COURSE DATA

Data Subject	
Code	34875
Name	Electronic and photonic devices
Cycle	Grade
ECTS Credits	6.0
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. year	Period
1403 - Degree in Telematics Engineering	School of Engineering	2	Second term

Subject-matter

Degree	Subject-matter	Character
1403 - Degree in Telematics Engineering	3 - Electronic and photonic components and circuits	Basic Training

Coordination

Name	Department
VILA FRANCES, JOAN	242 - Electronic Engineering

SUMMARY

This 6 ECTS subject is given in the first four-month period of the second course of the Grade of Telematics Engineering. The subject allows to the student to reach a basic electronic knowlege and is developped in 150 working hours for the student along the four-month period: 90 hours of self-organised work and 60 hours of classroom lessons.

This subject as part of the matter “Electronic and Photonic Components and Circuits” has a basic training nature and provides a basic knowledge about electronic and photonic components and circuits. Specifically, this subject tries to offer to the student of the Grade an introduction to the electronic circuits and to the devices, both electronics and photonics, used in those circuits. As it is expressed in the contents of the Module of the grades in which this subject is given:"It offers to the students an introduction to electronic circuits. It will be described the physical and electronic operation, constituent materials and the circuital models of the different electronic and photonic devices. Also the basic knowledge of circuit theory and its application to the devices will be acquired”. Also "the principles of digital logic will be known”. It is intended, in this subject, “the students learn to understand the electronic circuits and its devices, they can apply the different techniques to solve and design circuits and how to use the electronic devices in these circuits”.

Of all the contents of the subject “Electronic and Photonic Components and Circuits”, the course “Electronic and Photonic Devices” is responsible of the description of the devices from inside the device to its output characteristics in a macroscopic scale, including its equivalent circuits. At the end of the course there will be seen some circuits using these devices to emphasize the knowledge about their operation.

Apart from the purely theoretical contents, the course will provide the student with the general knowledge necessary to solve engineering problems. The knowledge of how to solve these problems will be acquired in the problem sessions of the course where the students must find solutions to problems whose approach requires obtaining several solutions prior to final result.

About the skills that are needed for any engineer, the course contributes with the knowledge necessary to assemble of basic circuits on laboratory boards. The course provides the student the skills of search the components needed in a circuit, schematic circuits understanding, assembly of several devices with common nodes, measure on the circuits with laboratory instrumentation, show a set of measurements both on a table and on a graph and, finally, interpretation of the above mentioned data once obtained.

The course general objectives are to provide the student the necessary knowledge to understand the inner behaviour of electronic and photonic devices, know how the internal space charge regions are produced and how the internal electric field and the contact potential are modified when a device is forward or reverse biased. Once the devices are understood from the internal point of view, its output characteristics and equivalent circuits are shown. To consolidate the material taught in the course, in the last part of the course several simple circuits where the devices learned are used will be seen.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

The needed background to follow the course is acquired in the mathematics courses and in the course Electronic Circuits taught in first year of the grade. Within this knowledge must be emphasized the integral and derivative operation, the recognition of graphs and the data extraction from them. For the last part of the course a basic understanding of circuit theory is needed.

COMPETENCES (RD 1393/2007) // LEARNING OUTCOMES (RD 822/2021)

1403 - Degree in Telematics Engineering

- G3 - Acquisition of the knowledge of the basic and technological subjects that allows students to learn new methods and theories and endows them with the versatility to adapt to new situations.

- G4 - Ability to solve problems with initiative, decision-making and creativity, and to communicate and transmit knowledge, abilities and skills, understanding the ethical and professional responsibility of the activity of a telecommunications technical engineer.
- B4 - Understand and master the basic concepts of linear systems and the related functions and transforms, electric circuit theory, electronic circuits, physical principle of semiconductors and logic families, electronic and photonic devices, materials technology and their application to solve engineering problems.

LEARNING OUTCOMES (RD 1393/2007) // NO CONTENT (RD 822/2021)

The main result of learning is to understand the macroscopic characteristics and performance of electronic and photonic devices through the knowledge of its behavior at a microscopic level. When a student of the Grade uses an electronic or photonic device, he will know that it has constraints and nonlinear characteristics that depend on the manufacturing process. (G3, G4, G5 y B4)

Other results obtained by the student's learning of this subject are the following:

- Understand the operation of basic electronic and photonic devices and their features and limitations. (G3, G4, G5 y B4)
- Known the different materials used to manufacture the devices and their basic characteristics. (G3, G4, G5 y B4)
- Linearize the different devices and obtain its equivalent circuits to understand its operation. (G3, G4, G5 y B4)
- Be able to recognize the basic electronic and photonic components and simple electronic circuits. (G5 y B4)

Skills to be acquired:

After completing the course the student should be able to:

- Understand the internal structure of the silicon crystal, its covalent bond and how the dopant atoms act on the silicon.
- Understand the internal structure of a junction diode, and how this structure changes depending on the applied voltage. Knowing the output characteristic, the equivalent circuit and the dynamic behavior of the junction diode. Knowing the different types of diodes, Schottky diodes and Zener diodes. Learn simple circuits that use diodes.
- Understand the internal structure of the bipolar transistor, its different configurations and characteristic curves. Know its operation regions and some examples of circuits with bipolar transistors.
- Understand the internal structure of unipolar transistors. Know the characteristics, the operating areas and the limitations of unipolar transistors.
- Know the small-signal models of unipolar transistors and their applications in simple circuits.
- Know the operation of bipolar and unipolar transistor in switching operation.
- Know the basic logic gates with unipolar transistors (CMOS).

- Know the devices that are light-sensitive, the devices that emit light when excited and know the most currently used devices that convert light into current.

After the student has completed the course “Electronic and Photonic Devices”, he must have acquired a number of social aptitudes. These social aptitudes can be classified as instrumental, personal and systemic.

Instrumental aptitudes:

- Ability to analyze an engineering problem for its optimal resolution.
- Ability to organize and plan the course like a project.
- Appropriate use of scientific-technical terms.
- Ability to manage the time spent for the study.
- Ability to write documents in a formal language understandable to other engineers.
- Ability to make decisions.

Personal aptitudes:

- Ability to work in a multidisciplinary team.
- Ability to work in an international context.
- Ability to communicate with experts in other areas.
- Skills in interpersonal relationships.
- Critical reasoning.
- Ethical commitment.

Systemic aptitudes:

- Ability to apply the knowledge acquired in the course.
- Ability to learn and work independently.
- Adaptation to new situations.
- Creativity. Ability to explore new solutions.
- Leadership. Initiative and enterprising spirit.
- Capacity of personal improvement in problem solving.

DESCRIPTION OF CONTENTS

1. Introduction

Topic 1: Introduction to semiconductor materials. Intrinsic and doped semiconductor materials. Doped techniques in semiconductor materials.

2. The semiconductor diode

Topic 2: The pn junction. The PN junction with and without polarization. The polarized PN junction. Currents in the PN junction. The static characteristic.
Topic 3: Types of diodes. The avalanche effect. The Zener diode. The Schottky diode. Parameters and characteristis of the different types of diodes. Datasheets.
Topic 4: Using diodes. Switching response. The small-signal model. Application examples using signal diodes. Circuits using Zener diodes.

PRACTICE 1: Introduction to the laboratory equipment. Experimental determination of the I-V characteristic of the Si junction diode. (5 hours)

3. The bipolar transistor

Topic 5: PNP and NPN junctions without polarization and polarized. Operating regions based on the minority carrierss concentration in the base. Parameters and currents depending on the internal characteristics of bipolar transistors. Parameters and characteristic curves of bipolar transistors.
Topic 6: Datasheets of bipolar transistors.
Topic 7: Use of bipolar transistors. Switching transients. The small-signal model. Examples of application of bipolar transistors.

PRACTICE 2: Obtaining experimental characteristic of the bipolar transistor (VCE-IC) in the common emitter configuration. Current gain for common emitter configuration. (2.5 hours)

4. The unipolar transistor

Topic 8: Internal structure of unipolar transistors. The MOSFET transistor. Operating regions and currents of unipolar transistors as function of their internal characteristics. Curves and characteristic parameters of the unipolar transistor.
Topic 9: Datasheets of unipolar transistors.
Topic 10: Using unipolar transistors. Switching study. The small-signal model. Application examples of unipolar transistors.

PRACTICE 3: MOSFET transistor characteristics. (2.5 hours)
PRACTICE 4: Switching bipolar and unipolar transistor: Comparative. (2.5 hours)

5. Families and logic gates

Topic 11: Families and logic gates. Basic logic gates.

PRACTICE 5: Transfer characteristic of logical gates (2.5 hours)

6. Photonic devices

Topic 12: Light-sensitive devices. Photoresistor. Photodiode. Phototransistor. Light-emitting devices. LED.

PRACTICE 6: Applications of photoresistors, leds and solar cells. (2.5 hours)
PRACTICE 7: Individual Test (2 hours).

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	30,00	100
Laboratory practices	20,00	100
Classroom practices	10,00	100
Attendance at events and external activities	1,00	0
Preparation of evaluation activities	50,00	0
Preparing lectures	9,00	0
Preparation of practical classes and problem	30,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

TECHNICAL LECTURES.

The technical lectures are master classes. During the master class the lecturer will ask some questions to the students to monitor the student progress in its self-organised work previous to each class. The master class will be supported by animated slides to improve the understanding of the abstract concepts involved in the devices junctions. All the support material used in the lectures (slides, papers, web links, bibliography, etc), will be available for the student in the online application “Aula Virtual”. Competencies G3 and B4 are worked.

PROBLEM CLASSES.

The problem classes will be held in the classroom with a smaller group of students that in the technical lectures. In the problem classes some of the more significant problems that appear in the Problem Sheet will be solved. The problems will be solved in the backboard by the professor or by the students. As in the technical lectures, all the teaching resources will be available in Aula Virtual. Competencies G4 and B4 are worked.

LABORATORY SESSIONS

The laboratory sessions will be held in the laboratories of the ETSE. During the first half an hour of each laboratory session, the professor will evaluate the student self-organised work about the contents of the scheduled session. This evaluation will be done through some short questions, time scheduled of 15 minutes, or through some individual questions to the students in those groups with fewer students. Competencies G3, G4, G5 and B4 are worked.

TUTORIALS

The students have a tutorial timetable to solve problems, doubts, work orientation, etc. The tutorial timetable is set at the beginning of the academic course. Competencies G3, G4, G5 and B4 are worked.

EVALUATION

Regarding the evaluation process, different dimensions of the teaching-learning process will be considered. Note that the evaluation is proposed as formative, that is, comments will be provided that favor the correction of aspects to be improved. Daily interaction between students and teachers, comments in the Aula Virtual or review sessions will be used for that purpose.

In both first and second call, the final grade (NF) responds to the evaluation instruments according to the following expression:

$$NF = Ex \cdot 0{,}35 + ExP \cdot 0{,}1 + TC \cdot 0{,}15 + AyP \cdot 0{,}05 + LabEC \cdot 0{,}14 + LabEx \cdot 0{,}21$$

In any case, (1) NF will be equal to Ex if the result of Ex is less than 4/10, (2) NF will be equal to LabEx if the result of LabEx is less than 4/10.

The different evaluation instruments are described below:

Ex: Exam. This is an individual objective test. It may contain both short questions, as well as the development of theoretical-practical questions, problems, etc. Any aspect presented during the course can be questioned. New problems related to the subject may also appear, as this is considered a useful methodology to assess the consolidation of competencies and content. This test will be carried out according to the ETSE exam calendar, Ex1 corresponds to the first call and Ex2 to the second.

Participation in Ex2 will be mandatory if the subject is not passed in the first call, otherwise the grade in the second call will be Not Presented. Any exception in this regard must be authorized by the teacher.

ExP: Midterm exam. During the course and during class hours, a test will be carried out to evaluate the consolidation of content and competences, as well as to give students the opportunity to face exercises like those that can be found in the Exam. The contents applicable to said test, as well as the rules to follow and the date will be communicated during the course. This test will not reduce contents for the Exam.

TC: Collaborative tasks. During the course, different collaborative tasks will be proposed, essentially problems. They can be proposed both in the classroom and in a non-face-to-face way. These tasks will be carried out as a team. Coordination between different members of a team, the discussion to reach consensus solutions, etc. will be worked on these tasks. Peer and continuous assessment techniques may be used to differentiate the grades of different members of a team. *Tasks delivered after the deadline will not be considered.*

AyP: Attendance and participation. The contents and competences worked on during the course often exceed the specific exercises and problems of the objective tests. Therefore, attendance and participation of students throughout the course is required to achieve the highest grade. Teachers will be able to use different techniques to assess attendance, and participation during the theory or problem sessions.

LabEC: Continuous evaluation of laboratories. Each lab session will have a note associated. The degree of achievement, autonomy, and ability to interpret the results will be evaluated. In addition, each session may have associated preparation tasks that can constitute up to a fourth of the mark for each practice. LabEC will be calculated as the average between the marks obtained in each session. Attendance is mandatory to have a note associated with the session.

Unjustified non-attendance at the laboratory may be penalized beyond a 0 in the corresponding practice.

LabEx: Laboratory examination. The students will undergo an individual laboratory examination with exercises similar to those carried out at the lab sessions. LabEx1 corresponds to the first call, its date of completion will be indicated during the course. LabEx2 corresponds to the second call and will be held on the official date designated by the ETSE.

Participation in LabEx2 will be mandatory for students who have not achieved a grade higher than 4/10 in LabEx1. Voluntary participation in LabEx2 must be authorized by the teachers.

In any case, the evaluation system will be governed by what is established in the Evaluation and Qualification Regulations of Universitat de València for Bachelor's and Master's degrees.

(http://www.uv.es/graus/normatives/2017_108_Reglament_avaluacio_qualificacio.pdf).

REFERENCES

Basic

- Electrónica. A.R. Hambley. Ed. Prentice-Hall International, Inc. 2001, 2ª Edición, ISBN 84-205-2999-0.
- Microlectronic Circuits. A.S. Sedra, K. C. Smith. Mc Graw Hill, 2ª Edición, ISBN 13-978-970-10-5472-7.
- Principios de Electrónica. A. Malvino, D. J. Bates, Ed. McGraw-Hill 2007, 7ª Edición, ISBN 978-84-481-5619-0.
- Semiconductor Devices. Kanaan Kano. Ed. Prentice-Hall International, Inc. 1998, 1ª edición, ISBN 0-02-361938-4.
- Semiconductor Devices. Physics and Technology. S.M. Sze. Ed. John Wiley & Sons 1985, ISBN 0-471-87424-8.
- Solid State Electronic Devices. Ben G. Streetman. Ed. Prentice-Hall International, Inc. 1995, ISBN 0-13-436379-5.
- Electronic Devices, Discret and Integrated, S.R. Fleeman, Ed. Prentice-Hall, 1990, ISBN 0-13-336181-0.
- Circuitos electrónicos: Análisis, simulación y diseño, N.R. Malik, Ed. Prentice-Hall, 1997, ISBN 978-84-89660-03-8.
- Optoelectronics. Endel Uiga. Ed. Prentice-Hall, Inc. 1995, 1ª edición, ISBN 0 02 422170-8.
- "Fiber-Optic Communications Technology", D.K. Mynbaev, L.L. Scheiner, Ed. Prentice-Hall, 2001, ISBN 0-13-962069-9.

Additional

- Microelectrónica: Circuitos y Dispositivos. M.N. Horenstein. Prentice-Hall Hispanoamericana, S.A., 2ª Edición, ISBN 968-880-707-9.
- Fundamentos de semiconductores. Robert F. Pierret. Ed. Addison-Wesley Iberoamericana 1994, ISBN 0-201-60144-3.
- El diodo PN de union. Gerold W. Neudeck. Ed. Addison-Wesley Iberoamericana 1993, ISBN 0-201-60142-7.
- El transistor bipolar de unión. Gerold W. Neudeck. Ed. Addison-Wesley Iberoamericana 1994, ISBN 0-201-60143-5.
- Dispositivos de efecto de campo. Robert F. Pierret. Ed. Addison-Wesley Iberoamericana 1994, ISBN 0-201-60141-9.
- Introduction to microelectronic fabrication. Richard C. Jaeger. Ed. Addison-Wesley Publising Company 1998, ISBN 0-201-14695-9.
- Optoelectronics. An Introduction to Materials and Devices. Jasprit Singh. Ed. McGraw-Hill Companies, Inc. 1996, 1ª edición, ISBN 0-07-057650-5.
- Fundamentos de microelectrónica, nanoelectrónica y fotónica. J.M. Abella Martín, J.M. Martínez-Duart, F. Agulló-Rueda. Ed. Prentice-Hall-Pearson Education. 2005, 1ª edición, ISBN 84 205 4651-8.