays, Wednesdays, and Fridays 8:45am – 9:45am

Class Schedule:
Lecture hours: Monday & Wednesday 10:00am – 11:50am
Lab hours: Fridays 10:00am – 2:00pm

Class Location: OHE 230

Course Website: http://blackboard.usc.edu

Teaching Assistant: Kunal Datta (kdatta@usc.edu)
TA Office Hours: TBD
TA Office Location: TBD

Course Description:
Analysis, design, and experimental evaluation of transistor-level communication circuits and micro-systems. Transmission lines, impedance matching, noise, distortion, tuned amplifiers, mixers, oscillators, phase-locked loops.

Prerequisite:
Analog circuits (EE348 or equivalent), signals and systems (EE301 or equivalent), basic semiconductor device physics (EE338 or equivalent)

Main Text Book:

Supplementary Texts:
Kenneth K. Clarke and Donald R. Hess, Communication Circuits: Analysis and Design
David B. Rutledge, The Electronics of Radio

Homework:
Handed out every Monday, due by a week later on Wednesday at the beginning of the class. Solutions will be posted on the class website on the same day.

Late homework will not be accepted. No exceptions except institution-established emergency reasons; credit for such late homework is with the discretion of the professor.

Limited collaboration in solving homework problems is allowed. This includes reviewing and discussing the problems with current EE448L students and TAs prior to writing down your solution. Everybody has to write his/her own solution independently and make sure to fully understand it. Exchanging solutions, consulting with people other than class members, finding solutions on the web or elsewhere, etc. are not allowed. Violations result in losing the credit for the entire homework set in addition to a significant percentage of the overall course grade, all with the discretion of the professor.

All answers should be clearly and fully justified. If we can’t figure out your steps from is turned in, points will be deducted, even if your final answer is correct.

Grading:
Homework 10%, midterm exam 20%, final exam 30%, design project 15%, lab 25%.
Tentative Syllabus (subject to change)

Review of Device Physics & Modeling (MOS & BJT)
Review of Basic Amplifiers & Biasing
Amplifier Frequency Response & Bandwidth Calculations
Noise
Review of RLC & Passive Resonators
Impedance Matching
Narrowband Low-Noise Amplifiers
Feedback & Root Locus Techniques
Oscillators
Wireless Communication Systems
Amplitude, Phase, and Frequency Modulation Techniques
Mixers and Multipliers
Nonlinearity & Distortion
Power Amplifiers (time permitting)
Transmission Lines (time permitting)

Laboratory

Laboratory Equipment (High-Frequency Oscilloscopes, RF Signal Generators, RF Spectrum Analyzers, RF Vector Network Analyzers, Power Supplies, Multi-Meters, etc.)
Printed Circuit Board Layout & Fabrication, Soldering Surface Mount Components
Design Experiment 1: Wideband Voltage Amplifier
Design Experiment 2: Narrowband Low Noise Amplifier
Design Experiment 3: Oscillator
Design Experiment 4: Nonlinearity Characterization
Design Experiment 5: Frequency Down-Conversion Mixer
Design Experiment 6: Wireless Receiver

Design Project

2.5-GHz Trans-Impedance Amplifier (TIA) for optical communication systems in a CMOS technology
## Tentative Schedule (subject to change)

### Week 1
- **Monday, January 13**: MOSFET device physics and large-signal expressions
- **Wednesday, January 15**: MOSFET small-signal models + basic amplifier stages (CS)
- **Friday, January 17**: Small-signal analysis (examples of CS, CG, etc.)

### Week 2
- **Monday, January 20**: Marin Luther King Holiday
- **Wednesday, January 22**: Basic amplifier cells (CS, CD, CG), Differential Pairs
- **Friday, January 24**: Differential amplifier examples + amplifier frequency response

### Week 3
- **Monday, January 27**: Frequency response (Assoc. poles to nodes) + Bode plot review
- **Wednesday, January 29**: Miller theorem, associating poles to nodes
- **Friday, January 31**: OCT Method

### Week 4
- **Monday, February 3**: SCT Method
- **Wednesday, February 5**: Biasing (Current Sources & Mirrors), Amplifier Design Example
- **Friday, February 7**: BJT Review: Device Physics, Small-Signal Model

### Week 5
- **Monday, February 10**: LAB #0: Introduction to Measurements
- **Wednesday, February 12**: BJT Amplifiers, Frequency Response, Differential Pair
- **Friday, February 14**: Noise: Mathematics, Physics, Noise Models

### Week 6
- **Monday, February 17**: President’s Day Holiday
- **Wednesday, February 19**: Noise: Circuit models + Noise Calculation in Circuits [Lab #1]
- **Friday, February 21**: Review of RLCT Circuits, Passive Resonators, Passive Conversions

### Week 7
- **Monday, February 24**: Maximum Power Transfer, Impedance Matching
- **Wednesday, February 26**: Low-Noise Amplifier, Narrowband Common-Gate/Base LNA
- **Friday, February 28**: Inductively-degenerated Common Source Amplifier

### Week 8
- **Monday, March 3**: Midterm Exam
- **Wednesday, March 5**: Post Midterm Review
- **Friday, March 7**: LAB #1: Wideband Amplifier

### Week 9
- **Monday, March 10**: Noise Figure, Low-Noise Amplifiers [Lab #2]
- **Wednesday, March 12**: Feedback (Basics)
- **Friday, March 14**: Feedback (Root Locus), Routh-Hurwitz,
- **Optical Communications, Trans-impedance Amplifier – Basics & Examples

### Spring Break

### Week 10
- **Monday, March 24**: Oscillator (Introduction + start-up condition)
- **Wednesday, March 26**: Oscillators (Large Signal Analysis) – Examples
- **Friday, March 28**: Oscillator examples (Colpitts)
- **More TIA Examples (Feedback, Regulated Cascode)

### Week 11
- **Monday, March 31**: Oscillator examples, Voltage Controlled Oscillators [Lab #3]
- **Wednesday, April 2**: Nonlinearity and Distortion (1/2)
- **Friday, April 4**: LAB #2: Low-Noise Amplifier

### Week 12
- **Monday, April 7**: Nonlinearity and Distortion (2/2) [Lab #4]
- **Wednesday, April 9**: Communication Systems (AM, PM, FM)
- **Friday, April 11**: LAB #4: Amplifier Nonlinearity Characterization

### Week 13
- **Monday, April 14**: Multipliers and Mixers [Lab #5]
<table>
<thead>
<tr>
<th>Event Description</th>
<th>Date</th>
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<tbody>
<tr>
<td>Communication Systems (Modulators &amp; Demodulators)</td>
<td>Wednesday, April 16</td>
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<tr>
<td>LAB #3: Oscillator</td>
<td>Friday, April 18</td>
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<tr>
<td><strong>Week 14</strong> Communication Systems (RX/TX Architectures)</td>
<td>Monday, April 21</td>
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<td>Communication Systems: Link Budget Analysis</td>
<td>Wednesday, April 23</td>
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<td>LAB #5: Mixer (frequency down-converter)</td>
<td>Friday, April 25</td>
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<tr>
<td><strong>Week 15</strong> Final Exam Review [Lab #6]</td>
<td>Monday, April 28</td>
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<tr>
<td>Project Presentations</td>
<td>Wednesday, April 30</td>
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<tr>
<td>LAB #6: Wireless Receiver</td>
<td>Friday, May 2</td>
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<td>Wideband Voltage Amplifier</td>
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