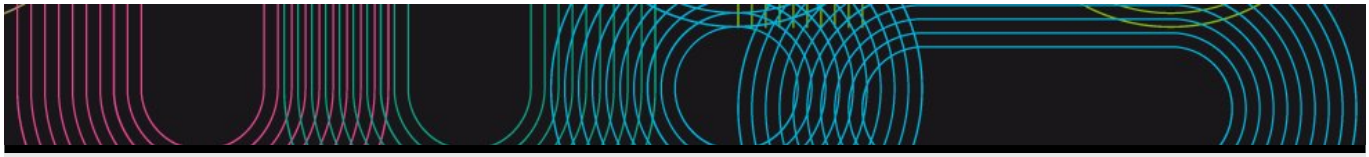

IDENTIFYING DATA				
Digital electronics and microcontrollers				
Subject	Digital electronics and microcontrollers			
Code	V12G330V01601			
Study programme	Grado en Ingeniería en Electrónica Industrial y Automática			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	9	Mandatory	3rd	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Soto Campos, Enrique			
Lecturers	Costas Pérez, Lucía Rodríguez Andina, Juan José Soto Campos, Enrique			
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Web	http://moovi.uvigo.es			
General description	The general objective of this subject is for students to acquire the skills and abilities necessary for the design, analysis, simulation, debugging, testing and maintenance of basic digital electronic circuits made with medium-scale integration circuits (MSI), with reconfigurable devices (FPGAs) or with microcontrollers. The content of the course emphasizes the following aspects: - Study the operating parameters of the logic families taking into account the manufacturing technology. - Study of the design methodology for combinational digital circuits. - Analysis of the basic functional blocks of combinational digital circuits. - Study of the design methodology of sequential digital circuits. - Analysis of the basic functional blocks of sequential digital circuits. - Description and use of hardware description languages (HDL) as a tool for the specification of digital circuits. - Description of the types of Semiconductor Memories, their operating parameters and their applications. - Study of the basic structure of a microprocessor and a microcontroller. - Study of the design methodology of digital systems based on microcontrollers. English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B3	CG3 Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations.
B4	CG4 Ability to solve problems with initiative, decision making, creativity, critical thinking and the ability to communicate and transmit knowledge and skills in the scope of industrial engineering in the field of Industrial Electronic and Automation.
C21	CE21 knowledge of the fundamentals and applications of digital electronics and microprocessors.
C24	CE24 Ability to design analog, digital and power electronic systems.
D2	CT2 Problems resolution.
D9	CT9 Apply knowledge.
D17	CT17 Working as a team.

Expected results from this subject	Training and Learning Results

Know the technologies of manufacture and parameters of operation of the logical families.	B3	C21 C24	
Dominate the technicians of design of digital circuits combinational and sequential.		C21 C24	D2 D9
Know the types and applications of semiconductor Memories.	B3	C21	
Know the basic structure of a microprocessor and microcontroller.	B3	C21 C24	
Dominate the procedures of design and realisation of application of microcontrollers.	B4	C21 C24	D2 D9 D17
Adquire basic skills of specification of digital electronic circuits with languages of description of hardware (HDL)		C21	
Know the methodologies and tools for the simulation purification and verification of operation of digital electronic circuits.		C21	

