EE85: ANALOG AND RF CIRCUITS LABORATORY

Course Syllabus – Winter Term / 2022

Electrical Engineering Department, California Institute of Technology

INSTRUCTOR Richard Kalantar Ohanian

EMAIL rohanian@caltech.edu

OFFICE B283 Moore, x4872

OFFICE HOURS MONDAYS 5PM-6PM (please email to confirm an appointment when possible or by appointment at other times)

TEACHING ASSISTANTS TBD

LOCATION AND TIME TBD, FRIDAYS 10:00AM – 11:55AM

COURSE DESCRIPTION

The overarching goal of this structured lecture and laboratory course is to enhance students' skills in designing and characterizing analog and RF circuits and further develop their thought process as hands-on engineers. This goal is accomplished by guiding students to actively learn the necessary intellectual and technical approach/process to design, simulate and characterize various analog and RF circuits through the guided mentorship of the Instructor and the Teaching Assistors. Students gain familiarity with components and circuit blocks and detailed circuit design techniques, circuit simulations and analysis, schematic capture and Printed Circuit Board layout, testing and verification as well as debugging techniques during weekly lectures and lab sessions by the instructor and the TAs. Students will also learn working with lab equipment functionalities, applications, and specifications during the course. There will be weekly problem sets and lab assignments. The instructor and the TAs will ensure students stay on schedule for completion of their lab work and projects. Grading for each student will be based on accumulated credits on homework sets, simulations and lab project and students class participation.

GENERAL INFORMATION

This is a 9-unit course.

Prerequisites: Prerequisite: EE40 or EE45.

EE Majors: EE85 is not a requirement for EE option.

COURSE ASSESSMENT

A student's grade is based on the following factors:

35%	Problem Sets
30%	Simulations
35%	Projects/Labs Reports

TENTATIVE COURSE SCHEDULE (SUBJECT TO CHANGE)

Week 1: Passive Components and Circuits
Session 1: Lumped vs Distributed Circuits, Wires, Resistors, Capacitors and Inductors models and equivalent circuits
Session 2: RLC resonant circuits, impedance transformation, RLC filters
TA Office Hour: Training on Breadboarding and LTSpice
Problem Set 1 and Lab 1: Design, simulation and breadboarding of a 4-element lowpass and a 4-element bandpass RLC filter

Week 2: Diode Circuits
Session 3: Inductors, Transformers, Diode Circuits, Diode Clipper, Clamp, TVS
Session 4: Zener Regulators, Half/Full Wave Diode Rectifiers AC to DC Converters
TA Office Hour: Training on LTSpice and lab equipment
Problem Set 2 and Lab 2: Design, simulation and breadboarding of an AC/DC Converter with Full Wave Bridge Rectifier

Week 3: Op Amps Circuits I
Session 5: Op Amps Models and Parameters, Inverting and Non-Inverting OpAmp Circuits
Session 6: Op Amp Integrator/Differentiator, Summing/Differential OpAmp Circuits,
TA Office Hour: How to read datasheets and select parts online
Problem Set 3 and Lab 3: Design and simulation and breadboarding of an Op Amp Integrator and Differentiator.

Week 4: Op Amps Circuits II
Session 7: Op Amp Oscillators
Session 8: Active Filters and Transimpedance Amplifier
TA Office Hour: Training on TINA simulation tool
Problem Set 4: Design and simulation of a 100kHz function generator (sinusoidal, square wave and triangular wave) using Op Amps

Week 5: Voltage Regulators and Converters
Session 9: Linear and Low Drop Out Voltage Regulators
Session 10: Buck/Boost and Flyback Switching Regulators
TA Office Hour: Training on WEBENCH simulation tool and bypass caps selections on Kemet website
Lab 4: Breadboarding of a 100kHz function generator (sinusoidal, square wave and triangular wave) using Op Amps

Week 6: RF Concepts and Amplifiers
Session 11: Transmission Lines, Microstrip and Striplines, single ended vs differential signaling
Session 12: Bode Plots, Smith Charts and Impedance Matching
TA Office Hour: Training on Altium Schematic and Footprint Libraries
Problem Set 5: Design and simulation of a 12V to +/- 5V and 3.3V voltage conversion circuitry

Week 7: RF Amplifiers I
Session 13: S parameters, Gain and Insertion Loss
Session 14: Amplifier biasing, small signal vs large signal analysis

