

Course Objectives

The goal of this course is to make you more proficient with analog circuits. By now you have seen basic circuit elements (resistors, capacitors, etc.), many circuit analysis techniques (nodal analysis, voltage division, and many more), active devices (transistors and diodes), amplifiers (single and multi-stage amplifiers, op amps), control theory, and a variety of common analog components. In this course, we will aim to tie these many topics together for a better overall understanding of how analog circuits work and how to approach their design.

At the end of the course the student should be able to:

- use transistors to design simple analog circuit components,
- describe the basic operation of common analog building blocks,
- use feedback to compensate multistage amplifiers,
- model and simulate analog circuits at different levels of abstraction, and
- analyze and design some common analog circuit components.

Course Operations

The course will be will aim to have the same structure each week. There will be readings (ideally these are done first), videos to supplement the readings, problems to be solved and a scheduled problem solving session.

- A *Weekly Course Outline*, posted each week will contain what to read and do.
- Readings, mainly from the references should be read first.
- Videos will highlight the key concepts.
- Problem sets to aid in understanding the lecture material and to extend the lecture material. They will not be graded, but will be discussed in the weekly live tutorial.

Tutorials Live: Thursdays 10:00am - 11:30

<https://us02web.zoom.us/j/87625900477?pwd=L2dxc2gzdmliRTFLRG92cDZlRU96QT09>

- Some weeks will also contain LT Spice simulation exercises.

Teaching Team:

Instructor:

Professor Nairn, Nairn@uwaterloo.ca, email for an appointment.

Teaching Assistant (Labs & behind the scene marking).

David Laor ALaor@uwaterloo.ca

References/Textbooks

1. A. Sedra and K.C. Smith, *Microelectronic Circuits*, 7th ed. Oxford University Press 2015.
2. W. Kester, *Analog-Digital Conversion Handbook*, Prentice Hall, 2004, available at:
<https://www.analog.com/en/education/education-library/data-conversion-handbook.html>
3. MATLAB reference, available at:
<https://www.mathworks.com/learn/tutorials/matlab-onramp.html>
4. LT Spice reference available at:
<https://www.analog.com/en/design-center/design-tools-and-calculators/ltspace-simulator.html>

Grading Scheme

Participation (occasional surveys)	5%	
LT Spice Simulation 1* Device Behaviour	5%	Due February 9 th 11:59pm
LT Spice Simulation 2* Biasing Diff. Pairs	5%	Due March 9 th 11:59pm
LT Spice Simulation 3* - Op Amp Design	20%	Due April 14 th 11:59pm
Midterm**	20%	
<u>Final Exam</u> **	<u>45%</u>	
	100%	

* You may work individually or in pairs. Collaboration between groups is unacceptable. Assignments are to be submitted through LEARN. Late assignments will be penalized 3 dB per day.

** The midterm and final exams are individual effort. Communicating exam material before or during the midterm and final exam with anyone other than the course instructor constitutes unauthorized collaboration. If for any reason you are unable to write the midterm exam, the weight will be transferred to the final exam.

Course Description & Major Topics

Analog integrated circuits seek to exploit the physical behaviour of electronic devices to create electronic systems that are compatible with current integrated circuit fabrication processes. After considering the special needs of analog circuits, basic elements like amplifiers and output stages will be studied. Then higher level analog functions such as references, filters, and data converters will be studied.

Circuit & System Techniques	<ul style="list-style-type: none"> • Discrete <i>versus</i> integrated circuits • Active RC, SC, Gm-C techniques
Review	<ul style="list-style-type: none"> • Single-stage and multi-stage amplifiers • Current mirrors, cascodes and terminal impedances
Frequency Response	<ul style="list-style-type: none"> • Pole identification • Bode plots
Feedback & Stability	<ul style="list-style-type: none"> • Feedback and stability • Compensation
Output stages	<ul style="list-style-type: none"> • Class A, B, & AB ... • Power & heat handling
Common Circuit Blocks	<ul style="list-style-type: none"> • Voltage references and linear regulators • Filters • Digital-to-Analog Converters • Analog-to-Digital Converters

The Fine Print:

Academic integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. For more information, see: <https://uwaterloo.ca/academic-integrity/integrity-students>

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4. When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for his/her actions (For more information, see: <https://uwaterloo.ca/academic-integrity/integrity-students>). A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate associate dean. For information on categories of offenses and types of penalties, students should refer to Policy 71, Student Discipline. For typical penalties, check Guidelines for the Assessment of Penalties.

Appeals: A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be appealed if there is a ground. A student who believes there are grounds for an appeal should refer to Policy 72, Student Appeals.

Note for students with disabilities: AccessAbility Services, located in Needles Hall, Room 1401 and <https://uwaterloo.ca/accessability-services/> collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

Contingencies for Remote Teaching: We are facing unusual and challenging times. To provide contingency for unforeseen circumstances, the instructor reserves the right to modify course topics and/or assessments and/or weight and/or deadlines with due notice to students. In the event of further challenges, the instructor will work with the Department/Faculty to find reasonable and fair solutions that respect rights and workloads of students, staff, and faculty.