University of California, Berkeley Extension

Professional Sequence in Semiconductor Technology Fundamentals

EL ENG X481: Introduction to Microelectronic Circuits

(1 semester unit in EL ENG, Online Format)

Course Syllabus

A. Course Description

This course reveals underlying concepts and industry-standard simulation tools for IC design, emphasizes the operational amplifier characteristics, and highlights the practical amplifier behaviors in the frequency domain. Designed for technical professionals, this course provides a practical blend of understanding analog circuit essence and properties through analysis-by-inspection and PSPICE simulation. Topics include basic operational amplifier (OPAMP) circuits and applications, s-domain analysis, bandwidth and slew rate limitations, and analyzing frequency limitations of amplifiers – a pivotal foundation for advancing to more intricate IC design topics such as oscillators and filters.

B. Prerequisite

- *"X480: Intro to Microelectronics"*

or working-level knowledge on basic electronics, such as

- *Amplifier basics*
- *OPAMP basics*
- *Circuit theory basics, including KVL, KCL, source transformation, and Miller theorem.*

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 90	Final exam setup	
Day 120	**Midterm exam**	
Day 120	Final exam date confirmed	Review
Day 150	**Proctored final exam**	
Day 180	Course ends	

- Pacing yourself well is one of the key factors to succeed in this course. *Mark your calendar* for the timeline and course events.
- The course registration date (Day 1) is the date you receive the login information and welcome email.
- *It is strongly suggested you reserve the last month (Day 151-180) for contingency.*
- *You final exam request/setup process normally takes up to a couple of months to finalize.*

D. Required Readings

PDF Slides (Downloadable in the Classroom).

E. Learning Objectives

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

- Perform the operational-amplifier circuit analysis, such as inverting amplifiers, integrators, low-pass filters, and differential amplifiers.
- Get a comprehensive understanding of the non-ideal characteristics of a real OPAMP, such as offset voltage, frequency response, slew-rate and output saturation, their causes, and dominant factors.
- Possess the intuitive analysis skill to forecast/illustrate the circuit simulation results.

H. Short Session-By-Session Summary

Session 1. Basic OPAMP Circuits

While starting from two of the most frequently used closed-loop amplifiers in OPAMP, the instructor will transcend the scope based on the assumption of ideal OPAMP to some of the insight analysis such as complementary transformation between these two configurations.

- *Closed-Loop Amplifier Configurations Based on OPAMP*

Session 2. *s*-Domain Analysis

Rather than walk through the tedious calculation in the complex math, the instructor will use sophisticated teaching skills to have students understand the two cores of the transfer function—magnitude and phase—from a real circuit perspective. The students will lay a foundation on the basic concepts and analysis skills in the complex-frequency domain (s-domain) as well as have more understanding on the amplifier frequency response by get the knowledge of magnitude and phase characteristics of the single-time-constant low-pass and high-pass network.

- *Basic Concepts in Frequency Domain Analysis*

Session 3. Applications of OPAMP

Having built the foundation on the s-domain analysis, the students will be able to use the skills to analyze the frequency domain performance of the four circuits—integrators, differentiators, low-pass filters, and high-pass filters. On the other side, while starting from an introduction of the OPAMP-based differential amplifier, the instructor will gradually direct the fundamental analysis such as input resistance and differential gain into more advanced discussion in the instrumentation amplifier and some striking waveforms from SPICE simulation.

- *Frequency Domain Applications of OPAMP*
- *Design and Simulation of Differential Amplifiers*

Session 4. Non-ideal Characteristics of OPAMP

A comprehensive understanding of the non-ideal characteristics such as frequency response, slew-rate and output saturation, their causes, and dominant factors is essential for tracking the small-signal as well as large-signal behavior of an OPAMP. Without having to going into details in the internal IC structure, the students will be able to use a simplified model to delineate the small-signal and large-signal behavior and the primary causes of the slew-rate and output saturation. Plus, the students will learn the causes, modeling, analysis skills, and circuit improvements with respect to the two dc problems of an OPAMP—input offset voltage and bias current.

- *Small-Signal Frequency Limitations of OPAMP*
- *Large-Signal Frequency Limitations of OPAMP*
- *Nonideal DC Characteristics of OPAMP*

Session 5. Into to Frequency Response of Amplifiers

With regards to the design tradeoff for an analog design, someone will probably trade the speed or bandwidth for the gain or power. So, it's important for the students to understand the cause of frequency limitations of amplifiers.

- *Frequency Domain Analysis: Complex Transfer Function*
- *Frequency Domain Analysis: Time-Constant Methods*

F. Course Length

- The 15-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 15-hour course length, you are expected to spend additional 30 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.

G. 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): 20 points
- Final Exam: 30 points

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