



ECE 511: Analog Electronics

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Teaching Assistants: Saleh Almahmoud saalmahm@ncsu.edu
Lectures: Mon. and Wed., 3 PM – 4:15 PM, EB2 1230

Web page <https://moodle-courses2425.wolfware.ncsu.edu/course/view.php?id=3939>

***Please use the course forums to ask/answer questions about lectures, HW, projects, etc. It is the best way to share information with 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 electronic design tools for circuit design and analysis.

Prerequisite:

ECE 403, a 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 for All Students (choose ONE of the following):

[CJM]: Carusone, Johns, Martin, *Analog Integrated Circuit Design*, Wiley, 2012, 2nd ed.

[GHLM]: Gray, Hurst, Lewis, Meyer, *Analysis & Design of Analog ICs*, Wiley, 5th ed.

(GHLM textbook is available as an electronic book through course website, see below)

➔ Additional Text for students with only one semester of undergraduate electronics

- Murmann, *Analysis and Design of Elementary MOS Amplifier Stages*, 1st edition, National Technology & Science Press, 2013. (available for free [on-line](#))

Supplementary Texts:

- Razavi, *Design of Analog CMOS Integrated Circuits*, McGraw-Hill, 2001.
- Kundert, *The Designer's Guide to Spice & Spectre*, Springer, 1995 (or equivalent).

e-Book:

This class is taking part in NC State's All-In program. The texts are available electronically on the course Moodle site. This is a cost effective way for you to obtain the textbook. You have free access through the drop/add date. You must purchase access during that time using the link on the Moodle page to the bookstore's website. If you do not purchase access by the drop/add date, YOU WILL LOSE ACCESS and will then have to acquire the text through another source.

Grading: 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+

Grading: Equal weighting assigned among the following:

Test 1	scheduled for Sep. 30, 2024
Test 2	scheduled for Nov. 06, 2024
Homework	roughly seven assignments
Design project	due on Tuesday, Dec. 02, 2024, with intermediate deadlines
Optional Final**	scheduled for Wednesday, Dec. 11, 2024, 3:30PM – 6:00PM

The final exam is optional. Students who choose **not to take the final exam will have their grade calculated based on equal weighting between Test 1, Test 2, homework, and the design project. Students who choose to take the final exam will have their grade calculated based on the maximum of their original grade (without the final) and their new grade (with the final), where the final is averaged together with Tests 1 and 2 to create a total test grade where Test 1, Test 2, and Final are each 16.67% of grade.

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 name/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 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 NC State account to avoid confusion about the origin of the file, and no sharing of files in any way is allowed. Absolutely no sharing of schematics or results are allowed for any Cadence-based assignment. Students found in violation of the academic integrity policy will be reported to the NC State Office of Student Conduct.

Homework:

Multiple homework assignments will be assigned through the course of the semester. Assignments will be uploaded through Moodle.

→**Late policy:** late homework will incur a 20% penalty and must be submitted no later than the end of the weekend following the day they are due.

Design Project:

One term 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 (or LTSPICE) 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.

→**Late policy:** reports must be submitted on-line before 11:55 PM on the due date. We will also have intermediate deadlines to help teams make progress throughout. Late submissions will incur a 1% penalty per hour, capped at maximum of 24% deduction.

Simulation:

SPICE-based circuit simulation will be used in the homework and projects. On-campus students will use the Cadence design environment, accessed through NC State servers, whereas EOL students can use either LTSPICE, which can be installed on a personal computer, or Cadence.

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 Health Center, Campus Box 7509, 515-7653. <http://www.ncsu.edu/dso>.

Health and Well-Being Resources:

Everyone is encouraged to take care of themselves and their peers. If you need additional support, there are many resources on campus to help you:

- Student Health Services ([Health Services | Student](#))
- If the personal behavior of a classmate concerns or worries you, either for the classmate's well-being or yours, we encourage you to report this behavior to the NC State CARES team: ([Share a Concern](#)).
- If you or someone you know are experiencing food, housing or financial insecurity, please see the [Pack Essentials](#) Program.

Need Help?

If you find yourself in a place where you need help, academically or otherwise, please review these [Step-by-Step Help Topics](#).

Other Important Resources

- [Keep Learning](#)
- Protect the Pack [Frequently Asked Questions](#)
- NC State Protect the Pack [Resources for Students](#)
- [Academic Success Center](#) (tutoring, drop in advising, career and wellness advising)
- NC State [Keep Learning Tips for Remote Learning](#)
- Introduction to Zoom for students: <https://youtu.be/5LbPzzPbYEW>
- Learning with Moodle, a [student's guide to using Moodle](#)
- NC State Libraries [Technology Lending Program](#)

Course Topics and Reading (refer to website for dates):

Lecture #	Topic	Reading: CJM	Reading: GHLM	Reading: Razavi	Project Milestone
1	Course introduction	Ch. 1	1.1-1.2	Ch. 1	
2	MOSFETs 1		1.3-1.4	Ch. 2	
3	MOSFETs 2		1.5-1.8		
4	Single-Stage Amplifiers	3.2-3.4	3.1-3.3	Ch. 3	
	NO CLASS -- LABOR DAY				
5	Cascodes	3.7	3.4		
6	Biasing 1: Current Mirrors	3.1, 3.5, 3.6	4.1-4.2	Ch. 5.1-5.2	
7	Diff Amps 1	3.8	3.5	Ch. 4	Deadline 1
8	Active Loads		4.3	Ch. 5.3	
9	Diff Amps 2				
10	Review for Test 1				
	Test 1	Ch. 1+3		Ch. 1-5	
11	Frequency Response 1	Ch. 4	7.1-7.2	Ch. 6	
12	Frequency Response 2		7.3		
13	Feedback 1	Ch. 5	8.1-8.7	Ch. 8	Deadline 2
14	Feedback 2		8.8		
	NO CLASS -- FALL BREAK				
15	Feedback 3		8.9		
16	Opamp 1	Ch. 6	6.1-6.3	Ch. 9	
17	Opamp 2		6.4-6.7		
18	Opamp 3		12.1-12.3		
19	Biasing 2 and Output Buffers	6.3, 7.2	4.4	Ch. 10	
20	Review for Test 2				
	Test 2				
21	Compensation and Stability	6.2	9.1-9.4, 9.6		
22	Common-Mode Feedback	6.8	12.4-12.9	Ch. 11	Deadline 3
23	Noise 1	Ch. 9	11.1-11.3	Ch. 7	
	NO CLASS -- THANKSGIVING				
24	Noise 2		11.4-11.8		
25	Biasing 3: Bandgaps	Ch. 7.3	4.4.3	Ch. 11	
26	Layout and Manufacturing	Ch. 2	2.1-2.14	Ch. 17-18	Project Due
	Optional Final Exam				