ENGG*4080 Micro and Nano-Scale Electronics

Fall 2019
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - September 04, 2019

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1 Course Details

1.1 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-toanalog 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.

Pre-Requisites: ENGG*3450

1.2 Timetable

Lectures

Monday	14:30–15:50	MCKN 234
Wednesday	14:30–15:50	MCKN 234

Laboratory sessions

Section 1	Tuesday	13:30–15:20	RICH 2531
Section 2	Thursday	08:30–10:20	RICH 2531

1.3 Final Exam

There is no final exam.

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2 Instructional Support

2.1 Instructional Support Team

Instructor: Stefano Gregori
Email: sgregori@uoguelph.ca
Telephone: 519-824-4120 ext. 56191
Office: RICH 3521
Office Hours: Friday, 17:30–18:20

Lab Technician: Matthew Kent
Email: mattkent@uoguelph.ca
Telephone: 519-824-4120 ext. 54113
Office: THRN 2332

2.2 Teaching Assistants

Teaching Assistant: Evan Fallis
Email: efallis@uoguelph.ca

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3 Learning Resources

3.1 Required Resources

Course webpage (Website)
Course materials, announcements, and grades will be posted to the course webpage on CourseLink. You are responsible for checking the site regularly.

Textbook (Textbook)
T. C. Carusone, D. Johns, K. Martin, Analog integrated circuit design, Wiley, 2nd ed., 2012, TK7874 .J65 2012

3.2 Recommended Resources

Readings (Readings)
Readings from the textbook will be posted on the course webpage. The readings are assigned with the intention that you will read them before class, so that you will be prepared to discuss the concepts and to follow the examples presented in class.

Lecture notes (Notes)
Lecture notes will be posted on the course webpage. The notes are prepared with the intention that you will fill in the blanks, take additional notes and write down examples in class. Attendance at lectures is expected, because material and interpretations not present in the notes or other resources will be discussed.

Problem sets (Other)
Problem sets will be available on the course webpage. The problems are selected with the

intention that you will solve them throughout the term as a way to reinforce and self-assess your understanding of the topics in the course.

Laboratory manuals (Lab Manual)
Laboratory manuals will be posted on the course webpage. The manuals are prepared with the intention that you will read them before each laboratory session to be ready for a safe and successful activity, and that you will consult them during the laboratory while taking your own notes. Attendance at laboratories is mandatory.

Design rules (Other)
The MOSIS Scalable CMOS Design Rules will be posted on the course webpage or distributed in the laboratory.

3.3 Additional Resources

Recommended books for consultation (Textbook)
F. Maloberti, Understanding microelectronics: a top-down approach, Wiley, 2012, TK7874 .M253 2012

B. Razavi, Fundamentals of microelectronics, Wiley, 2nd ed., 2014, TK7874 .R395 2014

Library resources (Textbook)
The textbook and the reference books above are available in the bookstore and on Course Reserve in the library. Additional references are indexed by library call numbers TK7800 to TK8360 (i.e. located on the 5th floor of the library).

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4 Learning Outcomes

This course introduces the fundamental ideas, techniques and tools in analysis and design of integrated circuits in CMOS technology. The main operating principles and performance characteristics are illustrated in order to understand how to apply the studied concepts to the analysis and design of micro and nano-scale circuits. The course also encourages to develop originality and innovation in the application of knowledge with the development of a mini-project using industry-grade design tools.

4.1 Course Learning Outcomes

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

1. Understand the basic properties of electronic systems in order to evaluate them and recognize their limits.
2. Describe the main signals and characteristics used in electronic systems in order to assess a parameter or to generate test signals for performance evaluation.
3. Define circuit building blocks and modify and interconnect them for obtaining given functions.
4. Read circuit and layout diagrams to identify critical points and estimate performance

constraints.

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.

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
2	Problem Analysis	1, 2
2.1	Formulate a problem statement in engineering and non-engineering terminology	1, 2
2.2	Identify, organize and justify appropriate information, including assumptions	1, 2
2.3	Construct a conceptual framework and select an appropriate solution approach	1, 2
2.4	Execute an engineering solution	1, 2
2.5	Critique and appraise solution approach and results	1, 2
3	Investigation	2, 3
3.1	Propose a working hypothesis	2, 3
3.2	Design and apply an experimental plan/investigative approach (for example, to characterize, test or troubleshoot a system)	2, 3
3.3	Analyze and interpret experimental data	3
3.4	Assess validity of conclusions within limitations of data and methodologies	3
4	Design	3, 4, 5, 6
4.1	Describe design process used to develop design solution	3, 4, 5, 6
4.2	Construct design-specific problem statements including the definition of criteria and constraints	3, 4, 5, 6
4.3	Create a variety of engineering design solutions	4, 5, 6
4.4	Evaluate alternative design solutions based on problem definition	4, 5, 6
4.5	Develop and refine an engineering design solution, through techniques such as iteration, simulation and/or prototyping	4, 5, 6
5	Use of Engineering Tools	4, 5

#	Outcome	Learning Outcome
5.1	Select appropriate engineering tools from various alternatives	4, 5
5.2	Demonstrate proficiency in the application of selected engineering tools	4, 5
5.3	Recognize limitations of selected engineering tools	4, 5
6	Individual & Teamwork	5, 6
6.3	Execute and adapt individual role to promote team success through, for example, timeliness, respect, positive attitude	5, 6
7	Communication Skills	2, 4, 6
7.2	Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode	2, 4, 6
7.3	Construct the finished elements using accepted norms in English, graphical standards, and engineering conventions, as appropriate for the message and audience	6

5 Teaching and Learning Activities

5.1 Lecture schedule

Week	Dates	Lecture topics	References	Learning objectives
1	Sep. 9–13	Integrated circuits and modelling	ch. 1	1, 4, 5
2	Sep. 16–20	Integrated-circuit fabrication and layout	ch. 2	1
3	Sep. 23–27	Current mirrors and amplifiers	ch. 3	1, 2, 3, 4, 6
4	Sep. 30–Oct. 4	Frequency response	chs. 4	1, 2
5	Oct. 7–11	Feedback	chs. 5	1, 2
6	Oct. 14–18	Amplifier design and compensation	ch. 6	1, 2, 3
7	Oct. 21–25	Biasing, references and regulators	ch. 7	4, 5
8	Oct. 28–Nov. 1	Comparators and sample-and-hold circuits	chs. 10, 11	4, 5
9	Nov. 4–8	Filters and discrete-time circuits	chs. 12, 13, 14	4, 5, 6

10	Nov. 11–15	Nyquist-rate data converters	chs. 15, 16, 17	4, 5, 6
11	Nov. 18–22	Advanced topics, if schedule permits	—	—
12	Nov. 25–29	Review	all	all

Topics schedule will be adjusted throughout the course as needed.

5.2 Laboratory schedule

Week	Dates	Laboratory topics	Due date
1	Sep. 9–13	Laboratory 1, introduction to design tools and laboratory safety	—
2	Sep. 16–20	Laboratory 2, device characteristics, sweep and transient analysis	—
3	Sep. 23–27	Laboratory 2 (continued)	Sep. 27
4	Sep. 30–Oct. 4	Laboratory 3, CMOS building cells and design flow	—
5	Oct. 7–11	Study-break week	—
6	Oct. 14–18	Laboratory 3 (continued)	Oct. 18
7	Oct. 21–25	IC design project	—
8	Oct. 28–Nov. 1	IC design project (continued)	—
9	Nov. 4–8	IC design project (design review)	Nov. 8
10	Nov. 11–15	IC design project (continued)	—
11	Nov. 18–22	IC design project (design presentation and feedback)	Nov. 22
12	Nov. 25–29	—	—

Topics schedule will be adjusted throughout the course as needed.

5.3 Other important dates

Monday, 14 October 2019: Holiday (i.e. no classes scheduled)

Tuesday, 15 October 2019: Study break day (i.e. no classes scheduled)

Thursday, 28 November 2019: Tuesday schedule in effect

Friday, 29 November 2019: Monday schedule in effect and drop date

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

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6 Assessments

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Laboratories	30
Midterm exam	40
Project	30
Total	100

6.2 Assessment Details

Laboratories (30%)
Learning Outcome: 4, 5, 6
Please see section 5.2 for schedule and due dates.

Midterm exam (40%)
Date: Mon, Oct 28, 2:30 PM - 3:50 PM
Learning Outcome: 1, 2, 3, 4
It is a closed-book exam, and it includes all the material covered in lectures and laboratories to-date. Please verify time and location on the course webpage.

Project (30%)
Learning Outcome: 5, 6
Please see section 5.2 for schedule and due date.

6.3 Course grading policies

Missed assessments:

If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please advise the course instructor in writing (with your name, student number and email contact) before the assessment time or due date. Please see the undergraduate calendar for information on regulations and procedures for academic consideration: https://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. Please see the undergraduate calendar for information on regulations and procedures for academic accommodation of religious obligations: https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Missed 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 the midterm exam, the instructor may consider an accommodation upon presentation of a written request and suitable documentation before the time of the exam.

Laboratory work:

Attendance is mandatory for submitting laboratory reports. There are no laboratory exemptions and no makeup laboratory sessions. In case you have a legitimate reason for missing a session, the instructor may consider an accommodation upon presentation of a written request and suitable documentation before the time of the session.

Late laboratory reports:

Any student not handing in a report receives a grade of zero for that submission. There are no makeup reports. Non-complying submissions, including late and incomplete submissions, are not accepted for marking. When you upload a report to the course webpage, you have to verify that the file can be opened and that it is the one you intended to upload.

Copies of reports:

Please keep reliable back-up copies of all out-of-class assignments, because you may be asked to resubmit your work.

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7 Course Statements

7.1 Communication and email policy

Communication is through announcements in class. Some information will be posted on the course webpage 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 receive information about the course. Please meet the instructor and the teaching assistants during the office hours when you have specific questions about concepts, problem sets, and laboratory experiments, and any question that cannot be answered easily or briefly with a reply email.

The course email policy is as follows:

- Use your University email account for correspondence relating to the course.
- Start the subject header with the course identifier "ENGG*4080" and add the topic of your message.
- Include a clearly written message and your name and student number.
- You will normally receive a reply in a timely manner (with the exception of nights, weekends, and holidays). If you do not receive a reply within two days, please resubmit your question or phone (leaving a message if necessary).

7.2 Relationships with other courses

Previous courses

ENGG*3450:

Semiconductors materials, pn junctions, semiconductor diodes, MOS transistors, small-signal operation and models, gain 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 CPUs, embedded and distributed circuit architectures.

ENGG*4200:

Wireless sensor networks, sensor characteristics, interface electronic circuits, data acquisition.

7.3 Recommendations about studying

You are encouraged to spread the learning periods over the entire term (e.g. it is a good idea to start studying from today). Try to avoid distractions while studying and during lectures and laboratory sessions. Take notes and outlines while reading or listening. Work on the assigned readings and problems regularly. Note down the questions and doubts that arise and get clarifications at the earliest possible time. When you are in a classroom or laboratory, as a courtesy to instructors and classmates, please keep your cellphone silenced and use your tablet or laptop only for course-related applications.

7.4 Recommendations about obtaining help

You can obtain help from the instructor during the office hours and from the laboratory technician and the teaching assistants 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 to 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 that works for both you and him.

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 (including a short-term disability), please refer to the Student Accessibility Services. 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.

7.5 Recommendations about laboratory safety

Please use good judgement and safe working habits, follow the posted laboratory policies, do not let unauthorized people in the laboratory, and do not wedge the doors open at any time. Please remember that food is not allowed in RICH 2531 and that drinks are permitted only if stored in a sealed, reusable container. Before the first laboratory session, you must read the manual on Safety and Laboratory Policies. In case of doubts about safety procedures, please consult with the laboratory technician before proceeding. Any violation of safety policies may result in loss of laboratory privileges.

7.6 Recommendations about academic integrity

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 reports, please remember that copying text, data, or figures is plagiarism, even if you received the material from a friend, if you found the material on the Internet, or if you are reusing material for which you have previously received credit. Letting others use your work is also not allowed. Therefore please keep your reports and data in a secure location.

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/

A section on Academic Misconduct and the Code of Ethics adopted by the School of Engineering are available in the Rules and Procedures Guide for engineering students.

Turnitin

In this course, Turnitin, integrated with the CourseLink Dropbox tool, will be used to detect possible plagiarism, unauthorized collaboration or copying as part of the ongoing efforts to maintain academic integrity at the University of Guelph.

All submitted assignments will be included as source documents in the Turnitin.com reference database solely for the purpose of detecting plagiarism of such papers. Use of the Turnitin.com service is subject to the Usage Policy posted on the Turnitin.com site.

7.7 Course materials and copyright

The instructor reserves the right to all materials made available for this course and all interpretations presented, which may not be reproduced, retained, or transmitted to others without the written consent of the instructor. Audio or video recording of lectures and instructional sessions are not allowed without the written consent of the presenter. All the materials available on the course webpage and on Course Reserve, and the materials distributed in class, in the laboratory and during the exams 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 further disseminated or retained beyond the duration of this course.

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.

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
