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

Spring 2020

Analog Integrated Circuit Design

Course Number : ECE 444
Credits: 3
Lecture : 8:00 - 9:15 am, Tuesday and Thursday
Location: 119 Barrows Hall
Pre–rerequisite: ECE 342 - Electronics I
Course Web Site: http://web.eece.maine.edu/kotecki/ECE444

Instructor

Dr. David E. Kotecki
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Office Hours

9:30 - 10:45 am Monday and Wednesday
1:00 - 2:00 pm on Monday — Thursday
You are strongly encouraged to drop by my office to ask questions and discuss homework problems related to this course. If you are unable to meet with me during these times, e-mail me to set up an appointment.

Text

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

Goal and Objectives of Course

The challenge for the *analog integrated circuit designer* is to design circuits that implement a required analog function while achieving high reliability of operation 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 (temperature and external noise).

This course provides a more in depth discussion of analog circuit design than is taught in ECE 342/343. Topics discussed include: state-of-the-art BJT and deep submicron MOSFET device characteristics and models; 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, including the frequency doubler and the Gilbert cell mixer.

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

Homework problems are located at the end of each chapter. Assigned problems are listed below. You are not expected to do the Spice simulations. Homework will neither be collected nor graded. I recommend you do all of the homework problems. Some of the in-class exam questions will be similar or identical to the problems assigned for homework.

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

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	5	5.1, 5.5, 5.6, 5.10, 5.18, 5.21
Homework #5	6	6.2, 6.4, 6.7, 6.10, 6.16, 6.18
Homework #6	7	7.1, 7.8, 7.14, 7.15, 7.21, 7.22, 7.33, 7.39
Homework #7	8	8.1, 8.7, 8.25, 8.26, 8.27, 8.28
Homework #8	10	10.1, 10.3, 10.5
Homework #9*	11	11.1, 11.2, 11.10

* Only if we cover this material.

Design Projects (40% of grade)

Two design projects will be used to provide understanding and insight into fundamental issues in analog integrated circuit design. The circuits will be designed using 65nm, 180nm, and 350nm CMOS processes. Typical design projects include:

1. single-stage amplifier
2. operational amplifier with bootstrapped bias circuit
3. band-gap reference circuit - voltage and temperature stabilization
4. Gilbert cell mixer or DAC

NGspice (`http://www.cppsim.com/about_ngspice.html`) and Matlab® will be used to perform circuit simulations. NGspice is an open source multi-platform circuit simulator. Everyone should install the NGspice simulator, the Sue2 schematic capture program and the Matlab® toolbox on their laptop before Lab #2. The easiest way to obtain the software is to install the CppSim package (`http://www.cppsim.com/download.html`).

Exams (60% of grade)

There will be two Preliminary Exams and a Final Exam. The preliminary exams are open–book, open–notes and may consist of an in–class portion and a take–home portion. The Final Exam will be open–book, open–notes and will be an in–class exam during final exam week. The tentative exam schedule is as follows:

Exam #1	27 Feb. 2020
Exam #2	14 Apr. 2020
Final Exam	7 May 2020, 8:00 - 10:00 am

Grading:

The final course grade is determined as follows:

Design Projects	40%
Exam #1	20%
Exam #2	20%
Final Exam	20%
Total	100%

Letter grades are assigned as follows:

$\geq 90\%$	A
87.5% – 90.0%	B +
80.0% – 87.5%	B
77.5% – 70.0%	C +
70.0% – 77.5%	C
67.5% – 70.0%	D +
60.0% – 67.5%	D
$<$ 60.0%	F

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.

Students with Disabilities Statement

If you have a disability for which you may be requesting an accommodation, contact Student Accessibility Services, 121 East Annex, 581.2319, as early as possible. Students who have already been approved for accommodations by SAS and have a current accommodation letter should provide a copy of the letter to me as soon as possible.

Course Schedule Disclaimer (Disruption Clause)

In the event of an extended disruption of normal classroom activities, 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.

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/