

IDENTIFICATION

Course code : ESI-SPI-CI-IN4-S7-UE2-EC1
ECTS : 1

DURATION

Lectures : 0
Tutorial classes : 18
Labs : 10
Total : 28

Project :
Personnal work :

ASSESSMENT

At least two continuous assessments, practical work sessions, and a mini embedded project.

TEACHING MATERIALS

Slides, directed work sheets, practical work sheets, embedded platforms (ESP32, STM32).

LANGUAGE

English

CONTACT

Provide theoretical and practical foundations for designing embedded real time applications in the context of the Internet of Things. Students will learn to identify, analyze, and solve issues related to real time constraints, limited resources, and reliability of connected embedded systems.
Modifié le : 14 juillet 2026

UE : UE7-IOT

COURSE : Internet of Things : Embedded and Real-Time Systems

SCOPE OF THE COURSE

OBJECTIVES

COMPETENCE AND SKILLS

- Apply programming and communication paradigms specific to embedded systems and IoT
- Design secure infrastructure and service solutions tailored for connected objects
- Implement an end-to-end IoT solution by identifying hardware architectures, terminal object networks, and communication with an IoT service platform

PROGRAM

— Real-Time Systems — Fundamentals

- Identify and understand real-time constraints (hard / soft real-time) associated with an embedded IoT application
- Analyze and quantify these constraints; recommend a scheduling solution type (Rate Monotonic, Earliest Deadline First)
- Feasibility analysis of a real-time task set

— Embedded Programming and RTOS

- Creating tasks, synchronization, and inter-process communication on a real-time operating system (FreeRTOS)
- Priority management, semaphores, mutexes, message queues
- Energy management : sleep modes, deep sleep, duty cycling

— Hardware Resources and Peripherals

- Identifying critical hardware and software resources of an IoT node (sensors, actuators, communication interfaces)
- Role and development of device drivers (GPIO, I2C, SPI, UART, ADC)
- Embedded communication buses and low-level protocols

— Design and Tools

- Specification tools and languages for developing embedded real-time applications (sequence diagrams, state machines)
- Cross-compilation toolchain, on-target debugging (JTAG/SWD)
- Sensor-microcontroller-network integration : from sensor to cloud (MQTT, CoAP)

— Practical Work

- Lab 1 : Getting started with FreeRTOS on ESP32 — tasks, priorities, scheduling
- Lab 2 : Inter-task communication and sensor management (I2C/SPI)
- Lab 3 : Energy management and low-power modes

- Lab 4 : Complete integration — sensor acquisition, real-time processing, MQTT transmission

BIBLIOGRAPHY

Jean-Philippe Babau — *Embedded Real-Time Systems* — Hermes/Lavoisier
Richard Barry — *Mastering the FreeRTOS Real Time Kernel* — freertos.org
Kolban — *Kolban's Book on ESP32* — leanpub.com
James F. Kurose and Keith W. Ross — *Computer Networking* — Pearson Education
Phillip A. Laplante et al. — *Real-Time Systems Design and Analysis : Tools for the Practitioner* — Wiley-IEEE Press
Elecia White — *Making Embedded Systems : Design Patterns for Great Software* — O'Reilly Media

REQUIREMENTS

- SR052 : Operating Systems and Command Language
- SR051 : Principles of Networks and IoT
- Basics of C/C++ programming