# ESE 330

# Digital Integrated Circuits

## Spring 2022

Stony Brook University
Department of Electrical and Computer Engineering

**Course Description**
This course presents a study of the analysis and design of digital integrated circuits. Topics include fabrication and modeling of MOS transistors; the transistor-level design of combinational and sequential digital logic; mask layout methods, design rules and processes; circuit characterization and performance estimation; computer-aided design tools and techniques. This material is directly applicable to industrial IC design and provides a strong background for more advanced courses.

**Prerequisites:** ESE 372

Instructor: Milutin Stanacevic
Office: 263 Light Engineering
Email: milutin.stanacevic@stonybrook.edu

**Classes:** MW 11:45pm-1:05pm, Humanities 3018

**Office hours:** MW 9:30am-11:30am, or by appointment using Zoom

**Teaching Assistant:** TBA

**Recommended Textbook:**
N.H. Weste, and D. M. Harris, *"CMOS VLSI design: a circuits and systems perspective,"*
Pearson, 4th edition, 2010.

**Grading**
1. Homework 10%
2. Midterm 35%
3. Final 35%
4. Project 20%

**Project**
There will be three design projects (20% of grade). The goal of the projects is the design and implementation of a modest-size CMOS digital integrated circuit. Cadence will be used as the industry-standard VLSI design and analysis tool.

# Course Outline

Week 1          Introduction (ch 1.1-1.3); Diode and MOS transistor operation (ch 2.1-2.2)

Week 2          MOS transistor (C-V characteristic and non-ideal I-V effects) (ch 2.2-2.3)

Week 3          DC transfer characteristic (ch 2.5)

Week 4          IC manufacturing (ch 3.1 - 3.3), Delay: RC delay model (ch 4.1-4.3)

Week 5          Delay: Linear delay model (ch 4.4 - 4.6)

Week 6          Power (ch 5.1-5.4)

Week 7          Interconnect (ch 6.1-6.4).

Week 8          Midterm. Robustness: variability and scaling (ch 7.2 and 7.4)

Week 9          Combinational circuit design (ch 9.2)

Week 10         Combinational circuit design (ch 9.3)

Week 11         Sequential circuit design (ch 10.2)

Week 12         Sequential circuit design (ch 10.3)

Week 13         Datapath Subsystems (ch 11.2-11.4)

Week 14         Array subsystems (ch 12.2 - 12.3)

**Goals:**
The course is designed to provide students with in-depth analysis and design capability required for digital integrated circuits.

**Objectives:**
Understand the I-V characteristics of deep-submicron MOS transistors.
Understand the limited validity of simple I-V MOS models and be able to extract model parameters.
Calculate the device parasitic capacitances.
Calculate the logic high/low input/output voltages of a specified NMOS and CMOS inverter and draw the transfer curve and calculate the noise margins of a specified CMOS inverter.
Design simple NMOS and CMOS logic gates for speed, area or power.
Analyze and design static and dynamic latches and flip-flops.
Be proficient at using a circuit simulator to study the circuit response.
Understand the sources of power dissipation.
Apply approximate methods to calculate the delays of inverters.
Understand and apply transistor sizing techniques for minimizing delay through a single combinational logic gate or a chain of logic gates.
Analyze and design dynamic logic gates.
Understand the architecture of ROM and RAM circuits.
Analyze and design a memory array decoder.
Analyze and design an SRAM memory cell.
Understand and apply the Elmore delay formula for RC delay calculations.

**How We Will Communicate:**

This course uses Blackboard for the facilitation of communications between faculty and students, submission of assignments, and posting of grades and feedback. The Blackboard course site can be accessed at https://blackboard.stonybrook.edu

If you are unsure of your NetID, visit https://it.stonybrook.edu/help/kb/finding-your-netid-and-password for more information. You must have an active Stony Brook University email account and access to the Internet. All instructor correspondence will be sent to your SBU email account. **Plan on checking your SBU email account regularly for course-related messages.** To log in to Stony Brook Google Mail, go to http://www.stonybrook.edu/mycloud and sign in with your NetID and password.

Technical Assistance:
If you need technical assistance at any time during the course or to report a problem with Blackboard you can:
- Phone: 631-632-9800 (client support, Wi-Fi, software and hardware)
- Submit a help request ticket: https://it.stonybrook.edu/services/itsm
- If you are on campus, visit the Walk-Up Tech Support Station in the Educational Communications Center (ECC) building.

**Student Accessibility Support Center Statement**

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, 128 ECC Building, (631) 632-6748, or via e-mail at: **sasc@stonybrook.edu**. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

**Academic Integrity:**

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at http://www.stonybrook.edu/commcms/academic_integrity/index.html

**Critical Incident Management:**

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.