Contents	
Topic	
Theory 1.1 INTRODUCTION TO DIGITAL ELECTRONICS	Number Codes. Boolean algebra. Basic logic gates.
Theory 1.2 DIGITAL ELECTRONIC TECHNOLOGIES	Digital technologies: electric and timing characteristics, circuits coupling, output circuits.
Theory 1.3 BASIC CONCEPTS OF HDLs	Methodologies of digital design. Hardware Description Languages. Structures and sentences of VHDL language: Types of descriptions, multivalued logic, examples, simulation.
Theory 1.4 ANALYSES AND DESIGN OF COMBINATIONAL CIRCUITS	Logic functions. Simplification of functions. Incomplete functions.
Theory 1.5 COMBINATIONAL FUNCTION BLOCKS	Decoders, coders, multiplexers, demultiplexers, Buffers, tri-state
Theory 1.6 BASIC SEQUENTIAL DIGITAL CIRCUITS	Definition and types of sequential systems. Bistables asyinchronous and synchronous. Specification of the timing behavior (cronograms). Functional blocks: registers (parallel, shift), counters. Descriptions in VHDL of the sequential functional blocks.
Theory 1.7 SEMICONDUCTOR DIGITAL MEMORIES	Definition and general properties. random and sequential access memories. Active and passive memories. Volatile memories and non-volatile. Static and dynamic memories. Memory control signals. Cronograms. Logical functions design with memories.
Theory 1.8 INTRODUCTION TO CONFIGURABLE CIRCUITS	Programmable Logic Array. PLDs: basic architecture. FPGAs: basic architecture. Functional blocks in FPGAs.
Theory 1.9 FINITE STATE MACHINES	State machine specification. FSM Analysis. FSM Design. Implementation with registers and counters. State coding. Descriptions in VHDL of FSMs.
Theory 1.10 COMBINATIONAL FUNCTION BLOCKS II	Arithmetic circuits, comparators, parity generators/detectors.
Theory 1.11 VHDL Hardware Description Language.	Signals and variables, parameters, subprograms, data types and analysis of the cycle of simulation cycle.
Theory 2.1 INTRODUCTION TO MICROCONTROLLERS	Introduction. Component of a microcontroller. Memory architectures. Instruction set architectures.
Theory 2.2 CHARACTERISTICS OF THE PIC MICROCONTROLLERS.	Introduction. General description of the internal structure. Arithmetical and logical unit. Memory of Program. Memory of Data. Peripherals.
Theory 2.3 PROGRAMMING OF A MICROCONTROLLER. INSTRUCTION SET I	Concept of computer program. Level of abstraction. Structure of the instructions. For the microcontroller of Microchip of the PIC18 family: Introduction to the instructions set, size and execution time of the instructions and codes of operation.
Theory 2.4 PARALLEL INPUT/OUTPUT OF THE PIC18	Introduction. Basic concepts of parallel I/O. Control of transfer. PIC18 Structure of I/O. Transfer in parallel. Examples of connection of peripherals.
Theory 2.5 PROGRAMMING OF A MICROCONTROLLER. INSTRUCTIONS SET II	Addressing modes. Addressing modes for the PIC18, structure of the instructions and other codes of operation.
Theory 2.6 PIC18F CHARACTERISTICS II	Control Unit . Pipelining. Management of tables in program memory.
Theory 2.7 PERIPHERAL MANAGEMENT. TIMERS. TIMERS IN THE PIC18.	Control of the transfer of information. Periodic poll. Basic structure of a timer. Timers/Counters in the PIC18F microcontroller
Theory 2.8 PERIPHERAL MANAGEMENT. INTERRUPTIONS IN THE PIC18	Concept of exception. Interruptions. Management of interruptions in the microcontroller PIC18.
Theory 2.9 ANALOG RESOURCES OF THE PIC18f	Introduction. Digital Analog/conversion in the PIC18 microcontroller.
Theory 2.10 EXAMPLES OF APPLICATIONS OF MICROCONTROLLERS	Examples of applications of microcontrollers made with the PIC18 microcontroller .

