

Western University
Faculty of Engineering
Department of Electrical and Computer Engineering

ECE 3349A: Introduction of VLSI

Course Outline 2021-2022

Description: This course is an introduction to concepts associated with the analysis and design of integrated circuits (IC) in the state of the art CMOS technologies. Continuous advances in microelectronics and Very Large Scale of Integration (VLSI) made an entire electronic system on a single chip (SoC) possible. Modern VLSI ICs contain more than two billion components per chip. Design and manufacturing of semiconductor devices present unique challenges, especially at the conceptual and design levels, therefore computer-assisted design (CAD) methods are sought to help manage these complex design. In particular, this course introduces CMOS semiconductor devices, physical principles behind IC design, design and analysis of digital logical gates, and the use of professional CAD tools for IC design.

Instructor: Prof. Arash Reyhani-Masoleh
TEB 243, 519-661-2111 ext. 81253, areyhani@uwo.ca
Consultation hours: By appointment, in person or via Zoom.

Academic Calendar Copy: This course covers fundamentals of semiconductor physics as applied to microelectronics, theory of semiconductor materials and devices. Students will be exposed to basic elements of CMOS circuitry design, including practical implementation of resistors, capacitors, diodes, transistors and MOSFET. Related topics such as delays, cross-talk, parasitics, temperature effects are included.

Contact Hours: 3 lecture hours, 1.5 laboratory hours, 0.5 course.

Prerequisites: [ES 1021A/B](#), [ECE 2233A/B](#), [ECE 2236A/B](#), [ECE 2240A/B](#), [ECE 2241A/B](#), [ECE2277A/B](#), [ECE 2238A/B](#) and successful completion of the second year of the Electrical or Computer Engineering program or Integrated Engineering Program.

Co-requisite:

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

CEAB Academic Units: Engineering Science 75%, Engineering Design 25%.

Required Textbook: Neil H.E. Weste and David Harris, “*CMOS VLSI Design, A Circuits and Systems Perspective*”, Pearson Education, 4th Edition 2011, (ISBN: 0321547748)

Other Required References: Lab manual documents available on the course OWL site.

Recommended References: See links on course OWL site.

General Learning Objectives (CEAB Graduate Attributes)

Knowledge Base	I	Use of Engineering Tools		Impact on Society and the Environment	
Problem Analysis		Individual and Team Work		Ethics and Equity	
Investigation		Communication Skills		Economics and Project Management	
Design		Professionalism		Life-Long Learning	

Notation: where x be I : Introductory, D : Intermediate, A : Advanced, or empty. I – The instructor will introduce the topic at the level required. It is not necessary for the student to have seen the material before. D – There may be a reminder or review, but the student is expected to have seen and been tested on the material before taking the course. A – It is expected that the student can apply the knowledge without prompting (e.g. no review).

Topics and Specific Learning Objectives

1. Semiconductor Devices and Technology

At the end of this section, students will be able to:

- a. Understand physical and engineering principles behind semiconductor technology.
- b. Understand CMOS processing steps.

2. CMOS Logic

At the end of this section, students will be able to:

- a. Understand theoretical principles behind CMOS logic gates.
- b. Understand CMOS circuits and layouts.
- c. Design and test functionality of basic gates by using CAD tools.

3. MOS Transistor Theory

At the end of this section, students will be able to:

- a. Understand theoretical principles behind MOS device operation.
- b. Understand practical engineering issues related to MOS device design.

4. Analog IC Characterization

At the end of this section, students will be able to:

- a. Understand DC and transient response of ICs.
- b. Understand delay, logical effort, and how to design fast ICs.
- c. Understand different sources of power dissipation and how to design low-power ICs.

5. Circuit Simulation

At the end of this section, students will be able to:

- a. Synthesize and analyze a basic digital logic IC.
- b. Design and verify IC operation by using Analog Cadence tools and SPICE simulator.

6. Combinational Circuit Design

At the end of this session, students will be able to:

- a. Understand techniques to optimize combinational circuits for lower delay and/or energy.
- b. Understand different circuit families.

7. Sequential Circuit Design

At the end of this session, students will be able to:

- a. Understand sequencing for both static and dynamic circuits.
- b. Understand how to circuit design of latches and flip-flops.

CEAB Graduate Attributes Indicator: Knowledge Base 3 (KB 3) for all the above-mentioned topics.

Evaluation

Course Component	Weight
Laboratory	25%
Midterm Test	25%
Final Examination	50%

To obtain a passing grade in the course, a mark of 50% or more must be achieved on the final examination as well as on the laboratory. A final examination or laboratory mark < 50% will result in a final course grade of 48% or less.

Laboratory: There will be four laboratory units throughout the course. After finalizing our CMC Educational license and setting up student accounts for accessing Cadence, detailed laboratory schedule and marking scheme will be announced on the course website. In order to secure 50% of the overall laboratory component mark, the student must participate in all laboratory units as scheduled. In order to be marked for the current laboratory experiment, at the end of each laboratory session the students are required to submit signed laboratory report sheets to the TA. Upon completion, each student must upload a report to the course OWL site. The details of the report, the marking scheme, and the submission deadlines for each laboratory will be posted on the OWL course site.

Midterm Test: The midterm test will be scheduled during the regular academic term; the exact date will be determined later. Students will be notified of the test date through the course OWL site in advance. The test will be an **in-person**, limited-open book test, where a single one side (8.5 inch by 11 inch paper) formula sheet is acceptable. Only original (i.e., not photocopied) handwritten notes on the formula sheet will be accepted. No circuit diagrams, figures, and solution to problems are allowed on the sheet. A non-programmable calculator may be used, but use of any other electronic device is not permitted during the test. The midterm test is **optional**, if students do not complete the midterm, that portion of their grade will be added to the final examination. If students do complete the midterm, but achieve a higher grade on the final examination than on the midterm, the final examination grade will be used instead.

Final Examination: The final examination will take place during the regular examination period. The final examination will be limited open book, where a single one side (8.5 inch by 11 inch paper) formula sheet is acceptable. Only original (i.e., not photocopied) handwritten notes on the formula sheet will be accepted. No circuit diagrams, figures and solution to problems are allowed on the sheet. A non-programmable calculator may be used, but use of any other electronic device is not permitted during the test.

Late Submission Policy: The late submission policy for each laboratory exercise is the following penalty schedule:

- 10% late deduction per day, up to 4 days late.
- Not accepted beyond 4 days late.

Tests and examinations that are not uploaded to the course OWL site before the submission deadline will receive a grade of zero. Student's must take responsibility for preparing their answers in an appropriate format for digital upload in a timely manner. If students have any concerns or problems with this, they should seek assistance from the instructor or the TAs as soon as possible. Neither the instructors nor the TA guarantee that assistance can be provided immediately before a submission deadline!

Assignment Submission Locker: No locker is provided. All submissions must be done through the course OWL website.

Use of English: In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Attendance: All laboratories are mandatory unless otherwise stated. Any student who, in the opinion of the instructor/TA, is absent too frequently from class or laboratory periods will be reported to the Dean (after due warning has been given). On the recommendation of the department, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

Online Activities: The course OWL site will be extensively used in delivering course content including announcements and lesson slides. Pre-recorded video lessons from last year's remote course delivery will be available as learning aids and to supplement in-class activities. Public distribution of lecture materials including course notes, slides, and video lessons is not permitted.

COVID-19 Contingency Clause: In the event of a COVID-19 resurgence during the course that necessitates the course delivery moving away from face-to-face interaction, all remaining course content will be delivered entirely online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will not change. Any remaining assessments will also be conducted online at the discretion of the course instructor.

Absence Due to Illness or Other Circumstances: Students should immediately consult with the instructor or department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see the attached “Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled”). The student should seek advice from the instructor or department Chair regarding how best to deal with the problem. Failure to notify the instructor or department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

For more information concerning medical accommodations, see the relevant section of the Academic Handbook:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf

For more information concerning accommodations for religious holidays, see the relevant section of the Academic Handbook:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf

Missed Lab: If a student misses a laboratory submission deadline and receives academic accommodation, the student is responsible for contacting the instructor within 48 hours to arrange a new submission deadline. After this period, the student will receive a grade of zero for the exercise if the lab submission is not rescheduled.

Cheating and Plagiarism: Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

All required papers may be subject to submission for textual similarity review to commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (<http://www.turnitin.com>).

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

Use of Electronic Devices: Not applicable.

Use of Personal Response Devices (“Clickers”): Not applicable.

Policy on Repeating All Components of a Course: Students who are required to repeat an Engineering course must repeat all components of the course. No special permissions will be

granted enabling a student to retain laboratory, assignment, or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted by the student for grading in subsequent years.

Internet and Electronic Mail: Students are responsible for regularly checking their Western e-mail and the course web site (<https://owl.uwo.ca/portal/>) and making themselves aware of any information that is posted about the course.

Accessibility: Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 519-661-2111 ext. 82147 for any specific question regarding an accommodation.

Support Services: Office of the Registrar, <http://www.registrar.uwo.ca/>
Student Development Centre, <http://www.sdc.uwo.ca/>
Engineering Undergraduate Services, <http://www.eng.uwo.ca/undergraduate/>
USC Student Support Services, <http://westernusc.ca/services/>

Students who are in emotional/mental distress should refer to Mental Health @ Western, http://www.health.uwo.ca/mental_health/, for a complete list of options about how to obtain help.