

# VLSI Circuits and Technology 1

EEE 4310 Section 0001

**Class Periods:** T, 10, 5:10PM-6:00PM; R, 10-11, 5:10PM-7:05PM

**Location:** LAR 0330

**Academic Term:** Spring 2024

## Instructor:

**Name:** Dr. Domenic Forte

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**Telephone:** 352-392-1525

**Office Hours:** Zoom (<https://ufl.zoom.us/j/8471254967>), Tuesdays from 9:00AM-11:00AM

## Teaching Assistant and Supervised Teaching Student:

- Sourav Roy, [sourav.roy@ufl.edu](mailto:sourav.roy@ufl.edu)

## Course Description

Introduction to VLSI circuit technology and manufacturing. Fabrication, device models, layout, parasitics, and simple gate circuits.

## Course Pre-Requisites / Co-Requisites

- EEL 3308: Electronic Circuits I
- EEL 3701C: Digital Logic

## Course Objectives

**Specific Outcomes of Instruction:** This course focuses on analysis and design of modern digital circuits. Silicon technology and transistors are introduced and described from a digital point of view, and the performance of various circuits is derived and estimated. CMOS digital circuits will be designed and analyzed. Students will layout and design digital complex circuits using layout software and SPICE and cover advanced topics such as manufacturing variations.

**Outcomes are addressed by this course:** EE2, a, c, e, I, k

## Materials and Supply Fees

N/A

## Relation to Program Outcomes (ABET):

Outcome	Coverage*
1. An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.	Medium
2. An ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs.	Medium
3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	
4. An ability to communicate effectively with a range of audiences	
5. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	

6.	An ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately.	
7.	An ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty	Medium

\*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

### **Required Textbooks and Software**

- i. Introduction to Microelectronic Fabrication  
Author - Richard C. Jaeger  
Publication date and edition - 2nd Edition, Modular Series on Solid State Devices, Volume 5, Prentice Hall  
ISBN Number - 0-201-44494-7
- ii. Digital Integrated Circuits, A Design Perspective  
Author - Jan. M. Rabaey, A. Chandrakasan, and B.Nikolic  
Publication date and edition - 2nd Edition, Prentice Hall  
ISBN Number - 0-13-090996-3, 2003
- iii. Computer and Software required: Workstations with CADENCE Design system on campus, off-campus can use XWindows or X-terminal on a high-speed internet link to UF Campus Computers, or can use equivalent IC design software

### **Recommended Materials**

- i. CMOS: Circuit Design, Layout, and Simulation  
Author: R. Jacob Baker  
Publication date and edition – 4th Edition, Wiley-IEEE Press  
ISBN Number - 978-1119481515, 2019

### **Course Schedule**

<b>Wk</b>	<b>Date</b>	<b>Tentative Topics</b>	<b>Book Chapter</b>
1	1/9-1/15	Syllabus; Design/Fabrication Flow; Introduction to Terminology; Moore's Law; Transistor Layout	Jaegar Chap 1
2	1/16-1/22	Fabrication Tools and Steps; Packaging; Design Rules; Diodes and MOSFETs	Rabaey Chap 2.1-2.3, 3.1-3.3
3	1/23-1/29	MOSFET Modes, Current Models, and Problem Formulations, Body Bias, Intro to SCEs, MOSFET Parameter Extraction	Rabaey Chap 3.3
4	1/30-2/5	Parasitic Capacitances; CMOS Inverter Operation Voltage Transfer Curves, and Static Noise Margin; Board Examples	Rabaey Chap 5.1-5.3
5	2/6-2/12	Exam 1 Review	
6	2/13-2/19	Intro to Semiconductor Memories; SRAM Operation, Design, and Layout	Rabaey Chap 12.1-12.2
7	2/20-2/26	Decoders and Sense Amps; DRAM and Flash	Rabaey Chap 12.2-12.4
8	2/27-3/4	ROM; CMOS Inverter Power Dissipation and Delay; CMOS Logic Gates;	Rabaey Chap 5.4-5.5. 6.1; Int D
9	3/5-3/11	Exam 2 Review	
10	3/12-3/18	SPRING BREAK	
11	3/19-3/25	CMOS Logic Gates Continued; CMOS Stick Diagrams and Layout; Pass Transistor Logic; CMOS Gate Delay, Sizing and Other Considerations	Rabaey Chap 6.2,

12	3/26-4/1	Intro to Sequential Logic; Basic Latch and Register Designs; Setup/Hold Time Constraints; Pipelining and Time Borrowing; Schmidt Trigger	Rabaey Chap 7.1-7.6
13	4/2-4/8	Threshold Voltage Calculation and Adjustment; Impact of Doping on Transistors; Punchthrough SCE; Dennard Scaling; Latchup; Interconnect and Contacts;	Jaegar Chap 9.1, 9.3-9.4, 7.1-7.4
14	4/9-4/15	Exam 3 Review	
15	4/16-4/22	Spacers and Silicides; SCEs, SOI, and FinFETs; Advanced Packaging	Jaegar Chap 7.5-7.8, 8
16	4/23-4/29	Final Exam Review	

### ***Assignments, Projects, and Exams Tentative Schedule***

<b>Wk</b>	<b>Date</b>	<b>Tentative Deadlines</b>
1	1/9-1/15	Homework #1 and Cadence Tutorial 1 Assigned;
2	1/16-1/22	Cadence Tutorial 1 due (1/14); Tutorial 2 Assigned;
3	1/23-1/29	Cadence Tutorial 2 due (1/21); Tutorial 3 Assigned;
4	1/30-2/5	Homework #1 Solutions Posted (2/1); Homework #2 Assigned
5	2/6-2/12	Exam #1 (2/8); Cadence Tutorial 3 Due (2/12); Cadence Project 1 Assigned;
6	2/13-2/19	
7	2/20-2/26	Cadence Project 1 Due (2/26); Final Cadence Project Assigned and Group Formation
8	2/27-3/4	Homework #2 Solutions Posted (2/29); Homework #3 Assigned
9	3/5-3/11	Exam #2 (3/7);
10	3/12-3/18	SPRING BREAK
11	3/19-3/25	
12	3/26-4/1	
13	4/2-4/8	Homework #3 Solutions Posted (4/4); Homework #4 Assigned
14	4/9-4/15	Exam #3 (4/11)
15	4/16-4/22	Final Cadence Project Due (4/18)
16	4/23-4/29	Homework #4 Solutions Posted (4/23)
17	4/30-5/3	Final Exam (5/1)

### ***Attendance Policy, Class Expectations, and Make-Up Policy***

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies:

<https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/>

In addition,

- Due to quantity and of material, it is important to make every attempt to attend class. Nevertheless, slides and recorded lectures will be posted on Canvas and Mediasite, respectively, for those who cannot attend lecture.
- To make more room in the schedule for practicing problems, some lecture classes will be flipped. Students will be required to watch lecture videos before attending the flipped class in those situations. Reminders will be sent to students.
- Participation grades will be determined by who is asking/answering questions in the classroom, watching lecture videos, and answering quiz questions on Mediasite.

- No exam make-up unless a valid excuse is presented beforehand. All valid excuses must be approved by the Professor. Excused absences must be in compliance with university policies in the Graduate Catalog (<https://catalog.ufl.edu/graduate/regulations/>) and require appropriate documentation.
- Homework assignments are voluntary. Solutions will be posted a week before the associated exam.
- All tutorials and projects must be handed in on time or credit will be deducted (10% each day).

### **Projects**

- Three Cadence tutorials and two layout/simulation projects will be assigned throughout the semester. All are completed individually except for the final project which is completed in groups.
- All project materials will be checked for plagiarism using Turnitin software feature in Canvas. See University Honesty Policy below.

### **Evaluation of Grades**

▪ Class Examinations	75%
(Exam #1)	(15%)
(Exam #2)	(15%)
(Exam #3)	(15%)
(Comprehensive Final Exam)	(30%)
▪ Attendance/Viewing & Participation/Quizzes	10%
▪ Cadence	15%
(Tutorial #1)	(0.75%)
(Tutorial #2)	(1.25%)
(Tutorial #3)	(1.75%)
(SRAM Assignment)	(3.75%)
(Final Project)	(7.5%)

### **Grading Policy**

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:

<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

### **Students Requiring Accommodations**

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

### ***Course Evaluation***

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

### ***In-Class Recording***

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

### ***University Honesty Policy***

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

### ***Commitment to a Safe and Inclusive Learning Environment***

The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University’s core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- HWCOE Human Resources, 352-392-0904, [student-support-hr@eng.ufl.edu](mailto:student-support-hr@eng.ufl.edu)
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)

- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@eng.ufl.edu](mailto:nishida@eng.ufl.edu)

### **Software Use**

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

### **Student Privacy**

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

### **Campus Resources:**

#### Health and Wellness

##### **U Matter, We Care:**

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

**Counseling and Wellness Center:** <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

##### **Sexual Discrimination, Harassment, Assault, or Violence**

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the [Office of Title IX Compliance](#), located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, [title-ix@ufl.edu](mailto:title-ix@ufl.edu)

##### **Sexual Assault Recovery Services (SARS)**

Student Health Care Center, 392-1161.

**University Police Department** at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

#### Academic Resources

**E-learning technical support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu). <https://lss.at.ufl.edu/help.shtml>.

**Career Connections Center**, Reitz Union, 392-1601. Career assistance and counseling; <https://career.ufl.edu>.

**Library Support**, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

**Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. <https://teachingcenter.ufl.edu/>.

**Writing Studio, 302 Tigert Hall, 846-1138.** Help brainstorming, formatting, and writing papers.  
<https://writing.ufl.edu/writing-studio/>.

**Student Complaints Campus:** <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>;<https://care.dso.ufl.edu>.

**On-Line Students Complaints:** <https://distance.ufl.edu/getting-help/>; <https://distance.ufl.edu/state-authorization-status/#student-complaint>.