Practice 1 INTRODUCTION To THE LABORATORY OF DIGITAL ELECTRONICS	Introduction to the laboratory of digital electronics, available resources, documentation, methodology of work. Study of the static and dynamic characteristics of a digital circuit. Setting of a combinational circuit with logic gates. Verification by means of the logical probe and the oscilloscope.
Practice 2 INTRODUCTION To THE SIMULATION OF DIGITAL CIRCUITS DESCRIBED IN VHDL.	Simulation environment of circuits described in VHDL. Modelling of combinational circuits in VHDL with concurrent sentences. Modelling of algorithms in VHDL (descriptions of behaviour) with sentences no concurrent. Design of a simulation test-bench. Simulation of the circuit.
Practice 3 STUDY OF THE OPERATION OF THE DIGITAL CIRCUITS SYNCHRONISED BY MEANS OF A CLOCK.	Study of the sequential circuits and of the Logical Analyser. Know the characteristics of the synchronous digital circuits. Analysis of the maximum frequency of work. Analysis of the evolution between states. Elimination of bounces. Analysis of the operation of a synchronous counter. Know the operation of the Logical Analyser.
Practice 4 INTRODUCTION To THE SIMULATION OF SEQUENTIAL DIGITAL CIRCUITS DESCRIBED IN VHDL.	Modelling of sequential circuits in VHDL using the sentence process. Modelling in VHDL by means of sentences no concurrent of a circuit counter. Design of a test bench for the circuit. Simulation of the circuit.
Practice 5 INTRODUCTION To THE IMPLEMENTATION OF DIGITAL CIRCUITS IN FPGAs.	Study of the development board with a configurable circuit. Study of the documentation associated to the configurable device used. Study of the available peripherals to make systems based in the device reconfigurable used. Synthesis of a simple example.
Practice 6 SIMULATION AND IMPLEMENTATION OF SYNCHRONOUS SEQUENTIAL SYSTEMS	Design and physical realisation of a synchronous digital circuit described by means of a state graph using a multiplexer and a counter. Structural modelling in VHDL. Design of a teste bench. Simulation of the circuit. Programming of the circuit in the device in the development board.
Practice 7 DESIGN AND IMPLEMENTATION OF A DIGITAL SYSTEMS BASED IN FPGA	Design and simulation of a synchronous sequential system of control of simple peripherals (display, LEDs, switches, keyboard, etc.). Implementation using a FPGA development board.
Practice 8 SIMULATING AND PROGRAMMING APPLICATIONS IN PIC MICROCONTROLLERS	Presentation of the computer tools and of the available hardware for the design, simulation and test of applications based in the Microchip microcontroller.
Practice 9 PARALLEL INPUT/OUTPUT	Program and check the operation of the peripherals of parallel I/O using the PIC microcontroller environment.
Practice 10 TIMERS / COUNTERS	Check the operation of the timer peripherals of the PIC microcontroller.
Practice 11 INTERRUPTIONS.	Check the management of interruptions of peripherals in the PIC microcontroller.
Practice 12 ANALOG INPUT	Program and check the operation of the digital to analog converter of the PIC microcontroller.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	48	84	132
Laboratory practical	24	54	78
Essay questions exam	4	11	15

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Explanation by the teaching staff of the relevant aspects of the contents labeled with the epigraph "Theory". For a better understanding of the contents and an active participation in the Session, the students must carry out a previous personal work on the proposed bibliography. In this way, students will be able to ask questions, ask for clarifications or express doubts, which may be resolved in the Session or in personalized tutorials. For a better understanding of certain contents, practical examples planned to increase student participation will be presented. Students must carry out subsequent personal work to assimilate the concepts and acquire the skills corresponding to each Session. They will be developed in the schedules and classrooms indicated by the direction of the center.

Laboratory practical	Activities to apply the theoretical knowledge acquired. They are intended for students to acquire abilities and skills related to the design, simulation, debugging, testing and maintenance of digital electronic circuits. In these sessions, students will use electronic instrumentation for the analysis of digital electronic circuits, design tools, simulation and debugging of digital electronic circuits based on reconfigurable devices (FPGAs), and tools for programming, simulation and debugging of digital electronic circuits based on microcontrollers. . Students will face the design and testing of simple digital electronic circuits based on FPGAs and microcontrollers. For each practice there will be a statement indicating the previous personal work that the students must carry out, the tasks that must be carried out in the practical session and the relevant aspects for the evaluation of the practice. They will be held in the Digital Electronics Laboratory of the Department of Electronic Technology, at the times indicated by the center's management. The students will be organized in groups of two people. An attendance check will be carried out.

Personalized assistance

Methodologies	Description
Lecturing	The students will have occasion to attend to personalised attendance in the office of the professor in the schedule that the professors will establish to such effect at the beginning of the course and that will publish in the web page of the subject. In it the professors of the subject will resolve the doubts related with the contents given in the sessions and will orient them on as tackle his study.
Laboratory practical	In addition to the attention of the professor of practicals during their realisation, the students will be able to attend to personalised attendance to pose and resolve the difficulties of the previous works recommended to make the practicals.

