COMP ENG 4EK4

Microelectronics

COURSE OUTLINE (21 July 2023)

Please refer to course website for updated information.

COURSE DESCRIPTION

McMaster UG Calendar:
CMOS and MOSFET integrated circuit design; fabrication and layout; simulation; digital and analog circuit blocks; computer-aided design and analysis; testing and verification.
Instructor: Prof. Jamal Deeni

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 and MODE OF DELIVERY

The material for this course will be delivered through a mixture of (i) in-person or live lectures, (ii) pre-recorded online lectures, (iii) live tutorials, (iv) pre-recorded online tutorials, and real & virtualized laboratories. The platform for each component is noted at the end of each line.

Lectures: Mondays & Wednesdays, Friday, 13:30 – 14:20 pm ABB 166

Tutorials: Mondays 08:30 - 10:20 am. JHE 210

Lab: Every Other Week: L01 Mondays 14:30 - 17:20 pm; ITB A304 (ECE 4EK4 & 6EK4)

                                                L02 Tuesdays 1 4:30 - 17:20 pm; ITB A304 (ECE 4EK4 & 6EK4)

                                                L03 Wednesdays 1 4:30 - 17:20 pm; ITB A304 (ECE 4EK4)

                                                L04 Thursdays 1 4:30 - 17:20 pm; ITB A304 (ECE 4EK4)

INSTRUCTOR

Instructor:	Dr. Jamal Deen
E-mail:	jamal@mcmaster.ca
Emails:	Please put "CE 4EK4 Fall 2022" and a "subject of the email" in the beginning of the subject header. (E.g. "CE 4EK4 Fall 2022 mid-term grade")
Office:	ITB 104; Extension: 27137
Office Hours:	Open office hours or by appointment.

TEACHING ASSISTANTS

Abu Ilius Faisal; faisaa4@mcmaster.ca; Ext. 27758; ITB-136
Neha Bhattacharya, bhattacn@mcmaster.ca, Ext. 27758, ITB 136
Office Hours: Provided on the course website.

COURSE WEBSITE/S

http://avenue.mcmaster.ca

COURSE OBJECTIVES

By the end of this course, students should have design exposure 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.

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.

Other :

• Class Lecture Notes, available at Avenue-to-Learn

COURSE OVERVIEW

Classes: Tuesday 05 September to Wednesday 06 December 2023. Mid-term recess: 09-15 October 2023.

WEEK #	TOPIC	READINGS
00 - SEP06	Introduction, Course Details etc.	Course notes
02 - SEP11	Active resistors and voltage sources	Course notes & parts of Ch. 6 in [1]
03 - SEP18	Design of cascode current sink/mirror	Course notes & parts of Ch. 21 in [1]
04 - SEP25	Sensitivity analysis of high-swing cascode current sink/mirror	Course notes & parts of Ch. 20 in [1]
05 - OCT02	Supply-independent biasing and its start-up circuits	Course notes & parts of Ch. 20 in [1]
06 – OCT09	Mid-term recess	
07 - OCT16	Differential amplifiers	Course notes & parts of Ch. 21 in [1]
08 - OCT23	Source-coupled pairs Mid-term Exam Fri 27 Oct 2023 @18:00	Course notes & parts of Ch. 22 in [1]
09 - OCT30	Frequency compensation	Course notes & parts of Ch. 21 in [1]
10 - NOV06	Output buffers	Course notes
11 - NOV13	Basic switched-capacitor circuits	Course notes & parts of Ch. 10 in [2]
12 - NOV20	Switched-capacitor integrators	Course notes & parts of Ch. 14 in [2]
13 - NOV27	Signal-flow-graph and first-order switched-capacitor filter	Course notes & parts of Ch. 10 in [2]
14 - DEC04	Memories	Course notes & parts of Ch. 16 in [1]

At certain points in the course, it may make sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, and on the course website).

LABORATORY OVERVIEW

There are no labs in the 1st week. Note: You do not need to attend any lab session, unless you make an appointment to demonstrate a lab to a TA.

WEEK(S)	TOPIC	READINGS
1	Using Computer-Added-Design (CAD) Simulation Tools	Spectre lab tutorial #1
2	Evaluation of Transistor Performance	Spectre lab tutorial #2
3 & 4	Design a high-swing cascode current sink	Spectre lab tutorial #3
6	Mid-term Recess	
5 & 7	Design of current references and differential amplifiers	Spectre lab tutorial #4
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 high-speed op-amps with all biasing sources & buffers	See above readings
13 & 14	Design of a switched capacitor circuit	See above readings

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 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.

- 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.

ASSESSMENT

Component	Weight
Assignment #1, #2, #3	30% (10% Each)
In-class	10%
Mid-Term Exam **(Fri 27 Oct 2023 @18:00)**	15%
Term Project	25%
Final Exam	20%
Total	**100%**

Grading and Evaluation 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.

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. It is your responsibility to understand what constitutes academic dishonesty.

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. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at https://secretariat.mcmaster.ca/university-policies-proceduresguidelines/

The following illustrates only three forms of academic dishonesty:

• plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.

• improper collaboration in group work.

• copying or using unauthorized aids in tests and examinations.

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, comparison with other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle,

ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, 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 a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, including lectures by University instructors.
The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online. It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

ACADEMIC ACCOMMODATIONS

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. 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 should submit their request to their Faculty 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.

REQUESTS FOR RELIEF FOR MISSED ACADEMIC WORK

McMaster Student Absence Form (MSAF): 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.

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

www.eng.mcmaster.ca/ece

Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

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 and online https://hr.mcmaster.ca/app/uploads/2019/07/2019-McMaster-Lab-Manual.pdf

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following whether conducting lab work at school or at home:

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.
9. Personal ergonomics should be practiced when conducting lab work. https://bit.ly/3fOE71E
10. Current University health and safety issues, and protocol should be known.
https://hr.mcmaster.ca/resources/covid19/workplace-health-and-safety-guidance-during-covid-19/

Location of Safety Equipment

Fire Extinguisher
On walls in halls outside of labs

Telephone
On the wall of every lab near the door

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

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 (On Campus 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 labs, 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

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

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	Mohamed Bakr- ITB A111	bakr@mcmaster.ca
ECE Administrator	Shelby Gaudrault - ITB A111	gaudraus@mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	