

Course guide

240275 - 240AU132 - Embedded Systems

Last modified: 16/05/2023

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: 2023 **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

Type	Hours	Percentage
Hours medium group	40,5	36.00
Self study	72,0	64.00

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 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

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

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:

- Ribbens, William B. Understanding automotive electronics : an engineering perspective [on line]. 8th ed. Oxford: Elsevier/Butterworth-Heinemann, an imprint of Elsevier, [2017] [Consultation: 29/03/2023]. Available on: <https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=4882541>. ISBN 9780128104347.
- Navet, Nicolas ; Françoise Simonot-Lio. Automotive Embedded Systems Handbook [on line]. New York: Taylor & Francis Group, LLC, 2009 [Consultation: 17/11/2022]. Available on: <https://doi-org.recursos.biblioteca.upc.edu/10.1201/9780849380273>. ISBN 9780849380266.
- Denton, Tom. Automobile electrical and electronic systems. 5th ed. Milton Park, Abingdon, Oxon: Routledge, 2017. ISBN 9780415725774.
- Held, Gilbert. Inter -and intra-vehicle Communications [on line]. Boca Raton: CRC Press, 2008 [Consultation: 30/06/2021]. Available on: <https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=321835>. ISBN 9780367388317.