University of California, Berkeley Extension

Integrated-Circuit Design and Techniques Program

X236: Fundamentals of Modern Data Converter Design

Course Syllabus

A. Course Description

Ever-increasing applications on signal-processing such as video and wireless communications demand high speed and high resolution data converter techniques. Teaching you how to become a more professional engineer through a practical online learning of diagnosing and tackling real-world issues, Dr. Chang will arm you with the solid foundation to reach a higher standard of proficiency. This course is intended for practitioners who have industry experiences or knowledge background on electronics and are interested in upgrading their hands-on design skills in the modern techniques for the data conversion. Include data converter fundamentals, characterization, performance limitations, and Nyquist-rate D/A and A/D converters.

B. Prerequisite

- *" X31: Fundamentals of Integrated-Circuit Design"*

or working-level knowledge on electronics is expected.

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 45	Homework 1	40% of lectures done
Day 90	Homework 2	80% 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	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

15 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 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. 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: Graduate School*
- *Number of Units: 1*

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

- Understand sampling basics and anti-aliasing.
- Grasp fundamental concepts of data converter design and the knowledge of converter characterization and performance limitations.
- Analyze and design different types of Nyquist-rate A/D and D/A converters.

H. Short Session-By-Session Summary

Session 1. Intro to Data Converters

The fundamental aspects of A/D and D/A data converters without respect to their internal circuits or architectures will be presented. A clear understanding of the properties of the quantization noise signal is essential for analyzing any practical data converter. The students will learn how to express the quantization error and understand the relationship between the SNR and number of bits.

- *Intro to Data Converters*
- *Sampling Basics and Anti-Aliasing*

Session 2. Characterization and Limitations

The characterization of data converters is very crucial in understanding their architecture design. The students will learn all the characterization parameters and their performance limitation formulations, such as resolution, full scale, dynamic range, SNR, ENOB, static conversion errors, integral nonlinearity, differential nonlinearity, monotonicity, speed, the dynamic impacts caused by the unity-gain bandwidth, the slew-rate, and the settling time of the OPAMP.

- *Static Characteristics of D/A Converters*
- *Dynamic Characteristics of D/A Converters*
- *Performance Limitations of A/D Converters*

Session 3. Fundamental Nyquist-Rate DACs

The students will be able to analyze the converters not only by writing down the relationships between the digital inputs and analog output but delineating the accuracy and the speed limitations.

- *Current Scaling D/A Converter: Binary-Weighted*
- *Voltage Scaling D/A Converter*

Session 4. Fundamental Nyquist-Rate ADCs

The students will understand the operation principle of two popular ADC structures—SAR and flash.

- *Successive-Approximation Register A/D Converters*
- *High-Speed A/D Converters: Flash*

I. Methods of Instruction

- Online bilingual presentation—English and Mandarin
- Discussion with the instructor via email
- Homework assignment

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

- Class participation & discussion=30%
- Homework assignments =20%
- Mid-term (Take-home exam)=20%
- Proctored final exam=30%

K. Additional Classroom Info

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