University of California, Berkeley Extension

Certificate Program in Semiconductor IC Design
Professional Sequence in Semiconductor Technology Fundamentals

EL ENG X490: IC Filters and Oscillators

(2 semester units in EL ENG, Online Format)

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.

Side-note: Student Testimony

I enjoyed the signal generator session very well, especially on the charging and discharging part of capacitors. I have been used to steady state analysis, and it's very helpful to me to learn more on transient analysis through this course. —Tianming Chen (2014)

B. Prerequisite

- *"X481: Intro to Microelectronic Circuits"*
- *"X483: Semiconductor IC Amplifiers"*
- *"X489: Fundamental Analog ICs"*

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

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

C. Timeline

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**	100% of lectures done
Day 120	Final exam setup	
Day 120	**Midterm Exam**	
Day 150	Final exam date confirmed	
Day 150	Optional final project	Extra bonus
Day 165	**Proctored final exam**	
Day 180	Course end	Lecture access expires

- 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.
- The course registration date (Day 1) is the date you receive the login information and welcome email.
- *You final exam request/setup process normally takes up to a couple of months to finalize. Therefore, it is strongly suggested you reserve the last two weeks (Day 165-180) for contingency.*
- *The official course end date is Day 180*, which is different from what you see on the classroom site where we add 20 additional days for pre-compensating technical access issues.

D. Required Readings

PDF Slides (Downloadable in the Classroom).

E. 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.

F. Intended Audience

This course is intended for technical professionals who want to enter the semiconductor market and are looking to acquire essential knowledge and skills in this area.

G. Course Content Outline

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*

H. Course Length

- The 30-hour course length covers not only the audio runtime but also the time to catch up by rewinding and replaying video. It also includes the time to take notes and to communicate/discuss with the instructor.
- 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.
- Most students watch the lecture video or read PDF slides two or three times before they can fully grasp the concepts, cultivate problem-solving skills, and have a good grade on the final exam.

I. Course Grade Weighting (Grading)

The student's cumulative grade in the course will be based on the following criteria:

- Discussion Participation: 10 points
- Progress Updates: 10 points
- Written Homework Assignments: 30 points

- Midterm Exam (Take-home exam): 20 points
- Final Exam: 30 points
- Optional Final Project (Extra bonus up to 10 points): 0 to 10 points

You must pass the final exam with a grade of at least 70 percent to pass the course.