COURSE OUTLINE
Fall 2009

Approved by the Department of Electrical and Computer Engineering on Sept. 3 2009.

1. Calendar Information

ENEL519.01 Topic 47 Analog CMOS Integrated Circuit Design

Review of static and dynamic models of field effect transistors. Basics of analog integrated circuit design. Computer-aided modeling. Fabrication processes and their influence on analog design. Building blocks for analog CMOS linear IC's. Operational voltage amplifier and transconductance amplifier design techniques.

Course Hours: H(3-2)

2. Learning Outcomes

At the end of this course, you will be able to:

- demonstrate an understanding of basic MOS transistor physical operation and modeling techniques appropriate to modern deep submicron transistors, operating in the linear region
- develop skills in modern computer aided simulation techniques using a basic commercial software tool (PSPICE from Cadence Systems)
- analyze and understand the characteristics of basic analog circuit building blocks such as current mirrors and differential pairs
- apply the knowledge to the analysis and design of commercially available linear integrated circuits
- design basic circuits based on the knowledge acquired in the course.

3. Timetable

Section	Days of the Week	Start Time	Duration (Minutes)	Location
L01	*Tues/Thurs*	*9:30 AM*	*75*	*ICT 446*
B01	*Friday*	*8:00 AM*	*110 minutes*	*ICT 320*

4. Course Instructors

Lecturers

Section	Name	Phone	Office	Email
L01	*Dr. J.W. Haslett*	*220-5808*	*ICT 414*	*haslett@enel.ucalgary.ca*

Dr. Haslett's home page:

www.enel.ucalgary.ca/People/Haslett/Haslett.htm

Laboratory Instructors

Section	Name	Phone	Office	Email
B01	*Dr. J.W. Haslett*	*220-5808*	*ICT 414*	*haslett@enel.ucalgary.ca*
B01	*Mostafa Rashdan*		*ICT 417 O*	*mabdelha@ucalgary.ca*

5. Examinations

The following examinations will be held in this course:

There will be *a midterm and a final* examination. All examinations will be *closed book and closed notes*. One 8.5/11 inch formula sheet will be allowed.

Note: The timetable for Registrar Scheduled exams can be found at the University's Enrolment Services website, http://www.ucalgary.ca/registrar/.

6. Use of Calculators in Examinations

Non-programmable scientific calculators without formulae storage and /or text display features may be used during examinations.

7. Final Grade Determination

The final grade in this course will be based on the following components:

Component	**Weight**
Assignments/Quizzes	15 %
Lab	15 %
Midterm Examination	20 %
Final Examination	50 %
TOTAL	100 %

Note: Quizzes will be announced in advance.

It is not necessary to earn a passing grade on the final exam in order to pass the course as a whole.

8. Principles of Conduct

The University of Calgary Calendar includes a statement on the Principles of Conduct expected of all members of the University community (including students, faculty, administrators, any category of staff, practicum supervisors and volunteers) whether on or off the University's property. This statement applies in all situations where the Members of the University Community are acting in their University capacities. All Members of the University Community have a responsibility to familiarize themselves with this statement, which is available at:

http://www.ucalgary.ca/pubs/calendar/2009/j-2.html

The Engineering Students' Society Code of Conduct was developed to ensure that students are safe and free from danger and risk, and that discussion, criticism and comment are encouraged within a framework of professional behaviour. The Engineering Students' Society Code of Conduct is available at:

http://ess.ucalgary.ca/downloads/official_documents/Code_of_Conduct.pdf

9. Academic Misconduct/Plagiarism

The University of Calgary Calendar defines plagiarism as:

> "submitting or presenting work in a course as if it were the student's own work done expressly for that particular course when, in fact, it is not."

Plagiarism is academic misconduct. Please read the section in the University Calendar on Plagiarism/Cheating/Other Academic Misconduct which is available at:

http://www.ucalgary.ca/pubs/calendar/2009/k-2.html

10. Textbook

The following textbook is recommended but not required for this course:

Title	Fundamentals of Microelectronics
Author(s)	Behzad Razavi
Edition, Year	2006
Publisher	Wiley

Supplementary Reading:

- David A. Johns, Ken Martin, ***Analog Integrated Circuit Design,*** John Wiley & Sons, Inc., 1997.
- Phillip E. Allen and Douglas R. Holberg, **CMOS Analog Circuit Design, 2nd Edition,** Oxford University Press, 2002.
- Adel S. Sedra, Kenneth C. Smith, ***Microelectronic Circuits,*** Oxford University Press, 5th edition, 2006.
- Daniel Foty, ***MOSFET Modeling with Spice-Principles and Practice,*** Prentice Hall, Inc., 1997.
- Kenneth R. Laker, Willy M.C. Sansen, ***Design of Analog Integrated Circuts And Systems,***McGraw-Hill, Inc., 1994.
- Paul R. Gray, P. J. Hurst, Stephen H. Lewis, Robert G. Meyer, ***Analysis and Design of Analog Integrated Circuits,*** Fourth Edition, John Wiley & Sons, Inc., 2001
- Roubik Gregorian, Gabor C. Temes, ***Analog MOS Integrated Circuits For Signal Processing,*** John Wiley & Sons, Inc., 1986, now reprinted.

11. Academic Accommodation Policy

It is the student's responsibility to request academic accommodations. If you are a student with a documented disability who may require academic accommodation and have not registered with the Disability Resource Centre, please contact their office at 403.220.8237. Students who have not registered with the Disability Resource Centre are not eligible for formal academic accommodation. You are also required to discuss your needs with your instructor no later than fourteen (14) days after the start of this course.

12. Engineering FOIP Policy

SCHULICH SCHOOL OF ENGINEERING - UNIVERSITY OF CALGARY
POLICY FOR IMPLEMENTATION OF FOIP REQUIREMENTS
Protection of Student Examinations and Course Work Under the Freedom of Information and Protection of Privacy Act of the Province of Alberta

The Schulich School of Engineering policy is intended to ensure that examinations and term-work of students in engineering courses are protected with respect to privacy. The philosophy behind the policy is that marked student examinations and term-work (hereafter called "student's work) should be available only to the student and to staff in the Schulich School of Engineering who have a need to see the material. This includes academic staff, graduate assistants and support staff. Please read the Schulich School of Engineering FOIP Policy:

http://www.ucalgary.ca/eng/courses/Engg/FOIPPOLICY.html

13. Environmental Health and Safety

The University of Calgary and the Schulich School of Engineering operate on the premise of the Internal Responsibility System which identifies that all individuals, including students and visitors, share the responsibility for ensuring a safe working, learning and living environment.

To this end students are responsible for:

- reporting any unsafe conditions or actions to their Professor or a University Representative;
- reporting all accidents or incidents to their Professor or a University Representative as soon as possible after the incident has occurred; there is a requirement to report incidents which include, a sudden or unforeseen event which could or has caused an injury or occupational illness; a release of hazardous materials to the environment, or a near miss;
- understanding that just because a hazard can't be seen doesn't mean it doesn't exist and evacuate the building immediately if the fire bells are initiated leaving through the nearest exit and moving away from the building. Failure to do so puts your safety and the safety of emergency responders at risk and goes against our premise of Safety First.

For more information on Occupational Health & Safety, please consult the University's Environmental Health and Safety website:

http://www.ucalgary.ca/safety

14. Additional Course Information

Course Outline:

1. ***Introduction and Review***

2. ***MOS Transistor Physics***

-Strong Inversion

-Moderate Inversion

-Subthreshold

3. ***Fabrication Technology***

-Submicron

-Deep Submicron

-Figures of Merit for Fabrication Processes

4. ***Important Static MOSFET Models***

-Shichman-Hodges Model (Level 1 SPICE Model)

-More Accurate Models for Deep Submicron Transistors

5. ***Small Signal MOSFET Models***

-Low Frequency

-High Frequency

6. ***Commercial Modeling Software***

7. ***Passive Components in the MOS System***

-Resistors

-Capacitors

-Inductors and Transformers

8. ***MOS Subcircuits***

-Diode-Connected Transistor

-Source Coupled Pair

-Biasing Circuits

-Current Sources

-Mirrors

-Gain Stages

-Bandgap References

9. ***Basic CMOS OPAMP Design***

-2 stage

-Folded Cascode

-Non-ideal Behavior

Lab Experiments:

1. **PSPICE Modeling**
2. **Analog Circuit Building Blocks**
3. **2-Stage Op Amp Part 1**
4. **2-Stage Op Amp Part 2**
5. **2-Stage Op Amp Part 3**

Template revised on 6 August 2009 (RWB)