ENGG*4080 MICRO AND NANO-SCALE ELECTRONICS

FALL 2014

UNIVERSITY of GUELPH

School of Engineering

(Revision 1: 2 September 2014)

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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

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2 LEARNING RESOURCES

2.1 Course website

Information and materials are posted on CourseLink. You are responsible for checking it regularly.

2.2 Required resources

Textbook:

- B. Razavi, *Fundamentals of microelectronics*, Wiley, 2nd ed., 2013.

2.3 Recommended resources

Reference books for consultation:

- P. R. Gray, P. J. Hurst, S. H. Lewis, R. G. Meyer, *Analysis and design of analog integrated circuits*, Wiley, 5th ed., 2009.

- B. Razavi, *Design of analog CMOS integrated circuits*, McGraw-Hill, 2001.

The textbook and the reference books above are available on Course Reserve in the library.

2.4 Additional resources

Additional references are indexed by library call numbers TK7800 to TK8360.

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.

Please use lectures and laboratory sessions as your main opportunity to ask questions about the course. Please your University email address for correspondence relating to the course and include the course identifier "ENGG*4080" in the subject header, a clearly written message, and your name and student number. If a question cannot be answered easily or briefly with a reply email, please see the instructor during the office hours instead.

As per University regulations, all students are required to check regularly their University email accounts. Email is the official route of communication between the University and its students.

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3 ASSESSMENT

3.1 Dates and distribution

Laboratories: 24%
  Please see section 5.3 for schedule and due dates.

Project: 16%
  Please see section 5.3 for schedule and due date.

Midterm exam 1: 15%
  Monday, 6 October 2014, 12:30 to 13:20, in ROZH 108.

Midterm exam 2: 15%
  Friday, 7 November 2014, 12:30 to 13:20, in ROZH 108.

Final exam: 30%
  Saturday, 6 December 2014, 08:30 to 10:30, please verify time and location on WebAdvisor.

3.2 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 at the earliest possible time. Please 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 or at the earliest possible time. Please 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: The passing grade is 50%.

Missed midterm exams: Any student not taking an exam receives a grade of zero for that exam. There are no makeup midterm exams. 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, because you may be asked to resubmit your work.

4 AIMS, OBJECTIVES AND GRADUATE ATTRIBUTES

4.1 Calendar description

The purpose of this course is to describe the operating principles of analog integrated micro and nano electronic circuits and to teach how to design and use such circuits systems. Course topics include: device and circuit fabrication in silicon and non-silicon based technologies; operation and layout of active and passive elements; analog and switched-capacitor filters; analog-to-digital and digital-to-analog converters; amplifiers; oscillators and circuits for radio-frequency and optical communications; readout channels for integrated sensors, and analog integrated circuits for mechatronics and bioengineering. The main emphasis is on device models, circuit operation, and design techniques.
Prerequisite(s): ENGG*3450

4.2 Course aims

This course introduces the main ideas and techniques in analysis and design of micro and nano-scale integrated circuits in CMOS technology. The main goals are to illustrate the operating principles and performance characteristics and to show how to apply the studied concepts to the analysis and design of engineering systems including micro and nano-scale integrated circuits.

The course also encourages to develop originality or innovation in the application of knowledge, to reinforce awareness of the limits of knowledge and of the steps to follow to increase knowledge, to consider the effects on global economics, society and the environment of microelectronics technology, to keep a high level of honour in academic work, and to mature the intellectual independence required for continuing professional development and the curiosity required for life-long learning.

4.3 Learning objectives

After successfully completing the course you will be able to:

1. Understand the basic properties of electronic systems in order to assess them and recognize their limits.

2. Describe the main signals used in electronic systems in order to know if a parameter is good or bad and to generate test signals for performance evaluation.

3. Define basic building blocks to be able to modify and interconnect them for obtaining given functions.

4. Read circuit schematic and layout diagrams to identify critical points and estimate performance.

5. Apply computer simulation tools to design, verify, and improve blocks and systems.

6. Identify terms, models, and technological parameters to communicate about specifications, designs, and applications.

4.4 Graduate attributes

Successfully completing this course will contribute to the following CEAB graduate attributes:

Graduate attributes	Learning objectives	Assessment
1. A knowledge base for engineering	1, 2	reports, project, exams
2. Problem analysis	1, 2, 3, 4	exams
3. Investigation	3, 4	reports
4. Design	3, 4, 5	reports, project
5. Use of engineering tools	5	reports, project
6. Communication skills	6	reports, project, exams
7. Individual and team work	6	reports, project, exams
8. Professionalism	4, 6	reports, project, exams
9. Impact of engineering on society and the environment	3, 5, 6	project, exams
10. Ethics and equity	6	project
11. Economics and project management	3, 4, 5	project
12. Life-long learning	4	project, exams

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.

You are encouraged to spread the learning periods over the entire semester. Start studying from today without postponement. You should try to avoid distractions while studying and during lectures, tutorials, and laboratory sessions. Take down notes and outlines while reading or listening. Note down the questions and doubts that arise and get clarifications immediately. When you are in the classroom, as a courtesy to classmates and instructors, please keep your cell phone silenced, do not eat (water or a drink in a leak-proof container are fine in the classroom), and use your tablet or laptop only for note-taking or course-related applications.

