Course Outline

COE718: Embedded Systems Design

Prerequisites
COE538 (Knowledge of µprocessors and a high-level language (e.g., C or Java)

Website
http://www.ee.ryerson.ca/~courses/coe718/

All course related information, announcements and material such as lab documents are available at the course website. It is student’s responsibility to check this website regularly.

Compulsory Texts

Laboratory/Project Manuals and Documents: Available through the course web page: http://www.ee.ryerson.ca/~courses/coe718/

Reference Text

Calendar Description
This course will cover the basics of embedded system organization, system on programmable-chip technologies and real-time systems. It provides the advance knowledge required for embedded computer design and development as well as real-time operating systems. Students are introduced to software development concepts applicable to real-time and embedded systems. Particularly ARM Cortex M3 will be studied as a representative embedded processor and embedded software development is carried out for ARM Cortex CPUs. The students will be able to grasp the main principles of embedded system design and understand the concept of hardware-software codesign, system on programmable chip (SoPC), real-time operating systems and scheduling techniques. Embedded system co-specification and partitioning is also introduced in the course. SystemC or other languages (e.g. UML, C, etc.) can be employed to present a unified view of the embedded systems. SystemC is introduced as a representative Co-specification language. Embedded hardware-software design and development tools (such as Altera Quartus II and SOPC builder) will be introduced.

Course Weight: 1.00
Billing Units: 1
Learning Objectives

At the end of this course, the successful student will be able to:

1. Interconnect engineering concepts related to microprocessors, computer hardware and software systems to design embedded systems for real-world applications. Learn to employ specialized knowledge of subsystems like processor cores and other hardware/software system components to design an embedded computer system. (1c) and (1d)

2. Improve their capabilities of using the technical knowledge of processor architecture, peripherals, programming, and CAD tools to design specific embedded computer systems. Solve various challenges of embedded software system design by employing real-time system software design methodologies to test and verify embedded software system design. (4a) and (4c)

3. Learn and efficient use of different embedded computer system simulation, modeling and prototyping tools such as SoPC builder and Quartus-II. These tools facilitate hardware software simulation and design of embedded computer systems. (5c)

4. Demonstrate the main features of the course-project and answer critical and project specific questions during project demo and oral sessions. Write project report by following a standard IEEE like format, where all the reports are evaluated based on their completeness, English, and citations. (7a) and (7b)

5. Communicate key project deliverables in a clear/concise manner in the form of a course project summary and interim progress report. Display a basic understanding of the issues in managing the project implementation during the design phase of the embedded computer system involving project requirements, specification, simulation, design and prototyping. (11b)

Note: Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board. For more information, see: http://www.feas.ryerson.ca/quality_assurance/accreditation.pdf

Course Organization

3 hours of lecture per week for 13 weeks, in 2-3 sections
2 hours of lab per week for 12 week
2 Lab sections of a maximum of 20 students
1-2 Teaching Assistant (TA), 2 sections per TA

Course Evaluation

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<tbody>
<tr>
<td>Midterm exam</td>
<td>25%</td>
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<tr>
<td>Labs</td>
<td>20%</td>
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<tr>
<td>Course Project</td>
<td>15%</td>
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<tr>
<td>Final exam</td>
<td>40%</td>
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<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
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- To achieve a passing grade, student must pass both the theory and laboratory/project components. Labs are mainly organized for ARM Cortex M3 core, RTX real-time operating system and embedded system design tools.
- Individual and team projects cover hardware-software design of embedded systems.

Examinations

Midterm exam in Week 8, 1.5 hours, closed book (covers Weeks 1-8 of lecture and laboratory material).
Final exam, during exam period, 2 hours, closed book (covers all the course material).

Project

Each project combines three separate components: a written component, a demonstration/presentation component and an oral component. It is an individual project but depending on the extended project selection, and with the consent of the instructor multiple students are allowed to undertake complex projects.
Project marks will be awarded out of 100 marks as per following schedule:

- Summary of Project (1-2 pages). Week 5. 5% Marks
• Demo of project progress in Week-8 lab session. 10% Marks
• Interim project report (4-6 typed pages). Start of week-10. 20% Marks
• Final demonstration, oral and presentation. Weeks-11 and 12 lab sessions. 30% Marks
• Final project report. Week 13. 35% Marks

Project Report Format
Final report of the project should be of 10-15 pages with the following IEEE like format.
1. The report must be typed and have some Figures and/or drawings of your own.
2. Avoid Cut and paste of Figures from other papers or manuals.
3. A suitable Font (Bookman, Courier, Times New Roman) of size 11 or 12 points.
4. Single line spacing.
5. Pages of letter size with 1.0" top, bottom, left and right margins.
6. The report must have the following sections:
   Introduction, Past Work or Review, Methodology, Hardware/Software Design, Conclusions, Reference. You can always have some more sections like Appendix, etc.

