Carleton University
Department of Electronics

ELEC 3500A : Digital Electronics Fall 2024

Course schedule:

Lecture Tue/Thu 11:35-12:55 ME4494

Lab A1 Wed 11:35-12:55, A2 Fri 11:35-14:25, A3 Wed 14:35-17:25 ME4166

Office Hours Tue/Thu 10:30-11:30 ME5148

Instructor: Ralph Mason, Ralph.Mason@carleton.ca

Teaching assistant: TBD

Course description and requirements:

Calendar description - Digital circuit design using verilog and logic synthesis, the electronic properties of logic gates, electrical interfacing between logic families, asynchronous to synchronous interfacing, clock distribution and timing, VLSI design options. Students implement substantial circuits with field-programmable gate arrays.

Content - The objective of this course is to introduce the student to design of CMOS logic gates, digital circuit design using Verilog HDL and logic synthesis, asynchronous to synchronous interfacing, clock distribution and timing issues, digital circuit implementation and verification, digital memory and signaling technologies.

Learning Objectives - A student who successfully fulfills the course requirements will have demonstrated an ability to:

- define the three levels of abstraction used in digital design
- design digital gates using NMOS, PMOS and CMOS logic families that implement boolean functions
- define the voltage transfer characteristics of a digital inverter
- design MUXes, latches and flip-flops using CMOS logic
- design linear feedback shift registers (LFSRs) that produce pseudo-random bit patterns
- design combinational and sequential logic circuits that can be synthesized using Verilog HDL
- define setup time, hold time and propagation delay of a flip-flop
- define synchronous and asynchronous signals
- define metastability and its effects on the output of a flip-flop
- design synchronization circuitry for interfacing asynchronous signals with synchronous circuits
- define positive and negative skew
- design circuits that perform effectively in the presence of clock skew
- implement digital circuits using FPGAs
- define digital verification and testing
- define random access memory (RAM), read only memory (ROM) and electrically erasable programable read only memory (EEPROM)
- use computer-aided tools in a lab environment with a lab partner to design, construct, simulate and test digital circuits
- write lab reports, answer essay type questions using text, equations and numeric values for assignments and examinations

Prerequisites - ELEC 2507 and ELEC 2607.

Accreditation Units –

Math	Natural Science	Complementary Studies	Engineering Science	Engineering Design
			50%	50%

Learning outcomes / Graduate Attributes –The Canadian Engineering Accreditation Board requires graduates of undergraduate engineering programs to possess 12 attributes. Courses in all four years of our programs evaluate students' progress towards acquiring these attributes. Aggregate data (typically, the data collected in all sections of a course during an academic year) is used for accreditation purposes and to guide improvements to our programs. Some of the assessments used to measure GAs may also contribute to final grades; however, the GA measurements for individual students are not used to determine the student's year-to-year progression through the program or eligibility to graduate.

This following list provides the GAs that will be measured in this course, along with the learning outcomes that are intended to develop abilities related to these attributes.

- 3.1-Investigation: Complex problem assessment
- 3.2-Investigation: Design of experiment
- 3.3-Investigation: Experimental procedure
- 3.4-Investigation: Data reduction methods and results
- 3.5-Investigation: Interpretation of data (synthesis) and discussion
- 4.1-Design: Clear design goals
- 4.2-Design: Detailed design specifications and requirements
- 4.4-Design: Design solution(s)
- 4.5-Design: Design implementation/task(s) definition
- 4.6-Design: Alternate solution(s) definition and evaluation
- 4.7-Design: Evaluation based on engineering principles

GA - Indicator	Assessment Tool
3.1	Labs 2 & 3
3.2	Labs 2 & 3
3.3	Labs 2 & 3
3.4	Labs 2 & 3
3.5	Labs 2 & 3
4.1	Lab 9
4.2	Lab 9
4.4	Lab 9
4.5	Lab 9
4.6	Lab 9
4.7	Lab 9

Texts (supplementary)

