



GENERAL INFORMATION

| Data of the subject | |
|---------------------|---|
| Subject name | Electronic Systems |
| Subject code | DEA-IND-512 |
| Main program | Official Master's Degree in Industrial Engineering . |
| Involved programs | Grado en Administración y Dirección de Empresas y Máster Universitario en Ingeniería Industrial [Fifth year] Grado en Administración y Dirección de Empresas y Máster Universitario en Ingeniería Industrial [Fifth year] Máster Universitario en Ingeniería Industrial + Máster en Medioambien. y Gest. Intel. de la Energía [First year] Máster Universitario en Ingeniería Industrial y Máster Universitario en Sistemas Ferroviarios [First year] Máster Universitario en Ingeniería Industrial + Máster en Industria Conectada / in Smart Industry [First year] Máster Universitario en Ingeniería Industrial + Máster en Medioambiente y Transición Energética [First year] Máster Universitario en Ingeniería Industrial + Máster en Ingeniería para la Movilidad y Seguridad [First year] Máster Universitario en Ingeniería Industrial y Máster Universitario en Administración de Empresas [First year] Máster Universitario en Ingeniería Industrial + Máster in Motorsport, Mobility and Safety [First year] Máster Universitario en Ingeniería Industrial [First year] Máster Universitario en Ingeniería Industrial y Máster Universitario en Administración de Empresas [First year] Máster Universitario en Ingeniería Industrial y Máster Universitario en Sector Eléctrico [First year] Máster Universitario en Ingeniería Industrial + Máster en Industria Conectada / in Smart Industry [First year] Máster Universitario en Ingeniería Industrial + Máster in Smart Grids [First year] Máster Universitario en Ingeniería Industrial + Máster en Ingeniería para la Movilidad y Seguridad [First year] |
| Level | Postgrado Oficial Master |
| Quarter | Semestral |
| Credits | 7,5 ECTS |
| Type | Obligatoria |
| Department | Department of Electronics, Control and Communications |
| Coordinator | Jaime Boal Martín-Larrauri and José Daniel Muñoz Frías |
| Office hours | Arrange an appointment through e-mail. |

| Teacher Information | |
|---------------------|---|
| Teacher | |
| Name | Jaime Boal Martín-Larrauri |
| Department | Department of Electronics, Control and Communications |
| Office | D-217 (Alberto Aguilera, 25) |



| | |
|----------------------------------|---|
| E-Mail | Jaime.Boal@iit.comillas.edu |
| Teacher | |
| Name | Romano Giannetti |
| Department | Department of Electronics, Control and Communications |
| Office | D-221 (Alberto Aguilera, 25) |
| E-Mail | Romano.Giannetti@iit.comillas.edu |
| Teacher | |
| Name | Santiago Lizón Martínez |
| Department | Department of Electronics, Control and Communications |
| Office | Electronics, Control, and Communications Department Office (Alberto Aguilera, 25 - 2nd floor) |
| E-Mail | slizn@icai.comillas.edu |
| Teacher | |
| Name | José Daniel Muñoz Frías |
| Department | Department of Electronics, Control and Communications |
| Office | D-219 (Alberto Aguilera, 25) |
| E-Mail | daniel@icai.comillas.edu |
| Teacher | |
| Name | Fermín Zabalegui Sanz |
| Department | Department of Electronics, Control and Communications |
| Office | Electronics, Control, and Communications Department Office (Alberto Aguilera, 25 - 2nd floor) |
| E-Mail | ferminzs@comillas.edu |
| Profesores de laboratorio | |
| Teacher | |
| Name | Álvaro Machón Benítez |
| Department | Department of Electronics, Control and Communications |
| E-Mail | amachon@icai.comillas.edu |
| Teacher | |
| Name | Álvaro Pérez Bello |
| Department | Department of Electronics, Control and Communications |
| E-Mail | apbello@comillas.edu |
| Teacher | |
| Name | Antonio Alejandro Rodríguez Blasco |
| Department | Department of Electronics, Control and Communications |
| E-Mail | aarblasco@icai.comillas.edu |
| Teacher | |



| | |
|-------------------|---|
| Name | Antonio José López Angulo |
| Department | Department of Electronics, Control and Communications |
| E-Mail | ajlopez@icai.comillas.edu |
| Teacher | |
| Name | Esther de Juana López |
| Department | Department of Electronics, Control and Communications |
| E-Mail | edejuana@icai.comillas.edu |
| Teacher | |
| Name | Francisco Javier Burgoa Román |
| Department | Department of Electronics, Control and Communications |
| E-Mail | fjburgoa@icai.comillas.edu |
| Teacher | |
| Name | Juan Pedro López Llorens |
| Department | Department of Electronics, Control and Communications |
| E-Mail | jplopez@icai.comillas.edu |
| Teacher | |
| Name | Pedro Casatejada Herrera |
| Department | Department of Electronics, Control and Communications |
| E-Mail | pcasatejada@comillas.edu |

DESCRIPTION OF THE SUBJECT

Contextualization of the subject

Prerequisites

Contribution to the professional profile of the degree

Within the professional profile of the industrial engineer, this course aims to provide advanced knowledge in the design of mixed analog/digital real-time embedded systems to control a plant. By the end of the course, students will be able to design systems composed of an analog signal capture and conditioning part, a digital processing module based on a dsPIC microcontroller programmed in C language using MPLAB X IDE, and several actuators.

