University of California, Berkeley Extension

Integrated-Circuit Design and Techniques Program

X139: Advanced Analog Microelectronics

A. Course Description

Integrated analog filters, oscillators, and multivibrators are a very significant category of building blocks in a circuit designer's effort to develop an analog module for implementing many applications in signal processing or wireless communications. Topics include feedback, filters, oscillators, and multivibrators. The scope of the individual research projects includes switch-capacitor circuits, continuous-time filters, and VCOs for PLL applications. The instructor will guide you to choose a practical research topic which can be implemented in the real-world applications, such as frequency synthesizers or televisions.

B. Prerequisite

- *"X31: Fundamentals of Integrated-Circuit Design"*
- *"X33: Fundamentals of Analog Microelectronic Techniques"*

or working-level knowledge on fundamental analog microelectronics, such as

- Operational amplifier
- Differential amplifier
- Small-signal analysis
- Frequency response

C. Timeline

Pacing yourself well is one of the key factors to succeed in this course. *Mark your calendar* for the timeline and course events. *Make a pla*n for studying lectures and then follow through. If you do that, the odds that you perform with excellence and succeed in this course are very high.

Timeline	Course events	Lecture pace
Day 30	Homework 1	30% of lectures done
Day 60	Homework 2	60% of lectures done
Day 90	Homework 3	90% of lectures done
Day 90	Final exam request	
Day 120	Midterm exam	100% of lectures done
Day 120	Final exam date confirmed	Review
Day 150	Proctored final exam	
Day 180	Project/Course end	Lecture access expires

The course registration date (Day 1) is the date you receive the login information and welcome email. Remember, the final exam request process could take up to a month to complete.

D. Course Length

30 hours.

- The course length covers not only the audio runtime but also the time you need to catch up with the lecture presentation, including the time to re-listen the soundtrack (rewind and play), the time to watch the slides (pause), and the time to take notes.
- The students are expected to *take notes*. Remember, the shortest pencil is longer than the longest memory. You haven't really studied unless you write things down, including primary circuit diagrams, analysis, and key concepts, etc.
- Other than the 30-hour course length, you are expected to spend additional 60 hours studying the lectures, digesting the materials, working on the assignments, and preparing for the exams. This is based on the level of effort that a "*UC Berkeley qualified*" student must spend to be successful in the course.
- Most students listen/watch the lectures two or three times before they can fully grasp the concepts, cultivate problem-solving skills, and have a good grade on the final exam.

E. Credit

- *Type of Credit: Academic credit at UC Berkeley campus level*
- *Campus Department: Electrical Engineering & Computer Science (EECS)*
- *Level: Upper Division (Junior/Senior)*
- *Number of Units: 2*

F. Instructors

- *Lead Instructor: Dr. Vincent Chang*
- *Program Instructor: Dr. Han-Bin Lin*
- *Instructor's bio: Please visit* http://www.ucberkeleyext.com/.

G. Learning Objectives

Upon successful completion of the course, students will be able to

- Grasp fundamental concepts of feedback, integrated analog filters, oscillators, and multivibrators.
- Thoroughly understand the operation principles of the chosen topics.
- Analyze, simulate, and design a basic analog building block related to those topics.
- Possess the intuitive analysis skill to forecast/illustrate the circuit simulation results.

H. Short Session-By-Session Summary

Session 1. Feedback

The fundamental concepts and practical analysis techniques of feedback circuits are presented. The students will learn a technique to analyze a practical feedback circuit by reducing to an ideal structure yet the practical effects will still be taken into account.

- *General Considerations of Feedback*
- *Type of Amplifiers and Feedback Topologies*
- *Effect of Loading in Series-Shunt Feedback*

Session 2. Integrated Analog Filters

The filter is one of the most extensively used building block in signal processing. Two circuit techniques for realizing integrated analog filtering are continuous-time filter and switched-capacitor filter. One of the interesting concepts the students will take away in the topic of the continuous-time filter is to use the two-integrator-loop technique to design a universal filter, which can be implemented in one circuit but offering two or three different filtering functions.

- *Basics of Second-Order LRC Low-Pass Filters*
- *Band-Pass & All-Pass Filters Based on LRC Resonators*
- *Second-Order Active-RC Filters Based on Inductor Replacement*
- *Single Amplifier Biquadratic Active-RC Filters*
- *Active-RC Filters Based on Two-Integrator-Loop Techniques*
- *Basic Principles of Switched-Capacitor Filters*

Session 3. Oscillators

Students will learn to employ Barkhausen Criterion to analyze a sinusoidal oscillator. However, it would be more challenging for them to design a nonlinear circuit and to stabilize the amplitude of oscillation in a practical circuit. On the other hand, it would very unusual for an electronic engineer not to involve directly or indirectly with a crystal oscillator.

- *General Considerations of Sinusoidal Oscillators*
- *Wien-Bridge Oscillator with Nonlinear Amplitude Control Network*
- *Colpitts and Hartley LC Oscillators*
- *Theory and Application of Crystal Oscillators*

Session 4. Multivibrators and Function Generators

Through the detailed instruction and illustration, the students will thoroughly understand the central concept of Schmitt trigger—hysteresis, operation principle of astable and monostable multivibrators, and the 555 timer, one of the most versatile and prevailing analog IC. Take-home knowledge includes the skills to design a 555 oscillator and multivibrator deep to the internal architecture or on-chip level as well as the techniques to design a CMOS multivibrator to the transistor level.

- *Key Concepts of Hysteresis in Bistable Multivibrators*
- *Generation of Square Waveforms Using Astable Multivibrators*
- *Generation of Triangular Waveforms Using Astable Multivibrators*
- *Generation of Pulse Waveforms Using Monostable Multivibrators*
- *Generation of Square Waveforms Using Integrated-Circuit Timer*
- *Generation of Square Waveforms Using CMOS Multivibrators*

I. Methods of Instruction

- Online bilingual presentation—English and Mandarin
- Interactive discussion with the instructor via email
- *Three* homework assignments

- Practices from not only hand analysis but also SPICE simulation

Discussion Policy

To create a positive sharing & learning environment where all students can be benefited by learning from each other, the instructor may select your questions along with the instructor's answers and *anonymously* put them into Discussion Q&A.

If you have a concern the question you ask the instructor might be *anonymously* posted in the Discussion Q&A or you *don't* want to *anonymously* share your question with other fellow classmates, you should notify the instructor via email within 30 days from the course registration date.

J. Grade Structure

- Progress update & discussion: 20%
- Homework assignments: 10%
- Mid-term (Take-home exam): 20%
- Proctored final exam: 25%
- Project: 25%

K. Additional Classroom Info

Additional information will be posted and updated on a regularly basis. Please visit your Classrooms at http://www.ucberkeleyext.com/.