

# ENGG\*4550 Micro and Nano-Scale Electronics

## Fall 2016



(Revision 0: September 8, 2016)

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## 1 INSTRUCTIONAL SUPPORT

### 1.1 Instructor

Instructor: Radu Muresan, Ph.D., P.Eng.  
Office: RICH 2509, ext. 56730  
Email: [rmuresan@uoguelph.ca](mailto:rmuresan@uoguelph.ca)  
Office hours: Fridays: 4:00 pm to 6:00 pm; Or by appointment

### 1.2 Lab Technician

Technician: TBD  
Office: NA  
Email: [technician@uoguelph.ca](mailto:technician@uoguelph.ca)

### 1.3 Teaching Assistants

GTA	Email	Office Hours
Kamal Kamal	<a href="mailto:kkamal@uoguelph.ca">kkamal@uoguelph.ca</a>	TBD

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## 2 LEARNING RESOURCES

### 2.1 Course Website

Course material, news, announcements, and grades will be regularly posted to the ENGG\*4550 CourseLink site and on my personal course webpage. You are responsible for checking the sites regularly.

### 2.2 Required Resources

1. R. Jacob Baker, CMOS Circuit Design, Layout, and Simulation, 3rd Edition (IEEE Press Series on Microelectronic System), 2010.
2. Radu Muresan, *ENGG4080 CMOS Circuit Design Lab Manual*, 45 nm Technology, University of Guelph, August 2016.

### 2.3 Recommended Resources

1. Neil H. E. Weste, David M. Harris, CMOS VLSI Design A Circuits and System Perspective, 4th Edition, Addison Wesley, 2011.

### 2.4 Additional Resources

**Lecture Information:** All lecture notes are posted on the ENGG\*4080 CourseLink system (Week #1 to Week #12) under ENGG4080 LECTURES module.

**Lab Information:** The ENGG4080 Lab Manual is posted on the ENGG\*4080 CourseLink system under the LABORATORY module.

**Assignments:** The assignments are posted on the ENGG\*4080 CourseLink system under the ASSIGNMENTS module and within the Lecture material.

**Exams:** After the midterm exam a complete solution of the exam with the marking scheme applied will be posted for your reference.

**Miscellaneous Information:** Other information related to VLSI digital design systems will be posted on the web page.

### 2.5 Communication & Email

Please use lectures and lab help sessions as your main opportunity to ask questions about the course. Major announcements will be posted to the course website. **It is your responsibility to check the course website regularly.** As per university regulations, all students are required to check their <mail.uoguelph.ca> e-mail account regularly: e-mail is the official route of communication between the University and its student.

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## 3 ASSESSMENT

### 3.1 Dates and Distribution

**Labs:** 50%

- Lab 1, Lab 2, and Lab 3 are worth 10% each (Demo is 4% and report is 6%)
- Lab 4/Project is worth 20% (Demo is 10% and report is 10%)

**Midterm:** 10%

Take home midterm exam requiring SPICE simulation: Due Week 7<sup>th</sup> of the classes.

**Final Exam:** 40%

December 14<sup>th</sup>, 2016: 2:30 pm to 4:30 pm, Room TBD

### 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. 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 at the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:

<http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml>

**Passing grade:** In order to pass the course, you must meet the following conditions:

1. Students must finalize and submit all the labs and projects (Demo + Report) and obtain a passing grade of 50% or higher in all the labs and projects. If an overall grade of lower than 50% is obtained in any lab, the students need to arrange with the instructor a new demo and report submission. In this case, a grade penalty of 10% deduction will be applied.
2. Students must submit the midterm assignment and write the final exam to pass the course and obtain an overall mark greater than 25% out of the cumulative mark of 50% allocated for the midterm assignment and the final exam.
3. If the course passing conditions 1 and 2 are not met then the final course grade will be 47%.

**Contesting marks:** All laboratory and midterm exam marks must be contested within 2 days from the grade submission.

**Missed midterm exam:** If you miss a test due to grounds for granting academic consideration or religious accommodation, you will need to arrange a makeup exam date with the instructor.

**Lab Work:** You must attend and complete all laboratories. If you miss a laboratory demo due to grounds for granting academic consideration or religious accommodation, arrangements must be made with the instructor to complete a makeup lab demo.

**Late Lab Reports:** Late submissions of lab reports will be accepted only with the approval of the course instructor. However, penalties on late submissions of up to 20% will be applied. Applied penalties will be posted on ENGG\*4080 CourseLink system.

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## 4 AIMS, OBJECTIVES & 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

*Corequisite(s):* None

### 4.2 Course Aims

This course is a senior level course in electrical and computer engineering. The main goals of the course are: (1) to teach students the fundamentals of the CMOS analog design including components and the models, and (2) teach basic analog CMOS integrated circuits design and analysis using the CMOS analog components.

### 4.3 Learning Objectives

At the successful completion of this course, the student will have demonstrated the ability to:

1. Understand the CMOS process technology and its basic layout techniques.
2. Understand the CMOS devices such as resistors, capacitors, MOSFETs used in the analog design.
3. Electrical noise and its effects.
4. Models for analog design.
5. The inverter and other simple gates as circuits in the analog design.
6. Current mirrors design and analysis.
7. Amplifiers design and analysis.
8. Voltage reference circuits and converters.
9. Memory circuits.
10. Use simulation and fabrication tools for nanoscale technology.
11. Design basic analog circuits using the 45 nm process technology.
12. Demonstrate and communicate circuit design results using design tools.

### 4.4 Graduate Attributes

Successfully completing this course will contribute to the following CEAB Graduate Attributes:

<b>Graduate Attribute</b>	<b>Learning Objectives</b>	<b>Assessment</b>
1. Knowledge Base for Engineering	1 to 9	Exams, Labs
2. Problem Analysis	5 to 9	Exams, Labs
3. Investigation	9, 10	Labs
4. Design	5 to 10	Exams, Labs
5. Use of Engineering Tools	4, 9, 10, 11	Labs
6. Communication	9, 10, 11	Labs
7. Individual and Teamwork	9, 10, 11	Labs
8. Professionalism	11	Labs
9. Impact of Engineering on Society and the Environment	1, 10	Exams
10. Ethics and Equity	-	-
11. Environment, Society, Business, & Project Management	-	-
12. Life-Long Learning	1, 9, 10	Labs

#### **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. All lecture notes plus various exercises, examples and referenced resources will be made available to students on CourseLink system in the appropriate module. However, these are not intended to be stand-alone course notes. During lectures, the instructor will expand and explain the content of notes and provide in class solutions to problems that supplement posted notes. Scheduled classes and labs will be the principal venue to provide information and feedback for tests and labs.

#### **4.6 Students' Learning Responsibilities**

Students are expected to take advantage of the learning opportunities provided during lectures and labs. In addition students are encouraged to consult the instructor and the TA during the scheduled office hours or to contact the instructor or TA for any help needed. 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.

#### **4.7 Relationships with other Courses & Labs**

##### **Previous Courses:**

**ENGG\*3450** (Electrical Devices): Semiconductor materials, diodes, transistors, electronic components and circuit analysis.

##### **Follow-on Courses:**

NA

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## 5 TEACHING AND LEARNING ACTIVITIES

### 5.1 Timetable

**Lectures:**

Mon, Wed, Fri    Sec 01    2:30 pm – 3:20 pm    RICH 2531

**Laboratory:**

Mon                    Sec 01    3:30 pm - 5:20 pm    RICH 2531

### 5.2 Lecture Schedule

Week	Lecture Topics	Text Book	Learning Objectives
1	Introduction to CMOS design	Chapters 1,2	1
2	The well, the metal layers, the active and poly layers	Chapters 3, 4	1,2
3	Resistors, capacitors, MOSFETs	Chapter 5	2
4	MOSFET operation	Chapter 6	2, 4
5	Models for analog design	Chapter 9	4
6	The inverter, gates	Chapters 11,12	5
7	Current mirrors	Chapter 20	6, 11
8	Amplifiers	Chapter 21	7, 11
9	Differential amplifiers	Chapter 22	7, 11
10	Voltage references	Chapter 23	8, 11
11	Electrical noise	Chapter 8	3, 11
12	Memory circuits	Chapter 16	9

### 5.3 Design Lab Schedule

Week	Activity	References	Learning Objectives
1	Lab safety presentation. Introduction to Lab 1: Cadence tools, supported simulations.	Lab Manual	1, 2, 10, 11,
2-4	Lab 1 implementation, demo and report	Lab Manual	10, 11, 12
4	Introduction to Lab 2: Design of a power decoupling circuit. Implementation	Lab Manual	2, 4, 10, 11
5-6	Lab 2 implementation, demo and report.	Lab Manual	2, 4, 10, 11, 12
6	Introduction to Lab 3: 45 nm current mirror circuit analysis	Lab Manual	6, 8, 10
7-8	Lab 3 implementation, demo and report.	Lab Manual	6, 8, 10, 11, 12

8	Introduction to Lab 4/Project: Implementation of a PUF. Implementation	Lab Manual	6, 7, 8, 10, 11
9-11	Lab 4 implementation, demo and report.		6, 7, 8, 10, 11, 12

## 5.4 Lab Schedule

Week	Topic	Due
1	Introduction to Lab Equipment and Safety Training	
1-4	Lab 1:.	Week 4: Demo Week 4: Report
4-6	Lab 2: 45 nm on-chip implementation of a power decoupling circuit for an 8-bit XOR circuit.	Week 6: Demo Week 6: Report
6-8	Lab 3: 45 nm current mirror circuit analysis	Week 8: Demo Week 8: Report
8-11	Lab 4/Project: Implementation of a physically unclonable function circuit as an unique device ID.	Week 11: Demo Week 11:Report

## 5.5 Other Important Dates

First day of class: Thursday Sept. 8, 2016  
 Thanksgiving: Monday, October xx, 2016 - no classes  
 Fall Study day: Tuesday October xx - no classes  
 Last day to drop: Friday November xx, 2016  
 Last day of class: Friday December xx, 2016

You can refer the student undergraduate calendars for the semester scheduled dates.

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## 6 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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## 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.

### 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 Misconduct 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>

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## 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 for a short-term disability should contact the Centre for Students with Disabilities as soon as possible.

For more information, contact CSD at [519-824-4120](tel:519-824-4120) ext. 56208 or email [csd@uoguelph.ca](mailto:csd@uoguelph.ca) or see the website: <http://www.csd.uoguelph.ca/csd/>



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## 9 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, classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

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## 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:

<http://www.uoguelph.ca/registrar/calendars/index.cfm?index>