

San José State University
Electrical Engineering Department
EE-288, Data Conversion for Analog and Mixed Signal ICs

Course and Contact Information

Instructor:	Dr. Shahab Ardalan
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Office Hours:	TBD
Class Days/Time:	TBD
Classroom:	TBD
Course Website:	http://www.engr.sjsu.edu/ardalan

Course Description

This course studies different architectures for integrated analog to digital converters and digital to analog converters. System level modeling and simulation using Matlab and Simulink. Design considerations and techniques for circuit implementation. The key essential blocks such as sampler, track-and-hold and voltage comparator will be explained in circuit level. Techniques and methods for data converters testing will be covered.

Course Goal and Student Learning Objective

- 1. Understanding data conversion concept and associate performance metrics such as INL, DNL, ENOB, THD, SNR, SNDR and ...*
- 2. Understanding Nyquist rate data converters architectures such as flash, pipeline, folding, interpolating, SAR*
- 3. The ability to model data converters using Matlab/Simulink*
- 4. The ability to design essential circuit block for data conversions such sampler, track and hold and comparators.*
- 5. Understanding oversampling data conversion concept*
- 6. Understanding sigma-delta modulator and noise shaping*
- 7. The ability to model and design delta sigma modulator and oversampling ADCs*

8. *Understanding mechanism and procedures for testing a data converter and design for testability (DFT).*

GE/SJSU Studies Learning Outcomes (LO)

Upon successful completion of this course, students will be able to:

- GELO 1. Students will be able to model, analyze and design different data converters circuits..*
GELO 2. Students will be able to understand the concept of INL, DNL, ENOB, THD, SNR, SNDR
GELO 3. Students will be able to use modern engineering modeling CAD tools for computations, modeling, simulations, analysis, and design.
GELO 4. Students will be able to verify the theory with hands-on lab simulations.

Required Texts/Readings

Textbook

“Data Conversion System Design”, B.Razavi, IEEE Press, 1995. (Available on IEEE explorer

Other Readings

“CMOS Data Converters for Communications”, Gustavsson, Wikner, Tan, Kluwer, 2000.

Course Requirements and Assignments

Class participation, Quizz, assignments, midterm exams, lab and final exam

Grading Policy

Exams will be closed book. However, students are allowed to bring 1/2 page of aid sheet, where can be option from this link (www.ardalan.ws/pdf). There will be no make-up exam and those absent will receive no credit. Students must write their answers clearly in an organized fashion. Further instructions will be provided during exams. The course is based on letter grading and grading percentage breakdown is as follow:

90% and above A
89% - 85% A-
84% - 82% B+
81% - 79% B
78% - 75% B-
74% - 72% C+
71% - 69% C
68% - 65% C-
64% - 62% D+
61% - 59% D
58% - 55% D
below 55% F

Total final grade is

Midterm Exam	30%
Final Exam	30%
Project	40%

Classroom Protocol

Students are required to be in class on time and no use of cell phone during the class.

University Policies

Dropping and Adding

Students are responsible for understanding the policies and procedures about add/drop, grade forgiveness, etc. Refer to the current semester's [Catalog Policies](http://info.sjsu.edu/static/catalog/policies.html) section at <http://info.sjsu.edu/static/catalog/policies.html>. Add/drop deadlines can be found on the current academic year calendars document on the [Academic Calendars webpage](http://www.sjsu.edu/provost/services/academic_calendars/) at http://www.sjsu.edu/provost/services/academic_calendars/. The [Late Drop Policy](http://www.sjsu.edu/aars/policies/latedrops/policy/) is available at <http://www.sjsu.edu/aars/policies/latedrops/policy/>. Students should be aware of the current deadlines and penalties for dropping classes.

Information about the latest changes and news is available at the [Advising Hub](http://www.sjsu.edu/advising/) at <http://www.sjsu.edu/advising/>.

Consent for Recording of Class and Public Sharing of Instructor Material

- “Common courtesy and professional behavior dictate that you notify someone when you are recording him/her. You must obtain the instructor’s permission to make audio or video recordings in this class. Such permission allows the recordings to be used for your private, study purposes only. The recordings are the intellectual property of the instructor; you have not been given any rights to reproduce or distribute the material.” To obtain the permission for recording the lectures you need to request it in formal writing for each lecture.
- “Course material developed by the instructor is the intellectual property of the instructor and cannot be shared publicly without his/her approval. You may not publicly share or upload instructor generated material for this course such as exam questions, lecture notes, or homework solutions without instructor consent.”

