COURSE PROGRAM

Academic Year: 2022/2023

Identification and characteristics of the course			
Code	501107	ECTS Credits	6
Course name (English)	**INDUSTRIAL COMPUTING**		
Course name (Spanish)	INFORMÁTICA INDUSTRIAL		
Degree programs	Degree in Electronics Engineering and Automation (Industrial Branch)		
Faculty/School	Industrial Engineering School		
Semester	7th	Type of course	Obligatory
Module	Specific Technology of Industrial Electronics and Automation		
Matter	Automation and Control		
Lecturer/s			
Name	Office	E-mail	Web page
José Ignacio Suarez Marcelo	D2.15	jmarcelo@unex.es	CVUEX
Subject Area	Systems Engineering and Automation		
Department	Electrical, Electronics Engineering and Automation		
Coordinating Lecturer (Ifmore than one)			

Competencies (see tablehttp://bit.ly/competenciasGrados)

Basic Competences	Check With an " X"	General Competences	Check With an " X"	Transversal Competences	Check With an " X"	Specific Competences Basic Formation	Check With an " X"	Specific Competences Common to the Industrial Branch	Check With an " X"	Specific Competences Specific Technology	Check With an " X"	Specific Competences Specific Technology	Check With an " X"
CB1	X	CG1	X	CT1	X	CEFB1		CECRI1		CETE1		CETE11	
CB2	X	CG2	X	CT2	X	CEFB2		CECRI2		CETE2		CETE12	
CB3	X	CG3	X	CT3	X	CEFB3		CECRI3		CETE3		CETE13	
CB4	X	CG4	X	CT4	X	CEFB4		CECRI4		CETE4		CETE14	
CB5	X	CG5	X	CT5	X	CEFB5		CECRI5		CETE5		CETE15	
		CG6	X	CT6	X	CEFB6		CECRI6		CETE6		CETE16	
		CG7	X	CT7	X			CECRI7		CETE7		CETE17	
		CG8	X	CT8	X			CECRI8		CETE8		CETE18	
		CG9	X	CT9	X			CECRI9		CETE9		CETE19	
		CG10	X	CT10	X			CECRI10		CETE10	X	CETE20	
		CG11	X					CECRI11				CETFG	
		CG12						CECRI12					

Contents

Course outline

Embedded control systems: architecture and programming

Course syllabus

THEORY

Block I: Introduction to Embedded Control Systems

- **Unit I.1 – Introduction to Embedded Systems (1.5 h)**
  - Definitions and basic concepts. Embedded vs. automated system. MCU vs MPU vs PLC.
- **Unit I.2 – Internal Architecture of an MCU (2.5 h)**
  - Harvard architecture, ALU and operands, instruction execution, oscillator.
- **Unit I.3 – MCU Memory (3.5 h)**
  - Program memory, partitioning, exception vector table. Special registers. Data memory, bank management, specific and general purpose registers, addressing modes. Stack operation.

Block II: Basic programming of an MCU

- **Unit II.1 – In-circuit Programming and Debugging (1.5 h)**
  - ICD vs ICSP. Vendor ecosystem. Basic concepts (debug, realese, debug executive). Configuration words
- **Unit II.2 – Programming in Assembler (2.5 h)**
  - Instruction set, classification, Computed-GOTO technique, creation and manipulation of variables, creation of program flow control structures.
- **Unit II.3 – I/O Ports (1.5 h)**
  - Internal diagram, operation and configuration of ports. Voltages, pull-ups, slew rate, open-drain. Pin remapping.
- **Unit II.4 – Interrupts (2.5 h)**
  - I/O techniques: interrupt vs. polling. Masks and flags. Interrupt service routine. Latency. Configuration and management of interrupts in assembly and C languages.

Block III: MCU Peripherals

- **Unit III.1 – Timers (2.5 h)**
  - Basic concepts, configuration, prescaler, postscaler. Role of the timer in the implementation of digital control algorithms. Timers and interrupts: creating precise timings, handling multiple tasks.
- **Unit III.2 – Data Converters (2 h)**
  - A/D converter: analog input model, configuration (channel selection, clock, format, automatic acquisition), conversion time. D/A converter: internal structure, configuration.
- **Unit III.3 – Signal Control and Generation Modules (1.5 h)**
  - CCP modules: operating modes and configuration. PWM modules: configuration, calculation of period and duty cycle, effective resolution.
- **Unit III.4 – Communication Modules (2 h)**
  - EUSART and MSSP modules: block diagrams, configuration, synchronous and asynchronous communications.

Block IV: Implementing controllers on an MCU

- **Unit IV.1 – Controller Discretization (2 h)**
  - Discretisation methods for analog controllers. Selection of sample time and its effects. Obtaining difference equations. Discretization of a PID.
- **Unit IV.2 – PID Controller Implementation on an MCU (3.5 h)**
  - Configuration and programming of the MCU interfaces in C language. Obtaining the sample time by configuring timers and interrupts. Implementation of the control algorithm. Generation of the output signal. Preparation for the next sampling period. Practical considerations. Preparation and handling of variables for real-time monitoring of the controller operation. Calculation of the execution time of the control algorithm.

PRACTICAL ACTIVITIES

The program of practical (laboratory) activities is designed to enable students to develop skills in the handling of (both HW and SW) the tools of a recognised manufacturer of 8-bit microcontrollers of with a very widespread in the Spanish and world markets. The program is divided into several sessions (LAB), in increasing order of complexity, which will allow, on the one hand, to consolidate the most important concepts of the subject and, on the other hand, to facilitate the development of the team work of the subject. The activities will be as follows:

- LAB1 – Simulation vs real-time execution (4 h)
- LAB2 – Implementing tables (4 h)
- LAB3 – Switch debouncing. Modular Programming (4 h)
- LAB4 – HW timing. Interrupts (4 h)
- LAB5 – Controller Implementation. Part I (4 h)
- LAB6 – Controller Implementation. Part II (2.5 h)

Educational activities

Student workload in hours by lesson		Lectures	Practical activities				Monitoring activity	Homework
Lesson	**Total**	**L**	**HI**	**LAB**	**COM**	**SEM**	**SGT**	**PS**
I.1	2.5	1.5						1
I.2	7.5	2.5		2				3
I.3	10.5	3.5		2				5
II.1	6.5	1.5		2				3
II.2	8.5	2.5		2				4
II.3	5.5	1.5		2				2
II.4	9.5	2.5		2				5
III.1	8.5	2.5		2				4
III.2	4	2						2
III.3	7.5	1.5		2				4
III.4	8	2		2				4
IV.1	8	2		2				4
IV.2	10	3.5		2.5				4
Assessment	9	1						8
Team work	44.5						3	41.5
TOTAL	**150**	**30**	**0**	**22.5**	**0**	**0**	**3**	**94.5**

L: Lectures (100 students)
HI: Hospital internships (7 students)
LAB: Laboratory or field practices (15 students)
COM: Computer room or language laboratory practices (30 students)
SEM: Problem classes or seminars or case studies (40 students)
SGT: Scheduled group tutorials (educational monitoring, ECTS type tutorials)
PS: Personal study, individual or group work and reading of bibliography

Teaching Methodologies

Among the teaching methodologies included in the formative program, in this course the following are used:

Teaching methodology	Used methodologies labelled as "X"
1. Explanation and discussion of theoretical contents.	X
2. Resolution, analysis and discussion of support examples or previously proposed exercises.	
3. Exposition of related topics by students.	X
4. Development of case studies or demonstrations at laboratory, computer room, etc.	X
5. Resolution of specific doubts in small groups in order to identify potential problems in the teaching-learning process, and academic guidance for essays, case studies, practical works, demonstrations, etc.	X
6. Search for information prior to the development of the topics, or for complementary information once they are in progress.	X
7. Preparation of essays, either individually or in groups.	X
8. Study of each topic, which may consist of: content study, analysis of practical exercises or case studies, preparation for examinations, etc.	X

The subject will be developed according to the following activities:

- Big-Group: lectures of theoretical contents with a lot of slides and examples to clarify the subject concepts. The student will be **continuously involved** in such a way to make him **to think and question**, with a critical attitude, all the theoretical concepts.
- Laboratory sessions: students will use computer tools for learning the process of programming an embedded control system based on a microcontroller. The learning will be continuous and from less to greater difficulty. Practical concepts, complementary to those seen in theory, will be studied.
- Monitoring sessions: They will be used for monitoring the students team work, clearing up some doubts and proposing some solutions or alternatives. In addition, documents and information are provided to assist students in the realisation of the electronic design of an embedded control system.
- Practical team work: In small groups, students will develop a design project of an embedded control system, based on some technical requirements and under the supervision of the teacher. They will apply knowledge learnt in theoretical and practical sessions and will develop their profession skills. The methodology will be based on **Project Based Learning (PBL)**, which is very appropriate for their formation and future work in a company. Periodically, a short progress report on the progress and partial results of the project is requested. On the other hand, students will make an oral presentation of the project and a practical demonstration of the system operation which must show that it fulfils the given requirements. Students will also deliver a technical report which summarizes the adopted solutions and a description of the development of the work.

Learning outcomes

The expected learning outcomes (RA) are as follows:

- RA1 – Knowledge of basic concepts of digital computers architecture.
- RA2 – Knowledge and skills related to basic I/O programming techniques used in digital computers.

- RA3 – Knowledge of the fundamentals of microcontrollers and their basic architecture.
- RA4 – Knowledge and skills related to microcontroller programming in assembly language and the associated tools
- RA5 – Knowledge and skills related to the fundamentals of designing embedded control systems based on microcontrollers

Assessment systems

Assessment criteria (CR):

- CR1 – To understand basic concepts of microcontrollers: basic architectures, I/O basic techniques, start-up, debugging, etc. (related to competences CB[1,3,4,5], CG[1,3,5,7,8,11] y CT[1,10]).
- CR2 – To show skills for programming in assembly and C languages by using the software and hardware tools and the vendor MCU datasheets. (related to competences CB[1,2,3,4,5], CG[1,3,5,7,8,11], CT[1,4,5,7,10] y CETE[10]).
- CR3 – To show skills for understanding and carrying out design projects of embedded control systems based on MCUs (related to competences CB[1,2,3,4,5], CG[1,2,4,6,7,8,11], CT[2,4,8,10], CETE[10] and **ENAEE transversal competences CTE[1, 2, 3]).**
- CR4 - To show skills for planning and allocating the tasks in a team work by presenting and submitting results and knowledge (related to competences CB[2,3,4,5], CG[1,2,4,5,6,8,9,10,11], CT[2,3,5,6,7,8,9,10], CETE[10] and **ENAEE transversal competences CTE[1, 2]).**

Assessment activities:

Among the assessment activities included in the formative program, in this course the following are used:

	Range fixed	Ordinary call	Extraordinary call	Global assessment
1. Final exam and/or partial examinations.	0%–80%	35 %	35 %	50 %
2. Practical activities in: classroom, lab, computers room, visits, etc	0%–50%	20 %	20 %	50 %
3. Solution and submission of activities (cases, exercises, assignments, projects, etc.), individually and/or in groups	0%–50%	35 % + 10 %	35 % + 10 %	
4. Active participation in the learning activities.	0%–10%			
5. Attendance to the learning activities.	0%–10%			

Description of the assessment activities:

CONTINUOUS EVALUATION

Examination Activities 1

- **Activity 1 (A1) – Oral defence and practical demonstration of the team work (CR[3,4])**
  - 35%, RECOVERABLE grade. **Rating (A1)** from 0 to 10.
  - The students will present orally the results of the practical project carried out as a team. At any time, the teacher may ask related questions addressed to one or all members of the team.

