# UNIVERSITAT POLITÈCNICA DE CATALUNYA
**UPC** BARCELONATECH

# Course guide
# 230707 - AES - Automotive Embedded Systems

**Last modified:** 11/04/2025

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| **Unit in charge:** | Barcelona School of Telecommunications Engineering |
| **Teaching unit:** | 744 - ENTEL - Department of Network Engineering. |

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| **Degree:** | MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject). |
| | MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject). |
| | MASTER'S DEGREE IN ELECTRONIC ENGINEERING (Syllabus 2022). (Optional subject). |

**Academic year:** 2025    **ECTS Credits:** 5.0    **Languages:** English

## LECTURER

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|---|---|
| **Coordinating lecturer:** | LUIS JAVIER DE LA CRUZ LLOPIS |
| **Others:** | Primer quadrimestre: |
| | JAIME ABELLA FERRER - 11 |
| | LUIS JAVIER DE LA CRUZ LLOPIS - 11 |
| | JUAN MANUEL MORENO AROSTEGUI - 11 |
| | JOAQUIM MOTGER DE LA ENCARNACION - 11 |

## TEACHING METHODOLOGY

Lectures
Application classes
Laboratory classes
Laboratory sessions
Individual work (not presential)
Group work (not presential)
Short-answer tests (Control)
Short-answer tests (Test)
Extended-response tests (Final Exam)

## LEARNING OBJECTIVES OF THE SUBJECT

Nowadays there is an evident evolution in the automotive sector towards vehicles that make an exhaustive use of electronic and communications technologies. Vehicles with all kinds of sensors and actuators (temperature, proximity, cameras, driving assistance, parking, ...), long and short range communications technologies (4G, 5G, RFID/NFC, WiFi, ...) and its associated services (Internet access, infotainment, teleoperation, ...) make driving more comfortable, reliable and safe. To provide vehicles with all these new functionalities, there are many companies, both national and international, which focus their efforts on the production of systems that allow vehicle factories to be at the vanguard in the market. These companies are currently an attractive destination for telecommunications and computer engineers with special interest in the development and programming of embedded systems.
This subject arises from the need to offer a first specialization for engineers who wish to guide their professional career towards the contribution in the development of these electronic communication systems. It has been designed in collaboration between research groups from different departments of the UPC and working groups of leading companies in the electronics sector for the automotive industry. Its contents include aspects related to embedded software development, real-time operating systems, communication buses and reference architectures. In addition, the processes related to the evaluation, verification, validation and functional safety of the developed software are studied. As a result, an interesting preliminary training is offered that allows graduates to enter with guaranteed success in this exciting industry.

## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Hours large group | 26,0 | 20.80 |
| Self study | 86,0 | 68.80 |
| Hours small group | 13,0 | 10.40 |

**Total learning time:** 125 h

## CONTENTS

### 1. Introduction

**Description:**
1. Introduction.
1.1. Opening.
1.2. Structure of the course. Practicalities.

**Full-or-part-time:** 0h 15m
Theory classes: 0h 15m

### 2. Telematics.

**Description:**
2.1. Vehicle internal communications.
2.1.1. CAN bus
2.1.2. Automotive Ethernet
2.2. V2X communications.
2.2.1. Intelligent Transportation Systems (ITS).
2.2.2. ETSI Architecture.
2.2.2.1. Application Layer.
2.2.2.2. Facilities Layer.
2.2.2.3. Networking and Transport Layer.
2.2.2.4. Acces Layer.
2.3. Laboratory
2.3.1. CAN bus

**Full-or-part-time:** 5h 45m
Theory classes: 5h 45m

## 3. Embedded software.

**Description:**
3.1. Embedded software design principles.
3.1.1. Algorithm design and coding practices.
3.1.2. Advanced I/O techniques.
3.1.2.1. DMA-handled I/O.
3.1.2.2. Interrupt-handled I/O.
3.1.3. MISRA-C design rules and good practices.
3.2. RTOS.
3.2.1. Introduction.
3.2.2. Kernel.
3.2.3. Tasks, multitasking and multithreading.
3.2.4. Scheduler.
3.2.5. Inter-process communication.
3.3. Laboratory sessions.
3.3.1. Introduction to the laboratory and the design tools.
3.3.2. Design of a standalone software application.
3.3.3. Design of a software application based on an RTOS.
3.4. MISRA C.

