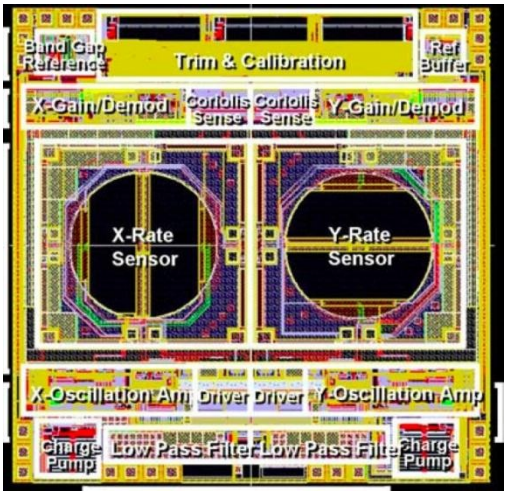
INSTITUTO FEDERAL
São Paulo
Câmpus Campinas

Analog IC Design



1. GENERAL INFORMATION

Course : Analog IC Design	**Code : AB01**
Workload : 80 hours of theoretical lectures **40 hour of complementary tutor classes**	**Period : Semester I/II / YEAR**
Professor :	**Contact :**
Main Topics: Basic CMOS structures, current mirrors, bias circuits, small signal and great signal models, amplifiers, feedback structures, noise, filters, switched capacitors, oscillators, and frequency synthesizers	

2. OBJETIVES

SCOPE	DESCRIPTION
General	Develop the fundamental analysis skills necessary for commercial design success and a professional working repertoire of analog designs and techniques.
Specific	• Familiarize the student with the basic building blocks of CMOS analog circuits to carry out detailed analyses, modeling, design, and verification of analog integrated circuits. • Analyze and create basic design blocks using MOSFET transistors • Use, design, and analyze basic CMOS topologies (amplifiers, mirrors, bias blocks, reference blocks, comparators, tuned amplifiers, differential amplifiers). • Make trade-offs and reduce the sources of noise in circuits. • Calculate and apply the transform function and analyze the circuit behavior in the frequency domain. • Identify closed loop structures and calculate stability conditions. • Design of practical filters for integrated circuits. • Use structures for sampling, and analyze issues with aliasing and noise in practical IC structures. • Understand the characteristics of advanced amplifier circuits and be able to work with second order effects of these components • Select appropriate topologies for specific circuit applications. • Discuss various methods of designing voltage references and distributing controlled bias currents, and ways to handle the associated issues of noise and crosstalk. • Analyze the oscillation robustness and noise characteristics of the oscillators. • Analyze in frequency a phase-locked loop design. • Design phase detectors and VCOs used in low and high frequency PLLs. • Detail practical designs for charge pumps in PLLs, and describe how higher order and fractional-n loops can be implemented in ICs.

3. CONTEXT and MOTIVATION

This Analog Integrated-Circuit (IC) course provides the student with theoretical and practical knowledge of the fundamental designs and techniques needed to develop analog integrated circuits for commercial applications. The Professor shows to the Students the theoretical concepts behind the main devices and topologies used in Analog circuit, and at the same time, teach them a variety of proven industry approaches for successful modeling, analysis, optimization, and performance measurement of a wide range of important analog functions using systematic methodologies that many only learn after years on the job.

The Professor is going to work together with the instructors, who are going to develop and guide 2 important activities: 1) they are going to coordinate the tutorial lesson, a complementary class which is going to take 4 hours per week, in which several practical examples, book problems and homework activities are going to be explain. 2) The Instructors are going to assign to the student practical design activities to be develop inside the laboratories, that are related to both the topic that is being studied in the theoretical lessons and to the EDA tool that the student is learning.

Students will become familiar with a variety of important analog topics, like Basic CMOS blocks; biasing and references circuits; Current sources and current mirrors; single stage, differential, multi stage amplifiers; sampled and continuous time filters; feedback systems, stability conditions and oscillators. Also, the Students will learn specify and how it is achieved the performance, even with the real-world design challenges and trade-offs that are present in modern analog integrated circuits.

4. COURSE OUTLINE

Main Topic	Detailed information
Basic CMOS Structures	MOS I/V characteristics, Second-order effects, MOS device models, CMOS logic structure, CMOS switching behavior
Current Mirrors	Current generators, basic and advanced current mirror topologies, output impedance and active loads.
Amplifiers	Gain and load lines, Active loads, Current mirrors, Differential pairs, Multi-stage amplifiers, Comparators, Achieving stability, Settling behavior, Compensation, Classes of amplifiers outputs, Tuned amplifiers, Differential amplifiers, Common-mode response,
Feedback and Stability	Open loop response, close loop response, stability parameters and compesantion.
Advanced Amplifiers	Amplifiers for switched-cap circuits, Low noise amplifiers, Impedance matching, Low-distortion amplifiers, Auto-zero and chopped amplifiers, Common-mode feedback.
Bias Circuits	Band-gap references, Bias distribution, Matching calculations, Noise considerations, Crosstalk issues.
Oscillators	Oscillation Conditions, Phase noise, Relaxation, LC oscillators, RC oscillators, Ring oscillators, Drift considerations, XTAL oscillators.
Noise	Statistical characteristics of noise, Types of noise (thermal, 1/f, etc), Representation of noise in circuits, Noise reduction techniques.
	Frequency-locked loops, Phase-locked loop basics, Stability, Phase detectors, Lock

Phase-locked Loops (PLL)	and acquisition, Noise analysis, Voltage-controlled oscillators (VCO), Advanced PLL Topics, Charge pumps, Higher order loops, Fractional-N loops

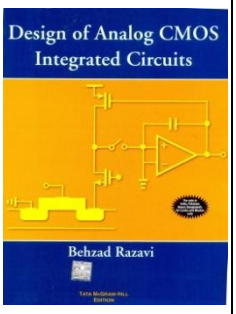
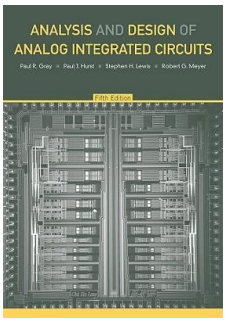
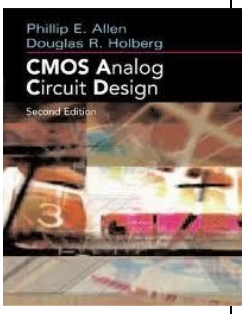
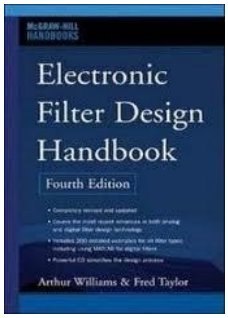
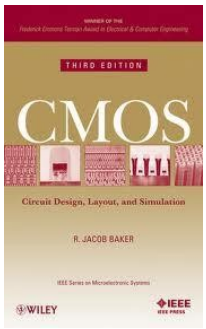
5. ACTIVITIES SCHEDULE

WEEK	Main Topic	Homework	EDA	Lab. Activity
1	Basic Cmos Structures	Mos transistor Basics		
2	Small signal model and Current mirrors	Current mirrors	ADE	Lab. Act 1: Linear circuits
3	Single stage amplifiers	Sensibility and amplifiers	ADE	Lab. Act 2: Current mirrors
4	Differential and multiples stages Amplifiers	Differential amplifiers	Spectre	Lab. Act 3: single stage amp
5	Feedback, stability and compensation	LDO as a feedback system	Verilog-A	Lab. Act 5: behavioral modeling of an amplifier
6	Advanced amplifiers / switched Capacitors	Fully differential amplifier design	layout	Lab. Act 6: schematic of an amplifier
7	Bias Circuits / Oscillators	oscillators and switched capacitors	LayoutXL	Lab. Act 4: Switched Capacitor
8	Noise / Filters	Noise and Filters	layoutXL+VCAR	Lab. Act xx: Active filter Design
9	PLL	PLL as a close-loop system	VCAR	Lab. Act XX: Layout of a single stage amp
10	Advanced PLL topics and Calibration			Lab. Act 7: layout of an operational amplifier

6. EVALUATION SYSTEM

EVALUATON	DESCRIPTION
Homeworks (H)	• Theoretical activity to be developed at home through the application of the concepts presented in the class.
Formal Presentation (FP)	• Individual presentation based on a given topic to be provided during the course.
Final Exam (FE)	• Theoretical verification of the acquired knowledge.

7. BIBLIOGRAPHY

SOURCE	ANALOG and RF BOOKS				
Library					
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	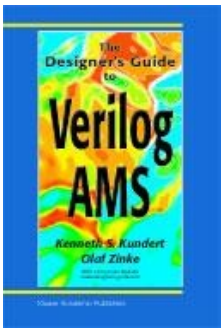	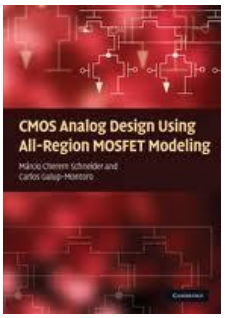	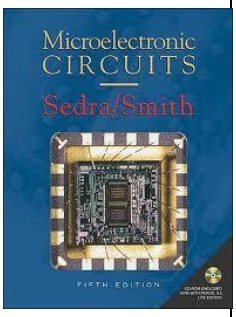	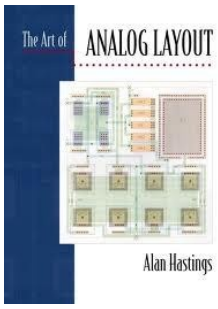	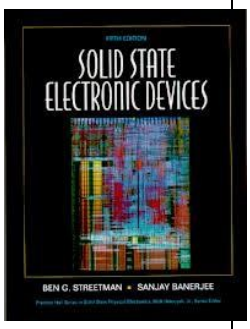
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