UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

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230471 - ELF - Physical Electronics

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering
Academic year: 2019
Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Teaching unit Compulsory)
ECTS credits: 6 Teaching languages: Catalan

Teaching staff

Coordinator: RAMON ALCUBILLA GONZALEZ

Others: CRISTOBAL VOZ SANCHEZ

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:

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.
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.

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

There will be three theoretical and two practical weekly sessions.

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.

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Study load

Total learning time: 150h	Hours large group:	65h	43.33%
	Self study:	85h	56.67%

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Content

1. Semiconductor physics.	Learning time: 37h 30m Theory classes: 9h 45m Practical classes: 6h Self study (distance learning): 21h Guided activities: 0h 45m

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.

2. PN junction diode	Learning time: 37h 30m Theory classes: 9h 45m Practical classes: 6h Self study (distance learning): 21h Guided activities: 0h 45m

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.

3. Field effect transistor	Learning time: 37h 30m Theory classes: 9h 45m Practical classes: 6h Laboratory classes: 0h 45m Work experience: 21h

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.

4. Bipolar junctio transistor	Learning time: 37h 30m Theory classes: 9h 45m Practical classes: 6h Laboratory classes: 0h 45m Work experience: 21h

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.

Qualification system

There will be a final exam (EF) and mid-semester exam (EP). The students' participation in class of problems (P) and work to be done in groups will be also taken into account.
The final mark results from max {EF, 0.65*EF+0:30*EP+0.05*P}.
The work will assesss generical skills

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Bibliography

Basic:

Streetman B.G.; Banerjee, S. Solid state electronic devices. 6th ed. Upper Saddle River: Prentice Hall, 2010. ISBN 9780132454797.

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: John Wiley & Sons Singapore, 2013. ISBN 9780470873670.