Assessment

	Description	Qualification	Training and Learning Results
Laboratory practical	As part of the continuous assesment of the subject, each student will be evaluated in each of the practicals. The evaluation will take into account the preparation work prior to carrying out the practical, attendance, punctuality and use. The previous work will have a maximum weight of 30% of the practice grade. The total qualification of the practicals will be obtained as an arithmetic mean of the qualification of each one of them. In order to make the average, it is necessary to obtain in each practical a grade equal to or greater than 30% of the maximum grade of the practical. For justified reasons you can miss doing one of the practicals. The grade corresponding to said practice will be zero (0.0). If the mean criterion cannot be applied, the grade for this part will be calculated by multiplying by 0.42 the grade obtained with the weighted average and it will not be compensable with the theory grade. The grade of individual practicals is not kept for successive academic years.	40	B4 C21 D2 C24 D9 D17
Essay questions exam	As part of the continuous assesment of the subject, each student will take two face-to-face written tests of two hours each weighting a 30% each one. The first, at the end of the contents related to Digital Electronics, in a master session programmed in the time planning of the subject. The second, of the contents related to Microcontrollers, coinciding with the date set for the final exam. If any of the tests is divided into several parts, to calculate the total mark as a weighted average of the parts, it is necessary to obtain a minimum mark of 30% of the total mark in each part. The final grade will be obtained as the arithmetic mean of the grade of the two tests. In order to make the average, it is necessary to obtain in each test a grade equal to or greater than 40% of the maximum grade of the test. In the case of not being able to apply the criterion of the average, the grade for this part will be calculated by multiplying by 0.56 the grade obtained with the weighted average and it will not be compensable with the practice grade.	60	B3 C21 D2 B4 C24 D9

Other comments on the Evaluation

In order to pass (theoretical contents of digital electronics, theoretical contents of microcontrollers or laboratory practices) between the first and the second call of the academic year, it is necessary to obtain a grade equal to or greater than 50% of the grade corresponding to the evaluation of said subject.

Continuous assessment students who have to take the second call of the academic year must complete:

A final exam whose grade will be 60% of the grade for the subject. It will consist of two parts: Digital Electronics short-answer questions and troubleshooting and Microcontrollers short-answer questions and troubleshooting. To pass the exam, you must achieve at least 40% of the grade for each of the parts. The final grade will be the arithmetic mean of the two grades. In order to compensate the grades of the different parts, at least 40% of the maximum grade must be reached.

If the minimum threshold is not reached somewhere, the final grade for the course will be failed and the numerical value will be calculated by multiplying by 0.62, the grade obtained with the weighted average (clarification on the coefficient: This coefficient is obtained by dividing 4.9 (maximum grade of failure) divided by 7.9 (maximum grade of the weighted average that can be obtained by failing the subject 6 in lecture sessions, 1.9 in practices [does not exceed the minimum threshold of 50%]).

The student that renounces the continuous evaluation will be qualified by means of a final exam of theoretical knowledge and problem solving and a Practice exam. The weight and evaluation criteria are the same as in continuous evaluation.

Those students who cannot attend two or more practices for the justified reasons set forth in the Student Statute, will have the right to a single laboratory test to be held in the exam period of the corresponding call established by the school.

Ethical Commitment: The student is expected to exhibit appropriate ethical behavior. In case of detecting unethical behavior (copying, plagiarism, use of unauthorized electronic devices, and others), it will be considered that the student does not meet the necessary requirements to pass the subject. In this case, the overall grade for this academic year will be fail (0.0).

Sources of information

Basic Bibliography

John F. Wakerly, **Digital Design: Principles and Practices**, 4,

Fernando E. Valdes Pérez, Ramón Pallás Areny, **Microcontroladores. Fundamentos y aplicaciones con PIC**, 1,

PIC18F27/47Q10 microcontrollers Data Sheet, Microchip Technology Inc., 2020

Enrique Mandado Pérez, **Sistemas Electrónicos Digitales**, 10, Marcombo, 2015

Complementary Bibliography

Recommendations

Subjects that it is recommended to have taken before

Fundamentals of electronics/V12G330V01402