**Full-or-part-time:** 9h
Theory classes: 9h

## 4. Functional safety and cybersecurity.

**Description:**
4.1. Introduction.
4.1.1. What is Functional Safety.
4.1.2. Functional Safety and Product Safety / Cybersecurity.
4.1.3. Functional safety standards and definitions.
4.1.4. ISO26262 overview.
4.2. Safety Concepts.
4.2.1. Hazard & Risk Analysis and determination of ASILs.
4.2.2. System-level architectures & examples.
4.3. Software safety.
4.3.1. Safety Requirements.
4.3.2. Sw Architectural descriptions for functional safety.
4.3.3. Patterns in Sw Architecture, E-Gas koncept.
4.3.4. Freedom from Interference concepts.
4.3.5. Safety Analysis at the sw level.
4.3.6. Autosar & Functional Safety.
4.3.7. Software safety process overview.
4.4. Cybersecurity.

**Full-or-part-time:** 9h
Theory classes: 9h

## 5. Verification and validation.

**Description:**
5.1. Introduction.
5.1.1. Definition and importance of Software Quality Assurance & Testing.
5.1.2. Managing risks.
5.1.3. Testing in Agile & DevOps.
5.1.4. Software testing economics.
5.2. Test levels (unit testing, system testing, integration testing, ...).
5.2.1. Ways of testing software.
5.2.2. The seven principles of testing.
5.2.3. Software testing levels and responsibilities.
5.2.4. Software testing types.
5.3. Test methods (black box, white box, grey box, ...).
5.3.1. V-model and test methods.
5.3.2. The testing lifecycle.
5.3.3. Testing Management.
5.3.4. Defect Management.
5.3.5. Test cases design.
5.3.6. Practicing the testing lifecycle (test case design, test case execution and defect reporting).
5.4. Test automation.
5.4.1. Introduction to test automation.
5.4.2. Towards an acceptance test automation framework.
5.4.3. Recording vs. Layered automation.
5.4.4. Basic concepts for JUnit+Selenium automation.
5.4.5. Automated testing for APIs.
5.4.6. Practicing test cases automation (the 10-levels challenge).
5.4.7. Automated testing in mobile devices (demo).
5.5. Test-driven development.
5.5.1. The concept of Test-Driven Development.
5.5.2. Test-First & Acceptance Test-Driven Development.
5.5.3. Practicing TDD through a small example.
5.6. Conclusions.
5.6.1. Conclusions.

**Full-or-part-time:** 6h
Theory classes: 6h

## 6. ADAS.

**Description:**
6.1. Introduction
6.2. Tecnologies
6.2.1. Radar
6.2.2. Ultrasonic
6.2.3. Lidar
6.2.4. Cameres
6.3. Block Diagram Video Pipeline
6.4. Image quality Testing (KPI)
6.5. Laboratory

**Full-or-part-time:** 9h
Theory classes: 9h

## GRADING SYSTEM

The evaluation is based on individual tasks or reports carried out by the students, corresponding to each of the different parts of the subject.
Students are required to submit one task for each module, and all them are weighted equally for the final evaluation.

## BIBLIOGRAPHY

**Basic:**
- Skiena, S.S. The algorithm design manual. Third edition. Cham: Springer, 2020. ISBN 9783030542559.
- Motor Industry Software Reliability Association. Guidelines for the use of the C Language in critical systems [on line]. Misra, 2012 [Consultation: 16/05/2018]. Available on: https://cds.cern.ch/record/2017046. ISBN 978-1-906400-11-8.
- International Organization for Standardization. ISO/DIS 26262. Road Vehicles - Functional Safety [on line]. 2009 [Consultation: 16/05/2018]. Available on: https://www.iso.org/obp/ui/#iso:std:iso:26262:-2:dis:ed-2:v1:en.
- ETSI EN. EN 302 636-3-V.1.1.2 Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 3: Network Architecture [on line]. 2014 [Consultation: 16/05/2018]. Available on: http://www.etsi.org/standards.
- Koomen, T.; Aalst, L.van der; Broekman, B.; Vroon, M. TMap Next for result-driven testing. Vianen: Sogeti Nederland B.V., 2014. ISBN 9789075414806.
- SPICE. Automotive SPICE® Process Reference and Assessment Model [on line]. RELEASE 3.1. 2017 [Consultation: 16/05/2018]. Available on: http://www.automotivespice.com/download/.
- AUTOSAR [on line]. [Consultation: 10/10/2022]. Available on: https://www.autosar.org/.