Universitat de Lleida

DEGREE CURRICULUM

SYSTEMS INTEGRATION I

Coordination: TRESANCHEZ RIBES, MARCEL

Academic year 2023-24

SYSTEMS INTEGRATION I 2023-24

Subject's general information

<table>
<tr><td>Subject name</td><td>SYSTEMS INTEGRATION I</td></tr>
<tr><td>Code</td><td>102130</td></tr>
<tr><td>Semester</td><td>1st Q(SEMESTER) CONTINUED EVALUATION</td></tr>
<tr><td>Typology</td><td>
<table>
<tr><th>Degree</th><th>Course</th><th>Character</th><th>Modality</th></tr>
<tr><td>Bachelor's Degree in Automation and Industrial Electronic Engineering</td><td>4</td><td>OPTIONAL</td><td>Attendance-based</td></tr>
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<tr><td>Course number of credits (ECTS)</td><td>6</td></tr>
<tr><td>Type of activity, credits, and groups</td><td>
<table>
<tr><th>Activity type</th><th>PRAULA</th><th>TEORIA</th></tr>
<tr><td>Number of credits</td><td>3</td><td>3</td></tr>
<tr><td>Number of groups</td><td>1</td><td>1</td></tr>
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<tr><td>Coordination</td><td>TRESANCHEZ RIBES, MARCEL</td></tr>
<tr><td>Department</td><td>INDUSTRIAL AND BUILDING ENGINEERING</td></tr>
<tr><td>Teaching load distribution between lectures and independent student work</td><td>(40%) 60 h classroom
(60%) 90 h autonomous work</td></tr>
<tr><td>Important information on data processing</td><td>Consult this link for more information.</td></tr>
<tr><td>Language</td><td>Speaking: As required (Catalan, Spanish or English).
Materials and resources: English.
Student workload: English.</td></tr>
<tr><td>Distribution of credits</td><td>Theoretical sessions: 1 ECTS
Experimental training sessions: 2 ECTS
Practical sessions: 3 ECTS</td></tr>
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SYSTEMS INTEGRATION I 2023-24

Teaching staff	E-mail addresses	Credits taught by teacher	Office and hour of attention
TRESANCHEZ RIBES, MARCEL	marcel.tresanchez@udl.cat	7,2	

Subject's extra information

It is **COMPULSORY** that the students bring the following elements of individual protection (EPI) to the practices at the laboratory.

- Blue laboratory gown from UdL (unisex)
- Protection glasses
- Mechanical protection gloves

They can be purchased through the shop of the UdL:

C/ Jaume II, 67 baixos
Centre the Cultures i Cooperació Transfronterera

http://www.publicacions.udl.cat/

The use of other elements of protection (for example caps, masks, gloves of chemical or electrical risk, etc.) will depend on the type of practice to be done. In that case, the teacher will inform of the necessity of specific EPI.

Not bringing the EPI's described or not fulfilling the norms of general security that are detailed below imply that the student cannot access to the laboratories or have to go out of them. The no realization of the practices for this reason imply the **consequences in the evaluation** of the subject that are described in this course guide.

GENERAL NORMS OF SECURITY IN LABORATORY PRACTICES

- Keep the place of realization of the practices clean and tidy. The table of work has to be free from backpacks, folders, coats...
- No short trousers or short skirts are allowed in the laboratory.
- Closed and covered footwear is compulsory in the laboratory.
- Long hair needs to be tied.
- Keep the laboratory gown laced in order to be protected from spills of chemicals.
- Bangles, pendants or wide sleeves are not allowed as they can be trapped.
- Avoid the use of contact lenses, since the effect of the chemical products is much bigger if they enter between the contact lenses and the cornea. Protection over-glasses can be purchased.
- No food or drink is allowed in the laboratory.
- It is forbidden to smoke in the laboratories.
- Wash your hands whenever you have contact with a chemical product and before going out of the laboratory.
- Follow the instructions of the teacher and of the laboratory technicians and ask for any doubt on security.

For further information, you can check the following document of the *Servei de Prevenció de Riscos Laborals de la UdL*: http://www.sprl.udl.cat/alumnes/index.html

Learning objectives

- Learning the internal working of a high-performance microcontroller of 32 bits.
- Being able to program any peripheral of a 32-bit microcontroller for an automated specific task.
- Knowing the ARM Cortex-M architecture and its application in microcontrollers of 32 bits.
- Understanding the operation with sensors, MEMS sensors and actuators systems by means of low cost microcontrollers.
- Learning the use of the main intra-board communication busses for integrated circuits.
- Acquire necessary knowledge to be able to design and program a intelligent integrated system.

Competences

Strategic Competences of the UdL

UdL2. Command of a foreign language.

UdL3. Mastering ICT's.

Cross-disciplinary competences

EPS4. To have the skills required to undertake new studies or improve the training with self-direction.

EPS9. Capacity for unidisciplinary and multidisciplinary teamwork.

Specific competences

GEEIA21. Knowledge of the basics and applications of the digital electronics and microprocessors.

GEEIA25. Knowledge and capacity for modelling and simulation of systems.

GEEIA27. Knowledge of principles and applications of robotic systems.