Examination Activities 2

- **Activity 2 (A2) – Laboratory sessions (LAB) (CR[1,2])**
  - 20%, NON-RECOVERABLE grade. **Rating (A2)** from 0 to 10, calculated as the average of the individual grades for each LAB, weighed by the **percentage of the student attendance (PA)**. Each LAB will be rated from 0 to 10, by answering related questions through the virtual campus. It is compulsory for the student to show the teacher that the practice works correctly; if not, the individual grade will be 0, regardless of the grade obtained on the virtual campus.
    Example:
    LABs average grade (A2) = 7
    Percentage of attendance (PA) = 60%.
    A2 = 7 x 0,6 = 0,84
  - The attendance control will be carried out by taking student signed or oral register in every laboratory session. The unsigned registers cannot be recovered.

Examination Activities 3

- **Activity 3 (A3) – Delivery of team work report (CR[1,2,3,4])**
  - 35%, RECOVERABLE grade. **Rating (A3)** from 0 to 10.

- **Activity 4 (A4) – Delivery of teamwork activities progress reports. (CR[1,2,3,4])**
  - 10%, NON-RECOVERABLE grade. **Rating (A4)** from 0 to 10.
  - Periodically, each team will be asked to submit a short progress report on the virtual campus indicating the progress, activities and partial results achieved so far, in order to evaluate the progress of the team work.

Final Grade

The final grade is obtained as follows:

- **FINAL GRADE = (0,35 x A1) + (0,2 x A2) + (0,35 x A3) + (0,1 x A4)**

GLOBAL EVALUATION

The global evaluation test shall consist of the following parts:

Examination Activity 1 (EA1)

- **Exam with contents related to theory and practice (CR[1,2])**
  - 50%. **Rating (R1)** from 0 to 10. Minimum rating 5.
  - **EA1 grade = 0,5 x R1 (if R1 ≥ 5)**
  - **EA1 grade = 0 (if R1 < 5)**

Examination Activity 1 (EA2)

- **Practical exam with the laboratory equipment (CR[1,2])**
  - 50%. **Rating (R2)** from 0 to 10. Minimum rating 5.
  - **EA2 grade = 0,5 x R2 (if R2 ≥ 5)**
  - **EA2 grade = 0 (if R2 < 5)**

Final Grade

- **FINAL GRADE = EA1 + EA2**

Bibliography (basic and complementary)

Basic Bibliography:

[B1] Subject slides (available on the virtual campus) and notes taken in class.

[B2] Vendor MCU datasheets and help documents (available on the virtual campus).

Complementary Bibliography:

[C1] T. Wilmshurst, "Designing Embedded Systems with PIC Microcontrollers", Newnes (2010). (Available as an electronic resource at the UEx Library Service).

[C2] G.F. Franklin, J. D. Powell, A. Emami-Naeini, "Feedback Control of Dynamics Systems" (7th Ed.), Pearson, 2014. (Previous versions available at the School Library and at the Central Library of the Badajoz campus).

[C3] M. Etxeberría Isuskiza, "Microcontroladores PIC: teoría y práctica", Creaciones Copyright (2011). (Available at the Central Library of the Badajoz campus).

[C4] J. M. Angulo Usategui, S. Romero Yesa, I. Angulo Martínez, "Microcontroladores PIC. Diseño Práctico de Aplicaciones (2ª parte)", McGraw-Hill Interamericana (2006). (Available at the School Library and at the Central Library of the Badajoz campus).

[C5] G. Sen Gupta, S. Chandra Mukhopadhyay, "Embedded Microcontroller Interfacing", Springer Berlin Heidelberg (2010). (Available as an electronic resource at the UEx Library Service).

[C6] B. Borowik, "Interfacing PIC Microcontrollers to Peripherial Devices", Springer Netherlands (2011). (Available as an electronic resource at the UEx Library Service).

Other resources and complementary educational materials

- **Microchip Developer Help** (https://www.microchip.com/en-us/education/developer-help). Resources, tutorials and courses from the vendor to get started with its SW and HW tools for the design of embedded systems based on its microcontrollers.