UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Laboratorio di Elettronica I

2627-1-F1703Q014

Aims

The Electronics Laboratory I course aims to provide students with the fundamental knowledge and practical skills required for the analysis, design, simulation, and characterization of CMOS analog integrated circuits, covering circuit building blocks of increasing complexity, from individual MOS devices to operational amplifiers. Through the use of professional Computer-Aided Design (CAD) tools and design methodologies adopted in both industry and research, the course introduces students to the professional integrated circuit development flow, from circuit design and simulation to design verification activities that prepare a circuit for silicon prototyping and subsequent experimental characterization.

The course is organized into three complementary activities:

1. Introduction to the principles of CMOS analog integrated circuit design, through the study of MOS devices, single-transistor building blocks, differential amplifiers, and operational amplifiers, with particular emphasis on the analysis and design methodologies of the main functional blocks of analog integrated circuits.
2. Introduction to the use of professional Computer-Aided Design (CAD) tools for the design, simulation, and verification of analog integrated circuits.
3. Introduction to electronic laboratory instrumentation, including oscilloscopes, power supplies, function generators, digital multimeters, and other basic laboratory equipment, together with the fundamental measurement techniques for the electrical characterization of electronic circuits.

Upon successful completion of the course, students will be able to analyze and simulate analog integrated circuits using professional CAD tools, critically interpret simulation results, and use standard electronic laboratory instrumentation to perform basic electrical measurements and experimental verification.

Expected learning outcomes

- Knowledge and understanding
  Students will acquire the fundamental knowledge of CMOS analog integrated circuit design, MOS devices and the main functional building blocks of analog electronics, the operating principles of professional

Computer-Aided Design (CAD) tools, and the use of standard electronic laboratory instrumentation.

- Applying knowledge and understanding
  Students will be able to analyze and simulate basic analog integrated circuits using CAD tools, perform fundamental circuit analyses, and use standard electronic laboratory instrumentation to carry out basic electrical measurements and experimental verification.

- Making judgements
  Students will develop the ability to critically interpret simulation and experimental results, compare them with theoretical predictions, and evaluate the behavior of the main analog circuit building blocks.

- Communication skills
  Students will be able to describe the operation of the analyzed circuits, discuss the results of simulations and laboratory measurements, and prepare technical reports using appropriate scientific and technical terminology.

- Learning skills
  Students will acquire the methodological skills required for independent learning in analog integrated circuit design, the use of professional CAD tools, and electronic measurement techniques, providing a solid foundation for the subsequent Electronics Laboratory II course and for more advanced studies in microelectronics and integrated circuit design.

Contents

- Concepts of analog design in CMOS technology
- Use of CADENCE software for simulation of CMOS analog circuits
- Concepts of electronic instrumentation for the characterization of integrated circuits

Detailed program

The course introduces students to the fundamental principles of CMOS analog integrated circuit design and is organized into three complementary activities.

1. Lectures covering the fundamentals of CMOS analog integrated circuit design.
   Topics include CMOS technology, MOS devices, analog switches, current mirrors, voltage and current references, gain stages, differential amplifiers, and operational amplifiers.
2. Computer-aided design laboratory sessions, aimed at learning the use of the Cadence® design environment for the design, simulation, and verification of analog integrated circuits. Laboratory exercises include, by way of example, the design and simulation of individual MOS transistors, with particular emphasis on the operating principles of nanoscale CMOS devices, differential amplifier stages, and single-stage and two-stage operational amplifiers.
3. Experimental laboratory sessions, dedicated to the use of standard electronic laboratory instrumentation—including oscilloscopes, power supplies, function generators, digital multimeters, and spectrum analyzers—for the electrical characterization of basic analog circuits and an introduction to fundamental electronic measurement techniques.

Prerequisites

Bachelor in physics or equivalent. Basic notions of analog electronics

Teaching form

The course consists of a total of 120 hours, organized into three complementary activities:

1. 48 hours of lectures, devoted to the fundamentals of CMOS analog integrated circuit design. The lectures cover the theoretical aspects of the analysis and design of the main functional building blocks of analog integrated circuits.
2. 48 hours of CAD laboratory sessions, dedicated to the use of the professional Cadence® design environment for the design, simulation, and verification of analog integrated circuits. The laboratory activities guide students through the development and analysis of basic circuit building blocks, including MOS devices, differential amplifiers, and operational amplifiers.
3. 24 hours of experimental laboratory sessions, devoted to the use of standard electronic laboratory instrumentation—including oscilloscopes, power supplies, function generators, digital multimeters, and spectrum analyzers—for the electrical characterization of basic analog circuits and the acquisition of fundamental electronic measurement techniques.

Attendance is strongly recommended, particularly for the CAD laboratory sessions and the experimental laboratory activities, which constitute an essential part of the course.

The course is normally taught in Italian. Upon request by one or more students, it may also be delivered in English.

Textbook and teaching resource

References:

A. Baschirotto “Dispense di Microelettronica”
Gray, Hurst, Lewis, Meyer, “Analysis and design on analog integrated circuits”
F. Maloberti, “Analog designfor CMOS VLSI systems”
B. Razavi, “Design of analog integrated circuits”
M. Norgia, R. Ottoboni, A. Pesatori, C. Svelto, “Misure - Dai fondamenti alla strumentazione”, Ed. Esculapio.
Nihal Kularatna, “Digital and Analogue Instrumentation: Testing and Measurement”, IEE.

Semester

1st semester

Assessment method

Oral examinations (colloquium) in presence on appointement (to be fixed via mail to andrea.baschirotto@unimib.it)

The student may present two Laboratory Reports based on:

1. Design and simulation of simple single transistor analog circuits;
2. Electrical and electronic measurements on simple circuit configurations.
   The exam will consist of:

- Colloquium on Laboratory Reports (if presented)
- Colloquium on topics covered during the lessons

Office hours

Discussions with prof. Baschirotto will take place upon appointment (contact via mail andrea.baschirotto, marcello.dematteis, valeria.vadala@unimib.it).

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE