ENGG*3050 Embedded Reconfigurable Computing Systems

Fall 2022

Section(s): C01

School of Engineering

Credit Weight: 0.50

Version 1.00 - September 28, 2022

1 Course Details

1.1 Calendar Description

This course introduces the students to the analysis, synthesis and design of embedded systems and the implementation of embedded systems using Field Programmable Gate Arrays. Topics include: review of digital design concepts; Programmable Logic Devices; Field Programmable Logic Devices; physical design automation (partitioning, placement and routing); Hardware Descriptive Languages; VHDL; Verilog; High Level Languages; System-C; Handle-C; Fixed Point and Floating Point Arithmetic; Hardware Accelerators; Reconfigurable Instruction Set Computers; Hardware Software Co-design techniques; Application of Field Programmable Logic in Embedded Systems.

Pre-requisites: ENGG*2410, ENGG*3380

Restrictions: This is a Priority Access Course. Enrolment may be restricted to the CENG specialization in the BENG and BENG:C programs. See department for more information.

1.2 Course Description

Reconfigurable Computing Systems (RCS) refers to a new class of computer architecture which take advantage of application level-parallelism. This course deals mainly with digital systems implemented on Field Programmable Gate Arrays (FPGA). In this course, we investigate the state-of-the-art in reconfigurable computing and the main factors driving it. Initially, we review the basic concepts of programmable logic in general and FPGAs in particular. Design entry based on Hardware Descriptive Languages and High Level Languages will also be covered. Specific reconfigurable computing systems (i.e architectures) will be examined with emphasis on limitations and future research opportunities.

1.3 Timetable

Lectures:			
Monday	8:30 AM - 9:50 AM	MCKN Room 234	
Friday	8:30 AM - 9:50 AM	MCKN Room 234	
Laboratory:			
Wednesday	10:30 AM - 12:20 PM	RICH Room 1532	For Section 1
Friday	1:30 PM - 3:20 PM	RICH Room 1532	For Section 2

1.4 Final Exam

Date: Friday, December 9th 2022, 8:30AM - 10:30AM
Location: (TBA)

2 Instructional Support

Instructional Support Team

Instructor: Sara Zimmo
Email: szimmo@uoguelph.ca
Office Hours: Mon, Fri 11:00AM-12:00PM or by email

2.2 Teaching Assistants

Teaching Assistant (GTA):	Marc Jayson Baucas	William Peters
Email:	baucas@uoguelph.ca	wpeters@uoguelph.ca

3 Learning Resources

3.1 Required Resources

Course Website (Website)

Course material, news, announcements, and grades will be regularly posted on course website on CourseLink.

3.2 Recommended Resources

"Reconfigurable Computing: The Theory and Practice of FPGA-Based Computing" Morgan Kaufmann, 2008, ISBN 978-0-12-370522. (Textbook)

"Introduction to Reconfigurable Computing: Architectures, Algorithms and Applications", by C. Bobda Springer, 2008, ISBN 978-1-4020-6088-5. (Textbook)

"VHDL for Engineers", by K. Short, 2nd Edition, Prentice Hall, 2008. (Textbook)

"The Designer's Guide to VHDL", by Peter Ashenden, Morgan Kaufmann, 2002, ISBN 1-55860-674-2. (Textbook)

3.3 Additional Resources

Lecture Information (Notes)

Lecture notes will be posted weekly on CourseLink.

Lab Information (Notes)

The handouts for all the lab sessions are within the lab section. All types of resources regarding tutorials, links to web pages can be found in this section.

Exams (Notes)

Some midterms and finals of previous years are posted as samples of exams. The solutions are also posted for your convenience.

Miscellaneous Information (Other)

Other information related to Reconfigurable Computing are also posted on the CourseLink.

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4 Learning Outcomes

Reconfigurable Computing Systems (RCS) refers to a new class of computer architecture which take advantage of application level-parallelism. This course deals mainly with digital systems implemented on Field Programmable Gate Arrays (FPGA). In this course, we investigate the state-of-the-art in reconfigurable computing and the main factors driving it. Initially, we review the basic concepts of programmable logic in general and FPGAs in particular. Design entry based on Hardware Descriptive Languages and High Level Languages will also be covered. Specific reconfigurable computing systems (i.e architectures) will be examined with emphasis on limitations and future research opportunities.

4.1 Course Learning Outcomes

By the end of this course, you should be able to:

1. Understand the basic concept of Reconfigurable Computing both from a hardware and software perspective.
2. Learn all details of digital hardware, its specification, analysis, design and implementation.
3. Get acquainted with both low level hardware description languages (HDL) and state of the art high level languages such as Vivado HLS.
4. Use different analysis and verification tools, implementation and synthesis methodologies and testability techniques that will enable them to design high performance and efficient digital systems.
5. Implement a complete digital system on FPGAs using state-of-the art CAD tools.

