1 INSTRUCTIONAL SUPPORT

1.1 Instructor
Instructor: Stefano Gregori
Office: RICH 3521, ext. 56191
Email: sgregori@uoguelph.ca
Office hours: posted on the course webpage or by appointment

1.2 Laboratory technician
Technician: Joel Best
Office: RICH 3501, ext. 54234
Email: jbest@uoguelph.ca

2 LEARNING RESOURCES

2.1 Course website
Information and materials will be posted in the course web page on CourseLink.

2.2 Required resources
Textbook:
2.3 Recommended resources

Reference books on digital design:


Reference journals:

- *IEEE Transactions on Very Large Scale Integration (VLSI) Systems*, ISSN 10638210.
- *IEEE Transactions on Computers*, ISSN 00189340.
- *IEEE Transactions on Circuits and Systems, Part I* and *II*, ISSN 10577122 and 10577130.
- *Electronics Letters*, ISSN 00135194.

The books above are available on Course Reserve in the library. Additional references are indexed by library call numbers TK7800 to TK8360.

The journal articles are available through http://ja.lib.uoguelph.ca/

2.4 Additional resources

Lecture information: Handouts will be provided in class and reading materials will be posted on the course web page.

Laboratory information: Laboratory instructions will be provided in class, while reference materials will be available through the course web page.

Midterm exam: More information related to the midterm exam will be given two weeks in advance.

2.5 Communication and email policy

Communication is through announcements in class. Some information will be posted on the course web page or sent via email messages to your University address. It is your responsibility to keep yourself informed about the course. As per University regulations, you are expected to check regularly your University email account on https://mail.uoguelph.ca, because email is the official route of communication between the University and its students.

When you send an email to the instructor or the laboratory technician, please start the subject line with “ENGG*6520,” so that it is easily distinguished from other emails.
3 ASSESSMENT

3.1 Dates and distribution

Laboratory 1: 20%
Please see section 5.3 for schedule and due dates.

Laboratory 2: 20%
Please see section 5.3 for schedule and due dates.

Midterm exam: 20%
Thursday, 19 June 2014, 15:00 to 17:00, in RICH 2531.

Project: 40%
Please see section 5.3 for schedule and due date.

3.2 Course grading policies

Failure to complete a course requirement: If you are unable to meet an in-course requirement because of illness or compassionate reasons, please advise the course instructor in writing at the earliest possible time. Please see the Graduate Calendar for information on academic consideration: http://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/

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 or at the earliest possible time.

Passing grade: The standard University letter equivalents for percentage grades are (since Fall 2012): “A+” for 90% to 100% (outstanding), “A” for 85% to 89% (excellent), “A−” for 80% to 84% (very good), “B+” for 77% to 79%, “B” for 73% to 76% (good), “B−” for 70% to 72%, “C+” for 67% to 69%, “C” for 65% to 66% (acceptable), “F” for 0% to 64% (fail).

Missed exams: Any student not taking an exam receives a grade of zero for that exam. In case you have a legitimate reason for missing an exam session, the instructor may consider an accommodation upon presentation of a written request and suitable documentation before the time of the exam.

Laboratory work: You must attend and complete all laboratories. In case you have a legitimate reason for missing a laboratory session, the instructor may consider an accommodation upon presentation of a written request and suitable documentation before the time of the laboratory.

Late laboratory and project reports: Any student not handing in a report receives a grade of zero for that submission. There are no makeup reports and late submissions are not accepted for marking.

Copies of reports: Please keep back-up copies of all out-of-class assignments (i.e. laboratory and project materials), because you may be asked to resubmit your work.

Questions about grades: If you have questions about the grade your submission received, please ask the instructor within two weeks after the document has been returned.
4 AIMS, OBJECTIVES, AND GRADUATE ATTRIBUTES

4.1 Calendar description
This course will introduce the principles of VLSI MOSFET digital design from a circuit and system perspective. Advanced topics include: power issues related to each level of design abstraction; voltage and frequency scaling; power to speed trade-offs; ASIC digital design flow; Verilog integration, ASIC case studies.

4.2 Course aims
The subject of this course is the analysis and design of digital integrated circuits (ICs) in complementary metal-oxide-semiconductor (CMOS) technology. It introduces the principles of analysis, design, synthesis, and fabrication of Very Large Scale Integration (VLSI) digital circuits. The main emphasis is on the three fundamental levels of design abstraction: device, circuit, and system. The course begins at device level with an introduction on CMOS technology, active and passive devices, interconnections and parasitics. The course continues at circuit level with inverters, transmission gates, static gates, dynamic gates, static latches and registers, dynamic latches and registers, pipelining principles and circuit styles. Finally, the course covers system-level aspects including design methods and tools, design flows, interconnect and clock structures, low-power design techniques, and design examples such as adders, multipliers, shifters, memories with array structures and subsystems.

4.3 Learning objectives
After successfully completing the course you will be able to describe operating principles and performance characteristics of VLSI digital circuits and to apply the studied concepts to the design of complex systems. To this purpose you will learn to:

1. Identify terms, quantities, and models used by engineers for describing VLSI devices.
2. Understand the importance of circuit structures, physical and technological parameters, layout construction, and device modelling.
3. Make use of techniques and skills for analyzing and designing VLSI circuits.
4. Read technological parameters, design specifications, circuit schematic and layout diagrams in order to estimate performance and to identify critical elements.
5. Comprehend the importance of design methods and tools and circuit architectures.
6. Conduct simulations, interpret results, and improve design of VLSI systems.
7. Communicate effectively about specifications, design, simulation, testing, and applications of VLSI systems.

4.4 Graduate learning outcomes
Successfully completing this course will contribute to the following University of Guelph learning outcomes for graduate degrees:
Critical and creative thinking: Lectures and assignments deal with the application of analysis, modelling, and design concepts to VLSI circuit operation. Design projects challenge the students to identify issues and formulate their individual solutions. Students demonstrate creativity and innovation in the application of knowledge to the analysis and solution of circuit problems. They make and justify VLSI design decisions on the basis of acquired knowledge and analysis.

Literacy: Lectures and assignments discuss design methods, technological parameters, and circuit and layout diagrams. Information from books, scientific journals, technical standards, and device data-sheets is introduced. Laboratory sessions include computer-aided design tools and related documentation. Students identify reliable information, select appropriate methods to undertake their assignments, and configure and apply test conditions to evaluate outcomes.

Global understanding: Course activities reinforce awareness of the limits of knowledge and of the steps to follow to increase knowledge. Lectures emphasize how VLSI solutions are based on principles of physics and mathematics and how VLSI technology has global economic, social, and environmental impact. Students apply modelling and design skills to realistic problems and consider ranges of applicability, limitations, and potential consequences.

Communicating: Course activities include giving and responding to instructions and inquiries, understanding and producing technical documentation, and giving and attending to presentations. Lectures emphasize how comprehending and communicating effectively complex VLSI concepts involve the acquisition of technical communication skills and terminology. Students receive and convey engineering concepts clearly and consistently by oral, written, and graphical means.

Professional and ethical behaviour: Throughout the course students are encouraged to ethical behaviour consistent with academic integrity and professional ethics and accountability. Students keep a high level of honour in their work and understand the importance of including the public good as a goal in engineering activities, even if this requirement is not explicitly articulated.

4.5 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. The lecture notes and materials available to students on the course web site are not intended to be a stand-alone course. During the lectures, the instructor expands and explains the course contents and provides example problems that supplement notes and textbook. Scheduled classes and laboratory sessions are the principal venue to provide information and feedback about exams and laboratories.

4.6 Students’ learning responsibilities

Students are encouraged to take advantage of all the learning opportunities provided by lectures and laboratory sessions. Students, especially those having difficulty with the course content, should also make use of additional 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 allows the instructor to recommend extra resources in a timely manner and provide consideration if appropriate.

4.7 Relationships with other courses

Success in this course requires a good understanding of the following elements:
• Mathematical tools for describing discrete-time systems and binary-logic systems.
• Techniques for electric circuit analysis and digital design.
• Fundamentals of electronic devices.

This material is roughly covered by undergraduate courses equivalent to ENGG*3450.

5 Teaching and Learning Activities

5.1 Timetable

Lectures:
Thursday, 16:00 to 17:20, in RICH 2531

Laboratory sessions:
Tuesday, 16:00 to 17:20, in RICH 2531

5.2 Lecture schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Dates</th>
<th>Lecture topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>May-07 to May-08</td>
<td>Introduction</td>
</tr>
<tr>
<td>1</td>
<td>May-11 to May-15</td>
<td>MOS transistor</td>
</tr>
<tr>
<td>2</td>
<td>May-18 to May-22</td>
<td>CMOS technology and layout</td>
</tr>
<tr>
<td>3</td>
<td>May-25 to May-29</td>
<td>CMOS logic</td>
</tr>
<tr>
<td>4</td>
<td>Jun-01 to Jun-05</td>
<td>Delay</td>
</tr>
<tr>
<td>5</td>
<td>Jun-08 to Jun-12</td>
<td>Power</td>
</tr>
<tr>
<td>6</td>
<td>Jun-15 to Jun-19</td>
<td>Combinational design</td>
</tr>
<tr>
<td>7</td>
<td>Jun-22 to Jun-26</td>
<td>Sequential design</td>
</tr>
<tr>
<td>8</td>
<td>Jun-29 to Jul-03</td>
<td>Datapath subsystems</td>
</tr>
<tr>
<td>9</td>
<td>Jul-06 to Jul-10</td>
<td>Array subsystems</td>
</tr>
<tr>
<td>10</td>
<td>Jul-13 to Jul-17</td>
<td>Review</td>
</tr>
<tr>
<td>11</td>
<td>Jul-20 to Jul-24</td>
<td>Review</td>
</tr>
<tr>
<td>12</td>
<td>Jul-27 to Jul-31</td>
<td>Review</td>
</tr>
</tbody>
</table>

Topics schedule will be adjusted throughout the course as needed.