TA Office Hour: Training on Altium Schematic Capture
Problem Lab 5: Breadboarding of a 12V to +/- 5V and 3.3V voltage conversion circuitry

Week 8: RF Amplifiers II
Session 15: Low Noise Amplifiers, RF amps lineup analysis
Session 16: Class A, B, AB, C, D Power Amplifiers
TA Office Hour: Training on Altium PCB Layout
Problem Set 6 and Lab 6: Design, simulation and breadboarding of a 10MHz class D PA with 20dB gain with impedance matching

Week 9: Passive and Active Mixers and Noise
Session 17: Passive and Active Mixers
Session 18: Noise
TA Office Hour: Training on Altium PCB Layout for RF circuits applications
Problem Set 7 and Lab 7: Design, simulation and breadboarding of a single balanced diode mixer

Week 10: Oscillators and Phased Locked Loops
Session 19: Voltage Controlled Oscillators, Crystal Oscillators
Session 20: PLLs
TA Office Hour: Catch up session on any topic
Lab: Breadboarding of labs 6 or 7

COURSE POLICIES

1. Drops

The drop day for the summer course is TBD

2. Extensions

No extensions will be granted beyond the summer to complete the coursework.

3. Laboratory Facilities and Equipment

EE85 is a lab and project-based course in which students are expected to design and construct a functional hardware prototype. To assist students in this endeavor, laboratory facilities and equipment are provided for student use.

Laboratory

- Students are responsible for maintaining a clean and orderly laboratory.
- Within a few days of the beginning of the course, identify and take possession of a lab bench with your name and phone number. The bench will be assigned to you for the entire term.
- Unless special advance arrangements have been made with the lecturer, your bench must be cleaned off by the Friday of finals week.

Supplies and Equipment

- The lab is equipped with measurement equipment, solder station and hot plate as well as necessary tools for prototyping.

- Supplies may be obtained from the EE Stockroom in the subbasement. If parts not carried by the stockroom are needed, they may be ordered through various local or online vendors. Students are responsible for fees associated with components.
- Return commonly used equipment each time you use it. Respect other's benches by only taking equipment that is not already being used. If difficulties occur, see a TA who will either arbitrate or locate additional equipment.
- **Students are responsible for fees associated with manufacturing and assembling the labs exercises.**

DETAILED LAB AND PROJECT GUIDELINES

1. LABS

Weekly lab assignments will be handed out and students are expected to finish the labs during the week.

2. Projects

Every week the same circuit that is assigned for weekly assignments will be prototyped and tested in the lab. Note that it is expected that the work done for each weekly project is done by the student while the student is registered for EE85. The quality of projects implementation and labs report will determine the projects grade that can be achieved for the course. Formal characterization of the performance of the projects (i.e., measurements indicating how well it did or did not meet its specifications) are also a substantial factor in grading.

3. Prepare a Lab Book

Each student must submit a lab book consisting of the following:

a. All lab reports for the weekly projects during each week.
b. A short writeup report describing each project, including what you learned, block diagrams, schematics, and component layouts. unexpected results, problems, etc.
c. It is essential that you fully characterize the performance of the projects matching what is covered during the week in class during lectures. All test and characterization data should be included in the projects report.

NOTE: The Lab Report book covering the Projects is due at the time of each week lab submissions.

4. EXAMS – MIDTERM AND FINAL EXAMS

There will not be a midterm and final examinations in this class.

DOES AND DON'TS

Collaboration.
Collaboration is one of the most important traits a student should develop in order to succeed in professional life.

Procrastination.
Do not procrastinate, or your grade will suffer accordingly.

Spinning the Wheels.
Do not spend a lot of time working on a problem that you cannot solve. If you spend more than a few hours on a problem and you still are not sure of the solution, ask the TAs or the instructor.

Parts Availability.
Students are responsible for selecting parts that are available in the market. There are many vendors online/offline that sell electronics part so do not wait more than a few days for parts to arrive.

HONOR CODE

"No member of the Caltech community shall take unfair advantage of any other member of the Caltech community". As applied to this course, it means that the circuit design you present and implement must be substantially your own. You can (and often should) receive help from various sources, but must not copy substantial parts of your design from another student, a book or the internet. You must thoroughly understand the operation of your circuit. If you do not, it will quickly become evident during the final presentation, with unfortunate consequences.

ACCESSIBILITY

In the case of a documented disability, please contact the Associate Dean of Students to coordinate any special accommodations.