4.7   Relationships with other courses

Previous courses:

ENGG*3450: semiconductors materials, pn junctions, semiconductor diodes, MOS transistors, small-signal operation and models, amplification stages, logic gates

Follow-on courses:

ENGG*4550: VLSI digital circuits, static and dynamic CMOS gates, static and dynamic latches, registers, pipelining, adders, multipliers, shifters

ENGG*4560: embedded system design, hardware/software abstractions, system-on-chip design and integration, embedded CUPs, embedded and distributed circuit architectures

ENGG*4650: integrated sensors and photonic devices, integration of sensors and microfabrication, sensor characteristics, interface electronic circuits, data acquisition

5 TEACHING AND LEARNING ACTIVITIES

5.1   Timetable

Lectures:

Monday	12:30 to 13:20	ROZH	108
Wednesday	12:30 to 13:20	ROZH	108
Friday	12:30 to 13:20	ROZH	108

Laboratory sessions:

Thursday	11:30 to 13:20	RICH	2531

5.2 Lecture schedule

W	Dates	Lecture topics	References	Learning objectives
0	Sep-04 to Sep-05	Introduction	Ch 1	1
1	Sep-08 to Sep-12	Semiconductors and fabrication	Ch 2	1, 2
2	Sep-15 to Sep-19	Device models	Ch 3, 6	1, 2
3	Sep-22 to Sep-26	Amplifiers and systems	Ch 7, 8	1, 2, 4
4	Sep-29 to Oct-03	Analog building cells and design flow	Ch 9	3, 4
5	Oct-06 to Oct-10	Analog building cells	Ch 10	3, 4
6	Oct-13 to Oct-17	Biasing, references and regulators	Ch 10	3, 4
7	Oct-20 to Oct-24	Digital building cells and design flow	Ch 16	3, 4
8	Oct-27 to Oct-31	Digital building cells	Ch 16	3, 5, 6
9	Nov-03 to Nov-07	Analog and digital processing blocks	Ch 13, 14	3, 5, 6
10	Nov-10 to Nov-14	Analog and digital processing blocks	Ch 13, 14	3, 5, 6
11	Nov-17 to Nov-21	Advanced topics	Ch 13, 14, 15	3, 5, 6
12	Nov-24 to Nov-28	Review	All	1 to 6

Topics schedule will be adjusted throughout the course as needed.

5.3 Laboratory schedule

W	Dates	Topics	Due
1	Sep-11	Introduction to design tools and laboratory safety	—
2, 3	Sep-18, Sep-25	Device characteristics, sweep and transient analysis	Sep-25
4, 5 , 6	Oct-02, Oct-09 , Oct-15	Analog building cells and design flow	Oct-15
7, 8	Oct-23, Oct-30	Digital building cells and design flow	Oct-24
9, 10, 11	Nov-06, Nov-13, Nov-20	Circuit design project	Nov-20
12	—	Feedback and review	—

5.4 Other important dates

Thursday, 4 September 2014:	First day of class
Monday, 13 October 2014:	Holiday (i.e. no classes scheduled)
Tuesday, 14 October 2014:	Study break day (i.e. no classes scheduled)
Friday, 31 October 2014:	Fortieth class day (i.e. drop date)
Thursday, 27 November 2014:	Tuesday schedule in effect
Friday, 28 November 2014:	Monday schedule in effect and last day of class

Please consult the Undergraduate Calendar to verify the schedule of dates for this term:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c03/c03-fallsem.shtml
Please consult the Undergraduate Calendar to find information about dropping courses:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

5.5 Obtaining help

You can obtain help from the instructor during his office hours (posted on the course web page) and from the laboratory technician during the laboratory time slots.

Please contact the instructor if you need help or you have fallen behind in your work. He is willing to put in as much effort to help you as you are willing to put in to help yourself. He is happy to work with you

on difficult concepts and hear your suggestions for improving the course. If you are busy during his office hours, then email him with some days and times you are free, and he will set an appointment.

If you are ill, please call the Student Health Services or a medical doctor. If you have emotional, family, or living environment problems that affect your ability to study, please visit the Counselling Services or your academic advisor. If you have a disability or a short-term disability, please refer to the Centre for Students with Disabilities. You are encouraged to use the available services and programs and you are welcome to discuss with the instructor your specific learning needs in this course at the earliest possible time.

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.

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.

Hurried submission of assignments does not excuse you from the responsibility for verifying the academic integrity of your work before submitting it. If you are in any doubt as to whether an action on your part could be construed as an academic offence, you should consult with a faculty member.

7.1 Resources

The Academic Misconduct Policy is detailed in the Undergraduate Calendar:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

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

Please also review the section on Academic Misconduct in your Engineering Program Guide.

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

7.2 Recommendations

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.

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. Therefore 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

Presentations which are made in relation to course work, including lectures, tutorials, and laboratory sessions, 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 or transmitted to others without the written consent of the instructor. The materials available on the course web page may be protected by copyright 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.