In the laboratory, in addition to the principles of design, assembly and testing of electronic circuits, students will also develop teamwork skills and improve their ability to present results, which are essential abilities for an industrial engineer.

Prerequisites

Fundamentals of analog and digital electronics.

Course contents



Contents

Theory

1. Introduction to electronic systems

Students receive a global vision of the subject and are motivated towards the final integration project they will develop during the last laboratory sessions.

2. Digital processing

Students learn how to provide "intelligence" to an electronic system using a dsPIC microcontroller programmed in C language. The architecture of the microcontroller is studied, as well as its main peripherals and the real-time programming methods that allow the development of programs that interact with the environment.

3. Perception and conditioning

The most used industrial sensors and the circuits necessary to amplify and condition the measured signal until it reaches the analog-to-digital (A/D) converter are studied. The concepts of sampling, quantization, and aliasing, so important in the A/D conversion process, are also introduced.

4. Actuation

The circuits that allow a digital system to act on a plant are presented. The circuits studied range from basic circuits such as transistors and relays, to more advanced circuits such as H-bridges controlled by PWM.

5. Complex electronic systems

Basic concepts to approach the design of complex projects: decomposition of the problem, top-down design, bottom-up implementation, documentation of an electronic system, electromagnetic compatibility...

Laboratory

1. Sensing and signal adaptation

Students test sensors similar to those they intend to use in the complex system that will be developed at the end of the semester. They will also have to solve the signal adaptation problems to interface with the microcontroller. Generally, it will be a non-linear sensor, which will have to be modeled, linearized, and amplified.

2. Quantization and digital processing

The objective is to process the measurements of a perception system by means of a dsPIC microcontroller to act on the environment. Emphasis will be placed on quantization problems, to which the student will have to propose solutions.

3. Actuation

Students test actuators that they will need to build their final project. In addition, they must solve signal adaptation problems to effectively excite the actuator.

4. Communication, synchronization and concurrency of processes

Students experience for themselves how to coordinate the different processes running on a microcontroller. The communication,

concurrency, and synchronization among the processes involved play an important role.

5. Design of a complex electronic system

In the final part of the course, a comprehensive project that integrates all the modules previously developed in the laboratory is developed and tested. Each team will face a different problem in the field of home automation, industry, energy...

EVALUATION AND CRITERIA

| Evaluation activities | Evaluation criteria | Weight |
|---|--|--------|
| <ul style="list-style-type: none"> Intermediate tests Final exam | <ul style="list-style-type: none"> Understanding of the theoretical concepts. Application of these concepts to problem-solving. Critical analysis of the numerical results. Oral and written communication skills. | 45 |
| <ul style="list-style-type: none"> Lab assignments Lab exam Final project presentation | <ul style="list-style-type: none"> Understanding of the theoretical concepts. Application of these concepts to problem-solving. Critical analysis of the numerical results. Oral and written communication skills. Quality of the results obtained. | 55 |

Grading

Regular assessment

The weighting of each of the evaluation activities will be as follows:

- Theory (45%)
 - Intermediate tests: 15%
 - Final exam: 30%
- Laboratory (55%). Depending on the previous knowledge of the students, two grading modalities exist.
 - If students have no prior knowledge of microprocessors:
 - Lab assignments: 15%
 - Lab exam: 15%
 - Project: 25%
 - Otherwise:
 - Lab assignments: 27.5%
 - Project (graded individually): 27.5%

The final grade will be computed according to these restrictions:

- The *examinations mark* will be the weighted average of the intermediate tests, the final exam, and the laboratory exam (if any), **provided that the final exam grade is greater than or equal to 4**. Otherwise, the examinations mark will be the minimum between the weighted average and the final exam grade.
- The *assignments mark* will be the weighted average of the lab assignments and the project.



- If the examinations mark is greater than or equal to 5 and the assignments mark is also greater than or equal to 5, the course grade will be obtained as indicated in the percentages above. Otherwise, the final grade will be the lower of the two marks.

Retake

A new final exam and another laboratory exam will be taken, the latter only if there was one in the regular assessment period and it does not have a passing grade. In case the assignments mark is lower than 5, the student will also carry out an individual project, which will be defended publicly at the latest on the day of the retake exam and whose grade will replace those of the lab assignments and the project. The marks of all those evaluation activities that do not have to be repeated will be preserved. The final grade will be computed as in the regular assessment period and according to the same restrictions.

Course rules

Class attendance is mandatory according to Article 93 of the General Regulations (Reglamento General) of Comillas Pontifical University and Article 6 of the Academic Rules (Normas Académicas) of the ICAI School of Engineering. Not complying with this requirement may have the following consequences:

- Students who fail to attend more than 15% of the lectures may be denied the right to take the final exam during the regular assessment period.
- Regarding laboratory, absence from more than 15% of the sessions can result in losing the right to take the final exam of the regular assessment period and the retake. Anyway, unjustified absences to laboratory sessions will be penalized in the evaluation.

Students who commit an irregularity in any graded activity will receive a mark of zero in the activity and disciplinary procedures will follow (cf. Article 168 of the General Regulations (Reglamento General) of Comillas Pontifical University).

WORK PLAN AND SCHEDULE

| Activities | Date of realization | Delivery date |
|--|-----------------------------|--|
| Midterm | Week 7 | |
| Final exam | Ordinary examination period | |
| Lab sessions | Weekly | |
| Self-study of the concepts covered in the lectures | After each lesson | |
| In-class problem solving | Weekly | |
| Submission of proposed problems | | To be indicated in class |
| Lab report writing | After every session | One week after the end of each session |
| Midterm preparation | Week 6 | |



| | | |
|------------------------|----------|--|
| Final exam preparation | December | |
|------------------------|----------|--|

BIBLIOGRAPHY AND RESOURCES

Basic References

- Slides and notes prepared by the instructors (available in Moodle).

Complementary bibliography

- D. E. Simon, An Embedded Software Primer, 1st Ed., Addison Wesley, 1999. ISBN-13: 978-0201-61569-2
- R. F. Coughlin and F. F. Driscoll, Operational Amplifiers and Linear Integrated Circuits, 6th Ed., Prentice Hall, 2000. ISBN-13: 978-0-13014991-6
- J. Fraden, Handbook of Modern Sensors, 5th Ed., Springer, 2016. ISBN-13: 978-3-319-19302-1
- Microchip Technology Inc., dsPIC33/PIC24 Family Reference Manual, [Online]. Available: <https://www.microchip.com/doclisting/TechDoc.aspx?type=ReferenceManuals>

In compliance with current regulations on the **protection of personal data**, we would like to inform you that you may consult the aspects related to privacy and data that you have accepted on your registration form by entering this website and clicking on "download"

<https://servicios.upcomillas.es/sedelectronica/inicio.aspx?csv=02E4557CAA66F4A81663AD10CED66792>

ELECTRONIC SYTEMS: TENTANTIVE WEEKLY SCHEDULE

| | THEORY | | | | | | | | | | | | | |
|---------------------------------------|--------|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|
| | W1 | W2 | W3 | W4 | W5 | W6 | W7 | W8 | W9 | W10 | W11 | W12 | W13 | W14 |
| Course overview | █ | | | | | | | | | | | | | |
| 1. Introduction to electronic systems | █ | | | | | | | | | | | | | |
| 2. Architecture of a microcontroller | █ | █ | | | | | | | | | | | | |
| Prerequisite review | █ | █ | █ | | | | | | | | | | | |
| 3. Parallel ports | | █ | █ | | | | | | | | | | | |
| 4. Timers y PWM | | | █ | █ | | | | | | | | | | |
| 5. Interrupts | | | | █ | █ | | | | | | | | | |
| 6. A/D converter | | | | | █ | █ | | | | | | | | |
| 7. Large variation resistive sensors | | | | | █ | █ | | | | | | | | |
| 8. Small variation resistive sensors | | | | | | █ | █ | | | | | | | |
| Midterm preparation | | | | █ | | | █ | | | | | | | |
| Midterm | | | | | | | █ | █ | | | | | | |
| Midterm correction | | | | | | | | █ | | | | | | |
| 9. Active sensors | | | | | | | | █ | █ | | | | | |
| 10. Drivers | | | | | | | | | █ | █ | | | | |
| Project: Proposal preparation | | | | | | | | | | █ | █ | | | |
| 11. Real-time systems | | | | | | | | | | | █ | | | |
| 12. Electric power measurement | | | | | | | | | | | █ | █ | | |
| 13. Proximity sensors | | | | | | | | | | | | █ | | |
| 14. Actuator conditioning | | | | | | | | | | | | █ | █ | |
| 15. Serial communications: UART | | | | | | | | | | | | | █ | |
| Project: Work session | | | | | | | | | | | | | | █ |
| Review and final exam preparation | | | | | | | | | | | | | | █ |

| | LABORATORY | | | | | | | | | | | | | | |
|---|------------|----|----|----|----|----|----------|----|----|-----|-----|-----|-----|-----|---|
| | W1 | W2 | W3 | W4 | W5 | W6 | W7 | W8 | W9 | W10 | W11 | W12 | W13 | W14 | |
| 1. Introduction to the development system | █ | █ | | | | | Midterms | | | | | | | | |
| 2. Parallel ports | | | █ | █ | | | | | | | | | | | |
| 3. Timers and PWM | | | | █ | █ | | | | | | | | | | |
| 4. Interrupts | | | | | █ | █ | | | | | | | | | |
| 5. A/D converter and sensor conditioning | | | | | | | | | █ | █ | | | | | |
| Lab exam | | | | | | | | | | | █ | █ | | | |
| Project | | | | | | | | | | | | █ | █ | █ | █ |