

ECE 511: Analog Integrated Circuits

Instructor:

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Course web page <https://moodle1415-courses.wolfware.ncsu.edu/course/view.php?id=2077>

***Please use the course bulletin board to ask questions about lectures, HW, projects, etc. It is the best way to broadcast questions that may be of interest to everyone.

Course Objective:

After taking this course, the student should be able to analyze and design fundamental analog integrated circuit blocks at the transistor level, including single and multi-stage amplifiers, bias networks, and both elementary and advanced operational amplifiers. The student should be able to determine the effect of feedback on circuit operation and then design appropriate feedback networks for amplifier and bias circuits. Finally, the student should be able to efficiently use Cadence design tools for circuit design and analysis.

Prerequisite:

ECE 403 (senior-level undergraduate microelectronics course covering (a) principles of transistor operation, (b) dc & small-signal analysis of single-stage and multi-stage analog circuits including differential amplifiers and current mirrors, and (c) SPICE analysis of these circuits)

Required Text:

- o Razavi, *Design of Analog CMOS Integrated Circuits*, McGraw-Hill, 2001.

Supplementary Texts:

- o Gray, Hurst, Lewis, & Meyer, *Analysis & Design of Analog Integrated Circuits*, Wiley, 5th ed.
- o Carusone, Johns, & Martin, *Analog Integrated Circuit Design*, Wiley, 2012, 2nd ed.
- o Kundert, *The Designer’s Guide to Spice & Spectre*, Springer, 1995 (or equivalent).

Grading:

- 40% Tests (2)
- 20% Final
- 20% Homework (roughly 8 assignments)
- 20% Design project

The course grades will be determined as follows:

Score	>97	93 – 97	87 – 93	83 – 87	77 – 83	73 – 77	67 – 73
Grade	A+	A	A-/B+	B	B-/C+	C	C-/D+

Simulation:

SPICE-based circuit simulation will be used in the homework and projects. Students will use the Cadence design environment and the Spectre SPICE based circuit simulator, and will learn how to use these tools through provided tutorials.

Academic Integrity:

Students should refer to the University policy on academic integrity found in the Code of Student Conduct (found in Appendix L of the Handbook for Advising and Teaching). *It is the instructor's understanding and expectation that the student's signature on any test or assignment means that the student neither gave nor received unauthorized aid.* Authorized aid on an individual assignment includes discussing the interpretation of the problem statement, sharing ideas or approaches for solving the problem, and explaining concepts involved in the problem. Any other aid would be unauthorized and a violation of the academic integrity policy. Any computer work submitted must be completed on your own personal computer or from your own NCSU account to avoid confusion about the origin of the file, and no sharing of files in any way is allowed. Students found in violation of the academic integrity policy will be reported to the NCSU Office of Student Conduct.

Homework:

Approximately 8 homework assignments will be assigned through the course of the semester, accounting for 20% of the grade. This year, all students will submit their homework assignment on-line through upload to the moodle course website.

→**Late policy:** late homework will automatically incur a 20% penalty and must be submitted no later than Friday the week they are due.

Design Project:

One major project is planned for this course on the design of a CMOS operational amplifier. Students will be creating designs using available industry design kits and Cadence / SpectreRF design tools and then write a comprehensive design report. The overall grading of the project will depend upon the quality and content of the design report and the performance of the design against specifications.

→**Late policy:** design projects must be submitted on-line before 11:55PM on the due date. Late submissions will automatically incur a 20% penalty PLUS an additional 1% per day late.

Captured Lectures:

This on campus course will be captured and distributed via the Internet and/or electronic media as part of the Engineering Online (EOL) program for the distance students. These video recordings may contain an image of you entering the classroom, asking a questions or being a part of the studio class. Please notify Dr. Linda Krute, Director of EOL, in writing at ldkrute@ncsu.edu if you **DO NOT** want your image to be included in the lecture presentation. If we do not hear from you after the first week of the class, we will assume that you are in agreement with this procedure.

Students with Disabilities:

Reasonable accommodations will be made for students with verifiable disabilities. To take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Hearth Center, Campus Box 7509, 515-7653. <http://www.ncsu.edu/dso>.

Supporting Fellow Students in Distress:

As members of the NC State community, we each share a personal responsibility to express concern for one another and to ensure that this classroom and the campus as a whole remains a safe environment for learning. Occasionally, you may come across a fellow classmate whose

behavior concerns or worries you. When this is the case, I would encourage you to report this behavior to the NC State Students of Concern website: <http://studentsofconcern.ncsu.edu/>.

Course Schedule:

Lecture #	Topic	Reading: Razavi
1	Course introduction	Ch 1
2	Device Physics 1	Ch 2
3	Device Physics 2	
	NO CLASS (Labor Day Holiday)	
4	Single-stage amplifiers	Ch 3
5	Cascodes	
6	Current Mirrors	Ch 5.1-5.2
7	Differential Amplifiers 1	Ch 4
8	Differential Amplifiers 2	
9	Active Loads	Ch 5.3
10	Review for Test	
	Test 1	Ch 1-5
11	Frequency Response 1	Ch 6
12	Frequency Response 2	
13	Feedback 1	Ch 8
14	Feedback 2	
15	Feedback 3	
16	Operational Transconductance Amp 1	Ch 9
17	Operational Transconductance Amp 2	
18	Operational Transconductance Amp 3	
19	Bias Networks 1	Ch 10
20	Review for Test	
	Test 2	
21	Compensation and Stability	
22	Common-Mode Feedback	Ch 11
23	Noise 1	Ch 7
24	Noise 2	
	NO CLASS, (Thanksgiving Holiday)	
25	Bandgap references	Ch 11
26	Layout and Manufacturing	Ch 17-18
	Final Project Due at 11:55PM	
	Final Exam, 1-4PM	