

The University of Maine
Department of Electrical and Computer Engineering
ECE 445 – Design and Analysis of Digital Integrated Circuits

Spring 2024

Design and Analysis of Digital Integrated Circuits

Course Number : ECE 445.

Credits: 3.

Pre-requisite: ECE 342 - Electronics I.

Lectures: 11:00 am - 12:15 pm, Tuesday and Thursday, 206 Williams Hall.

Web Site: Brightspace (<https://courses.maine.edu>).

Instructor

Dr. David E. Kotecki

Office: 277 Barrows Hall.

Virtual Office: <https://maine.zoom.us/my/davidkotecki> (Password: circuits24).

e-mail: kotecki@maine.edu

Phone: 207.581.2248

Office Hours

9:00 - 10:00 am, Monday, Wednesday, and Friday.

2:00 - 4:50 pm, Monday, Tuesday, and Thursday, (221 Barrows Hall).

You are encouraged to drop by my office, either in-person or virtual, 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.

Primary Text

“Analysis and Design of Digital Integrated Circuits In Deep Submicron Technology, (3rd edition)”

Authors: David A. Hodges, Horace G. Jackson, and Resve A. Saleh

Publisher: McGraw Hill

Year: 2004

ISBN: 0-07-228365-3

Reference Texts

“Digital Integrated Circuits, (2nd Edition)”

Authors: Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolic

Publisher: Prentice Hall Electronics and VLSI Series

Year: 2003

ISBN-10: 0130909963

“CMOS Digital Integrated Circuits, (4th edition)”

Authors: Sung-Mo Kang, Yusuf Leblebici and Chulwoo Kim

Publisher: McGraw Hill

Year: 2015

ISBN: 978-0-07-338062-9

Course Material and Goals

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

Topics to be discussed: technology nodes and MOSFET device scaling; characteristics of short channel MOSFET devices and device models; interconnect strategy and interconnect scaling; parasitic resistance, capacitance and inductance associated with interconnects; the inverter; static logic gates; dynamic logic gates; sizing gates using the method of logic effort; trade-offs between performance, power, reliability, noise immunity and cost among various logic families including CMOS, pseudo-NMOS, domino logic, pass-gate logic and differential cascade voltage swing logic (DCVSL); fundamentals of combinational logic circuits; fundamentals of sequential logic circuits; adder circuits and pipelining; memory circuits including ROM, E²PROM, DRAM, SRAM, MRAM, FLASH and PCM; timing characteristics; and low power design techniques.

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

Most of the course material will follow the text book. Additional material will be provided and will be posted on the course website.

Homework Assignments

Homework problems are located at the end of each chapter. Assigned problems are listed below. Note: you do not need to do the Spice simulation associated with any homework problem; hand calculations will suffice. If you have questions about any of the problems, either stop by my office or we can discuss the problem during class.

Homework is collected the same day as the exams. Solutions to the homework problems should be submitted electronically using Brightspace. Only 2-3 of the problems will be graded and the grade will count as part of the exam grade.

Assignment	Problems
Homework #1	1.1, 1.3, 1.7, 1.8, 1.10
Homework #2	2.2, 2.3, 2.4, 2.5, 2.9
Homework #3	3.2, 3.8, 3.11, 3.12
Homework #4	4.1, 4.4, 4.7, 4.9, 4.14
Homework #5	5.1, 5.3, 5.8, 5.11, 5.14
Homework #6	6.7, 6.8, 6.9, 6.12, 6.14
Homework #7	7.2, 7.4, 7.6, 7.9, 7.14
Homework #8	8.1, 8.4, 8.7, 9.8, 9.11
Homework #9	10.1, 10.3, 10.9

Design Projects

A design and simulation project will be used to provide additional understanding and insight into fundamental issues in deep-submicron digital design. Details of the project are posted on Brightspace. The project will utilize a 65nm CMOS process and consist of two parts. The first part will involve the design, simulation, and characterization of a 3 GHz ring oscillator. The second and major portion of the project will involve the design and simulation of a 3 GHz, 5-bit, carry ripple adder. A final report is expected at the end of the project. You may work on the design projects individually or as a team with one other person. A prize will be awarded to the person or team with the best design.

Exams

There are three exams and the tentative exam dates are below. The exams are open-book and open-notes. The third exam will take place during the scheduled final exam period.

