CONCORDIA UNIVERSITY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ELEC 423/6051 Introduction to Analog VLSI
Fall 2011

Course Outline

INSTRUCTOR:
Glenn Cowan, Assistant Professor, Electrical and Computer Engineering
Office: EV5.237, Telephone: 848-2424 Ext. 4108
Office Hours: TBD

LECTURE:
Tuesdays 5:45 – 8:30 pm, Room H 537

USEFUL TEXTBOOKS WORTH CONSULTING:
- R. J. Baker, "CMOS Circuit Design, Layout, and Simulation," revised 2nd edition, Wiley, 2008.
- P. R. Gray, P. J. Hurst, S. H. Lewis, R. G. Meyer, "Analysis and design of analog integrated circuits," 4th edition, Wiley, 2001.
- D. Johns and K. Martin, "Analog Integrated Circuit Design," Wiley, 1997.
- B. Razavi, "Design of Analog CMOS Integrated Circuits," McGraw-Hill, 2001.

CALENDAR DESCRIPTION

ELEC 423 *Introduction to Analog VLSI* (4 credits)
Prerequisite: ELEC 311. CMOS transistor layout considerations, design rules, circuit extraction. MOSFET modelling, I-V equations, AC equivalent circuits for high-frequency operation, computer-based simulation. Analysis and design of small-scale integrated circuit building blocks including MOS switch, active resistor, current source, current mirror, voltage amplifiers, voltage-reference circuits, multipliers. Analysis and design of medium-scale integrated circuit building blocks including op-amps, fully-differential op-amp and common mode feedback circuits, transconductance amplifiers, transimpedance amplifiers, comparators. Noise analysis. Mismatch analysis and modelling, offset removal techniques. Analog VLSI system examples. Lectures: three hours per week. Laboratory: 30 hours total.

OVERALL COURSE OBJECTIVES:

The objective of the course is for students to gain analysis and design skills necessary for Analog IC design, either in industry or academia. The syllabus, assignments, project, and tests have been developed based on the analysis and design problems analog IC designers face.

By the end of the term, students should be able to:
1. Demonstrate an understanding of MOS terminal characteristics and capacitive effects.
2. Create integrated circuit layouts showing an awareness of the underlying process technology and layout parasitics as well as their impact on circuit performance.
3. Show a working knowledge of and an ability to analyze basic gain stages, current mirrors, and active loads. Students should be able to make choices among these building blocks.
4. Select the length, width, and bias level of transistors with an awareness of biasing trade-offs associated with the transistor's level of inversion.
5. Analyze a circuit to determine input and output referred noise power spectral density. Students should also be able to propose design modifications to reduce noise levels and be able to determine which transistors contribute most to noise levels.
6. Analyze a circuit to determine input and output referred offsets. Students should also be able to propose design modifications to reduce offsets and be able to determine which transistors contribute most to offsets.

7. Analyze various single-stage and two-stage opamp circuits to determine gain (differential and common-mode), frequency response, output resistance, short-circuit transconductance, input common-mode range, and output signal range. Students should be able to compensate an opamp for closed loop stability, given a certain feedback factor.
8. Compute an opamp's required dc gain, slew rate, and unity-gain frequency based on the required closed-loop settling dynamics of a sample-and-hold system.
9. Recognize situations that require common-mode feedback and propose a *suitable* common-mode feedback scheme comprised of a common-mode detector, an amplifier, and a control mechanism. Students should also make choices that lead to a stable common-mode feedback loop with loop dynamics similar to the differential-mode loop.
10. Apply the Barkhausen criteria to a circuit or system in order to determine if it is likely to oscillate. Students should be able to analyze various ring-oscillators and *LC* oscillators to compute the required gain for oscillation and the approximate frequency of oscillation.
11. Show awareness of global process variation and its effect on circuit performance.
12. Analyze basic voltage and current reference circuits

PREREQUISITE MATERIAL:

This course assumes that students have a basic command of the following topics:

