CLASSICAL AND MODERN PHYSICS, ELECTRONICS, MATERIALS 1_12 ECTS

Introducing

Description

Évaluation

L'évaluation des acquis d'apprentissage est réalisée en continu tout le long du semestre. En fonction des enseignements, elle peut prendre différentes formes : examen écrit, oral, compte-rendu, rapport écrit, évaluation par les pairs...

Practical info

Location(s)

Toulouse

In-depth study of electronic circuits

Introducing

Description

Electrical characteristics of diodes and transistors (MOSFETs, JFETs and bipolar transistors). Biasing circuits and corresponding amplifying classes. Models of active components and equivalent small-signal electrical schemes for LF and/or HF signal analysis. Main functions and associated circuitry (current generation, current mirrors, differential amplifiers, etc. ...). Amplifying, filtering and impedance adaptation. Implementation of models in an electrical circuit simulator.

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts) :
- The electrical characteristics of diodes and transistors.
- The concept of static biasing and the principle of small signal behaviour around the bias point.
- The different amplification classes for transistors based circuits.
- The concepts of low and high frequency modelling in order to design advanced functional circuits.

The student will be able to:
- Design and realise a bias circuit which is well adapted to a given function.
- Extract the equivalent small signal scheme suited for low or high frequency signal analysis.
- Recognize and implement the basic circuitry such as differential amplification, current generators and mirrors.
- Know how to use an electrical circuit simulator and the suited models of active components as well as their limitations.
- Know how to build an amplifying and filtering chain with a view to integration.
- Conceive circuits especially adapted to sensors.
- Conceive a power amplifying stage taking into account the power dissipation.

Necessary prerequisites

Fundamentals of electricity, Kirchhoff's laws, Thévenin and Norton's and superposition theorems, voltage and current sources. Fourier's and Laplace's transforms.

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Practical info

Location(s)

Toulouse

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Semiconductors

Introducing

Description

Part 1: Fundamentals of Materials Physics

Presentation of quantum mechanics concepts underlying the electronic structures of the atom.
Introduction to chemical bonding and the organization of matter.
Study of crystalline structures.
Understanding band diagrams to distinguish insulators, semiconductors, and metals, as well as the concept of density of states within a material.
Review of elementary statistical physics to explain how to modify charge densities in a semiconductor material through doping.

Part 2: Doping and PN Junction

Understanding different types of semiconductor doping.
Construction of a simple component like the PN junction, introducing band diagrams of these structures at thermodynamic equilibrium and non-equilibrium (under bias or illumination).
Study of charge carrier diffusion laws to establish the laws governing current levels observed in PN junctions under bias.

Part 3: Bipolar Transistors

Understanding the operation of the PN junction and its integration within a bipolar transistor.
Explanation of various physical properties of bipolar transistors, particularly their role as amplifiers.
Highlighting the links between the electronic properties of components and physical phenomena, such as the current gain parameters Alpha and Beta of bipolar transistors.

Part 4: CMOS Technologies

Emphasizing the physical links between materials and the electronic operation of MOS capacitors, MOS transistors, and their integration through CMOS technologies.
This course aims to provide students with the fundamental knowledge and practical skills necessary to understand and apply the principles of materials physics and components in information technologies.

Part 5: Practical Work

As part of our module on semiconductor materials and their characterization, you will have the opportunity to participate in 7 hours of practical work in a cleanroom at AIME. These sessions will allow you to implement the knowledge acquired in lectures and tutorials. During these practical sessions, students will construct and electrically characterize photovoltaic cells following the Lumelec procedure developed at AIME. For more details, the Lumelec manual for this practical work is available at the following link: https://www.aime-toulouse.fr/wp-content/uploads/2024/04/FasciculeLumelec_EN_2024-2.pdf

These practical sessions are an excellent opportunity to enhance your technical skills and understand the practical applications of the theoretical concepts covered in the course.

Objectives

This course introduces the physics of materials and components involved in technologies associated with the transmission, processing, and storage of information. It focuses on timeless fundamental principles in a rapidly developing field.

Expected Competencies:

By the end of this course, the student will be able to:

1- Clearly describe and express the various physical principles involved in the processing, transmission, and storage of information.
2- Comprehend the overall technologies based on semiconductors, from the atomic level to the application of components.
3- Enhance their understanding of the physical properties of semiconductors, particularly the PN junction, which serves as the basic technological building block present in all modern components, whether discrete (such as diodes or bipolar transistors) or integrated (such as field-effect transistors).

Évaluation

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Practical info

Location(s)

Toulouse

Waves and propagation

Introducing

Description

Program (detailed content):
Electromagnetism in dielectric, conductive, and magnetic media. Propagation of electromagnetic waves in linear, homogeneous, and isotropic media. Continuity relations. Application to reflection and refraction. Propagation in rectangular metallic waveguides and optical fibers.

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

The fundamental concepts related to the propagation of electromagnetic waves in simple media (linear, homogeneous, isotropic, as well as dielectric, magnetic, or conductive). Reflection and refraction at the interface between two media, the functioning of metallic and dielectric waveguides (optical fibers), and the associated energy transfer.

The student should be able to:

Waves and Propagation: Use Maxwell's equations generalized for different media to determine the nature of the electromagnetic waves present in a simple system (L.H.I. medium, interface between two media, confined space between two plates of a good conductor). The student should be able to determine the conditions and characteristics of the modes that lead to the propagation of electromagnetic waves in various waveguides.

Necessary prerequisites

Electromagnetism in a vacuum

Évaluation

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Practical info

Location(s)

Toulouse

Hamiltonian mechanics

Introducing

Description

Newtonian mechanics, D'Alembert's principle and virtual work, Lagrangian formulation and Hamilton's principle of least action, Hamiltonian formulation, Canonical transformations and Poisson's bracket

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

D'Alembert's principle, principle of least action, Lagrangian and Hamiltonian formulation of mechanics, notion of generalized coordinates and generalized forces, canonical transformations, Poisson representation of Hamiltonian mechanics, notion of phase space.

Students should be able to use the Euler-Lagrange and Hamiltonian equations to study the motion of an object.

Necessary prerequisites

Newtonian mechanics

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Practical info

Location(s)

Toulouse