UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Laboratory of Electronics II

2627-1-F1703Q015

Aims

The Electronics Laboratory II course aims to provide students with the knowledge and practical skills required for the analysis, design, simulation, and experimental characterization of analog electronic circuits.

The course consists of two complementary activities. The first focuses on the design and simulation of analog integrated circuits using professional Computer-Aided Design (CAD) tools. The second is devoted to the electrical characterization of basic analog circuits through laboratory measurements using electronic instrumentation such as power supplies, function generators, oscilloscopes, spectrum analyzers, and other dedicated laboratory equipment.

Particular emphasis is placed on the design and analysis of operational amplifiers, analog filters, charge amplifiers, and low-noise amplifiers for sensor applications implemented in CMOS technology, together with the evaluation of nominal and statistical circuit performance and the characterization of static, dynamic, and noise behavior.

Upon successful completion of the course, students will be able to design and simulate basic analog integrated circuits using professional CAD tools, critically interpret simulation results, and experimentally characterize their electrical behavior through laboratory measurements.

Expected learning outcomes

- Knowledge and understanding
  Students will acquire the fundamental knowledge of analog integrated circuit design and simulation, the operating principles of professional Computer-Aided Design (CAD) tools, the techniques for the electrical characterization of analog circuits, and the main factors affecting integrated circuit performance, including process variations, temperature, and electronic noise.

- Applying knowledge and understanding
  Students will be able to design and simulate basic analog integrated circuits using CAD tools, perform DC, transient, AC, and noise analyses, evaluate circuit performance under different operating conditions, and experimentally characterize basic analog circuits using standard electronic laboratory instrumentation.

- Making judgements
  Students will develop the ability to critically interpret simulation and experimental results, compare alternative circuit solutions, and evaluate the effects of process variability, temperature, and electronic noise on analog circuit performance.

- Communication skills
  Students will be able to present and discuss the results of circuit design, simulation, and experimental characterization activities using appropriate scientific and technical terminology, and prepare clear and comprehensive technical reports.

- Learning skills
  Students will acquire the methodological skills necessary for independent learning in analog integrated circuit design, the use of professional CAD tools, and electronic measurement techniques, providing a solid foundation for more advanced courses in microelectronics and integrated circuit design.

Contents

- Introduction to Analog Circuits Design by Computer-Aided-Design (CAD)
- CMOS Design of Operational Transconductance Amplifiers (OTA)
- Operational Transconductance Amplifiers Design Procedure
- Nominal Conditions Simulations (operating point, frequency, time, noise in both time and frequency domain, closed-loop stability)
- Noise Power Spectral Density in Closed-Loop Circuits
- Process-Voltage-Temperature Simulations
- Montecarlo Simulations
- Circuital exercises in the laboratory

Detailed program

Lesson 1: Miller-Compensated Operational Transconductance Amplifiers (OTA)

- Introduction
- Class-A OTA Basic Scheme
- OTA Operating Point
- Small-Signal
- Large-Signal
- Noise: Class-A OTA Input Referred Noise
- Common-Mode Feedback Circuit

Lesson 2: Miller OTA Design Procedure

- Introduction
- Opamp Specifications
- Input Differential Stage
- Miller Capacitance
- Class-A Output Stage
- Class-AB Output Stage
- Common ModeFeedback Circuit

Lesson 3: CAD Tools

- Creating a schematic and symbol.
- Simulating simple analog circuits using Analog Design Environment.
- Running process/voltage/temperature simulations.
- Running Montecarlo simulations.

Prerequisites

Bachelor in physics or equivalent.

Teaching form

LECTURES in which the fundamental concepts of analogue design in CMOS technology will be presented.

Classroom EXERCISES with presentation and discussion of examples of analog circuits at the transistor level. EXERCISES in the electronics laboratory where students will be divided into groups (2 students per group). Students will follow guided exercises, preceded by a classroom presentation.

GROUP WORK for development and simulation of analogue stages.

Attendance is strongly recommended and is essential for all activities.

The course will be delivered in Italian.

Textbook and teaching resource

- Lecture notes provided by the instructor
- Johns, David A., and Ken Martin. *Analog integrated circuit design*. John Wiley & Sons, 2008.
- Sansen, Willy M. *Analog design essentials*. Vol. 859. Springer Science & Business Media, 2007.
- Kularatna, Nihal. *Digital and analogue instrumentation: testing and measurement*. No. 11. IET, 2003.
- M. Norgia, R. Ottoboni, A. Pesatori, C. Svelto. *Misure - Dai fondamenti alla strumentazione*. Ed. Esculapio.

Semester

second semester

Assessment method

The exam consists of an ORAL EXAM.

During the oral exam, the student will present two Laboratory Reports:

1. RelazioneCAD: Design and simulation at transistor level of an analog circuit (whose general scheme will be provided by the course teachers during the lessons);
2. Meas Report: Electrical and electronic measurements on simple circuit configurations.
   The exam will consist of:

- Interview on Laboratory Reports;
- Interview on topics covered in class.

The SKILLS and knowledge required are based on:

- analysis and synthesis of analog stages with transconductance amplifier operation (active amplifiers and filters);
- CAD simulations of the analogue stages covered by the CAD Report;
- in-depth knowledge of the measurement setup issues covered by the CAD Report.

The evaluation CRITERIA are:

- level of knowledge of the circuits covered by the two laboratory reports, both at an architectural and transistor level;
- level of originality and in-depth analysis of the circuit solutions adopted relating to the RelazioneCAD and the RelazioneMeas.

Office hours

Monday 10-12

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE