Project/Course Programme

Name of the course	DIGITAL ELECTRONICS		
Subject / branch of study	ELECTRONICS		
Module	TELECOMMUNICATIONS AND ELECTRONICS FUNDAMENTALS		
Degree	DEGREE IN TELECOMMUNICATION TECHNOLOGIES ENGINEERING DEGREE IN SPECIFIC TELECOMMUNICATION TECHNOLOGIES ENGINEERING		
Study Plan	512 460	**Code**	46611 45012
Teaching Period	1ST SEMESTER	**Category**	COMPULSORY
Level	DEGREE	**Course Year**	2ND
ECTS Credits	6 ECTS		
Language of instruction	ENGLISH		
Responsible teacher/s	LUIS ALBERTO MARQUÉS CUESTA		
Contact details (E-mail, telephone...)	TELEPHONE: 983 185503 E-MAIL: lmarques@uva.es		
Department	ELECTRICITY AND ELECTRONICS		

1. Presentation

1.1 Contextualization

We are living in an age that sociologists have called “the digital revolution”. Like any true revolution, it is widespread and has a great impact on society. It is as fundamental to our present economic and social order as was the industrial revolution in the nineteenth century, as it affects the thinking patterns and life-styles of every individual.

Almost all fields related to engineering are permeated by digital electronics. Communication systems for most companies throughout the world have already gone digital or will certainly do so in the near future. For example, cell phones and other types of wireless communication such as television, radio, process controls, automotive electronics, consumer electronics, global navigation and military systems, to name only a few applications, depend heavily on digital electronics.

This subject is designed to serve as a first contact to digital systems for telecommunications, electrical, electronics and computer science engineers. In particular, it belongs to the block of basic matters of both Telecommunications degrees. It covers topics going from the mathematics fundamentals of the Boolean algebra to the analysis and design of all types of digital circuits, both combinational and sequential, that serve as the building blocks of any computer based system.

1.2 Relationship with other courses within the subject and/or module

The topics covered in the present subject constitute, along with Analog Electronics (also taught in the first semester of the second course of both Telecommunications degrees), the fundamentals of all types of electronic circuits. In turn, the digital circuits studied here will serve to construct algorithmic state machines and computers that are covered in detail in the subject Microprocessor-based Electronic Systems (on the second semester of the second course in both Telecommunications degrees).

1.3 Prerequisites

None.

2. Competencies

2.1 General Competencies

- GB1. Ability to reason, analysis and synthesis.
- GB3. Ability to make decisions in the resolution of basic telecommunications engineering problems, as well as their identification and formulation.
- GB5. Knowledge of basic subjects, of scientific and technological character, which enables you to learn new methods and technologies.
- GC1. Ability for organization, planning and time management.
- GC2. Ability to communicate, both in writing and orally, knowledge, procedures, results and ideas related to telecommunications and electronics.
- GC3. Ability to work in any context, individually or in group, learning or professional, local or international, respecting fundamental rights, equality of sex, race or religion, and the principles of universal accessibility, as well as the culture of peace.

2.2 Specific Competencies

- B4. Understanding and mastery of the basic concepts of linear systems and related functions and transformations, electrical circuit theory, electronic circuits, physical principle of semiconductors and logical families, electronic and photonic devices, materials technology and their application for solving problems related to engineering.
- T9. Ability to analyze and design combinational and sequential circuits, synchronous and asynchronous, and to use microprocessors and integrated circuits.
- T10. Knowledge and application of the fundamentals of hardware description languages (HDLs).

3. Objectives

At the end of the course, the student must be able to:

- Know and understand fundamental concepts related to digital electronic circuits.
- Analyze and design (synthesize) basic digital electronic circuits at the logic gate level.
- Understand the differences between logic families and their evolution to the present.
- Choose, among the different types of mass storage systems, those that fit a specific application.
- Use component specification sheets to extract the most relevant data and be able to compare between different alternatives.
- Work in groups to use CAD tools based on hardware description languages for the design of digital blocks and the subsequent verification of their correct operation.
- Organize, plan and manage laboratory time.
- Communicate, both in writing and orally, the procedure used in the laboratory and the difficulties that may arise.

4. Contents and/or thematic modules

Single module: "Digital Electronics"

Workload in ECTS credits: 6

a. Contextualization and justification

This subject consists of a single block and therefore it is not necessary to contextualize or justify it.

b. Learning objectives

This subject consists of a single block that includes, therefore, the learning objectives of the complete course (see section 3).

c. Contents

UNIT 1 – FUNDAMENTALS

1.1.- Introduction.
1.2.- Boolean Algebra.
1.3.- Two-variable logic functions. Functional completeness.
1.4.- Information coding.
1.5.- Minimization of logic functions. Canonical form.

UNIT 2 – LOGIC FAMILIES

2.1.- Introduction.
2.2.- The MOS transistor.
2.3.- The CMOS family.
2.4.- Other families. Comparative.

UNIT 3 – COMBINATIONAL CIRCUITS

3.1.- Introduction.
3.2.- AND-OR design and analysis.
3.3.- NAND-NOR design and analysis.
3.4.- Hazards.