- Jan Rabaey, *Digital Integrated Circuits*, Prentice Hall, 1996
- S. Palnitkar, *Verilog HDL*, Prentice Hall, 1996
- J. P. Hayes, *Introduction to Digital Logic Design*, Addison Wesley, 1993

Course Schedule -

Week	Dates in 2024	Lectures	Labs	Assignments/Readings/Comments
0,1	Sept 2-13	Introduction & MOSFET		Labs start week of Sept 9-13
2	Sept 16-20	CMOS Logic Gates		Also some discussion on Asynchronous Circuits in preparation for labs
3	Sept 23-27	CMOS Logic Gates and Intro to Verilog HDL		Assignment 1, due Oct. 10, 2024
4	Sept 30-Oct4	Verilog HDL I		Introduction to Verilog Example verilog code
5	Oct 7-11	Verilog HDL II Sequential Circuits		
6	Oct 14-18	Digital Circuit Implementation		October 14th University Closed Assignment 2, due Oct. 31, 2024
7	Oct 21-25			**Fall break no classes or labs**
8	Oct 28-Nov1			**Review old midterm Oct. 39 in class** **Midterm on Thur. Oct. 31 during class**
9	Nov 4-8	Asynchronous		

10	Nov 11-15	System Clocking		Assignment 3, due Nov. 28, 2024
11	Nov 18-22	Digital Design Verification		
12	Nov25-29	Memory and Signal Technologies and Review		
13	Dec 2-6	Review		Dec. 6 follows Monday class schedule

Evaluation and Marking Scheme - All the elements that will contribute to the cumulative grade earned and the overall approximate grade breakdown for the course.

- Laboratory 30% **Students must complete all labs**
- Assignments 10%
- Midterm Exam 15% Thursday Oct. 31st, 2024 during class hours
- Final Exam 40% **A minimum of 50% on the final exam is required to pass the course**
- Bonus Quizzes 10%

Final Exam -

- Final exam is for evaluation purpose and will not be returned to students.
- Final exam with be on campus and proctored using paper format
- Closed Book with a double sided 8”x11.5” crib sheet with scientific calculator
- Minimum grade on final exam to pass the course is 50%
- Final exam Weight is 40%
- Students who are unable to write the final examination because of a serious illness/emergency or other circumstances beyond their control may apply for accommodation by contact the Registrar’s office. Consult the Section 4.3 of the University Calendar

(https://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/examinations/)

Midterm Exam –

- Closed Book with a double sided 8”x11.5” crib sheet with scientific calculator
- Midterm exam Weight is 15%

Additional Requirements -

- Students are required to complete all labs (i.e. must achieve at least part marks for all labs)

Self-Declaration form and Deferred Term work

- Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor and in all cases this must occur no later than three (3) days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule.
- **Contact the instructor with the completed self-declaration form no later than 3 days after the date/deadline of term work including test/midterm, labs, assignments.**

Copyright:

Generative Artificial Intelligence (AI):

Use of generative AI tools (such as ChatGPT) in course work is prohibited unless explicitly authorized by the course instructor for specific elements of the course. Submission of AI generated work without authorization may lead to an academic integrity investigation.

Advising and Counselling services:

Engineering Academic Advising –

- The Engineering Academic Support Service : https://carleton.ca/engineering-design/current-students/undergrad-academic-support/ assists undergraduate engineering students with course selection, registration, and learning support from first-year through to graduation.
- Academic Advisors Contact : https://carleton.ca/engineering-design/current-students/undergrad-academic-support/undergraduate-advisors/

Student Mental Health Service –

As a University student you may experience a range of mental health challenges that significantly impact your academic success and overall well-being. Carleton's Wellness Services Navigator https://wellness.carleton.ca/navigator/ is designed to help students connect with mental health and wellness resources. If you need to talk to someone, please reach out for assistance: https://carleton.ca/health/emergencies-and-crisis/.

