Course guide
300266 - LOWPOW - Low-Power Systems with Energy Harvesting

Last modified: 12/06/2026

Unit in charge: Castelldefels School of Telecommunications and Aerospace Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.

Degree: MASTER'S DEGREE IN APPLIED TELECOMMUNICATIONS AND ENGINEERING MANAGEMENT (MASTEAM) (Syllabus 2015). (Optional subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).
ERASMUS MUNDUS MASTER IN COMMUNICATIONS ENGINEERING AND DATA SCIENCE (CODAS 1) (Syllabus 2024). (Optional subject).
ERASMUS MUNDUS MASTER IN COMMUNICATIONS ENGINEERING AND DATA SCIENCE (CODAS 2) (Syllabus 2024). (Optional subject).

Academic year: 2026 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Defined at the infoweb

Others: Defined at the infoweb

PRIOR SKILLS

DC and AC circuit analysis, linear system theory, basic lab instruments, implementation and test of basic circuits

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Generical:
03 DIS. (ENG) Diseñar aplicaciones de alto valor añadido basadas en las Tecnologías de la Información y las Comunicaciones (TIC), aplicadas a cualquier ámbito de la sociedad.

Transversal:
02 SCS. SUSTAINABILITY AND SOCIAL COMMITMENT. Being aware of and understanding the complexity of social and economic phenomena that characterize the welfare society. Having the ability to relate welfare to globalization and sustainability. Being able to make a balanced use of techniques, technology, the economy and sustainability.
03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

Basic:
CB6. Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context.
CB9. Students will be able to communicate their conclusions and the knowledge and ultimate reasons that support them to specialized and non-specialized audiences in a clear and unambiguous manner.
CB10. Students will acquire learning skills that allow them to continue studying in a way that will be largely self-directed or autonomous.

TEACHING METHODOLOGY

Lectures
Blended teaching and flippled classroom
Resolution of problems and cooperative learning
Lab work and Project based learning

LEARNING OBJECTIVES OF THE SUBJECT

When finishing this subject, students should be able to:

Knowledges
K1. Identify and describe low-power sensor nodes and wireless sensor networks for different applications, including the Internet of Things (IoT).
K2. Identify and describe energy harvesters to power sensors nodes and also their constituent blocks and functionalities.
K3. Identify and apply suitable theoretical analyses for designing energy harvesters to power sensor nodes.

Skills
S1. Use of lab instruments and other tools to perform lab experiments.
S2. Test and assess sensor nodes and the energy harvesters to power them.

Competences
C1. Design, implement and assess sensor nodes and the energy harvesters to power them.
C2. Perform tasks and projects in groups, according to some instructions or initial requirements.
C3. Communicate orally and in writing with others about the outcome of learning and decision-making.

STUDY LOAD

Type	Hours	Percentage
Self study	48,0	64.00
Hours large group	4,0	5.33
Hours medium group	23,0	30.67

Total learning time: 75 h

CONTENTS

Introduction

Description:
Introduction to the course: basic info, Prior skills, Teaching methodology, Learning outcomes, contents, training activities, assessement criteria, bibliography
Low power systems -> Sensor nodes: introduction, applications
Energy harvesting: introduction

Related activities:
- In classroom: note-taking, class participation, solving exercises.
- Outside class: reviewing theoretical concepts, homework.

Full-or-part-time: 1h 30m
Theory classes: 1h
Self study : 0h 30m

Sensor Nodes

Description:
Introduction
Sensing: sensors vs. quantities, I/O characteristics, power consumption
Processing: analog, digital, analog-to-digital conversion, power consumption
(Wireless) Communication: protocols. transceivers, antennas and RF propagation, power consumption
Power consumption: summary, switching between operation modes, power profile
Power supply: primary batteries, lifetime, energy harvesting
Esperimental assessment of a sensor node

Related activities:
With respect to theory classes
- In classroom: note-taking, class participation, solving exercises.
- Outside class: reviewing theoretical concepts, homework.
With respect to laboratory classes
- In classroom: experimental work.
- Outside class: homework, reports.

