COMP ENG 4EK4
Microelectronics

COURSE OUTLINE
Please refer to course website for updated information.

CALENDAR/COURSE DESCRIPTION

CMOS and MOSFET integrated circuit design; fabrication and layout; simulation; digital and analog circuit blocks; computer-aided design and analysis; testing and verification.

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): Registration in level III or greater in any Computer or Electrical Engineering Program; ELECENG 3EJ4
Antirequisite(s): COMPENG 4EK3, ELECENG 4EK3

SCHEDULE

Lectures: Tuesdays and Wednesdays, 12:30 - 13:20 pmm, BSB B155
Tutorial: Wednesdays 8:30 - 10:20 am, HH 102
Labs: Every Other Week: L01 Tuesdays 14:30 - 17:20 pm; ITB A304.
L02 Wednesdays 14:30 - 17:20 pm; ITB A304.
L03 Thursdays 14:30 - 17:20 pm; ITB A304.

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Dr. Jamal Deen, Distinguished University Professor
ITB-104
jamal@mcmaster.ca
905-525-9140 Ext. 27137
Office Hours: Open or by appointment

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

Wei Jiang
jiangw35@mcmaster.ca
Ext. 27758
ITB-136
Office Hours: Tuesdays 9:00am-11:00am

Mahdi Naghshvarianjahromi
naghshvm@mcmaster.ca
Ext.24971
ITB-A201
Office Hours: Mondays & Tuesdays 10:00am-11:00am

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

http://avenue.mcmaster.ca / **Email (most of the course material will be sent by email)**

COURSE OBJECTIVES

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

- Analyze the circuit performance (e.g., gain) based on the equivalent circuit models of active devices (e.g., transistors) and passive components (Indicator 1.4)
- Apply the physics of semiconductor devices and the operation principle of analog circuits to determine the dimension of active and passive devices in an analog circuit to meet the specs, such as gain, bandwidth, stability, … etc. (Indicator 4.3)
- Use specialized computer-aided simulation tools to evaluate the effects of altering parameters in the design of analog integrated circuits such as voltage/current sources, differential amplifiers, buffers, and operational amplifiers (Indicator 5.2)
- Design and evaluate complex open-ended analog circuits using a triple bottom line of sustainability dimensions: social, economic and environmental. An awareness of the wide range of engineering societies, literature, conferences, and other information sources (Indicator 13.1)
- Develop partnership, leadership, time management, and communication skills practiced through the final projects.

ASSUMED KNOWLEDGE

Good knowledge of course material from EE 2EI5 and EE 3EJ4, especially on

- I-V characteristic and the small-signal model of metal-oxide-semiconductor field effect transistors
- dc and ac analysis of common-source, common-gate, and common-drain amplifiers
- Analysis of feed-back circuits
- Discrete Fourier Transform

COURSE MATERIALS

Required Texts: R.J. Baker, CMOS Circuit Design, Layout, and Simulation, 3rd Edition, Wiley-IEEE Press, 2010. ISBN 978-0-470-88132-3 (see http://cmosedu.com/cmos1/book.htm).

Calculator:
Only the McMaster Standard Calculator (Casio FX-991 MS or MS Plus) will be permitted in tests and examinations. This is available at the Campus Store.

COURSE OVERVIEW

Week	Topic	Readings
1	Active resistors and voltage sources	Course notes and parts of Ch. 6 in [1]
2	Design of cascode current sink/mirror	Course notes and parts of Ch. 21 in [1]
3	Sensitivity analysis of high-swing cascode current sink/mirror	Course notes and parts of Ch. 20 in [1]
4	Supply-independent biasing and its start-up circuits	Course notes and parts of Ch. 20 in [1]
5	Differential amplifiers	Course notes and parts of Ch. 21 in [1]
6	Source-coupled pairs	Course notes and parts of Ch. 22 in [1]
7	Mid-term recess	
8	Output buffers	Course notes
9	Frequency compensation	Course notes and parts of Ch. 21 in [1]
10	Basic switched-capacitor circuits	Course notes and parts of Ch. 10 in [2]
11	Switched-capacitor integrators	Course notes and parts of Ch. 10 in [2]
12	Signal-flow-graph and first-order switched-capacitor filter	Course notes and parts of v in 10 [2]
13	Memories	Course notes and parts of Ch. 16 in [1]
14	Memories	Course notes and parts of Ch. 16 in [1]

References:

[1] R. J. Baker, CMOS Circuit Design, Layout, and Simulation, 3rd Edition, Wiley-IEEE Press, 2010. ISBN 978-0-470-88132-3 (see http://cmosedu.com/cmos1/book.htm)

[2] D. A. Johns and K. Martin, Analog Integrated Circuit Design, John Wiley & Sons Inc., 1997. ISBN 0-471-14448-7.

LABORATORY OVERVIEW

Week(s)	Topic	Readings
1	Using Computer-Added-Design (CAD) Simulation Tools	Spectre lab tutorial #1
2 & 3	Evaluation of Transistor Performance	Spectre lab tutorials #2 and 3
4 & 5	Design a high-swing cascode current sink	See above readings
6	Design of current references and differential amplifiers	See above readings
7	Mid-term Recess	
8	Design of current references and differential amplifiers	See above readings
9& 10	Design of push-pull buffer with 3-stage floating-current-source	See above readings
11 & 12	Design of a high-speed op-amps with all biasing sources & buffers	See above readings
13 & 14	Design of a switched capacitor circuit	See above readings

LABORATORY OPERATION

Teaching assistants (TA) will be available to help students during the lab hours from 2:30pm to 5:30pm. After the assigned lab hours, students can enter the lab room at ITB-A304 using their electronic access cards to complete the assignments and projects. The computers for the after-hour access are first-come, first-serve. Every student is required to sign in and sign out on a list prepared by the TA on duty before and after each lab.

Week		Date	Section	TA
2	Tuesday	Sep-10	L01	Wei
	Wednesday	Sep-11	L02	Wei
	Thursday	Sep-12	L03	Wei
4	Tuesday	Sep-24	L01	Mahdi
	Wednesday	Sep-25	L02	Mahdi
	Thursday	Sep-26	L03	Mahdi
6	Tuesday	Oct-8	L01	Wei
	Wednesday	Oct-9	L02	Wei
	Thursday	Oct-10	L03	Wei
8	Tuesday	Oct-22	L01	Mahdi
	Wednesday	Oct-23	L02	Mahdi
	Thursday	Oct-24	L03	Mahdi
10	Tuesday	Nov-5	L01	Wei
	Wednesday	Nov-6	L02	Wei
	Thursday	Nov-7	L03	Wei
12	Tuesday	Nov-19	L01	Mahdi
	Wednesday	Nov-20	L02	Mahdi
	Thursday	Nov-21	L03	Mahdi
13	Tuesday	Dec-3	L01	Wei
	Wednesday	Dec-4	L02	Mahdi
	Thursday	Dec-5	L03	Wei

LABORATORY OPERATION

- At the beginning of every term, every Undergraduate student using an ECE Lab is required to complete the ECE Lab Safety Quiz (one completed quiz covers every course that term). The quiz and other information is provided on the webpage: https://www.eng.mcmaster.ca/ece/resources#health-safety
- Access to all labs is restricted in the interest of security and safety. Information on accessing and using the lab can be found on the webpage: https://www.eng.mcmaster.ca/ece/labs-and-health-safety#Labs-Access-and-Use
- Please obtain your own Access Card for use during regular building hours / The TA will open the lab at regularly scheduled lab times
- The labs for this course will be held in ITB-A304
- The labs will be performed in groups of two students
- Each lab will involve a significant amount of pre-lab work. You may submit one pre-lab report per group, should you so wish. This is optional

- The TAs and the instructor reserve the right to interview students to assess their understanding of the per-lab material. Such interviews will be held at random and we reserve the right to adjust the pre-lab mark based on the outcome of the interview.

ASSESSMENT

Component	Weight
Assignment #1, #2, #3	30% (10% Each)
In-class	10%
Mid-Term Exam	15%
Term Project	25%
Final Exam	20%
Total	100%

Grading policies:

For each assignment and the term project, report format: 20%, operation principle: 30%, design procedure: 30%, results and discussion: 20%.

For each exam, demonstration of correct concept: 80%, results: 20%.

Late submissions of assignments or project report are subject to 20% penalty per day (less than one day is counted as one day).

No make-up midterm tests will be granted. Weight of a missed midterm test will be transferred to final exam.

ACCREDITATION LEARNING OUTCOMES

Note: The *Learning Outcomes* defined in this section are measured throughout the course and form part of the Department's continuous improvement process. They are a key component of the accreditation process for the program and will not be taken into consideration in determining a student's actual grade in the course. For more information on accreditation, please ask your instructor or visit: http://www.engineerscanada.ca .

Outcomes	Indicators	Measurement Methods(s)
Analysis of circuit performance (e.g., gain) based on the equivalent circuit models of active devices (e.g., transistors) and passive components.	1.4	Examination questions
Applying the physics of semiconductor devices and the operation principle of analog circuits to determine the dimension of active and passive devices in an analog circuit to meet the specs, such as gain, bandwidth, stability, … etc.	4.3	Examination questions
Use of specialized software to evaluate the effects of altering parameters in the design of analog integrated circuits such as voltage/current sources, differential amplifiers, buffers, and operational amplifiers.	5.2	Assignments and term project
Obtains substantiated conclusions as a result of a problem solution including recognizing the limitations of the solutions.	2.3	Assignments and term project
Partnership, leadership, time management, and communication skills practiced through the final projects.		Term project

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at http://www.mcmaster.ca/academicintegrity

The following illustrates only three forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. Improper collaboration in group work.
3. Copying or using unauthorized aids in tests and examinations.

ACADEMIC ACCOMMODATIONS

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) to make arrangements with a Program Coordinator. Student Accessibility Services can be contacted by phone 905-525-9140 ext. 28652 or e-mail sas@mcmaster.ca . For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students requiring a RISO accommodation should submit their request to the Engineering Student Services office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations.

Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

STUDENT ABSENCE AND SUBMISSION OF REQUEST FOR RELIEF FOR MISSED ACADEMIC WORK

In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

AUTHENTICITY / PLAGIARISM DETECTION

In this course we will be using a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work.
Students will be expected to submit their work electronically either directly to Turnitin.com or via Avenue to Learn (A2L) plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish to submit their work through A2L and/or Turnitin.com must still submit an electronic and/or hardcopy to the instructor. No penalty will be assigned to a student who does not submit work to Turnitin.com or A2L. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). To see the Turnitin.com Policy, please go to www.mcmaster.ca/academicintegrity .

ONLINE ACCESS OR WORK

In this course we will be using email and computer-aided design tools. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in this course will be deemed consent to this disclosure.

If you have any questions or concerns about such disclosure please discuss this with the course instructor.

RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf.

The Department of Electrical & Computer Engineering website:
www.eng.mcmaster.ca/ece

Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

This document is for users of ECE instructional laboratories in the Information Technology Building.

This document provides important information for the healthy and safe operation of ECE instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in ECE. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory.

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following:

1. Food and beverages are not permitted in the instructional laboratories.
2. A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.
3. Laboratory equipment should only be used for its designed purpose.
4. Proper and safe use of lab equipment should be known before using it.
5. The course TA leading the lab should be informed of any unsafe condition.
6. The location and correct use of all available safety equipment should be known.
7. Potential hazards and appropriate safety precautions should be determined, and sufficiency of existing safety equipment should be confirmed before beginning new operations.
8. Proper waste disposal procedures should be followed.

Location of Safety Equipment

Fire Extinguisher
On walls in halls outside of labs

First Aid Kit
ITB A111, or dial “88” after 4:30 p.m.

Telephone
On the wall of every lab near the door

Fire Alarm Pulls
Near all building exit doors on all floors

Who to Contact

Emergency Medical / Security: On McMaster University campus, call Security at extension **88** or **905-522-4135** from a cell phone.
Non-Emergency Accident or Incident: Immediately inform the TA on duty or Course Instructor.
University Security (Enquiries / Non-Emergency): Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.
See TA or Instructor: For problems with heat, ventilation, fire extinguishers, or immediate repairs
Environmental & Occupational Health Support Services (EOHSS): For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.
ECE Specific Instructional Laboratory Concerns: For non-emergency questions specific to the ECE laboratories, please contact 24103.

In Case of a Fire (Dial 88)

When calling to report a fire, give name, exact location, and building.

1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!
4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people

1. Douse with water from safety shower immediately or
2. Roll on floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents.

Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:

1. Immediately discontinue use of the equipment.
2. In Power Lab, press wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol for Safe Laboratory Practice

Leave equipment in a safe state for the next person - if you're not sure, ask!

In general, leave equipment in a safe state when you finish with it. When in doubt, consult the course TA

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Defined Roles

TA	The first point of contact for lab supervision	
ECE Lab Supervisor	Steve Spencer- ITB 147	steve@mail.ece.mcmaster.ca
ECE Chair	Tim Davidson- ITB A111	davidson@mcmaster.ca
ECE Administrator	Kerri Hastings- ITB A111	hastings@mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	