Subject contents

Lesson 1. Introduction to integrated systems

1.1 Embedded systems types
1.2 Applications of embedded systems
1.3 Robotic Integrated Systems Solutions

Lesson 2. Operation of a microcontroller

2.1 Unit of instruction
2.2 Records
2.3 Memory
2.4 Buses and peripherals

Lesson 3. ARM Cortex-M architecture

3.1 ARM license model
3.2 ARM Cortex-M family
3.3 Von Neuman and Harvard architectures
3.4 Bus interconnection
3.5 Interruptions

3.6 CMSIS support and DSP library

Lesson 4. STM32F4 microcontrollers

4.1 STM32F407VGT6
4.2 STM32F4Discovery
4.3 CMSIS files and libraries
4.4 Registers and memory management

Lesson 5. Input and output

5.1 Digital inputs and outputs
5.2 Analog inputs and outputs (ADC and DAC)

Lesson 6. Debugging and monitoring

6.1 Debugging and monitoring with SWV and ITM
6.2 Debugging with USART

Lesson 7. System configuration

7.1 System clock
7.2 Interrupts (NVIC) and EXTI interface

Lesson 8. Synchronization and multitasking

8.1 Polling Synchronization and Interrupt
8.2 Scheduling with interrupts and DMA
8.3 Real-time operating systems (RTOS)

Lesson 9. Timing

9.1 System timers (SysTick)
9.2 Timers of an ARM microcontroller
9.3 PWM modulation
9.4 Input capture and output comparison

Lesson 10. Serial communication

10.1 I2C communication
10.2 SPI and I2S communication
10.3 USART communication

Methodology

The subject will be developed by conducting several experimental works to be carried out in the electronics lab 2.05 (2nd floor) of the
Polytechnic School (EPS).

Learning systems integration will be carried out by STMicroelectronics development tools, mainly with STM32F4-Discovery.

Development kits will be provided entirely by the school where each student will work both individually or in groups.

Practical exercises will be based on microcontroller programming using C language development environments.

The sessions will be divided into three consecutive stages repeated for each of the contents of the subject:

- **Sessions of theory** (classroom/virtual): Preliminary theoretical concepts.

- **Experimental training sessions** (electronics lab): Acquire skills with teacher support.
- **Practice sessions** (electronics lab) : Individual student work with exercises and activities.

Development plan

Week	Methodology	Content	Asynchronous Content[2]	HTP [3]	HTNP [4]
1	Masterclass	Lesson 1		2	2
1, 2	Masterclass	Lesson 2		3	4
2	Masterclass	Lesson 3		3	4
3, 4	Experimental Sessions	Lesson 4	Lesson 7	5	5
4	Experimental Sessions	Lesson 5	Lesson 8, 9	3	6
5	Laboratory: Practical Exercise 1	Lesson 1-5	Lesson 7, 8	2	8
6	Experimental Sessions	Lesson 6, 7	Lesson 10	4	6
7	Experimental Sessions	Lesson 8	Lesson 9	4	7
8	Laboratory: Practical Exercise 2	Lesson 5-7	Lesson 9, 10	4	8
9	Prectices doubts[1]	Lesson 5-7		2	2
10	Experimental Sessions	Lesson 8, 9		4	4
11	Laboratory: Practical Exercise 3	Lesson 5-10		2	4
12	Experimental Sessions	Lesson 10		4	4
13-15	Laboratory: Final Project	All		12	18
16, 17	Practices doubts[1]	All		2	2
18	Tutorials	All		2	2
19	Make-up Exams: Evaluation	All		2	4
			TOTAL	60	90

[1] Week for exams. As there are no written tests, they are dedicated to classes of practical questions.
[2] Content that has not yet been taught but part of it has been introduced to follow the the subject.
[3] HTP = Face-to-face hours
[4] HTNP = Homework hours

Evaluation

The course assessment will take place continuously and be based on the weighted evaluation of the reports of the activities undertaken throughout the course.

These experimental exercises should be carried out individually except the final project that will be done in groups. Each student will have available the electronics devices required to work with the proposed exercises at home and at hours of electronics laboratory.

The practical exercises are made up of three practical tasks and one final project. The difficulty of the activities will be increased as regarding on the punctuation weight of final qualification: 2, 2 and 2.5 points respectively. Finally, there will be a final project that will be focused on the global knowledge acquired. This project will be carried out in workgroups and will have a weight about final qualification of 35% (3.5 points).

The activities to be carried out will be the following:

P1. Control sincronyzed tasks using inputs, outputs and interrupts.
P2. Program an automaton system controlled by a command interpreter.
P3. Capture, sample and record data from a MEMS sensor.
PF. Programing a low-cost smart embedded system based on a 32-bit microcontroller.

At this way, the course qualification (NC) will be calculated as:

NC = P1*0.20 + P2*0.20 + P3*0.25 + PF*0.35

If NC is lower than 5.0 there will be an optional exam with a weight of 8 points, the final mark will be computed with:

NF = NR + (NC x 0,2)

Bibliography

- Warwick A. Smith (2009) **C Programming for Embedded Microcontrollers**. Publitronic-Elektor. ISBN: 978-0905705804.

- Noviello, C. (2016) **Mastering the STM32 Microcontroller.** Leanpub.

- Jonathan W Valvano (2015) **Embedded Systems: Introduction to Arm® Cortex(TM)-M Microcontrollers** , Fifth Edition. ISBN: 978-1477508992

- Joseph Yiu (2013) **The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors**. Elseiver. Cambidge, UK.

- Donald Reay (2015) **Digital Signal Processing and Applications Using the Arm Cortex M4**. Wiley. ISBN: 978-1118859049.

- ARM Cortex-M architecture: http://www.arm.com/products/processors/cortex-m/

- STM32 32-bit ARM Cortex MCUs: http://www.st.com/web/en/catalog/mmc/FM141/SC1169

- STM32F4Discovery – STMicroelectronics: http://www.st.com/web/catalog/tools/FM116/SC959/SS1532/PF252419