Learning and Working Environment:

The University and all members of the University community share responsibility for ensuring that the University's educational, work and living environments are free from discrimination and harassment. Should you have concerns about harassment or discrimination relating to your age, ancestry, citizenship, colour, creed (religion), disability, ethnic origin, family status, gender expression, gender identity, marital status, place of origin, race, sex (including pregnancy), or sexual orientation, please contact the Department of Equity and Inclusive Communities at equity@carleton.ca

We will strive to create an environment of mutual respect for all through equity, diversity, and inclusion within this course. The space which we work in will be safe for everyone. Please be considerate of everyone's personal beliefs, choices, and opinions.

Academic Integrity and Plagiarism:

- Please consult the Faculty of Engineering and Design information page about the Academic Integrity policy and our procedures: https://carleton.ca/engineering-design/current-students/fed-academic-integrity Violations of the Academic Integrity Policy will result in the assignment of a penalty such as reduced grades, the assignment of an F in a course, a suspension or, expulsion.
- One of the main objectives of the Academic Integrity Policy is to ensure that the work you submit is your own. As a result, it is important to write your own solutions when studying and preparing with other students and to avoid plagiarism in your submissions. The University Academic Integrity Policy defines plagiarism as "presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one's own." This includes reproducing or paraphrasing portions of someone else's published or unpublished material, regardless of the source, and presenting these as one's own without proper citation or reference to the original source.
- Examples of violations of the policy include, but are not limited to:
  - any submission prepared in whole or in part, by someone else;
  - using another's data or research findings without appropriate acknowledgement;
  - submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own; and
  - failing to acknowledge sources of information through the use of proper citations when using another's work and/or failing to use quotations marks.

Health and Safety: Respecting lab safety precautions and following directions of lab staff is essential to keep everyone safe.

It is important to remember that COVID is still present in Ottawa. The situation can change at any time and the risks of new variants and outbreaks are very real. There are a number of actions you can take to lower your risk and the risk you pose to those around you including being vaccinated, wearing a mask, staying home when you're sick, washing your hands and maintaining proper respiratory and cough etiquette.

General lab safety precautions are still important and can be found at https://carleton.ca/ehs/programs/working-lab/laboratory-health-and-safety/

Advising and Counselling services

a) Engineering Academic Advising

The Engineering Academic Support Service : https://carleton.ca/engineering-design/current-students/undergrad-academic-support/ assists undergraduate engineering students with course selection, registration, and learning support from first-year through to graduation.
Academic advisors contact information: https://carleton.ca/engineering-design/current-students/undergrad-academic-support/undergraduate-advisors/

b) Student Mental Health Service

As a University student you may experience a range of mental health challenges that significantly impact your academic success and overall well-being. Carleton's Wellness Services Navigator https://wellness.carleton.ca/navigator/ is designed to help students connect with mental health and wellness resources. If you need to talk to someone, please reach out for assistance: https://carleton.ca/health/emergencies-and-crisis/.

Learning and working environment

The University and all members of the University community share responsibility for ensuring that the University's educational, work and living environments are free from discrimination and harassment. Should you have concerns about harassment or discrimination relating to your age, ancestry, citizenship, colour, creed (religion), disability, ethnic origin, family status, gender expression, gender identity, marital status, place of origin, race, sex (including pregnancy), or sexual orientation, please contact the Department of Equity and Inclusive Communities at equity@carleton.ca
We strive to create an environment of mutual respect for all through equity, diversity, and inclusion within this course. The space which we work in will be safe for everyone. Please be considerate of everyone's personal beliefs, choices, and opinions.

Academic Accommodation

Academic accommodation refers to educational practices, systems and support mechanisms designed to accommodate diversity and difference. At no time should academic accommodation undermine or compromise the learning objectives that are established by the academic authorities of the University.

a) Academic Accommodations for Students with Disabilities: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation.
If you are already registered with the PMC, contact your PMC coordinator to initiate a Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with the instructor to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable).

b) Accommodation for Student Activities: Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation will be provided to students who compete or perform at the national or international level. Contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf

c) Pregnancy obligation: contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For accommodation regarding a formally-scheduled final exam, you must complete the Pregnancy Accommodation Form.

d) Religious obligation: contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist.

e) **Survivors of Sexual Violence:** As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: https://carleton.ca/equity/sexual-assault-support-services