Lab session 1 – Structural design (1st part).

UNIT 4 – COMBINATIONAL MODULES

4.1.- Introduction.
4.2.- Decoder.

4.3.- Encoder.

4.4.- Code converter.

4.5.- Multiplexer.

4.6.- Demultiplexer.

4.7.- Comparator.

4.8.- Adder.

4.9.- Arithmetic-Logic Unit (ALU).

Lab session 2 – Structural design (2nd part).

Lab session 3 – RTL design.

UNIT 5 – LATCHES AND FLIP-FLOPS

5.1.- Introduction.

5.2.- Static latches.

5.3.- Dynamic latches.

5.4.- Flip-flops.

UNIT 6 – SEQUENTIAL CIRCUITS

6.1.- Introduction.

6.2.- Design procedure.

6.3.- Moore and Mealy automata.

Lab session 4 – Algorithm-based description (1st part).

UNIT 7 – SEQUENTIAL MODULES

7.1.- Introduction.

7.2.- Storage registers.

7.3.- Transferring digital information. Buses.

7.4.- Counters.

7.5.- Shift registers.

7.6.- Operational registers.

Lab session 5 – Algorithm-based description (2nd part).

UNIT 8 – MEMORIES

8.1.- Introduction.

8.2.- Random access memories.

8.3.- Sequential memories.

d. Teaching method

- Master class for the exposition of theoretical contents. Participation of the students in the class development will be encouraged.
- Resolution of proposed exercises by the teacher with the collaboration of students.
- Laboratory sessions for the use of CAD tools and hardware description languages (Verilog) for the design of digital circuits, their verification and the analysis of their operation.

e. Working plan

See section 6.

f. Assessment

The assessment of the acquisition of competencies will be based on:

- Midterm written exam (contents from unit 1 to unit 4).
- Final written exam on the entire content of the subject at the end of the semester.
- Student performance during a final lab exam.

g. Basic bibliography

- *Fundamentals of Digital Electronics.* D. Natarajan. Springer, 2020 (link).
- *Logic and Computer Design Fundamentals*. M.M. Mano, C.R. Kime. Pearson, 2014 (link).
- *Solved problems in Digital Electronics*. I. del Villar, F.J. Arregui, J. Goicoechea. Marcombo, 2018 (link).
- M.D: Ciletti, *Modeling, Synthesis and Rapid Prototyping with the Verilog HDL*, Prentice Hall, 1999 (link).
- James M. Lee. *Verilog Quickstart*, 3rd edition (link).

h. Complementary bibliography

- *Digital Design and Computer Architecture*. D.M. Harris, S.L. Harris. Morgan Kaufmann, 2013.
- *Digital Design Principles and Practices*. J.F. Wakerly. Pearson, 2018.
- *Engineering Digital Design*. R.F. Tinder. Academic Press, 2000.
- *Fundamentals of Digital Logic and Microcomputer Design*. M. Rafiquzzaman. Wiley, 2005.
- *Digital Electronics*. D.K. Kaushik. Dhanpat Rai Publishing Company, 2015.

i. Resources

The following resources will be provided:

- Transparencies to follow during the development of master classes.
- Support documentation for the resolution of problems in the classroom and for the realization of practical work in the laboratory.
- PC lab with software for digital circuit design and simulation.

j. Timing

ECTS LOAD	EXPECTED PERIOD FOR IMPLEMENTATION
Single module “Digital Electronics”, 6 ECTS	Weeks 1 to 15

5. Teaching method and methodological principles

See section 4.d.

6. Table of estimated dedication time of the student to the course

CLASS ACTIVITIES	Number of hours	OUT OF CLASS ACTIVITIES	Number of hours
Master classes	28	Personal study	90
Resolution of exercises	20		
Lab sessions	10		
Midterm exam (theory)	2		
Total	**60**	**Total**	**90**

7. Assessment

Assessment instruments		FINAL GRADE percentage	Observations
LABORATORY (L)		50%	Individual lab exam at the end of the semester about the design and simulation of a digital circuit with Verilog.
THEORY	Units 1 to 4 (T1)	50%	The theoretical contents of units 1 to 4 (T1) are evaluated from 0 to 4 points in the: - Midterm exam, halfway through the semester. - Final exam, in an optional session, only for those students who did not attend the midterm exam or who want to improve their mark in this part of the subject.
	Units 5 to 8 (T2)		The theoretical contents of units 5 to 8 (T2) are evaluated from 0 to 6 points in the final exam.

Assessment Criteria
Ordinary call: The subject grade (from 0 to 10 points) is calculated by the geometric mean of the marks obtained in the two assessment instruments, theory and laboratory, according to the following formula: FINAL GRADE = (T1 mark + T2 mark)^0.5 * (L mark)^0.5 **Extraordinary call:** If any of the L, T1 or T2 procedures has been passed (with L ≥ 5, T1 ≥ 2, T2 ≥ 3) in the ordinary call, the corresponding mark is kept for the extraordinary call. In such cases, the students only have to attend the failed procedures, or those in which they want to improve their marks. The final grade is obtained with the same formula that was specified for the ordinary call.

8. Final considerations