Tentative exam dates:

Exam 1: Tuesday, 27 February 2024

Exam 2: Tuesday, 16 April 2024

Exam 3: Thursday, 2 May 2024 (8:00 - 10:00 am)

Grading:

The final course grade is determined as follows:

Design Project	40% each
Exam 1	20% each
Exam 2	20% each
Exam 3	20% each
Total	<u>100%</u>

Letter grades are assigned as follows:

$\geq 90\%$	A
87% – 90%	B +
80% – 87%	B
77% – 80%	C +
70% – 77%	C
67% – 70%	D +
60% – 67%	D
$< 60\%$	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 OSVP website for a complete list of services at <http://www.umaine.edu/osavp/>

COVID-19 Statement

COVID-19 is an infectious disease caused by the coronavirus SARS-CoV-2. The virus is transmitted person-to-person through respiratory droplets that are expelled when breathing, talking, eating, coughing, or sneezing. Additionally, the virus is stable on surfaces and can be transmitted when someone touches a contaminated surface and transfers the virus to their nose or mouth. When someone becomes infected with COVID-19 they may either have no symptoms or symptoms that range from mild to severe and can even be fatal. During this global pandemic, it is imperative that all students, faculty, and staff abide by the safety protocols and guidelines set forth by the University to ensure the safety of our campus. All students are encouraged to make the Black Bear Cares Pact to protect the health of themselves, the health of others, and the College of Our Hearts Always.

Black Bears Care Pact: <https://umaine.edu/return/black-bears-care/>

Symptom checking: The symptoms of COVID-19 can range from mild to severe, and even people with mild symptoms may transmit the virus to others. Students are encouraged to use the symptom checking app each day before attending class or moving about campus and follow the recommendation prompted within the app. Students should monitor for the following symptoms daily: fever (temperature >100.4F/38.0C) or chills, new cough, loss of taste or smell, shortness of breath/difficult breathing, sore throat, diarrhea, nausea, or vomiting, or the onset of new, otherwise unexplained symptoms such as headache, muscle or body aches, fatigue, or congestion/runny nose.

Physical distancing: Students need to make every effort to maintain physical distancing (6 feet or more) indoors and outdoors including within classrooms. The University classrooms and physical spaces have been arranged to maximize physical distancing. Follow the traffic patterns outlined in each building and outdoor space to avoid crowding. If students are in an academic setting (i.e. clinical or lab class) that requires them to reduce physical distancing, they should follow the instructor's guidelines.

Face coverings: Students must wear appropriate face coverings in the classroom. Face coverings must be worn in indoor and outdoor spaces on campus unless people are alone in a room with a door closed or when they are properly physically distanced and do not expect someone to approach them. When face coverings are removed people are placing themselves and those surrounding them at increased risk for COVID-19.

Eating and drinking in classrooms: Students may not eat or drink in the classrooms and are encouraged to take their food or drink into areas designated for these purposes where they can maintain 6 feet physical distance from others.

Hand hygiene: Proper hand hygiene is an effective measure to prevent the spread of COVID-19. Students should wash their hands often with soap and water or use a hand sanitizer with at least 60

Contingency plans: Classes will be held in various formats to offer flexibility, compassion, and empathy during these unprecedented times. Under certain circumstances, students or instructors

may need to miss classes or in-person classes may be disrupted. Students are expected to notify their instructor if they are unable to attend an in-person or online class but will not be penalized for missing class due to illness or the need to care for a family member affected by COVID-19. If a disruption occurs, your instructor will provide communication and contingency plans.

What to do if you have or suspect you have COVID-19: If you have symptoms of COVID-19 or have been possibly exposed to someone with COVID-19, you should stay home, not interact with others, and contact your health care provider immediately to be tested for COVID-19. You may not attend in-person classes and should suspend interactions with others until you are tested. Prior to receiving test results you should quarantine in your living area according to the Maine CDC guidelines below. Please follow the guidance of your health care professional regarding testing, quarantine, and isolation during the testing process and potential illness period.

What to do if someone you know has or may have COVID-19: If someone you know or that you have had close contact with (defined by the ME CDC as 15 mins or more within 6 feet or less) has tested positive for COVID-19, you should stay home and quarantine according to the guidance of the ME CDC, contact your health care provider, and continue to monitor for symptoms. You may be required to quarantine and/or be tested for COVID-19 under these circumstances. You may also have been exposed to COVID-19 by someone you do not know, and it is possible that you could be contacted through contact tracing to determine if you were exposed. Everyone should respond to these confidential questions to ensure the safety of themselves and those around them.

Maine CDC guidelines: <https://www.maine.gov/dhhs/mecdc/infectious-disease/epi/airborne/coronavirus/general-information.shtml>

If you have questions or would like additional information related to the University of Maine COVID-19-specific policies or procedures please use the following sources:

University Webpages: umaine.edu/return and [together.maine.edu](https://umaine.edu/together)

COVID-19 Information line: 207.581.2681

Emergency Operations Center Email Contact: umaine.alerts@maine.edu