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		
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Department	ELECTRICITY AND ELECTRONICS		

1. Presentation

1.1 Contextualization

We are living in an age that sociologist 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 enable 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.

3. Objetives

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 construct digital circuits from basic integrated components, and to use electronic instruments to check and test them.
- 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 – Implementation of a combinational circuit with logic gates.

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 – Circuit implementation using combinational modules.

UNIT 5 – LATCHES AND FLIP-FLOPS

5.1.- Introduction.

5.2.- Static latches. D-type latch.

5.3.- RS latch. Dynamic latches.

5.4.- D-type flip-flop.

5.5.- JK and T-type flip-flops.

UNIT 6 – SEQUENTIAL CIRCUITS

6.1.- Introduction.

6.2.- Design procedure.

6.3.- Moore and Mealy automata.

Lab session 3 – Implementation of a sequential circuit.

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 4 – Implementation of a register-based circuit.

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.
- Design, simulation and implementation of basic digital circuits in the laboratory. Analysis and checking of its operation. Failure detection and correction. Possible alternatives and modifications.

e. Working plan

See section 6.

f. Assessment

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

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

g. Basic bibliography

- *Digital Logic Circuit Analysis & Design.* V.P. Nelson, H.T. Nagle, J.D. Irwin, B.D. Carrol. Prentice Hall, 2001.
- *Logic and Computer Design Fundamentals*. M.M. Mano, C.R. Kime. Pearson, 2008.
- *Solved problems in Digital Electronics*. I. del Villar, F.J. Arregui, J. Goicoechea. Marcombo, 2018.
- *Theory and principles of Digital Electronics*. R.L. Tokheim. McGraw-Hill, 1994.

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.

- Basic electronics lab equipment, needed for signal generation, measurement and assembling of digital circuits.
- Fungible lab material, basically consisting of integrated circuits.
- 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
UNIT 1: Master classes Resolution of problems	4 3	Personal study	10.5
UNIT 2: Master classes	5	Personal study	7.5
UNIT 3: Master classes Resolution of problems Lab session	2 4 2	Personal study Resolution of problems Preparation of the lab work	3 6 3
UNIT 4: Master classes Resolution of problems Lab session	4 4 2	Personal study Resolution of problems Preparation of the lab work	6 6 3
PARTIAL EXAM	2	Review of contents from unit 1 to unit 4	3
UNIT 5: Master classes	4	Personal study	6
UNIT 6: Master classes Resolution of problems Lab session	4 6 2	Personal study Resolution of problems Preparation of the lab work	6 9 3
UNIT 7: Master classes Resolution of problems Lab session	3 3 2	Personal study Resolution of problems Preparation of the lab work	4.5 4.5 3
UNIT 8: Master classes Resolution of problems	2 2	Personal study Resolution of problems	3 3
Total	**60**	**Total**	**90**

7. Assessment

Assessment instruments		FINAL GRADE percentage	Observations
LABORATORY	Lab sessions	10%	Assessed by systematic observation of the work done during the lab sessions.
	Individual exam	10%	In the date fixed by the E.T.S.I.T.
THEORY	Partial exam	30%	Assessment of concepts learned from unit 1 to unit 4 (around the semester half).
	Final exam	(30% +) 50%	In the date fixed by the E.T.S.I.T. Divided into two parts: - First one, with a grade percentage of 30%, to assess concepts learned from unit 1 to unit 4. It is equivalent to the partial exam. It is optional, meant for students who did not attend the partial exam or did not get good marks. - Second one, with a grade percentage of 50%, to assess concepts learned from unit 5 to unit 8.

Assessment Criteria
Ordinary call: • To pass the subject it is necessary to achieve at least a grade percentage of 10% in the laboratory instrument and of 40% in the theory instrument. • Those students who have not reached the minimum grade in one of the instruments will have to repeat the failed instrument in the extraordinary call. Grades over the minimum will be maintained in the corresponding instrument. **Extraordinary call:** • Those students who did not reach in the ordinary call the minimum grade percentage of 40% in the theory instrument will have to take a theory exam covering ALL the subject contents. This exam will have a grade percentage of 80%. • Those students who did not attend the lab sessions or did not pass the laboratory instrument in the ordinary call will have to take an individual laboratory exam. This lab exam will have a grade percentage of 20%. • Similarly to the ordinary call, to pass the subject is necessary to obtain a minimum grade percentage of 10% in the laboratory instrument and of 40% in the theory instrument. In any of the calls, for those students who have not reached the minimum grade percentage in the theory or lab assessments, the final grade will determined by the mark of the failed instrument.

8. Final considerations