ENGG*3050 Embedded Reconfigurable Computing Systems

01

Fall 2023
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - September 08, 2023

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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. Non-BENG students may take a maximum of 4.00 ENGG credits.

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:

Tuesday	8:30 AM - 9:50 AM	MCKN 237
Thursday	8:30 AM - 9:50 AM	MCKN 237

Laboratory:

Monday	15:30 PM - 17:20 PM	RICH 1532

1.4 Final Exam

Date: Friday, December 15th 2023, 14:30 PM - 16:30 PM

Location: (TBA)

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2 Instructional Support

2.1 Instructional Support Team

Instructor:	Shawki Areibi PhD
Email:	sareibi@uoguelph.ca
Telephone:	5198244120 x53819
Office:	THRN 2335
Office Hours:	Thursday 15:00 PM-16:00 PM or by email
Lab Co-ordinator:	Haleh Vahedi PhD
Email:	hvahedi@uoguelph.ca
Telephone:	+1-519-824-4120 x54741
Office:	RICH 1509

2.2 Teaching Assistants

Teaching Assistant (GTA):	Sam Van Den Eijnden MASc
Email:	vandenes@uoguelph.ca
Office:	THORN 1425
Office Hours:	Fridays: 2:00 PM - 3:00 PM

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3 Learning Resources

3.1 Required Resources

Course Website (Website)
http://islab.soe.uoguelph.ca/sareibi/TEACHING_dr/ENG3050_html_dr/eng3050.html
Course material, news, announcements, and grades will be regularly posted on course website on courselink

Courselink (Other)
https://courselink.uoguelph.ca/shared/login/login.html
All lectures, lab handouts, assignments and other resources are linked to the course website

Edited by S. Hauck and A. Dehon Reconfigurable Computing: The Theory and Practice of FPGA-Based Computing Morgan Kaufmann, 2008, ISBN 978-0-12-370522. (Textbook)

3.2 Recommended Resources

"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)
http://islab.soe.uoguelph.ca/sareibi/TEACHING_dr/ENG3050_html_dr/eng3050.html
Lecture notes will be posted weekly on CourseLink.

Lab Information (Notes)
http://islab.soe.uoguelph.ca/sareibi/TEACHING_dr/ENG3050_html_dr/eng3050.html
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)
http://islab.soe.uoguelph.ca/sareibi/TEACHING_dr/ENG3050_html_dr/eng3050.html
Some midterms of previous years are posted as samples of exams.

Miscellaneous Information (Other)
Other information related to Reconfigurable Computing are also posted on the web page.

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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. 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.
4. Get acquainted with both low level hardware description languages (HDL) and state of the art high level languages such as Vivado HLS.
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, 3, 5
1.3	Recall, describe and apply fundamental engineering principles and concepts	1, 2, 3, 5
2	Problem Analysis	2, 3, 4
2.2	Identify, organize and justify appropriate information, including assumptions	2, 4
2.3	Construct a conceptual framework and select an appropriate solution approach	3
2.4	Execute an engineering solution	3
4	Design	2, 3, 4, 5
4.1	Describe design process used to develop design solution	2, 4
4.2	Construct design-specific problem statements including the definition of	3, 4, 5

#	Outcome	Learning Outcome
	criteria and constraints	
4.3	Create a variety of engineering design solutions	3
5	Use of Engineering Tools	2, 3, 4, 5
5.1	Select appropriate engineering tools from various alternatives	2, 3, 4, 5
5.2	Demonstrate proficiency in the application of selected engineering tools	3
6	Individual & Teamwork	2, 3, 4, 5
6.1	Describe principles of team dynamics and leadership	3
6.2	Understand all members' roles and responsibilities within a team	2, 3, 4, 5
7	Communication Skills	3, 4, 5
7.1	Identify key message(s) and intended audience in verbal or written communication as both sender and receiver	3
7.2	Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode	3, 4, 5

5 Teaching and Learning Activities

5.1 Lecture Schedule

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 6 labs throughout the term. Below are the *tentative* start and due dates:

Topic	**Weight**	**Report**	**Date**
L1: Intro to Tools & FPGA Boards	5%	Yes	Week #1
L2: Design of Arithmetic Logic Unit (ALU)	10%	Yes	Week #2
L3: Design of Control Unit	15%	Yes	Week #3
L4: Design for Performance	20%	Yes	Weeks #4-#5
L5: Design of Custom IPs	25%	Yes	Weeks #6-#7
L6: Design using High Level Synthesis (HLS)	25%	Yes	Weeks #8-#9

5.3 Other Important Dates

1. **Thursday, 7th September 2023:** Classes Start.
2. **Monday, 9th October 2023:** Thanks Giving Holiday, No Classes Scheduled.
3. **Tuesday, 10th October 2023:** Fall Study Break, No Classes Scheduled.
4. **Thursday, 30th November 2023:** Lecture (Tuesday Oct. 10th Schedule in Effect).
5. **Friday, 1st December 2023:** Last Class (Monday Oct 9th Schedule in Effect).

6 Assessments

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Assignments	10
Labs	35
Paper Review	10
Final Exam	45
Total	100

6.2 Assessment Details

Assignments (10%)
Date: Fri, Sep 16 - Fri, Dec 2, Submit in dropbox

Labs (35%)
Learning Outcome: 2, 3, 4, 5
See Section 5 for due dates

Paper Review (10%)
Due: Week 11, During Lecture
Learning Outcome: 1, 2, 3, 4, 5

Final Exam (45%)
Date: Fri, Dec 15, 2:30 PM - 4:30 PM, 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.

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.

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 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).
