Software Eng. 2DA4
Digital Systems and Interfacing
Sept. 2024

INSTRUCTOR:
Dr. Ryan Leduc
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Office Hours: Friday 15:30-16:20.
Term: 1

LECTURES:

- Location: KTH B135.
- Time: Tuesday, Thursday, Friday 14:30PM - 15:20PM.

Note: Announcements will be posted to the course's Avenue to Learn page. It's your responsibility to check the page regularly.

LABS:

- Location: ITB/237.
- Labs start: TBA.

MIDTERM: TBA.

TEACHING ASSISTANTS: The TA names and contact information will be posted on the course's Avenue page.

MSAF and LABS: MSAF applied to labs are for a single lab session, not the entire lab.

MISSION:

This course teaches the design (logical, not physical) of computers and other digital circuits. While students learn about the basic physical limitations on the implementation of logical functions (e.g. heat dissipation, propagation delay, power requirements), the course stresses the use of the gate/flip-flop abstractions and teaches the organisation of synchronous and asynchronous circuits that perform complex functions. We will also discuss software/hardware codesign.

OBJECTIVES:

The students will learn systematic design procedures; Combinatorial circuit design, design of sequential machines, number representations, organisation of large logic circuits. Use of logic simulators. Knowledge of software/hardware codesign issues.

GRADING SCHEME:

- Assignments 10%
- Labs 10%
- Midterm 30%
- Final Exam 50%

(All work on assignments is to be done individually.)

TEXT:

1. S. Brown and Z. Vranesic, *Fundamentals of Digital Logic with Verilog Design, 3rd Ed.*, McGraw-Hill Higher Education, 2014.
2. Custom courseware for SE 2DA4: Readings from Embedded System Design (can access from "Contents" section of course's Avenue page).

REFERENCES:

Frank Vahid and Tony Givargis, *Embedded Systems Design: A Unified Hardware/Software Introduction*, John Wiley & Sons, Inc., 2002.

DETAILED COURSE OUTLINE:

Introduction to Combinational Logic :

- motivation
- switches and logic gates
- logic functions, truth tables and variables
- boolean axioms and laws, sum of products, product of sums
- simple algebraic minimization - making things cheaper

Technology & Practical Considerations :

- logic voltage levels
- transistors as a switch
- NMOS and CMOS logic gates
- real propagation delay, and timing diagrams
- fanout and fanin constraints
- fanout dependent delay
- TTL Logic, Programmable Logic Devices: PLAs, PALs, CPLDs
- introduction to Verilog and CAD tools

Combinational Logic & Optimization :

- minimization goals - speed and cost
- Karnaugh Maps
- Don't Cares
- multi-level logic optimization
- multiplexors & tristate gates
- multiplexors as logic; decoders

Numbers and Arithmetic :

- number representations: binary, ones & twos complement representation of negative numbers, floating-point, overflow
- basic adder/subtracter
- carry lookahead fast adder

Sequential Logic :

- distinction between combinatorial and sequential logic (gates and flip-flops)
- cross-coupled NOR gates as storage element
- clocked D latch
- Master-Slave D flip-flop
- shift registers
- counters
- Read Only Memory & Random Access Memory

Synchronous Sequential Circuits :

- Finite State Machines:
  - how logic is controlled
  - Mealy/Moore state machines
  - state diagrams & state tables
  - state machine synthesis
  - state encoding and optimization
  - state machines in Verilog

Asynchronous Sequential Circuits :

- comparison of synchronous/asynchronous circuits
- dealing with asynchronous inputs
- asynchronous hazards

Software/Hardware Co-design :

- implementing software as a single purpose processor
- digital camera example
- memory mapped I/O

NOTES:

Calculators

Calculators are not needed for this course and their use will not be permitted during tests.

Academic Dishonesty

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: Grade of F assigned for academic dishonesty), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy (https://secretariat.mcmaster.ca/app/uploads/Academic-Integrity-Policy-1-1.pdf), located at https://secretariat.mcmaster.ca/university-policies-procedures- guidelines/

The following illustrates only a few forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not ones own or for which other credit has been obtained.
2. Improper collaboration in group work.
3. Copying or using unauthorized aids in tests and examinations.
4. Giving a copy of old assignments, midterms, or solutions to other students.
5. Allowing another student to look at or copy your assignment.
6. Using assignment solutions from previous years, other courses, from the internet or the textbook solution manual.
7. Using midterm or exam solutions from previous years that are not given to you by the current instructor.
8. Discussing specifics of how to solve an assignment question with people other than the instructor or the TAs.

Authenticity/Plagiarism Detection

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is

subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMasters use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

Courses With an On-line Element

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

Online Proctoring

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

It is unlikely that this course will use proctoring software.

Conduct Expectations

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the Code: https://secretariat.mcmaster.ca/app/uploads/Code-of-Student-Rights-and-Responsibilities.pdf). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students access to these platforms.

Academic Accommodation of Students With Disabilities

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS: https://sas.mcmaster.ca/) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster Universitys Academic Accommodation of Students with Disabilities policy (https://secretariat.mcmaster.ca/app/upl Accommodations-Policy.pdf).

Requests for Relief For Missed Academic Term Work

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar Requests for Relief for Missed Academic Term Work.

Academic Accommodation for Religious, Indigenous or Spiritual Obersvances (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy (https://secretariat.mcmaster.ca/app/uploads/2019/02/Academic-Accommodation-for-Religious-Indigenous-and-Spiritual-Observances-Policy-on.pdf). Students should submit their request to their Faculty Office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

Copyright and Recording

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, including lectures by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

Extreme Circumstances

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

Prerequisite Learning Objectives

The precondition of the course is the set of university-level learning objectives that the student is expected to have achieved before the start of the course.

1. Introduction to basic electrical principles from 1st year physics course.

Learning Objectives: Postcondition

A learning objective for a course is something the student is expected to know and understand or to be able to do by the end of the course. The learning objectives for this course are given below. Taken together, this set of learning objectives constitute the postconditions of the course.

1. Students should know and understand
   (a) how to express logic functions as logic gates
   (b) Boolean algebra and fundamental axioms and theorems
   (c) how to implement basic logic gates using transistors
   (d) basic electrical safety properties of a circuit, including short circuit issues
   (e) propagation delay, fan in and fan out issues
   (f) standard implementation technologies such as standard gate types, FPGA, and CPLD devices
   (g) Karnaugh maps
   (h) number representations such as signed and unsigned binary integers, and floating point
   (i) adder and subtractor circuits
   (j) sequential logic devices such as latches, flip-flops, registers, and counters
   (k) synchronous finite state machines (FSM)
   (l) asynchronous sequential state machines, including race conditions and hazards
   (m) basic hardware and software codesign concepts
   (n) memory mapped I/O
2. Students should be able to
   (a) perform simple algebraic manipulation
   (b) optimize logic functions using Karnaugh maps
   (c) design and analyze combinational circuits
   (d) design and analyze synchronous sequential finite state machines
   (e) perform state minimization on synchronous sequential finite state machines
   (f) implement combinational circuits and synchronous sequential circuits using standard circuit components
   (g) implement digital logic circuits in programmable logic devices such as FPGAs
   (h) express combinational circuits and synchronous sequential circuits using a hardware description language such as Verilog or VHDL