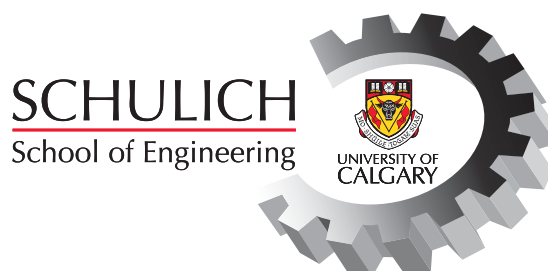


September 2008

**COURSE NAME / NUMBER***ENEL 647*

TITLE OF COURSE	HOURS	SESSION	YEAR
<i>Analog Integrated Circuit Design</i>	<i>H(3-1)</i>	<i>Fall</i>	<i>2008</i>

COURSE OUTLINE**1. DESCRIPTION**

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. Operational amplifier design techniques. Case studies of complementary metal oxide semiconductor (CMOS) designs. CMOS analog integrated circuit design project.

2. OBJECTIVES

Students will:

- demonstrate an understanding of basic transistor fabrication, physical operation and modeling techniques appropriate to modern deep submicron transistors
- develop skills in modern computer aided modeling and simulation techniques using commercial industry standard software tools
- understand the characteristics of basic analog circuit building blocks such as current mirrors and differential pairs
- apply the knowledge to the analysis of existing linear integrated circuits from a variety of manufacturers
- apply the knowledge to design linear integrated circuits for a specific application via a course project

3. LECTURES/LABS/TUTORIALS

L/B/T	SESSION	DAYS OF THE WEEK	START TIME	DURATION/ MINUTES	LOCATION
<i>L01</i>	<i>Fall</i>	<i>Tues/Thurs</i>	<i>09:30 am</i>	<i>75</i>	<i>ICT 446</i>

4. COURSE INSTRUCTOR

SECTION	NAME	TELEPHONE	OFFICE	EMAIL
L01	Dr. J.W. Haslett	220-5808	ICT 414	haslett@atips.ca

Home Page containing ENEL 647 material: www.enel.ucalgary.ca/People/Haslett/Haslett.htm

5. EXAMINATIONS

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.

6. Use of CALCULATORS in Examinations

Scientific and any other calculators may be used during examinations.

7. FINAL GRADE DETERMINATION

The final grade in *ENEL 647* will be based on the following components:

<i>Quizzes</i>	5	%
<i>Assignments</i>	10	%
<i>Project</i>	35	%
<i>Midterm Examination</i>	15	%
<i>Final Examination</i>	35	%
TOTAL	100	%

The course project must be completed with a passing grade of 50% in order to pass the course. 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/2008/how/How_LB.htm

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/2008/how/How_MB.htm

10. TEXTBOOK

- **Prescribed Text:** Behzad Razavi, *Design of Analog CMOS Integrated Circuits*, McGraw Hill, 2000.
- Also see the following:
 - 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*, Fourth Edition, Oxford University Press, 1998.
 - Daniel Foty, *MOSFET Modeling with Spice-Principles and Practice*, Prentice Hall, Inc., 1997.
 - Kenneth R. Laker, Willy M.C. Sansen, *Design of Analog Integrated Circuits 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 ACCOMODATION 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 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. ADDITIONAL COURSE INFORMATION SECTION

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
