University of California, Berkeley Extension

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

EL ENG X491: Analog IC Design
(2 semester units in EL ENG, Online Format)

Course Syllabus

A. Course Description

Advances in signal processing, analog/digital conversion, power management, and continuingly scaling down of CMOS nanotechnology have ushered in the era of analog IC design with multi-standard challenges in the 21st century. This state-of-the-art course includes stability of feedback, frequency compensation, multistage OPAMPs, and CMOS OPAMP designs with HSPICE. You are required to work on a research project which scope covers the design of an advanced CMOS OPAMP, a compact low-voltage low-power OPAMP, and high-performance CMOS comparators for flash ADC applications.

Side-note: Student Testimony

The course has benefited me a lot in terms of loop stability analysis. We are working on RF power amplifiers and RF leaks to bias circuits all the time. Being able to stabilize the bias loop is extremely important to us. I used knowledge learned from this class and fixed one loop instability this year. Feel very rewarding.—Tianming Chen (2013)

B. Prerequisite

- *"EL ENG X489: Fundamental Analog ICs"*
- *"EL ENG X490: IC Filters and Oscillators"*

or possess working-level knowledge on fundamental analog ICs, such as

- *Feedback*
- *Current mirrors*
- *Differential amplifiers & single-stage amplifiers*
- *Frequency response & class AB output stages*

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 ends

- 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 stability and frequency compensation and important characteristics of an OPAMP.
- Analyze, simulate, and design a multistage OPAMP and single-stage CMOS OPAMP.
- Possess the intuitive analysis skill to forecast/illustrate the circuit simulation results.
- Work on a hands-on design project with the scope including design of advanced CMOS OPAMP, a compact low-voltage low-power OPAMP, and high-performance CMOS comparator for the flash ADC application.

F. Intended Audience

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

G. Course Content Outline

Session 1. Stability

- *Stability of Feedback: Basic Concepts*
- *Stability Study of an OPAMP-Based Noninverting Amplifier*
- *Root Locus: Effect of Pole Locations on Stability*

Session 2. Frequency Compensation

- *Frequency Compensation: Basic Concepts*
- *Frequency Compensation: Implementation Techniques*
- *Miller Compensation & Pole-Splitting*

Session 3. Bipolar Multistage OPAMP

- *The Multistage OPAMP: Identification of Parts and Functions*
- *(Optional) DC Analysis of Bias Circuitry*
- *(Optional) DC Analysis of Input and Gain Stages*
- *(Optional) DC Analysis of Class AB Output Stage*
- *Frequency Response: Hand Analysis vs. Simulation*
- *Slew-Rate: Hand Analysis vs. Simulation*

Session 4. CMOS OPAMP

- *Two-Stage CMOS OPAMP: Part I*
- *Two-Stage CMOS OPAMP: Part II*
- *Cascode CMOS OPAMP*
- *Folded-Cascode CMOS OPAMP*
- *(Optional) Design of Two-Stage CMOS OPAMP Using HSPICE*
- *(Optional) Design of Cascode CMOS OPAMP Using HSPICE*
- *(Optional) Design of Folded-Cascode CMOS OPAMP Using HSPICE*

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.