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	**Outcome**	**Learning Outcome**
1	Knowledge Base	1, 2, 4, 5
1.3	Recall, describe and apply fundamental engineering principles and concepts	1, 2, 4, 5
2	Problem Analysis	2, 3, 4
2.2	Identify, organize and justify appropriate information, including assumptions	2, 3
2.3	Construct a conceptual framework and select an appropriate solution approach	4
2.4	Execute an engineering solution	4
4	Design	2, 3, 4, 5
4.1	Describe design process used to develop design solution	2, 3
4.2	Construct design-specific problem statements including the definition of criteria and constraints	3, 4, 5
5	Use of Engineering Tools	2, 3, 4, 5
5.1	Select appropriate engineering tools from various alternatives	2, 3, 4, 5
6	Individual & Teamwork	2, 3, 4, 5
6.2	Understand all members' roles and responsibilities within a team	2, 3, 4, 5
7	Communication Skills	3, 4, 5
7.2	Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode	3, 4, 5

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5 Teaching and Learning Activities

5.1 Lecture Schedule (Tentative)

Lectures	**Lecture Topics**	**References**	**Learning Objectives**
1-2	Introduction to Reconfigurable Computing	Chapter 1,2,3	1
3-4	Digital Design: Advanced Topics	Mano	1
5-6	Programmable Logic Devices (FPGAs, CPLDs)	Chapter 2,3	1,2,3
7-9	Hardware Descriptive Languages (VHDL)	Chapter 5,6	1,2,3,4
10-12	Hardware Descriptive Languages (VHDL)	Chapter 5,6	2,3,4,5
13-15	CAD for FPGAs (Placement, Routing, Synthesis)	Chapter 13,14	2,3,4,5
16-18	Hardware/Software Co-Design	Chapter 26	2,3,5
19-21	Electronic System Level (Vivadlo HLS)	Chapter 7	3,4,5
22-24	Dynamic Run-time Reconfiguration	Chapter 4	2,3,4,5
25-27	Application Specific Instruction Processors	Chapter 10	2,3,4,5
28-30	Operating Systems for RTR	Chapter 11	4,5
31-33	RTR Applications and Recommendations	Chapter 13	5
34-36	*Course Review*	-	5

5.2 Lab Schedule

There will be 4 labs throughout the term. Below are the *tentative* start and due dates:

Topic	Weight	Report
L1: Xilinx Vivado and NEXYS A7 Board (Adder)	15%	Yes
L2: Design of Data Path (ALU)	25%	Yes
L3: Design of a Control Unit	30%	Yes
L4: Design for Performance (Adders)	30%	Yes

5.3 Other Important Dates

1. **Thursday, 8th September 2022:** Classes Start.
2. **Monday, 10th October 2022:** Holiday.
3. **Tuesday, 11th October 2022:** Fall Study Break, No Classes Scheduled.
4. **Thursday, 1st December 2022:** Lecture (Tuesday Oct. 11th Schedule in Effect).
5. **Friday, 2nd December 2022:** Last Class (Monday Oct 10th Schedule in Effect).

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6 Assessments

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Assignments	5
Reflection	10
Labs	25
Mini Project	15
Final Exam	45
Total	**100**

6.2 Assessment Details

Assignments (5%)

Date: Fri, Sep 16 - Fri, Dec 2, Submit in dropbox

Reflection (10%)

Weekly during class, due end of day

Labs (25%)

Learning Outcome: 2, 3, 4, 5
See Section 5 for due dates

Mini Project (15%)

Due: Week 12, During Lab
Learning Outcome: 1, 2, 3, 4, 5

Final Exam (45%)

Date: Fri, Dec 9, 8:30 AM - , 10:30 AM, TBA
Learning Outcome: 1, 2, 3, 4, 5

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7 Course Statements

7.1 Course Grading Policies

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic Consideration: http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Consideration of Religious Obligations: http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Passing grade: In order to pass the course, you must pass both the project/laboratory and exam course portions. Students must obtain a grade of 50% or higher on the exam portion of the course in order for the project and laboratory write-up portion of the course to count towards the final grade.

Missed midterm/quiz tests: If you miss a test due to grounds for granting academic consideration or religious accommodation, the weight of any missed test will be added to the final exam weight. There will be no makeup midterm tests.

Lab Work: You must attend and complete all laboratories. If you miss a laboratory due to grounds for granting academic consideration or religious accommodation, arrangements must be made with the teaching assistant to complete a makeup lab.

Late Lab/Project Reports: Late submissions of lab reports will be penalized unless you have good reasons. Explain to the instructor and/or teaching assistant the circumstances of why your lab report is submitted late.

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8 School of Engineering Statements

8.1 Instructor's Role and Responsibility to Students

The instructor’s role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

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9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

9.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

Associate Diploma Calendar - Dropping Courses https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website
https://www.ridgetownc.com/services/accessibilityservices.cfm

9.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff, and students-to be aware of what constitutes academic misconduct and

to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars https://www.uoguelph.ca/academics/calendars

9.9 Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings, changes in classroom protocols, and academic schedules. Any such changes will be announced via CourseLink and/or class email. This includes on-campus scheduling during the semester, mid-terms and final examination schedules. All University-wide decisions will be posted on the COVID-19 website (https://news.uoguelph.ca/2019-novel-coronavirus-information/) and circulated by email.

9.10 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g.. final exam or major assignment).

9.11 Covid-19 Safety Protocols

For information on current safety protocols, follow these links:

- https://news.uoguelph.ca/return-to-campuses/how-u-of-g-is-preparing-for-your-safe-return/
- https://news.uoguelph.ca/return-to-campuses/spaces/#ClassroomSpaces

Please note, these guidelines may be updated as required in response to evolving University, Public Health or government directives.