University of California, Berkeley Extension

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

EL ENG X489: Fundamental Analog ICs

(2 semester units in EL ENG, Online Format)

A. Course Description

Gain competitive advantages and enriching experiences by learning how to analyze, simulate, and design true-to-life examples—CMOS analog integrated-circuits. This course is intended for working professionals who have no strong foundation on analog design but are interested in either upgrading their knowledge and skills or redirecting career development in the valuable semiconductor market. Lectures covered include: basic current mirrors, high-performance current mirrors, single-stage CMOS amplifiers, differential amplifiers, output stages, and short-circuit protection circuitry.

B. Prerequisite

- *"EL ENG X488: Semiconductor Devices for IC Design"*
- *"EL ENG X483: Semiconductor IC Amplifiers"*

or working-level knowledge on basic microelectronic circuits and semiconductor devices, such as

- *BJT and MOS I-V characteristics*
- *Low-frequency and high-frequency modeling of BJT and MOS*
- *Small-signal analysis and analysis-by-inspection skills*
- *High-frequency analysis and analysis-by-inspection skills*

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.*

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 CMOS devices and integrated-circuits.
- Thoroughly understand analog IC schematic diagrams.
- Analyze, simulate, and design a basic building block of a CMOS analog IC.
- 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 in this area.

G. Course Content Outline

Session 1. Basic Current Mirrors

The fundamental principles of basic current mirrors are presented. Students will not only learn how to analyze current mirrors but also get a clear understanding about the concept of output resistance.

- *General Considerations of BJT Current Mirrors*
- *General Considerations of MOS Current Mirrors*
- *Simulation and Design of BJT Widlar Current Mirror*

Session 2. High-Performance Current Mirrors

Built upon the foundation of the basic current mirrors, students will experience different high-performance current mirrors and taste a couple of bias design in modern commercial IC, such as very powerful one--CMOS Gm-stabilized bias design.

- *BJT Wilson Current Mirror*
- *MOS Cascode Current Mirror*
- *CMOS Transconductance-Stabilized Bias Design*

Session 3. Differential Amplifiers

The analysis skills and fundamental concepts, such as differential-mode vs. common-mode, of a differential amplifier are illustrated. While many students have been struggling with the complicated mathematical derivation from the small-signal model, our participants will be trained by quick analysis-by-inspection method.

- *Input Common-Mode Range*

- *Small-Signal Analysis Skills of Differential Amplifiers*
- *MOS Differential Amplifiers*
- *Differential-Mode vs. Common-Mode Half-Circuit*
- *Active-Load Differential Amplifiers*
- *High Frequency Response of Differential Amplifiers*
- *Wide-Band Differential Amplifiers*

Session 4. Single-Stage CMOS Amplifiers

Only active-load CMOS amplifiers are discussed here because these types of amplifiers are more practical than other types in the analog IC design. Students will be cultivated to have an intuitive analysis skill which is valuable for the complex circuit configuration, like double cascade.

- *Active-Load NMOS IC Amplifier*
- *High Frequency Response of CMOS IC Amplifier*
- *CMOS & BiCMOS IC Amplifiers*

Session 5. SPICE Simulation and Analysis of Output Stages

Both hand analysis and simulation skills for different output stages are presented. Students will learn an impressive concept and practical techniques to design a short-circuit protection circuitry for the real world applications.

- *Class A Output Stage: Simulation & Analysis*
- *Class B Push-Pull Output Stage*
- *Design of Class AB Output Stage*

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.