Full-or-part-time: 14h
Theory classes: 3h
Laboratory classes: 2h
Self study : 9h

Energy sources and transducers

Description:
Introduction: primary batteries vs. energy harvesting, energy sources
Light: energy sources, radiometric and photometric quantities, PV cells
Thermal: energy sources, thermoelectrical generators
Mechanical: energy sources, transducers
Radiofrequency (RF): energy sources, antennas, RFID systems
Benchmarking, energy balance and commercial products
Experimental assessment of a PV module

Related activities:
With respect to theory classes
- In classroom: note-taking, class participation, solving exercises.
- Outside class: reviewing theoretical concepts, homework.
With respect to laboratory classes
- In classroom: experimental work.
- Outside class: homework, reports.

Full-or-part-time: 16h 50m
Theory classes: 4h
Laboratory classes: 2h
Self study : 10h 50m

Energy storage

Description:
Introduction
Batteries: operating principle, primary vs. secondary. Secondary batteries: characteristics, types and sizes, charge methods, protection circuits, benchmarking.
Supercapacitors: operating principle, characteristics, charge/discharge
Benchmarking and hybrid storage
Energy balance

Related activities:
With respect to theory classes
- In classroom: note-taking, class participation, solving exercises.
- Outside class: reviewing theoretical concepts, homework.
With respect to laboratory classes
- In classroom: experimental work.
- Outside class: homework, reports.

Full-or-part-time: 11h 10m
Theory classes: 2h
Laboratory classes: 2h
Self study : 7h 10m

Power management

Description:
Introduction
Output stage: voltage regulation and types
Input stage: voltage regulation, MPPT, startup circuits, AC/DC conversion, storage management
Energy balance

Related activities:
With respect to theory classes
- In classroom: note-taking, class participation, solving exercises.
- Outside class: reviewing theoretical concepts, homework.
With respect to laboratory classes
- In classroom: experimental work.
- Outside class: homework, reports.

Full-or-part-time: 11h 20m
Theory classes: 2h
Laboratory classes: 2h
Self study : 7h 20m

Project

Description:
Lab project based on the topics presented at the theory classes and practiced in the guided labs. In particular, an energy harvester using a PV module will be used for powering a sensor node. The harvester will be designed, implemented and tested.

Related activities:
- In classroom: discussion of the project design with the instructor; implementation and testing of the project.
- Outside classroom: project design and reporting.

Full-or-part-time: 11h 10m
Laboratory classes: 4h
Self study : 7h 10m

Theoretical exam

Description:
Individual theoretical exam to assess the topics presented in the theory classes

Related activities:
In classroom: doing the exam.
Outside class: solving questions with the instructor, specific study for the exam.

Full-or-part-time: 9h
Theory classes: 3h
Self study : 6h

GRADING SYSTEM

Any academic fraud, plagiarism or use or possession of unauthorised means in an assessment activity leads to a mark of zero (0) for the affected test or assignment. Furthermore, in accordance with the University's regulations, if disciplinary proceedings are initiated the subject is recorded as "Pending Assessment" until a decision is reached. These incidents are managed in accordance with the **Action Framework for Academic Integrity in Assessment at the UPC**.

Defined at the infoweb

BIBLIOGRAPHY

Basic:
- Penella López, María Teresa; Gasulla Forner, Manuel. Powering Autonomous Sensors : An Integral Approach with Focus on Solar and RF Energy Harvesting [on line]. Dordrecht: Springer, 2011 [Consultation: 27/08/2025]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-94-007-1573-8. ISBN 9789400715721.
- Beeby, Stephen; White, Neil. Energy harvesting for autonomous systems [on line]. 1 st ed. Norwood, Massachusetts: Artech House, 2010 [Consultation: 18/07/2025]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=946528. ISBN 9781523117130.

RESOURCES

Other resources:
Theory:
- Slides, collection of exercices, electronic books, technical documents, scientific papers, internet resources
Laboratory
- Basic lab instruments: power source, digital multimeter, waveform generator and oscilloscope
- Accessories for the lab work: electronic devices and components, breadboard and cables
- Lab scripts
- Manuals, datasheets and internet resources