5.3 Laboratory schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Dates</th>
<th>Topics</th>
<th>Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2</td>
<td>May-11 to May-22</td>
<td>Introduction to design tools and laboratory safety</td>
<td></td>
</tr>
<tr>
<td>3, 4</td>
<td>May-25 to Jun-05</td>
<td>Device characteristics and logic gates</td>
<td>Jun-05</td>
</tr>
<tr>
<td>5, 6</td>
<td>Jun-08 to Jun-19</td>
<td>Digital building cells and design flow</td>
<td>Jun-19</td>
</tr>
<tr>
<td>7, 8, 9, 10</td>
<td>Jun-22 to Jul-17</td>
<td>Circuit design project</td>
<td>Jul-17</td>
</tr>
<tr>
<td>11, 12</td>
<td>Jul-20 to Jul-31</td>
<td>Feedback and review</td>
<td></td>
</tr>
</tbody>
</table>
5.4 Other important dates

Thursday, 7 May 2015: classes begin
Monday, 18 May 2015: holiday
Wednesday, 1 July 2015: holiday
Friday, 3 July 2015: drop date
Friday, 31 July 2015: classes end
Monday, 3 August 2015: holiday
Thursday, 6 August 2015: examinations begin
Friday, 14 August 2015: examinations end

The last date to drop one-semester courses, without academic penalty, is Friday, 3 July 2015. Two-semester courses must be dropped by the last day of the add period in the second semester. Please consult the Graduate Calendar to verify the schedule of dates for this term:
http://www.uoguelph.ca/registrar/calendars/graduate/current/sched/

5.5 Obtaining help

You can obtain help during the instructor’s office hours and after lectures. Please come and talk to me if you have fallen behind in your work. I am willing to put in as much effort to help you as you are willing to put in to help yourself. I am happy to work with you on difficult concepts and hear your suggestions for ways to make the course better.

I hope you enjoy the course and I am looking forward to your feedback to make the material more interesting or more connected to your research activity or your final project. Do not hesitate to actively participate during lectures with questions and remarks. If something is not clear, please let me know. If you are excited about the subject and want to develop a project, contact me. VLSI design is a lot of fun.

6 Laboratory safety

Safety is critically important to the School of Engineering and is a shared responsibility among faculty, staff, and students. As a student you are responsible for taking all reasonable safety precautions and following the approved safety procedures specific to the laboratory you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor or the faculty responsible.

Please use good judgement and safe working habits and remember that food and drink are not allowed in laboratories. In case of doubts about safety procedures please consult with the laboratory supervisor or the instructor before proceeding. Any violation of safety policies may result in loss of laboratory access.

You are required to comply with the University of Guelph Acceptable Use Policy for Information Technology, which is available on: https://www.uoguelph.ca/cio/content/aup-acceptable-use-policy/. If you have any question about this policy, please ask the laboratory technician or the instructor.
7 ACADEMIC MISCONDUCT

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 discourages misconduct. 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.

The academic misconduct policy is detailed in the Graduate Calendar: http://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/

A tutorial on Academic Misconduct produced by the Learning Commons can be found at: http://www.academicintegrity.uoguelph.ca/

The School of Engineering has adopted a Code of Ethics that can be found at: http://www.uoguelph.ca/engineering/undergrad-counselling-ethics/

You are encouraged to familiarize yourself with your responsibilities, review the tutorial on Academic Integrity, and discuss any question you may have with the instructor or a faculty member.

Working together to solve assignments and sharing schematics, layouts, or simulations is not allowed. When writing laboratory and project reports, please remember that copying text, data, or figures is plagiarism, even if you received the material from a friend or you found it on the Internet. Letting others use your work is also not allowed, please keep your reports, designs, and simulation results in a secure location.

8 ACCESSIBILITY

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community’s shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability or a short-term disability should contact the Centre for Students with Disabilities as soon as possible.

For more information, please contact the Centre for Students with Disabilities at ext. 56208 or email csd@uoguelph.ca or see the website: http://www.uoguelph.ca/csd/
9 RECORDING OF MATERIALS AND COPYRIGHT

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

The instructor reserves the right to all materials made available for this course and all interpretations presented in class, which may not be reproduced, transmitted to others, stored, or archived in electronic backup media without the written consent of the instructor. The resources that are made available during course activities or through the course web page or the University IT infrastructure may be protected by copyright, technology usage agreements, or non-disclosure agreements and are only for the use of students enrolled in this course for the purposes associated with this course and may not be retained or further disseminated.

10 RESOURCES

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

This course outline includes sections and standard statements adapted with permission from the course outline template of the School of Engineering and from the course outline checklist of the University of Guelph. In case of any discrepancy, please refer to the current Academic Calendars.