Course guide
230471 - ELF - Physical Electronics

Last modified: 25/05/2023

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.

Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Understanding the physics of semiconductors. Knowledge of microelectronic devices and their applications in nanotechnology, biophysics, photonics and communications. Ability to analyze the performance of electronic devices and integrated circuits.

Generical:
5. They will have acquired knowledge related to experiments and laboratory instruments and will be competent in a laboratory environment in the ICC field. They will know how to use the instruments and tools of telecommunications and electronic engineering and how to interpret manuals and specifications. They will be able to evaluate the errors and limitations associated with simulation measures and results.
4. ABILITY TO IDENTIFY, FORMULATE, AND SOLVE PHYSICAL ENGINEERING PROBLEMS. Planning and solving physical engineering problems with initiative, making decisions and with creativity. Developing methods of analysis and problem solving in a systematic and creative way.

Transversal:
1. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.
2. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 2. Using strategies for preparing and giving oral presentations. Writing texts and documents whose content is coherent, well structured and free of spelling and grammatical errors.
3. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.

TEACHING METHODOLOGY

Three teaching hours of theory and two hours of practice per week.

LEARNING OBJECTIVES OF THE SUBJECT

Undrstand the basics of semiconductor devices.
To know the basic principles and to be able to analyze cuantitaviley their behaviour.
Yo have the tools allowing to understand future devices.

STUDY LOAD

Type	Hours	Percentage
Self study	85,0	56.67
Hours large group	65,0	43.33

Total learning time: 150 h

CONTENTS

1. Semiconductor physics.

Description:
1.1. Energy bands. Charge carriers: electrons and holes. Direct and indirect semiconductors. Effective mass of carriers.
1.2. Concentration of electrons and holes. Effective density of states. Fermi level.
1.3. Intrinsic and extrinsic semiconductors. Donor and acceptor impurities. Equation of electrical neutrality. Statistics.
1.4. Mobility of carriers. Currents. Einstein relations.
1.5. Generation and recombination of carriers. Lifetime. Quasi-Fermi levels.
1.6. Continuity equation. Injection of carriers. Diffusion length.

Full-or-part-time: 37h 30m
Theory classes: 9h 45m
Practical classes: 6h
Self study (distance learning): 21h
Guided activities: 0h 45m

2. PN junction diode

Description:
2.1. The abrupt pn junction. Electrostatic balance. Loading zone space. Built-in voltage.
2.2. The pn junction under bias. Current-voltage characteristics of ideal diode.
2.3. Current-voltage characteristic of the real diode. Generation and recombination in the space charge zone. Rupture. The zener diode.
2.4. Dynamic resistance of the diode. Small-signal model.
2.5. Metal-semiconductor junctions. Ohmic contact and Schottky diode.
2.6. Introduction to optoelectronic devices: light emitting diode LED, laser diode, photodiode and solar cell.

Full-or-part-time: 37h 30m
Theory classes: 9h 45m
Practical classes: 6h
Self study (distance learning): 21h
Guided activities: 0h 45m

3. Field effect transistor

Description:
3.1. Classification of field effect transistors. The MOSFET transistor.
3.2. Electrostatic analysis of the MOS structure. Flat-band voltage and threshold voltage. MOS Capacity.
3.3. Static characteristics of MOSFET transistor.
3.4. Modes: cut, linear, and saturation.
3.5. Substrate effect. Features sub-threshold.
3.6. Equivalent circuits.
3.7. Scaling the MOSFET and hot electron effects.
3.8. Effects of short channel.
3.9. Example of digital implementation. CMOS inverter logic.

Full-or-part-time: 37h 30m
Theory classes: 9h 45m
Practical classes: 6h
Laboratory classes: 0h 45m
Work experience: 21h

4. Bipolar junctio transistor

Description:
4.1. Device structure. Transistor effect.
4.2. Static characterisitics. Ebers-Moll model. Cut-off, saturation, active (directe and reverse).
4.3. Parameters: Emitter injection efficiency, tranport factor, gain.
4.4. Non ideal effects: Base width modulation, high injection, breakdown.
4.5. Small signa equivalent circuit Pi model.
4.6. Amplifier circuit using bipolar transistor.

Full-or-part-time: 37h 30m
Theory classes: 9h 45m
Practical classes: 6h
Laboratory classes: 0h 45m
Work experience: 21h

GRADING SYSTEM

There will be a final exam (EF) and mid-semester exam (EP).
The final mark results from max{EF, 0.6*EF+0.4*EP}.

BIBLIOGRAPHY

Basic:
- Neamen, D.A. Semiconductor physics and devices: basic principles. 4th ed. New York: Mc Graw Hill, 2012. ISBN 978007352958-5.
- Sze, S.M.; Lee, M.K. Semiconductor devices: physics and technology. 3rd ed.; int. stud. version. Singapore: Wiley, 2013. ISBN 9788126556755.
- Streetman B.G.; Banerjee, S.K. Solid state electronic devices. 7th ed., global ed. Essex: Pearson, 2016. ISBN 9781292060552.