Course Content

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<thead>
<tr>
<th>Week</th>
<th>Detailed Description</th>
<th>Hours</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction to Embedded and Real time Systems</td>
<td>3</td>
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<tr>
<td>2</td>
<td>Introduction to Hardware Software Co-design</td>
<td>3</td>
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<td>3</td>
<td>Embedded SoPC (System on Programmable Chips)</td>
<td>3</td>
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<tr>
<td>4-5</td>
<td>Embedded Processors - ARM Cortex M3, NIOS-II and other CPU Cores</td>
<td>6</td>
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<td>6</td>
<td>Multitasking and Real-time Scheduling Techniques – Pre-emptive and Non-pre-emptive Scheduling</td>
<td>3</td>
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<tr>
<td>7</td>
<td>ARM CPU, Cortex M3 and Multitasking Application</td>
<td>3</td>
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<tr>
<td>8</td>
<td>Review and Midterm Exam</td>
<td>3</td>
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<tr>
<td>9-10</td>
<td>RTX – Real-time Operating System Real-time Scheduling Techniques. Earliest-Deadline-First (EDF) and Rate-Monotonic Scheduling.</td>
<td>6</td>
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<tr>
<td>11</td>
<td>Introduction to Priority Inversion Problem and its Solutions</td>
<td>3</td>
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<tr>
<td>12</td>
<td>Fault-tolerant Embedded Systems Hardware and Software Fault-Tolerance Techniques</td>
<td>3</td>
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<tr>
<td>13</td>
<td>Catching up and Review</td>
<td>3</td>
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Laboratory/Projects - Room ENG408

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<thead>
<tr>
<th>Labs.</th>
<th>Detailed Description</th>
<th>Week</th>
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<tbody>
<tr>
<td>1</td>
<td>Lab 1: SoPC Design and Implementation</td>
<td>2-3</td>
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<tr>
<td>2</td>
<td>Lab 2: Introduction to ARM/Keil uVision IDE and ARM Cortex M3</td>
<td>4</td>
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<tr>
<td>3</td>
<td>Lab 3: Exploring ARM Cortex-M3 Features</td>
<td>5</td>
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<td></td>
<td><strong>Start of the Project</strong></td>
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<tr>
<td>4</td>
<td>Lab 4: Scheduling Multitasking Applications with RTX (Task and thread level)</td>
<td>6-7</td>
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<tr>
<td>5</td>
<td>Lab 5: Real-time Scheduling using RTX (Bonus/Optional)</td>
<td>9</td>
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Project
Students are required to investigate, design and prototype an embedded system for a media player. Student can also choose a comparable some other embedded application including multimedia, biomedical, communication, smart-home, automotive or any other industrial applications. An on-line project presentation and a formal professionally written project report are due at the end of the term.

Note: Schedule of lectures and labs is tentative. There may be some changes in the schedule that will be announced in the class and posted at the course website.
Important Notes

1. All of the required course-specific written reports will be assessed not only on their technical/academic merit, but also on the communication skills exhibited through these reports.

2. All assignment and lab/tutorial reports must have the standard cover page which can be completed and printed from the Department website at www.ee.ryerson.ca. The cover page must be signed by the student(s) prior to submission of the work. Submissions without the cover pages will not be accepted.

3. Should a student miss a mid-term test or equivalent (e.g. studio or presentation), with appropriate documentation, a make-up will be scheduled as soon as possible in the same semester. Make-ups should cover the same material as the original assessment but need not be of an identical format. Only if it is not possible to schedule such a make-up may the weight of the missed work be placed on the final exam, or another single assessment. This may not cause that exam or assessment to be worth more than 70% of the student’s final grade. If a student misses a scheduled make-up test or exam, the grade may be distributed over other course assessments even if that makes the grade on the final exam worth more than 70% of the final grade in the course.

4. Students who miss a final exam for a verifiable reason and who cannot be given a make-up exam prior to the submission of final course grades, must be given a grade of INC (as outlined in the Grading Promotion and Academic Standing Policy) and a make-up exam (normally within 2 weeks of the beginning of the next semester) that carries the same weight and measures the same knowledge, must be scheduled.

5. Medical or Compassionate documents for the missing of an exam must be submitted within 3 working days of the exam. Students are responsible for notifying the instructor that they will be missing an exam as soon as possible.

6. Requests for accommodation of specific religious or spiritual observance must be presented to the instructor no later than two weeks prior to the conflict in question (in the case of final examinations within two weeks of the release of the examination schedule). In extenuating circumstances this deadline may be extended. If the dates are not known well in advance because they are linked to other conditions, requests should be submitted as soon as possible in advance of the required observance. Given that timely requests will prevent difficulties with arranging constructive accommodations, students are strongly encouraged to notify the instructor of an observance accommodation issue within the first two weeks of classes.

7. The results of the first test or mid-term exam will be returned to students before the deadline to drop an undergraduate course in good Academic Standing.

8. Students are required to adhere to all relevant University policies including:

9. Students are required to obtain and maintain a Ryerson Matrix e-mail account for timely communications between the instructor and the students.

10. Any changes in the course outline, test dates, marking or evaluation will be discussed in class prior to being implemented.

11. In-class use of cellular telephones is not permitted. Please turn off your cell phone prior to class. Quiet use of laptops, text-messengers and similar non-audible devices are permitted only in the rear rows of the class. This restriction allows use of such devices by their users while limiting audible and visual distractions to other students. This policy may change without notice.

12. Labs, projects handed in past the due date and time will not be accepted for marking and will receive a mark of ZERO. In some genuine cases late submission will be allowed with a penalty of 5% per day.

13. Students found to have plagiarized any portion of their labs and final project will receive a grade of zero on the complete project. This automatically will lead to a failing grade