ENGG*4560 Embedded System Design

01

Winter 2021
Section(s): C01

School of Engineering
Credit Weight: 0.75
Version 1.00 - January 05, 2021

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1 Course Details

1.1 Calendar Description

This course introduces the basic principles of embedded system design. It utilizes advanced hardware/software abstractions to help design complex systems. Topics include: design of embedded CUPs; embedded architecture cores; system-on-chip designs and integration using processor cores and dedicated core modules; embedded computing platforms; embedded programming design and analysis; processes and operating systems; networks for embedded systems; distributed embedded architectures; design examples that target robotics, automobile, and communication systems.

Pre-Requisites: ENGG*3380 or ENGG*3640

1.2 Course Description

This course is a senior level course in electrical and computer engineering and introduces basic principles of embbeded systems design. Topics include: hardware description language for embedded system design and simulation; system-on-chip design and integration using processor cores and dedicated hardware core modules; on-chip busses; hardware/software interfaces; coprocessor design; embedded computing platforms; security with applications for embedded systems; design examples.

1.3 Timetable

Lectures

Monday Sec 01 2:30 pm – 3:50 pm; Virtual

Friday Sec 01 2:30 pm – 3:50 pm; Virtual

Laboratory

Wednesday Sec 01 2:30 pm – 5:20 pm; Virtual -- Take home deveopment boards

1.4 Final Exam

Final Exam: 40%

April 24th, 2021: 2:30 pm – 4:30 pm; Type: virtual, open resources exam

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2 Instructional Support

2.1 Instructional Support Team

Instructor:	Radu Muresan Ph.D., P.Eng.
Email:	rmuresan@uoguelph.ca
Telephone:	+1-519-824-4120 x56730
Office:	RICH 2509
Office Hours:	Monday: 4 pm - 5 pm; Virtual office hour

Note: students can make an appoinment as necessary for in office meeting.

Lab Technician:	Kevin Dong
Email:	kdong@uoguelph.ca
Office:	RICH 2506

2.2 Teaching Assistants

Teaching Assistant:	Vaidehi Mistry
Email:	mistryv@uoguelph.ca
Office:	Virtual
Office Hours:	TBA: Virtual

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3 Learning Resources

3.1 Required Resources

Course Website (Website)
Course material, news, announcements, and grades will be regularly posted to the ENGG*4560 CourseLink site. You are responsible for checking the course site regularly.

[1a] ENGG4560 Lecture E-Notes (Notes)
https://courselink.uoguelph.ca/d2l/le/content/668341/Home
ENGG*4560 W21 CourseLink, University of Guelph, Radu Muresan

[1B] Lecture Recordings (Other)
https://web.microsoftstream.com/channel/6e74c751-73bf-44ca-8224-

d3988675c6bb
ENGG4560_Lecture_Recordings W21, University of Guelph, Radu Muresan

[2] A Practical Introduction to Hardware/Software Codesign (Textbook)
P. R. Schaumont, Springer, 2010.

[3] The Block Cipher Companion (Textbook)
L. R. Knudsen, M. J. B Robshaw, Springer 2011

[4] Verilog for Digital Design (Textbook)
F. Vahid, R. Lysecky, Wiley, 2007.

[5] GEZEL (Website)
http://www.islab.soe.uoguelph.ca/rijndael.ece.vt.edu/gezel2/index.html

[6] ENGG4560 Lab Manual, W21 Version (Lab Manual)
Radu Muresan and Kevin Dong, University of Guelph, CourseLink Resource

3.2 Recommended Resources

[7] Introduction to Cryptography (Textbook)
Alexander Stanoyevitch, CRC Press, 2013

3.3 Additional Resources

[8] Design through Verilog HDL (Textbook)
T. Padmanabhan, B. Sundari, Wiley, 2004.

Additional Resources (Other)
Lecture Information: All lecture notes are posted on the ENGG*4560 CourseLink system (Week #1 to Week #12) under LECTURES module.

Lab Information: The ENGG*4560 Embedded Systems Design Lab Manual is posted on the ENGG*4560 CourseLink system under the LABORATORY module.

Assignments: Course material assignments are introduced throughout the lecture notes.

Exams: Some example solutions of previous final exams will be posted on the ENGG*4560 CourseLink system under the EXAM EXAMPLES section.

Miscellaneous Information: Other information related to embedded systems design will be posted on the web page.

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4 Learning Outcomes

4.1 Course Learning Outcomes

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

1. Use of mainstream HDL such as Verilog, VHDL, or SystemC
2. Use of open source cycle-based HDL GEZEL
3. Design simple system-on-chip components using HDL
4. Design complex system-on-chip applications with hardware processor and FPGA cores (DE1-SOC Architecture)
5. System-on-chip design concepts
6. On-chip busses
7. Design Hardware/Software Interfaces
8. Coprocessor design concepts and example applications
9. Design security components for embedded systems
10. Explore and present new research results in the field of embedded systems design through reports and presentations
11. Use of embedded systems design tools

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
1	Knowledge Base	5, 6, 7, 8, 9
1.4	Recall, describe and apply program-specific engineering principles and concepts	5, 6, 7, 8, 9
2	Problem Analysis	1, 2, 3, 4, 5, 6, 7, 8, 9, 11
2.3	Construct a conceptual framework and select an appropriate solution approach	1, 11
2.4	Execute an engineering solution	1, 2, 3, 4, 5, 6, 7, 8, 9, 11
4	Design	1, 3, 4, 5, 6, 7, 8, 9, 11
4.3	Create a variety of engineering design solutions	1, 3, 4, 5, 6, 7, 8, 9, 11
5	Use of Engineering Tools	1, 2, 3, 4, 11
5.2	Demonstrate proficiency in the application of selected engineering tools	1, 2, 3, 4, 11
6	Individual & Teamwork	4, 7, 8, 9, 10,

#	Outcome	Learning Outcome
		11
6.1	Describe principles of team dynamics and leadership	4, 7, 8, 9, 10, 11
6.2	Understand all members' roles and responsibilities within a team	4, 7, 8, 9, 10, 11
6.3	Execute and adapt individual role to promote team success through, for example, timeliness, respect, positive attitude	4, 7, 8, 9, 10, 11
7	Communication Skills	10
7.1	Identify key message(s) and intended audience in verbal or written communication as both sender and receiver	10
7.2	Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode	10
7.3	Construct the finished elements using accepted norms in English, graphical standards, and engineering conventions, as appropriate for the message and audience	10
7.4	Substantiate claims by building evidence-based arguments and integrating effective figures, tables, equations, and/or references	10
7.5	Demonstrate ability to process oral and written communication by following instructions, actively listening, incorporating feedback, and formulating meaningful questions	10

5 Teaching and Learning Activities

The course activities are given on weeks. The total number of weeks of classes for this term is 12.The week number indicated for the activities in this section refers to the the weeks of active classes not the weeks of the term.

5.1 Lecture

Week 1-2

Topics: HDL Basics, Verilog

References: [1], [4], [8]

Learning Outcome: 1, 3

Week 3

Topics: SoC FPGA Devices

References: [1], [6]

Learning Outcome: 5

Week 4

Topics: HDL Hardware/Software Codesign Environment, GEZEL

References: [1], [5]

Learning Outcome: 2, 3

Week 5-7

Topics: Embedded systems design, system-on-chip design concepts:

1. Introduction

2. On-Chip Busses

3. Design Hardware/Software Interfaces

4. Coprocessor Control Shell Design

5. Embedded Design Applications, AES, Trivium

References: [1], [2]

Learning Outcome: 5, 6, 7, 8, 9

Week 8-11

Topics: Embedded systems design, applications to security:

1. Cryptography algebra and algorithms, background theory

2. Public key cryptograhpy

3. AES mathematical foundation, and AES security

4. Block ciphers applications

5. Authentication

References: [1], [3], [7]

Learning Outcome: 9

Week 12

Topics: Research survey paper week

Researcy survey paper due: Week 12 of classes, Thursday.

Learning Outcome: 10

5.2 Lab

Week 1 - 2

Topics: LAB 0: Preparation and tool installation

References: [6]

Week 3

Topics: Lab/Tutorial 1: Introduction to Quartus SoC Development Tools

References: [6]

Learning Outcome: 3, 4, 11
SOC design tutorial plus FPGA component implementation

Week 4: Demo Due

Week 4

Topics: Lab/Tutorial 2: SoC Design of FPGA Components Using HDL

References: [6]

Learning Outcome: 3, 4, 11
Week 5: Demo Due

Week 5

Topics: Lab/Tutorial 3: SOC Design with HPS and FPGA Components

References: [6]

Learning Outcome: 3, 4, 11
Week 6: Demo Due

Week 6 - 12

Topics: Project: Embedded systemd design implementation using HPS and FPGA hardware coprocessor

References: [6]

Learning Outcome: 4, 7, 8, 9, 11
The project component includes a demo of the implementation and a final complete report (minimum 8 pages and maximum 10 pages, font size 12 Time Romans); Sections of the report should include: Introduction, Background and Theory, Methodology, Results and Analysis, Conclusions, and References. Your report must detail your overall block diagram

and explain the overall components design and functionality. Analyse the performance of the implementation and discuss possible improvements.

Project development schedule:

1. Week 8: Progress Design Demo Due

2. Week 11: Final Project Demo Due

3. Week 12: Project Report Due

5.3 Other Important Dates

You can refer the student undergraduate calendars for the semester scheduled dates.

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6 Assessments

6.1 Marking Schemes & Distributions

Marking Scheme Distribution Table below applies only if the result in the final exam is a passing mark (>= 50%).

When the result in the final exam is a passing mark (>=50%) the final exam weight is 40% and the total group weight is 60%.

When the result in the final exam is a failing mark (<50%) the final exam weight is 60% and the total group weight is 40%.

Name	Scheme A (%)
Labs + Project	45
Research Survey Paper	15
Final Exam	40
Total	100

6.2 Assessment Details

Labs (45%)

Learning Outcome: 1, 3, 4, 7, 8, 9, 11

Lab 1, Lab 2, and Lab 3 have only a demo that is worth 4%, 6%, and 8%, respectively (See due dates in Laboratory Activity section)

Project has a progress design demo, a final project demo and a final project report.

The projecte is marked as follows: progress demo is worth 5%, final project demo is worth 10%, and project report is worth 12%

Research Survey Paper (15%)

Date: Week 12
Learning Outcome: 10
Current topics in embedded systems design, research paper survey (Due date: Thursday, Week 12 of classes)

This research survey paper is weighted to 15% of the final course mark, and is a group report in a conference paper format.

This research report should be a survey on current embedded systems design topics that presents latest research trends in a topic that has been assigned to the group. The paper must be developed following the paper survey samples posted on CourseLink. The paper length should be 5 pages, and the paper should follow the IEEE conference paper format and style.

Final Exam (40%)

Date: Sat, Apr 24, 2:30 PM - 5:15 PM, Virtual
Learning Outcome: 1, 2, 3, 4, 5, 6, 7, 8, 9
Final Exam: The weight of the final exam is conditional on the final mark obtain in the exam (See Marking Schemes Table). The final exam will cover the entire course material with some exceptions that will be posted on CourseLink. The final exam is virtual type, open resources exam (2 hours exam). Your exam solutions must be uploaded as a pdf file to the assigned final exam dropbox on CourseLink. You can write the exam solutions on normal letter size paper that you can scan, or on a tablet. You will have 45 minutes extra to convert the exam paper solutions into a pdf readable file format using a scanner or a webcam app scanner. I advise using a good webcam app scanner. Please prepare ahead and install a webcam app on your cellphone and practice ahead with using the app. However, if you use a tablet to write your final exam make sure that your file divides and prints in readable letter size pages. You will need to upload the final exam paper as pdf file to the assigned dropbox folder on CourseLink. I will print the exam as uploaded to the dropbox folder and mark the hard copy of the exam.

Requirements: the exam paper must present independent work only. Please work independently, no collaboration with other students enrolled in the course or other persons helping is allowed during this exam. Present your own original solutions to the problems; uphold the University standards and do not plagiarize by utilizing other student's work or online solutions. Upload your final solution paper in a pdf format file by 5:15 pm. Please present readable and neat solutions with explanations and mark all the solutions nicely so they are clear .

Self and Peer Evaluation (0%)

Date: Week 12, Virtual
Learning Outcome: 7, 8, 9, 10, 11
This is a self and peer evaluation questionnaire which asks about how you and each of

your teammates contributed to the team work during the laboratory activity and the research survey report. This assessment is for the purpose of providing data for the graduate attribute #6 from our GA list. Specifically:
6.1.18 Describe principles of team dynamics and leadership
6.2.18 Understand all members' roles and responsibilities within a team
6.3.18 Execute and adapt individual role to promote team success through, for example, timeliness, respect, positive attitude

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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 at the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Passing grade: This course has mark distritubution assignments that are conditional to passing the final exam (See Assesments Section). In order to pass the course the students must obtain passing marks in all labs and the research presentation and write the final exam and obtain an overall course mark greater than 50%. If the student obtains a passing mark in the final exam (>=50%) then the final course mark distribution is: final exam weight is 40%; labs plus research survey paper weight is 60%. If the student obtains a failing mark in the final exam (<50%) then the final course mark distribution is: final exam weight is 60%; labs plus research survey paper weight is 40%.

Lab/Project Work: You must attend all lab demos and complete all lab reports. If you miss a laboratory demo due to grounds for granting academic consideration or religious accommodation, arrangements must be made with the instructor to complete a makeup lab demo.

Late Lab/Project Reports: Late submissions of lab reports will be accepted only with the approval of the course instructor. However, penalties on late submissions will be applied. Applied penalties will be posted on ENGG*4560 CourseLink system.

7.2 Relationships with other Courses & Labs

Previous Courses:

ENGG*3640 (Microcomputer Interfacing): instruction set architecture, microcontroller architecture and design, interfacing principles and components.

ENGG*3380 (Computer Organization and Design): CPU design, instruction set design, microprocessor architectures and design, interfacing principles and components.

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 book their exams at least 7 days in advance and not later than the 40th Class Day.

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 and academic schedules. Any such changes will be announced via CourseLink and/or class email. 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

The University will not normally require verification of illness (doctor's notes) for fall 2020 or winter 2021 semester courses. However, requests for Academic Consideration may still require medical documentation as appropriate.
