Universidad de Alcalá

TEACHING GUIDE

Digital Electronic Systems

Degree in
Industrial Electronics and Automatics Engineering

Universidad de Alcalá

Academic Year 2022/2023

3rd Year - 1st Semester

Approved by the School Board on June 3, 2022

TEACHING GUIDE

Course Name:	**Digital Electronic Systems**
Code:	**600030**
Degree in:	**Industrial Electronics and Automatics Engineering**
Department and area:	**Electrónica** **Electronic Technology**
Type:	**Compulsory**
ECTS Credits:	**6.0**
Year and semester:	**3rd Year, 1st Semester**
Teachers:	Juan Manuel Miguel Jiménez Marta Marrón Romera
Tutoring schedule:	It will be communicated at the beginning of the course
Language:	English

1. COURSE SUMMARY

Digital Electronic Systems aims to train students in the design of digital systems that are based on a microprocessor or a microcontroller. This course addresses the design of digital systems based on a Cortex-M3 microcontroller architecture, focusing on the study of typical internal peripherals, as well as various semiconductor memory devices required in the design of more complex embedded systems, whose needs require microcontroller versions that include external bus for memory connection. The subject contents advance, therefore, in the study of digital electronics with the evolution in programmable systems, data storage devices and industrial informatics, with in-depth knowledge of these systems overall operation. In this subject, hardware and software aspects are covered.

In order to fully benefit the students from this subject, they must possess prior knowledge acquired during previous semesters in the subjects of Digital Electronics, Computing and Information Industrial Informatics, since those concepts are applied in this subject.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following generic skills, which are defined in the Section 3 of the Annex to the Orden CIN/351/2009:

en_TR2 - Knowledge in basic and technological subjects, which enables them to learn new methods and theories, and gives them versatility to adapt to new situations.

en_TR3 - Ability to solve problems with initiative, decision making, creativity, critical reasoning and to communicate and transmit knowledge, skills and abilities in the field of Industrial Engineering.

en_TR4 - Knowledge to carry out measurements, calculations, assessments, appraisals, appraisals, studies, reports, work plans and other similar works.

en_TR9 - Ability to work in a multilingual and multidisciplinary environment.

en_TRU1 - Capacity of analysis and synthesis.

en_TRU2 - Oral and written competencies.

en_TRU3 - Ability to manage information.

en_TRU4 - Autonomous learning skills.

en_TRU5 - Team work.

Professional Skills

This course contributes to acquire the following professional skills, which are defined in the Section 5 of the Annex to the Orden CIN/351/2009:

en_CEI3 - Knowledge of the fundamentals and applications of digital electronics and microprocessors.

en_CEI6 - Ability to design analog, digital and power electronic systems.

en_CEI10 - Applied knowledge of industrial computing and communications.

Learning Outcomes

After succeeding in this subject the students will be able to:

- **RA1**: Programming peripheral in a microprocessor system for developing control systems of industrial processes.
- **RA2**: Designing a specific electronic system for industrial process control including sensors, actuators, interfaces and a microprocessor.

3. CONTENTS

Contents	Total number of hours
Topic 0: Introduction Presentation of the Teaching Guide content. Explanation of the methodology of work, timings and assessment.	1 hour
Topic 1: Introduction to the Cortex-M3. LPC1768 Microcontroller Introduction to ARM Cortex- M3 architecture: buses, memory map and pipeline. Block diagram of a commercial system with architecture ARM Cortex- M3 based LPC1768. Exceptions: types, vector table, external interrupts, priorities, the NVIC module, exception input and output sequences. The reset. Other system exceptions. Generating the clock signal. SysTick timer. Low power modes.	4 hours
Topic 2: Peripherals in the LPC1768 General description of peripherals in a microcontroller: examples. Timers: capture inputs, PWM generation, RTC and Watchdog. Synchronous and asynchronous serial communication: I2C, SPI, UART. Analogic Input/Output: A/D and D/A conversion modules.	14 hours
Topic 3: Memory management and access Memory maps. Description and implementation of memory expansion: size and number, examples. Design of a memory map: address decoding and selection logic, implementation alternatives, design examples. Memory management: structuring in banks and bus connection. Analysis of the data management: Big and Little Endian models, data aligned and non-aligned. Basic timing charts read/write asynchronous memories: temporal analysis of connecting an external device to a microprocessor, inserting wait cycles, and examples. Memory Map in the Cortex-M3, examples. EMC module Description: features, configuration registers, access to static memory, wait cycles, examples. MPU module description.	10 hours

Topic 4: Memory expansion Memory types: volatile and non-volatile, synchronous and asynchronous. Memory hierarchy. Synchronous memories: features, timing charts and access cycles. Dynamic Memory: internal architecture, refreshment, timing charts and access cycles. Dynamic Memory Access with EMC module LPC178x: control signals, wait cycles, examples. Dual-Port (DPRAM) memories: internal architecture, arbitration, timing charts and access cycles. Systems interconnection using Dual-Port: design examples and applications. FIFO: internal architecture, and expansion, timing charts, design examples and applications.	4 hours
Design and implementation of an embedded system Design and implementation of a real embedded system based on an LPC1768, using professional Keil tools for designing and debugging.	24 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	58 hours (56 hours on-site +2 exams hours)
Number of hours of student work:	92
Total hours	150

4.2. Methodological strategies, teaching materials and resources

In the teaching and learning process, the following training activities will be undertaken:

- Theoretical Classes and example solving.
- Practical Classes: laboratory and exercise solving.
- Tutorials: individual and/or in groups.

The following complementary resources, among others, will also be available for use:

- Individual or group tasks: after completing a project, students can present it publically in front of the rest of their classmates in order to stimulate debate.
- Attendance at conferences, meetings or scientific discussions which are related to the module content.
- Watching videos about the content of this subject.

In the course of the year, both theoretical and practical activities and tasks will be proposed to the

students. Different practical tasks will be undertaken at the same time as theoretical concepts are taught, so that students can experiment both individually and in groups, thus consolidating their knowledge of the concepts they have learnt.

In order to complete these practical tasks, the students will have access to an area in the laboratory with certain basic equipment (oscilloscopes, power supplies, signal generators, etc.), the necessary hardware system as well as a computer with the required design and simulation software.

In the course of the module, the students must make use of different bibliographic resources, so that they familiarise with the type of documentation that they will use professionally in their future.

5. ASSESSMENT: procedures, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Learning Assesment Guidelines, LAG, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Learning Assesment Guidelines as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

Ordinary Call

Continous Assessment:

The main assessment tools will be:

1. Intermediate assessment test (PEI) consisting of various tests, type questions and/or problems (of analysis and/or synthesis), which refer to specific aspects of the syllabus covered by the theoretical sessions (20% of the student's final mark).
2. Development of laboratory practices, with mandatory attendance (PL). The practices will cover all the contents presented in the theoretical sessions (40% of the student's final mark).
3. Global assessment exam (PEG), with various tests, questions and/or problems (of analysis and/or synthesis), which refer to specific aspects of the syllabus so that its content is covered by the theoretical sessions, exercises and laboratory practices (40% of the student's final mark).

Assessment through final exam:

In the case of evaluation by means of a final exam, the evaluation elements to be used will be the following:

1. Development of laboratory practices, with mandatory attendance (PL). The practices will cover all the contents presented in the theoretical sessions (40% of the student's final mark).
2. Global assessment exam (PEG), with various tests, questions and/or problems (of analysis and/or synthesis), which refer to specific aspects of the syllabus so that its content is covered by the theoretical sessions, exercises and laboratory practices (60% of the student's final mark).

Extraordinary Call

The procedure will be the same as that described for the assessment by means of a final exam in the ordinary call.

When partially demonstrated acquisition of the related competences in the ordinary assessment, the students could preserve their marks for this assessment as follows:

A. Theoretical content (PEI –if following the continuous assessment model- + PEF), (representing 60% of the final mark).

B. Practical content related to the laboratory (PL), (representing 40% of the final mark).

5.2. EVALUATION

EVALUATION CRITERIA

The assessment criteria measure the level in which the competences have been acquired by the student. For that purpose, the following are defined::

The student should be able to solve, conceptually and correctly, problems related to the design of digital electronic systems that are based on a microprocessor. Although these problems will be similar to the theoretical topics explained in class, the solutions will be new and distinct from the results of the class exercises.

CE1: The student should be able to integrate the conceptual knowledge explained in the different topics so to solve problems related to the digital electronic systems design in a correct, creative and original manner.

CE2: The student should be able to implement circuits that provide solutions to the problems raised by integrating the acquired knowledge about the digital electronic system operation and the C programming language, making use of resource and design libraries and debug tools.

CE3: The student should be able to prove and defend their proposals when solving theoretical and practical problems in a clear and reasoned manner.

CE4: The student should be able to write clear, precise and correctly edited technical documentation on any completed theoretical and practical task (related to software and hardware). The library research, analysis and reference (related to the different manuals and datasheets of the different commercial electronic components) would be an in important part in such documentation.

GRADING TOOLS

The work of the student is graded in terms of the assessment criteria above, through the following tools:

1. Ordinary call
    a. Continuous assessment, with three assessment exams (PEI,PEF,PL).
    b. Final assessment (PEF,PL)
2. Extraordinary call. Final assessment (PEF,PL)

GRADING CRITERIA

In the ordinary call-continuous assessment the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
en_TR2-en_TR4, en_TR8, en_TR9, en_TRU1-en_TRU5, en_CEI3, en_CEI6, en_CEI10	RA1, RA2	CE1, CE2	PEI	20%
			PEF	40%
		CE1-CE4	PL	40%

Students who do not participate in the continuous assessment will be marked as Absent. A student is supposed to have quitted this assessment if he or she neither attend the PEI nor the laboratory.

The student will pass continuous assessment if he demonstrates the required level in the related competences acquisition. To consider so, the following specifications must be fulfilled:

- Satisfactory performance in the assessment of competencies related to theoretical content (PEI + PEF). A student is considered to have acquired the required level of these competencies if he/she gets at least 40% on the PEF and the weighted score of both exams, PEI and PEF, is higher or equal to 40% of the possible maximum.
- Satisfactory performance in the assessment of competencies related to practical content related to the laboratory. A student is considered to have acquired the required level of these competencies if he attends to the laboratory sessions and the mark obtained in the related assessment tool (PL) results to be higher or equal to 50% of the possible maximum.
- Global weighed mark equal or higher to 5 over 10, summing the results from all assessments tools.

In case of not exceeding 40% in the theoretical tests (PEI + PEF) or 50% in laboratory practices, the grade obtained will be the weighted average of all the tests and the laboratory, cutting the grade to a maximum of 4.5 out of 10.

In the ordinary call-final evaluation, the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
en_TR2-en_TR4, en_TR8, en_TR9, en_TRU1-en_TRU5, en_CEI3, en_CEI6, en_CEI10	RA1, RA2	CE1-CE2	PEF	60%
		CE1-CE4	PL	40%

In this case, the student will pass continuous assessment if he demonstrates the required level in the related competences acquisition. To consider so, the following specifications must be fulfilled:

- Satisfactory performance in the assessment of competencies related to theoretical content. A student is considered to have acquired the required level of these competencies if the mark obtained in the related assessment tool (PEF) results to be higher or equal to 50% of the possible maximum.
- Satisfactory performance in the assessment of competencies related to practical content related to the laboratory. A student is considered to have acquired the required level of these competencies if the mark obtained in the related assessment tool (PL) results to be higher or equal to 50% of the possible maximum.
- Global weighed mark equal or higher to 5 over 10, summing the results from all assessments tools.

Extraordinary call

In the case of the extraordinary call, the same percentages that have been established in the case of the evaluation by means of a final exam will be maintained.

When partially demonstrated acquisition of the related competences in the ordinary assessment, the students could preserve their marks for this assessment as follows:

A. Theoretical content (PEI –if following the continuous assessment model- + PEF), (representing 60% of the final mark).

B. Practical content related to the laboratory (PL), (representing 40% of the final mark).

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- Documentation specifically prepared by the teaching staff, which will be supplied directly to the students, or will be published on the subject webpage.
- Video-classes covering the theoretical knowledge of this subject.
- The Definitive Guide to the ARM Cortex-M3, Second Edition. Joseph Yiu. Publisher: Newnes. 2009. ISBN: 185617963X
- Webpages related to the subject's matter which will be selected in advance by the teaching staff.

6.2. Additional Bibliography

- Sistemas Digitales basados en microprocesador. MC68000. José Luis Lázaro y otros. Editorial Servicio de publicaciones de la Universidad de Alcalá. 2000.
- Fundamentals of Embedded Software: With the ARM Cortex-M3. Always learning. (2nd Ed.) Daniel W. Lewis. ISBN 0132916541. Editorial Pearson College Division. 2012.
- Embedded Systems: Real-Time Interfacing to the ARM Cortex-M3. Vol. 2. (2nd Ed.) Jonathan W. Valvano. ISBN 1463590156. Editorial CreateSpace. 2011.
- Embedded Systems: Real-Time Operating Systems for the ARM Cortex-M3. Vol. 3. Jonathan Valvano. ISBN 1466468866. Editorial CreateSpace. 2012.
- ARM Assembly Language: An Introduction. (2nd Ed.) J.R. Gibson. Editorial Lulu.com.
- Microprocessor System Design. Alan Cements. Editorial PWS-KENT. 1991.
- Circuitos electrónicos digitales. Manuel Mazo y otros. Editorial Servicio de publicaciones de la Universidad de Alcalá. 1998.
- Fundamentos de sistemas digitales. (7ª Ed.) Thomas L. Floyd. Editorial Prentice Hall. 2000.
- Sistemas digitales, principios y aplicaciones. (6ª Ed.) Ronald J. Tocci. Editorial Prentice Hall Hispanoamericana. 1996
- Circuitos digitales y microprocesadores. Herbert Taub Osborne. Editorial McGraw-Hill. 1993.
- Advanced microprocessors (2ª Ed.) Daniel Tabak. Editorial McGraw-Hill. 1995.
- Lógica digital y microprogramable. Antonio Serna Ruiz y José Vicente García Gil. Editorial Paraninfo. 2000.
- Advanced Semiconductor Memories: Architectures, Designs, and Applications. Ashok K. Sharma. Wiley-IEEE Press. 2002.

Disclosure Note

The University of Alcalá guarantees to its students that, if due to health requirements the competent authorities do not allow the total or partial attendance of the teaching activities, the teaching plans will achieve their objectives through a teaching-learning and evaluation methodology in online format, which will return to the face-to-face mode as soon as these impediments cease.