UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Microelectronics for Physics Technologies

2627-2-E3004Q013

Aims

The course provides the fundamental knowledge of analog electronics required to understand the operation of the main semiconductor electronic devices and basic analog circuits for signal processing.
Particular emphasis is placed on the analysis and design of circuits based on diodes, MOSFET transistors, and operational amplifiers, including biasing techniques, time- and frequency-domain analysis, and the use of small-signal models.
The course integrates lectures, problem-solving sessions, and laboratory activities through the use of Computer-Aided Design (CAD) tools for circuit simulation and design, enabling students to acquire both analytical and design-oriented skills in analog electronics. The CAD laboratory activities are carried out using tools and methodologies compatible with the design of real integrated circuits, similar to those employed in modern silicon technologies, allowing students to become familiar with design flows commonly adopted in industrial and research environments.

Contents

Review of linear time-invariant electrical networks.
Semiconductor diodes and their circuit applications.
MOSFET transistors: operating principles, biasing techniques, and small-signal models.
Single-transistor amplifier stages.
Feedback theory and operational amplifiers.
Time-domain and frequency-domain circuit analysis.
Introduction to noise in electronic circuits.
Simulation and design of analog circuits using Computer-Aided Design (CAD) tools.

Detailed program

1. Review of linear time-invariant electrical networks and circuit analysis techniques.
2. Resistive and dynamic circuits in the time and frequency domains.
3. Semiconductor diodes: electrical characteristics, circuit models, and main applications.
4. MOSFET transistors: structure, operating principles, regions of operation, and static characteristics.
5. MOSFET biasing techniques and operating-point determination.
6. Large-signal and small-signal equivalent models.
7. Analysis of voltage gain, input impedance, and output impedance.
8. Single-transistor amplifier stages in common-source, common-gate, and common-drain configurations.
9. Frequency response of amplifiers and their main dynamic limitations.
10. Introduction to noise sources in electronic circuits.
11. Principles of feedback in electronic amplifiers.
12. Ideal and non-ideal operational amplifiers.
13. Main operational-amplifier circuit configurations and their applications.
14. Use of Computer-Aided Design (CAD) tools for analog circuit simulation and design.
15. CAD-based analysis and verification of operating points, time-domain response, frequency response, and noise performance.

Prerequisites

A general understanding of the fundamental concepts of electrostatics, electric fields, electrical circuits, and basic mathematics is recommended, with particular reference to algebra, complex numbers, and functions of a single variable. Any prerequisite topics required for the understanding of the course will be briefly reviewed during the lectures.

Teaching form

The course includes both Lecturing Activities (DE) and Interactive Learning Activities (DI).
Lecturing activities consist of 24 hours of classroom lectures devoted to the theoretical foundations of analog electronics, semiconductor devices, and basic analog circuits for signal processing.
Interactive learning activities consist of 12 hours of theoretical and numerical problem-solving sessions aimed at applying the concepts introduced during the lectures, and 12 hours of CAD laboratory sessions dedicated to the simulation and design of analog circuits using Computer-Aided Design (CAD) tools.
During the exercises and laboratory activities, students will be involved in problem-solving tasks, case studies, and circuit-performance verification through simulation, fostering the development of practical and design-oriented skills.
Activity Breakdown
24 hours of lectures (DE);
12 hours of theoretical and numerical exercises (DI);
12 hours of CAD laboratory and circuit simulation activities (DI).

Textbook and teaching resource

The teaching material includes lecture slides, solved examples and exercises for individual study, supplementary notes provided by the instructor, and material related to the CAD laboratory activities.
Additional resources, including technical articles, application notes, and reference documentation, may be made available throughout the course via the University's e-learning platform.

Professional CAD tools for electronic circuit simulation and design will be used during the laboratory activities.
Reference Textbook
A. S. Sedra, K. C. Smith, Microelectronic Circuits, Oxford University Press, latest available edition.
Additional Reading
W. Sansen, Analog Design Essentials, Springer.

Semester

Second Semester

Assessment method

The final grade is based on two components:

1. Individual CAD Project, to be carried out during the semester and submitted by the examination date. The project consists of the analysis and simulation of an analog circuit using CAD tools. Its purpose is to assess the student's ability to apply the theoretical concepts acquired during the course and to correctly use circuit simulation tools. The project contributes up to a maximum of 3 points to the final grade.
2. Individual Written Examination, aimed at assessing theoretical knowledge as well as circuit analysis and design skills. The examination consists of three exercises, each worth up to 9 points:

- one exercise on electrical network theory and/or diode circuits;
- one exercise involving the analysis and design of MOSFET-based circuits;
- one exercise involving the analysis and design of operational-amplifier-based circuits, possibly including MOSFETs and diodes.

The written examination evaluates the understanding of the fundamental principles of analog electronics, the ability to apply circuit analysis techniques, and the capability to solve quantitative engineering problems.
The final grade is expressed on a 30-point scale and is obtained by summing the score of the written examination (maximum 27 points) and the CAD project (maximum 3 points). A minimum score of 18/30 is required to pass the examination.

Office hours

Monday 10-12

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE