The University of Maine
Department of Electrical and Computer Engineering
ECE 444 – Analog Integrated Circuit Design

Spring 2023

Analog Integrated Circuit Design

Course: ECE 444
Credits: 3
Lectures: 9:30 - 10:45 am, Tuesday and Thursday, 203 Williams Hall
Web Site: Brightspace (https://umaine.edu/studentaccessibility/brightspace)
Prerequisite: ECE 342 - Electronics I
Co/Pre-requisite: ECE 343 - Electronics II

Instructor

Dr. David E. Kotecki
Office: 277 Barrows Hall
Virtual office: https://maine.zoom.us/my/davidkotecki (passcode: circuits23)
e-mail: kotecki@maine.edu
Phone: 207.581.2248

Office Hours

10:00 - 11:00 am, Wednesday and Friday
2:00 - 4:30 pm, Monday, Tuesday, and Thursday (221 Barrows)
You are encouraged to drop by my office or lab, either in-person or virtually, to ask questions and discuss homework problems. If you are unable to meet during these times, e-mail me to set up an appointment.

Primary Text

Text: “Analysis and Design of Analog Integrated Circuits, (5th Edition)”
Authors: Paul R. Gray, Paul L. Hurst, Stephen H. Lewis, and Robert G. Meyer
Publisher: Wiley
Year: 2009
ISBN: 978-0-470-24599-6

Reference Texts

Text: “Analog Integrated Circuit Design 2nd Edition”
Authors: Tony Chan Carusone, David Johns, and Kenneth Martin
Publisher: Wiley
Year: 2011
ISBN: 978-0470770108

Text: “Design Of Analog Cmos Integrated Circuit , 2nd Edition ”
Authors: Behzad Razavi
Publisher: McGraw Hill
Year: 2017
ISBN: 978-9325983274

Goal and Objectives of Course

The challenge for the analog integrated circuit designer is to design circuits that implement the required analog function while achieving a high level of reliability and a good balance between cost, performance, and power. The design must operate properly in the presence of process variations, supply voltage fluctuations, and changes in environmental conditions including temperature and external noise.

This course provides a more in depth discussion of analog circuit design than is taught in ECE 342 and ECE 343. Topics discussed include characteristics and models of state-of-the-art BJT and deep submicron MOSFET devices; basic building blocks of analog integrated circuits including single-transistor and multi-transistor amplifier configurations, current mirrors, current sources, voltage-insensitive circuits, band-gap reference circuits, active loads and output stages; various operational amplifier designs including the effect of transistor mismatch on amplifier performance; noise sources present in analog circuits; and non-linear analog circuits, such as the frequency doubler, the Gilbert cell mixer. and the phase-lock loop (PLL).

New techniques for analog circuit analysis are introduced. These include: signal distortion analysis, zero-time constant analysis, return ratio analysis and Blackmann’s impedance formula.

Primary Goal of Course: Provide an understanding of the fundamentals of Analog Integrated Circuit Design from the transistor-level point of view with an emphasis on **design trade-offs** required for optimization of circuit performance, cost, power consumption, noise immunity and reliability.

Homework Assignments (25% of grade)

Homework problems are located at the end of each chapter. There are fifty problems plus three extra-credit problems. Each problem is worth 0.5 points. Assigned problems are listed below. You are not expected to do the Spice simulations associated with the problems.

After completing each assignment, scan or photograph your solutions and upload them to the Assignment section in Brightspace.

Homework	Chapter	Problems
Homework #1	1	1.1, 1.2, 1.3, 1.11, 1.12, 1.15, 1.19, 1.22
Homework #2	3	3.2, 3.3, 3.9, 3.10, 3.13, 3.18, 3.21, 3.27
Homework #3	4	4.1. 4.3, 4.9, 4.11, 4.20, 4.22, 4.32, 4.34
Homework #4	6	6.2, 6.4, 6.7, 6.10, 6.16, 6.18
Homework #5	7	7.1, 7.8, 7.14, 7.15, 7.21, 7.22, 7.33, 7.39
Homework #6	8	8.1, 8.7, 8.25, 8.26, 8.27, 8.28

Feel free to discuss the problems and your solutions with other students in the class. If you have questions about any of the problems, we can discuss them in class or you can stop by my office.

Design Project (30% of grade)

A design project will be used to provide additional understanding and insight into fundamental issues in analog integrated circuit design. The circuits can be designed using 65nm, 180nm, and 350nm CMOS processes.

The design project will consist of a band-gap reference circuit for voltage and temperature compensation. A project report will be due at the end of the semester.

NGspice (http://www.cppsim.com/about_ngspice.html) and Matlab® (https://umaine.edu/it/software/matlab/) will be used to perform circuit simulations. A link to instructions for configuring NGspice are located on the Brightspace home page. Alternatively, LTspice version 17 or above can also be used.

Exams (45% of grade)

There are three Exams. Each exam is worth 22.5% of your grade and the lowest exam grade is dropped. The exams may consist of an in-class portion and a take-home portion. The exams are to be completed individually; do not discuss the exam with any other student during the examination period.

The tentative exam schedule is as follows:

Exam #1	7 March 2023
Exam #2	20 April 2023
Final Exam	2 May 2023 (8:00 am - 10:00 am)

Letter Grade Assignment

The final course letter grade is determined as follows:

$90\% \leq$ Average $\leq 100\%$	A
$88\% \leq$ Average $< 90\%$	B+
$80\% \leq$ Average $< 88\%$	B
$78\% \leq$ Average $< 80\%$	C+
$70\% \leq$ Average $< 78\%$	C
$68\% \leq$ Average $< 70\%$	D+
$60\% \leq$ Average $< 68\%$	D
Average $< 60\%$	F

COVID-19 Statement

https://drive.google.com/file/d/1jOhqbS41nmC9HLYfge5JA2mtlBLL0Ao9/view

Academic Honesty Statement

Academic honesty is very important. It is dishonest to cheat on exams, to copy term papers, to submit papers written by another person, to fake experimental results, or to copy or reword parts of books or articles into your own papers without appropriately citing the source. Students committing or aiding in any of these violations may be given failing grades for an assignment or for an entire course, at the discretion of the instructor. In addition to any academic action taken by an instructor, these violations are also subject to action under the University of Maine Student Conduct Code. The maximum possible sanction under the student conduct code is dismissal from the University. Please see the University of Maine System's Academic Integrity Policy listed in the Board Policy Manual as Policy 314: www.maine.edu/board-of-trustees/policy-manual/section-314/.

Students Accessibility Services Statement

If you have a disability for which you may be requesting an accommodation, please contact Student Accessibility Services, 121 East Annex, 581.2319, as early as possible in the term. Students who have already been approved for accommodations by SAS and have a current accommodation letter should meet with Dr. Kotecki privately as soon as possible.

Course Schedule Disclaimer (Disruption Clause)

In the event of an extended disruption of normal classroom activities (due to COVID-19 or other long-term disruptions), the format for this course may be modified to enable its completion within its programmed time frame. In that event, you will be provided an addendum to the syllabus that will supersede this version.

Observance of Religious Holidays/Events

The University of Maine recognizes that when students are observing significant religious holidays, some may be unable to attend classes or labs, study, take tests, or work on other assignments. If they provide adequate notice (at least one week and longer if at all possible), these students are allowed to make up course requirements as long as this effort does not create an unreasonable burden upon the instructor, department or University. At the discretion of the instructor, such coursework could be due before or after the examination or assignment. No adverse or prejudicial effects shall result to a student's grade for the examination, study, or course requirement on the day of religious observance. The student shall not be marked absent from the class due to observing a significant religious holiday. In the case of an internship or clinical, students should refer to the applicable policy in place by the employer or site.

Sexual Violence Policy: Sexual Discrimination Reporting

The University of Maine is committed to making campus a safe place for students. Because of this commitment, if you tell a teacher about an experience of sexual assault, sexual harassment, stalking, relationship abuse (dating violence and domestic violence), sexual misconduct or any form of gender discrimination involving members of the campus, your teacher is required to report this information to the campus Office of Sexual Assault & Violence Prevention or the Office of Equal Opportunity.

If you want to talk in confidence to someone about an experience of sexual discrimination, please contact these resources:

For confidential resources on campus: Counseling Center: 207-581-1392 or Cutler Health Center: at 207-581-4000.

For confidential resources off campus: Rape Response Services: 1-800-310-0000 or Spruce Run: 1-800-863-9909.

Other resources: The resources listed below can offer support but may have to report the incident to others who can help: For support services on campus: Office of Sexual Assault & Violence Prevention: 207-581-1406, Office of Community Standards: 207-581-1409, University of Maine Police: 207-581-4040 or 911. Or see the OSAVP website for a complete list of services at http://www.umaine.edu/osavp/