Background Topics	Sections from Microelectronics 5th Ed. (Sedra and Smith)
DC, square-law operation of MOSFETs	4.1, 4.2
Low- and high-frequency small-signal models of MOSFETs	4.6, 4.8
AC and DC analysis of single transistor amplifiers with resistive loads	4.3, 4.5, 4.7
AC and DC analysis of single stage amplifiers with active loads	6.5, 6.7, 6.8, 6.9, 6.10
Basic current mirrors	6.3, 6.12
Differential pairs	7.1, 7.2, 7.5
Analysis techniques associated with multi-stage amplifiers	7.7
High-frequency analysis techniques such as Miller's Theorem and the method of Open Circuit Time Constants	4.9, 6.4, 6.6, 6.7, 6.8, 6.9, 6.10, 7.6
Principals of feedback and basic stability analysis	8.1-8.11
Analysis of circuits with operational amplifiers	2.1-2.3

TENTATIVE LECTURE SCHEDULE:

Lecture	Date	Topics
1	Sept 6th	Introduction of Course **Background check quiz** (not counted) and student information sheet Review of MOS Modeling
2	Sept 13th	Process Technology and layout considerations
3	Sept 20th	Current mirrors & other basic circuits
4	Sept 27th	**Background quiz** (Counted, see grading scheme) Weak inversion operation, biasing trade-offs, short channel effects
5	Oct 4th	Noise: signal descriptions, models, analysis, design considerations
6	Oct 11th	Mismatch: Causes, models, analysis, design considerations
7	Oct 18th	**Midterm Exam,** Operational amplifier basics, project overview
8	Oct 25th	Advanced opamps.
9	Nov 1st	Common-mode feedback

10	Nov 8th	Oscillators
11	Nov 15th	References
12	Nov 22nd	Design in the presence of global process variation
13	Nov 29th	Design in very-low supply voltages **Project Due in class**

ASSIGNMENTS:
A combination of paper/pencil and CAD based assignments will be given. These will reinforce concepts developed in class and prepare students for the project.

PROJECT:
A design project will be given in the second half of the semester.

GRADING SCHEME:

	Undergrad Students	**Graduate Students**
Assignments	10%	10%
Week 4 Quiz	5%	5%
Midterm test	15%	15%
Project	20%	30%
Final examination	50%	40%
Total:	**100%**	**100%**

Please note that the Midterm exam will count. No alternate scheme in which the midterm is not counted will be offered. During the midterm test and the final exam, only one of the two ENCS-approved calculators (CASIO FX-300MS and SHARP EL-531) will be allowed.

Assignments, labs, and the project must be accompanied by a signed copy of ENCS's Expectations of Originality form.
See: http://www.encs.concordia.ca/current-students/forms-and-procedures/expectation-of-originality/

NOTES ON PLAGIARISM (Source: The Academic Integrity Website:
http://provost.concordia.ca/academicintegrity/plagiarism/)**:**

The most common offense under the Academic Code of Conduct is plagiarism which the Code defines as "the presentation of the work of another person as one's own or without proper acknowledgement." This could be material copied word for word from books, journals, internet sites, professor's course notes, etc. It could be material that is paraphrased but closely resembles the original source. It could be the work of a fellow student, for example, an answer on a quiz, data for a lab report, a paper or assignment completed by another student. It might be a paper purchased through one of the many available sources. Plagiarism does not refer to words alone - it can also refer to copying images, graphs, tables, and ideas. "Presentation" is not limited to written work. It also includes oral presentations, computer assignments and artistic works. Finally, if you translate the work of another person into French or English and do not cite the source, this is also plagiarism.

In Simple Words:
Do not copy, paraphrase or translate anything from anywhere without saying where you obtained it!

LIST OF SERVICES

Concordia Counselling and Development offers career services, psychological services, student learning services, etc.
http://cdev.concordia.ca/

The Concordia Library Citation and Style Guides:
http://library.concordia.ca/help/howto/citations.html

Advocacy and Support Services
http://supportservices.concordia.ca/

Student Transition Centre
http://stc.concordia.ca/

New Student Program
http://newstudent.concordia.ca/

Access Centre for Students with Disabilities
http://supportservices.concordia.ca/disabilities/

Student Success Centre
http://studentsuccess.concordia.ca/

The Academic Integrity Website
http://provost.concordia.ca/academicintegrity/

Financial Aid & Awards
http://web2.concordia.ca/financialaid/

Health Services
http://www-health.concordia.ca/