Academic integrity

Your commitment, as a student, to learning is evidenced by your enrollment at San Jose State University. The [University Academic Integrity Policy S07-2](http://www.sjsu.edu/senate/docs/S07-2.pdf) at <http://www.sjsu.edu/senate/docs/S07-2.pdf> requires you to be honest in all your academic course work. Faculty members are required to report all infractions to the office of Student Conduct and Ethical Development. The [Student Conduct and Ethical Development website](http://www.sjsu.edu/studentconduct/) is available at <http://www.sjsu.edu/studentconduct/>.

Campus Policy in Compliance with the American Disabilities Act

If you need course adaptations or accommodations because of a disability, or if you need to make special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible, or see me during office hours. [Presidential Directive 97-03](http://www.sjsu.edu/president/docs/directives/PD_1997-03.pdf) at http://www.sjsu.edu/president/docs/directives/PD_1997-03.pdf requires that students with disabilities requesting accommodations must register with the [Accessible Education Center](http://www.sjsu.edu/aec) (AEC) at <http://www.sjsu.edu/aec> to establish a record of their disability.

Accommodation to Students' Religious Holidays

San José State University shall provide accommodation on any graded class work or activities for students wishing to observe religious holidays when such observances require students to be absent from class. It is the responsibility of the student to inform the instructor, in writing, about such holidays before the add deadline at the start of each semester. If such holidays occur before the add deadline, the student must notify the instructor, in writing, at least three days before the date that he/she will be absent. It is the responsibility of the instructor to make every reasonable effort to honor the student request without penalty, and of the student to make up the work missed. See [University Policy S14-7](http://www.sjsu.edu/senate/docs/S14-7.pdf) at <http://www.sjsu.edu/senate/docs/S14-7.pdf>.

EE-288, Data Conversion for Analog and Mixed Signal ICs, Course Schedule

Course Schedule

- Lecture - 1 Introduction to data conversion, ideal sampling
- Lecture – 2 Time and Data Quantization
- Lecture – 3 Data Reconstruction
- Lecture – 4 Data Conversion Metrics (INL, DLN, ENOB, THD,..)
- Lecture – 5 Nyquist Rate DACs
- Lecture – 6 Sampler: Concept and Modeling
- Lecture – 7 Sampler circuits
- Lecture – 8 Sampler circuits and non-idealities
- Lecture – 9 Comparators: Concept and Modeling
- Lecture – 10 Comparators: circuits implementation
- Lecture – 11 Nyquist Rate ADC
- Lecture – 12 Flash ADCs-1 (Modeling)
- Lecture – 13 Flash ADCs-2 (Design Considerations)
- Lecture – 14 Folding ADCs
- Lecture – 15 Interpolating ADCs
- Lecture – 16 Midterm
- Lecture – 17 Pipeline ADCs-1 (Concept)
- Lecture – 18 Pipeline ADCs-2 (Modeling)
- Lecture – 19 Pipeline ADCs-3 (Circuit Design)
- Lecture – 20 Pipeline ADCs-4 (Design Considerations)
- Lecture – 21 SAR ADCs-1 (Concept and Modeling)
- Lecture – 22 SAR ADCs-2 (Design Considerations)
- Lecture – 23 Oversample ADC-1 (Concept: Noise Shaping and introduction to $\Sigma\Delta$)
- Lecture – 24 Oversample ADC-2 (Concept: $\Sigma\Delta$ Modulator)
- Lecture – 25 Oversample ADC-3 ($\Sigma\Delta$ Modulator Modeling)
- Lecture – 26 Oversample ADC-4 (Design Consideration-1)
- Lecture – 27 Oversample ADC-5 (Design Consideration-2)
- Lecture – 28 Data Converters Testing
- Lecture – 29 Project Demo and Presentation-1
- Lecture – 30 Project Demo and Presentation-2
- Lecture – 31 Final Exam