ENGG*4080 Micro and Nano-Scale Electronics - DRAFT

Fall 2018
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - October 15, 2018

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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-Requisite(s): ENGG*3450

1.2 Timetable

Lectures

Monday	8:30–9:50	MCKN	233
Wednesday	8:30–9:50	MCKN	233

Laboratory sessions and tutorials

Sect. 1	Friday	11:30–13:20	RICH	2531
Sect. 2	Monday	11:30–13:20	RICH	2531

1.3 Final Exam

The final exam is on Thursday, 13 December 2018, 8:30 to 10:30. Please verify time and location on the exam schedule webpage and on WebAdvisor.

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2 Instructional Support

2.1 Instructor(s)

Stefano Gregori
Email: sgregori@uoguelph.ca
Telephone: 519-824-4120 ext. 56191
Office: RICH 3521
Office Hours: on course webpage or by appointment

2.2 Instructional Support Team

Lab Technician: Joel Best
Email: jbest@uoguelph.ca
Telephone: 519-824-4120 ext. 54234
Office: THRN 1416

2.3 Teaching Assistant(s)

Teaching Assistant: Evan Fallis
Email: efallis@uoguelph.ca
Office Hours: on course webpage or by appointment

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3 Learning Resources

3.1 Required Resource(s)

Course webpage (Website)
Please check regularly the course webpage on CourseLink for information and resources.

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

3.2 Recommended Resource(s)

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

P. R. Gray, P. J. Hurst, S. H. Lewis, R. G. Meyer, *Analysis and design of analog integrated circuits*, Wiley, 5th ed., 2009, TK7874 .A588 2009

B. Razavi, *Design of analog CMOS integrated circuits*, McGraw-Hill, 2nd ed., 2017, TK7874.654 .R39 2017

Library resources (Readings)
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).

3.3 Additional Resource(s)

Lecture notes (Notes)
Lecture notes will be posted on the course webpage. The posted notes are prepared with the intention that you will fill in the blanks, take additional notes and write down examples during class.

Problem sets (Other)
Problem sets will be posted on the course webpage.

Laboratory manuals (Lab Manual)
The laboratory manuals will be distributed in the laboratory or posted on the course webpage.

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

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4 Learning Outcomes

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 and 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 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.

4.1 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 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 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.

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome Set Name	Course Learning Outcome
1	Knowledge Base	1, 2
1.1	Recall, describe and apply fundamental mathematical principles and concepts	1, 2
1.2	Recall, describe and apply fundamental principles and concepts in natural science	1, 2
1.3	Recall, describe and apply fundamental engineering principles and concepts	1, 2
1.4	Recall, describe and apply program-specific engineering principles and concepts	1, 2
2	Problem Analysis	1, 2, 3
2.1	Formulate a problem statement in engineering and non-engineering terminology	1, 2, 3
2.2	Identify, organize and justify appropriate information, including assumptions	1, 2, 3
2.3	Construct a conceptual framework and select an appropriate solution approach	1, 2, 3
2.4	Execute an engineering solution	1, 2, 3
2.5	Critique and appraise solution approach and results	1, 2, 3
3	Investigation	3, 4
3.1	Propose a working hypothesis	3, 4
3.2	Design and apply an experimental plan/investigative approach (for example, to characterize, test or troubleshoot a system)	3, 4
3.3	Analyze and interpret experimental data	3, 4
3.4	Assess validity of conclusions within limitations of data and methodologies	3, 4
4	Design	4, 5, 6
4.1	Describe design process used to develop design solution	4, 5, 6
4.2	Construct design-specific problem statements including the definition of criteria and constraints	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	4, 5, 6

#	Outcome Set Name	Course Learning Outcome
	as iteration, simulation and/or prototyping	
5	Use of Engineering Tools	5
5.1	Select appropriate engineering tools from various alternatives	5
5.2	Demonstrate proficiency in the application of selected engineering tools	5
5.3	Recognize limitations of selected engineering tools	5
6	Individual & Teamwork	5, 6
6.1	Describe principles of team dynamics and leadership	5, 6
6.2	Understand all members' roles and responsibilities within a team	5, 6
6.3	Execute and adapt individual role to promote team success through, for example, timeliness, respect, positive attitude	5, 6
6.4	Apply strategies to mitigate and/or resolve conflicts	5, 6
6.5	Demonstrate leadership through, for example, influencing team vision and process, promoting a positive team culture, and inspiring team members to excel	5, 6
7	Communication Skills	1, 2, 3, 4, 5, 6
7.1	Identify key message(s) and intended audience in verbal or written communication as both sender and receiver	1, 2, 3, 4, 5, 6
7.2	Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode	1, 2, 3, 4, 5, 6
7.3	Construct the finished elements using accepted norms in English, graphical standards, and engineering conventions, as appropriate for the message and audience	1, 2, 3, 4, 5, 6
7.4	Substantiate claims by building evidence-based arguments and integrating effective figures, tables, equations, and/or references	1, 2, 3, 4, 5, 6
7.5	Demonstrate ability to process oral and written communication by following instructions, actively listening, incorporating feedback, and formulating meaningful questions	1, 2, 3, 4, 5, 6
8	Professionalism	4, 6
8.1	Demonstrate an understanding of what it means to be a professional engineer and distinguish between legislated and non-legislated professions	4, 6
8.2	Effectively describe engineering law and its impact on professional	4, 6

#	Outcome Set Name	Course Learning Outcome
	engineering practice	
8.3	Demonstrate professional behaviour	4, 6
9	Impact of Engineering on Society and the Environment	3, 5, 6
9.1	Analyze the safety, social, environmental, and legal aspects of engineering activity	3, 5, 6
9.2	Evaluate the uncertainties and risks associated with engineering activities	3, 5, 6
9.3	Anticipate the positive and negative impacts of introducing innovative technologies to solve engineering problems	3, 5, 6
10	Ethics & Equity	1, 2, 3, 4, 5, 6
10.1	Summarize ethical theories and equity, diversity, and inclusivity principles	1, 2, 3, 4, 5, 6
10.2	Determine an ethical course of action by applying ethical theories and the PEO Code of Ethics	1, 2, 3, 4, 5, 6
10.3	Demonstrate values consistent with good ethical practice, including equity, diversity, and inclusivity	1, 2, 3, 4, 5, 6
11	Economics and Project Management	6
11.1	Apply project management techniques and manage resources within identified constraints	6
11.2	Identify risk and change management techniques, in the context of effective project management	6
11.3	Estimate economic impact and feasibility of an engineering project or design using techniques such as cost benefit analysis over the life of the project or design	6
12	Life Long Learning	1, 2, 3, 4, 5, 6
12.1	Identify personal career goals and opportunities for professional development	1, 2, 3, 4, 5, 6
12.2	Self-assess skills relative to career goals and SOE defined learning outcomes	1, 2, 3, 4, 5, 6
12.3	Demonstrate capability for continuous knowledge and skill development in a changing world	1, 2, 3, 4, 5, 6

5 Teaching and Learning Activities

5.1 Lecture schedule

Week	Dates	Lecture topics	References	Learning objectives
—	Sept. 6–7	Introduction and basic concepts	ch. 1	1, 4, 5
1	Sept. 10–14	IC fabrication and layout	ch. 2	1
2	Sept. 17–21	Device models	ch. 1	1, 2
3	Sept. 24–28	Current mirrors and amplifiers	ch. 3	1, 2, 3, 4, 6
4	Oct. 1–5	Frequency response and feedback	chs. 4, 5	1, 2
5	Oct. 8–12	Building cells and design flow	ch. 6	1, 2, 3, 4, 6
6	Oct. 15–19	Amplifier design and compensation	ch. 6	2, 3, 4, 5
7	Oct. 22–26	Biasing, references and regulators	ch. 7	4, 5
8	Oct. 29–Nov. 2	Filters and mixed-signal blocks	chs. 12, 13, 14	4, 5
9	Nov. 5–9	Data converters	chs. 15, 16	4, 5, 6
10	Nov. 12–16	Data converters	chs. 17, 18	3, 4, 5
11	Nov. 19–23	Advanced topics	—	3, 4, 5, 6
12	Nov. 26–30	Review	all	1 to 6

Topics schedule will be adjusted throughout the course as needed.

5.2 Laboratory schedule

Week	Dates	Laboratory and tutorial topics	Due date
—	Sept. 6–7	—	—
1	Sept. 10–14	Laboratory 1, introduction to design tools and laboratory safety	—
2	Sept. 17–21	Laboratory 2, device characteristics, sweep and transient analysis	—
3	Sept. 24–28	Laboratory 2 (continued)	Sept. 24–28
4	Oct. 1–5	Laboratory 3, CMOS building cells and design flow	—
5	Oct. 8–12	Study-break week	—
6	Oct. 15–19	Laboratory 3 (continued)	Oct. 15–19
7	Oct. 22–26	Circuit design project	—
8	Oct. 29–Nov. 2	Circuit design project (continued)	—
9	Nov. 5–9	Circuit design project (continued)	—
10	Nov. 12–16	Circuit design project (final design review)	Nov. 12–16
11	Nov. 19–23	Circuit design project (design presentation and feedback)	—
12	Nov. 26–30	Review	—

Topics schedule will be adjusted throughout the course as needed.

5.3 Other important dates

Thursday, 6 September 2018: First day of class
Monday, 8 October 2018: Holiday (i.e. no classes scheduled)
Tuesday, 9 October 2018: Study break day (i.e. no classes scheduled)
Friday, 2 November 2018: Fortieth class day (i.e. drop date)

Thursday, 29 November 2018: Tuesday schedule in effect

Friday, 30 November 2018: 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

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6 Assessments

6.1 Assessment Details

Laboratories (24%)
Please see section 5.2 for schedule and due dates.

Project (16%)
Please see section 5.2 for schedule and due date.

Midterm exam (20%)
Monday, 15 October 2018, 8:30 to 9:50 in MCKN 233. Please verify time and location on the course webpage.

Final exam (40%)
Thursday, 13 December 2018, 8:30 to 10:30. Please verify time and location on the exam schedule webpage and on WebAdvisor.

6.2 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) at the earliest possible time. 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 at the start of the semester to make alternative 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:
There are no laboratory exemptions, and attendance is mandatory for submitting laboratory reports. There are 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 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. When you use the CourseLink Dropbox tool, please follow the posted instructions and verify that your submission is correctly uploaded by the deadline.

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 ask questions about the course. Please use your University email account for correspondence relating to the course, start the subject header with the course identifier "ENGG*4080," include 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 or the teaching assistant during the office hours instead.

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

7.2 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, tutorials, and laboratory sessions. Take notes and outlines while reading or listening. 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 classmates and instructors, please keep your cellphone silenced, do not eat (water or a drink in a leak-proof container are usually fine), and use your tablet or laptop only for note-taking and course-related applications.

7.3 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 CPUs, embedded and distributed circuit architectures.

ENGG*4200:

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

7.4 Recommendations about obtaining help

You can obtain help from the instructor and the teaching assistants during the office hours (posted on the course webpage) 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 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 or 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, 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 or the instructor before proceeding. Any violation of safety policies may result in loss of laboratory privileges.

7.6 Recommendations about academic misconduct

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 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 that you have previously submitted elsewhere. 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, your instructor will be using Turnitin, integrated with the CourseLink Dropbox tool, 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 Recording of materials

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. The materials available on the course webpage 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.

7.8 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.

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.

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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.

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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 regulations and procedures for Academic Consideration are detailed in the Undergraduate Calendar.

9.3 Drop Date

Courses that are one semester long must be dropped by the end of the fortieth class day; two-semester courses must be dropped by the last day of the add period in the second semester. The regulations and procedures for Dropping Courses are available in the Undergraduate Calendar.

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.

More information: www.uoguelph.ca/sas

9.6 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 or faculty advisor.

The Academic Misconduct Policy is detailed in the Undergraduate Calendar.

9.7 Recording of Materials

Presentations which are made in relation to course work—including lectures—cannot be recorded or copied without the permission of the presenter, whether the instructor, a classmate 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 which apply to undergraduate, graduate and diploma programs.
