# Communication Electronics

ECE145B/ECE218B - Winter 2012 University of California, Santa Barbara

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Course contents.
ECE 145B/218B explores the design and analysis of radio frequency circuits, systems and the corresponding measurement techniques. Receiver system performance, mixers, voltage controlled oscillators, and phase locked loops are studied this quarter.

ECE145B and ECE218B are co-listed in the catalog. Graduate students should enroll in 218B.

Subject material:


II. Mixer design and characterization: Modes of operation, balance, conversion gain, image rejection and quadrature signals.

III. Oscillator design: Resonators, tapped L and C impedance transformers, analysis, oscillators- both feedback and negative resistance, varactor tuning, LO buffer amplifiers.

IV. Frequency compensation of feedback amplifiers: Stability of feedback amplifiers, phase margin and root locus methods, compensation.

V. Phase locked loops and their applications: PLL operation, analysis by linear feedback methods, loop filter design, applications to frequency synthesis.

Prerequisite:
ECE145A/218A or permission of instructor. You should be familiar with transmission lines, Smith Chart, matching network design, amplifier gain, stability, noise figure. You should also have a basic knowledge of the use of Agilent ADS simulation tools.

References:
The primary references are the lecture notes and the supplemental readings.

1. ECE145B/218B reader. (Alternative, 6556 Pardall Rd, Isla Vista.). This and the lecture notes will be the primary source for reading material.

2. Lecture notes, data sheets, application notes, ADS simulation files and tutorials will be posted on the course web page:

3. T. H. Lee, The Design of CMOS Radio-Frequency Integrated Circuits, Second Edition. Cambridge Univ. Press, 2004. I have selected this textbook that is an excellent reference. This book gives lots of insight but is weak on analysis. For those of you who are truly interested in the subject, it will prove to be a valuable investment. I will pick a few chapters from the book for reading during the quarter.
Tools:
Each lab group will be provided with a toolbox. The components and tools (expensive! handle with care) will be checked out by the ECE electronics shop. You will be responsible for returning these in good working order. Your BARC account will be charged for anything missing.

Grading.
The grading for seniors and graduate students will be separate. Graduate students taking the course will have more difficult assignments. The final is on Tuesday, June 9, 4-7pm. The grade for this course will be based on the following:

Lab Projects 40%
(lab1: 5%; lab2 20%; lab3 15%)
Final 30%
Midterm 20%
Homework 10%

Laboratory projects:
1 Large signal amp and mixer characterization
2 VCO
3 PLL Frequency Synthesizer

Laboratory:
The lab is in room 5162D. It will be accessible by card key. You may work in teams of two for the lab projects. A single report for the team will be sufficient.

Project checkout.
Design projects (Labs 2 & 3) must be demonstrated to the TA or instructor to verify that all specifications are met. You will need to make an appointment with the TA when you are ready to checkout. At the end of the quarter you will need to give a presentation on one of the design projects.

Notebooks:
Each student will be expected to maintain a lab notebook. Pages should be numbered and entries dated that document activity on the lab projects. Handwritten and computer plotted or generated measured data should be kept in the notebook. Keeping a sequential record of your work is an important discipline to acquire. Its purpose is twofold:

1. It provides a written record of your design process. In a professional setting, you need a written record of key design decisions, simulations, analysis, and measurement data. The notebook should be written so that an intelligent engineer unfamiliar with your particular project could pick up the project and reproduce or support the design. Most often that intelligent, unfamiliar design engineer is you! It is remarkable how quickly we forget details of our work when we move to other projects.
2. Many companies make lots of money on patents. New ideas must be documented by written, sequential, dated records in order to qualify for patent. Patent applications are very time sensitive, and properly documented notebooks play a central role in establishing date of concept. (In most cases, a bound notebook is required, but computer generated data is more easily included in an open notebook. Since you won’t be filing for a patent on our projects, it is ok to use a 3 ring binder, but do number and date pages).

The notebook can contain circuit analysis work, design alternatives, ADS printouts, diagrams, measured data, or anything that seems relevant at the time. Incorrect or ineffective approaches and ideas should not be erased. You may want to refer back to something previously done.

Lab Reports:
Your ability to clearly and concisely present your work in a formal manner to those who sponsor it, or the ability to clearly describe a proposed plan of action in order to obtain the necessary funding will play a huge role in your success as an engineer. Unfortunately, many engineers haven't made the effort to learn the necessary skills. Formal lab reports on the design projects will be required in order to help you improve your writing and communication skills.

Lab reports should be written in similar factual style: goals, approaches considered, analysis, simulations, details regarding construction, measurements, difficulties faced, reconciliation of measurement with theory.

Grading Standards
The standards for grading of the design projects are as follows. Please refer to the report format below to understand expectations.

Seniors
A  Project meets all expectations. Report is well organized and written.
A- , B+  Project comes close to meeting expectations; report is well organized and written, or the project meets expectations but the report is lacking in one component.
B  Project comes close to meeting expectations; report is lacking in two components.
B - , C+  The project is adequate, but is poorly documented in the report.
C, C -  Project doesn't work or is incomplete.
F  Project bursts into flames during demo and burns TAs hand, or no project
and report is submitted.

Graduate Students
A  Project exceeds expectations. Report shows evidence of exceptional understanding. Innovative approaches were successfully employed at some point in the design.

A-  Project meets all expectations. Report is well organized and written.

B+  Project comes close to meeting expectations, and report is well organized and written.

B - C+  The project meets expectations, but is poorly documented in the report.

C  Project doesn't work or is incomplete.

F  Project bursts into flames during demo and burns TAs hand, or no project and report is submitted.

Lab report format for design labs (2 & 3)
All labs this quarter are design labs. We will be looking for each of the items listed below. The report should be organized in such a way that the reader can clearly follow your discussion and see the connections between your design, analysis, and the performance characterization.

1. Title page.

2. Introduction. Describe the objectives of the experiment and summarize the approach taken. Design specifications should be presented here as well.

3. Analysis and Implementation. Present the circuit in overview (block diagram) and describe the function of each important circuit block. Present the analysis and design equations used for each part of the design. Include any assumptions made, and discuss tradeoffs that affected your design choices. Schematic diagrams and description and evaluations of any unusual components should be included. Second generation design improvements should be discussed.

4. Performance. Describe the measurement methods used to evaluate your project, and discuss any important factors that influenced your measurements. Summarize the results of your measurements and compare the results to the specifications, calculations and simulations. Attempt to explain any discrepancies. Note that tables of raw data should not
be in the report; they should be found in your notebook. But, graphs or summary tables of the results may enhance the presentation and should be included in the report when appropriate.

5. Cost analysis and power dissipation. Make an estimate of the cost to build the final design in moderate volume (1000 units). Measure the power dissipation. Include these in your report for 5% of the report grade.

6. Conclusions. This section should identify which part of the experiment was most difficult and why. Identify unresolved problems that arose, and suggest ways to solve them if time permitted. Finally, if you have some ideas on how the experiment or circuit could be further improved, suggest them here.