Course guide
240275 - 240AU132 - Embedded Systems

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.
Degree: MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Optional subject).
MASTER'S DEGREE IN AUTOMOTIVE ENGINEERING (Syllabus 2019). (Optional subject).

Academic year: 2022   ECTS Credits: 4.5   Languages: Catalan, Spanish

LECTURER
Coordinating lecturer: Calomarde Palomino, Antonio

Others:

PRIOR SKILLS
Basic software programming principles
Knowledge of a basic programming language (python, C/C++)
Basic knowledge of microcontrollers

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES
Specific:
CEAU 4. (ENG) Explicar els sistemes elèctrics, electrònics i de control de què disposa un vehicle.

TEACHING METHODOLOGY
The course uses, approximately, the exposition/participation methodology in 25%, individual work in 50%, and group work in 25%. Cooperative work techniques and problem- and project-based learning techniques are also used. The realization of the lab sessions is a condition to pass the subject.

LEARNING OBJECTIVES OF THE SUBJECT
The objective is to provide a comprehensive overview about existing and future automotive electronic systems. The distinctive features of the automotive world in terms of requirements and technologies are highlighted and state-of-the-art methodological and technical solutions are presented in the following areas:
• In-vehicle architectures
• Multipartner development processes (subsystem integration, etc.)
• Software engineering methods
• Embedded communications
• Safety and dependability assessment: validation, verification, and testing

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Hours medium group</td>
<td>40,5</td>
<td>36.00</td>
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<tr>
<td>Self study</td>
<td>72,0</td>
<td>64.00</td>
</tr>
</tbody>
</table>

Total learning time: 112.5 h
## CONTENTS

### Chapter 1. Introduction to Embedded Systems

**Description:**
- An overview of embedded systems
- Examples of embedded systems
- Features of embedded systems
- Software for embedded systems
- Embedded systems programming and debugging

**Full-or-part-time:** 2h  
Theory classes: 1h  
Self study : 1h

### Chapter 2. MCU architecture

**Description:**
- Arm processor families
- The ARM Cortex-R series
- The Arm Cortex-M series

**Full-or-part-time:** 2h  
Theory classes: 1h  
Self study : 1h

### Chapter 3. Introduction to Cortex-M4 Programming

**Description:**
- Cortex-M4 Processor Overview
- Cortex-M4 Block Diagram
- Cortex-M4 Registers
- Cortex-M4 Memory Map
- ARM Cortex-M4 Processor Instruction Set

**Full-or-part-time:** 3h  
Theory classes: 1h  
Self study : 2h

### Chapter 4. MCU extensions

**Description:**
- Digital inputs and outputs
- Analog inputs and outputs
- Timers and PWM
- Serial communication
- DMA

**Full-or-part-time:** 6h  
Theory classes: 2h  
Self study : 4h
### Chapter 5. Interrupts and Low Power Features

**Description:**
- Exception and Interrupt Concepts
- Core Interrupts
- Using Port Module and External Interrupts
- Timing Analysis
- Program Design with Interrupts
- Sharing Data Safely Between ISRs and Other Threads

**Full-or-part-time:** 2h  
Theory classes: 1h  
Self study: 1h

### Chapter 6. Real Time Operating Systems

**Description:**
- Operating System Overview
- What is an Operating System?  
- Functions, types, and services of Operating Systems  
- Real-Time Operating System (RTOS)  
- RTOS overview
- RTOS task scheduling
- Keil RTX RTOS
- RTOS on Mbed Platform
- Mbed RTOS API  
- Using Mbed RTOS API for your project
- Threads, Mutex, and Semaphore

**Full-or-part-time:** 2h  
Theory classes: 1h  
Self study: 1h

### Chapter 7. Design of algorithms

**Description:**
- Vehicle Functional Domains and Their Requirements  
- Application of the AUTOSAR Standard  
- Intelligent Vehicle Technologies

**Full-or-part-time:** 4h  
Theory classes: 2h  
Self study: 2h

### Chapter 8. Embedded Communications

**Description:**
- A Review of Embedded Automotive Protocols  
- FlexRay Protocol
- Dependable Automotive CAN Networks

**Full-or-part-time:** 12h  
Theory classes: 6h  
Self study: 6h
Chapter 9. Embedded Software and Development Processes

Description:
Product Lines in Automotive Electronics
Reuse of Software in Automotive Electronics
Automotive Architecture Description Languages
Model-Based Development of Automotive Embedded Systems

Full-or-part-time: 14h
Theory classes: 7h
Self study : 7h

Chapter 10. Verification, Testing, and Timing Analysis

Description:
Testing Automotive Control Software
Testing and Monitoring of FlexRay-Based Applications
Timing Analysis of CAN-Based Automotive Communication Systems
Scheduling Messages with Offsets on Controller Area Network: A Major Performance Boost
 Formal Methods in the Automotive Domain

Full-or-part-time: 8h
Theory classes: 4h
Self study : 4h

Laboratory sessions

Description:
Introduction to the software design tools
Design and programming or ordering algorithms
Introduction to the hardware design tools

Full-or-part-time: 26h
Theory classes: 13h
Self study : 13h

Grading System

The final grade for the course will be:
NF = max (0.60 * NE + 0.4 * NL; 0.6 * NEF + 0.4 * NL)
NF: Final mark.
NE: Exercises, problems and/or tests.
NL: Lab. sessions.
BIBLIOGRAPHY

Basic: