Course guide  
230733 - EMST - Electronic Measurement Science and Technology

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

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). (Compulsory subject).

Academic year: 2022  
ECTS Credits: 5.0  
Languages: English

LECTURER

Coordinating lecturer: Consultar aquí / See here:  
https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here:  
https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

PRIOR SKILLS

Analog functions design, basic analog and digital filter design, basic electronic instruments knowledge: use of instruments and block diagrams. Statistics: random variables and stochastic processes. Basic uncertainty assessment according to GUM, basic signal processing: Fourier transform, sampling theorems

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CMEE8. Implement distributed instrumentation systems and advanced sensor networks including self-sufficient systems based on the harvesting of energy from the environment.
CMEE9. Design, implement and operate high-performance electronic laboratory instrumentation, with emphasis on error analysis, calibration and virtual control.
CMEE10. Evaluate the suitability of the measurement methods and estimate the associated uncertainty.
CMEE11. Design and implement sensor-based and application-oriented systems

Transversal:
CTMEE4. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically assess the results of said management.

TEACHING METHODOLOGY

- Lectures
- Application classes
- Project Based Learning
- Laboratory practical work
- Exercises
- Short answer test
- Extended answer test
LEARNING OBJECTIVES OF THE SUBJECT

The aim of this course is to train students in methods of design, implementation and operation of advanced instrumentation and sensor systems. This includes instrumentation and sensor networks, recovering of signals in noisy environments, advanced sensor conditioning methods, smart sensor systems, information codification in non-analog domains and advanced uncertainty analysis.

Learning results of the subject:
- Know the physical principles and manufacturing technology of advanced sensors.
- Know how to design and manage network measurement systems.
- Understand the technical specifications of high-performance measurement equipment.
- Know the basic principles of the calibration of instruments and systems based on sensors and the techniques used to carry it out.
- Know how to design virtual instrumentation and automatic test systems.
- Know how to design the measurement and processing blocks of IoT devices.
- Know and know how to interpret the regulations that affect electronic products.

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>26.0</td>
<td>20.80</td>
</tr>
<tr>
<td>Hours small group</td>
<td>13.0</td>
<td>10.40</td>
</tr>
<tr>
<td>Self study</td>
<td>86.0</td>
<td>68.80</td>
</tr>
</tbody>
</table>

Total learning time: 125 h

CONTENTS

Introduction

Description:
Introducción and description of course objectives, contents and activities

Full-or-part-time: 1h
Theory classes: 1h

Advanced Uncertainty Analysis

Description:
Limits of GUM
Non Gaussian variables. Numerical estimation methods
Combining different classes of errors

Full-or-part-time: 14h
Theory classes: 3h
Laboratory classes: 1h
Self study: 10h
### Signal Recovery from Noise

**Description:**
- Optimal estimators for DC signals
- Optimal estimators for vector (AC) signals
- Noise analysis
- Interference analysis

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

### Standards and Calibration. Time standards

**Description:**
- Codification of information in time-domains
- Universal counters
- Standard oscillators
- Uncertainty analysis in time measurements

**Full-or-part-time:** 15h  
Theory classes: 4h  
Laboratory classes: 1h  
Self study: 10h

### Application-based sensor systems design

**Description:**
- Case study of a specific sensor application *
- Requirements and specifications extraction

*(The case study will be an Electrical Impedance Spectroscopy based sensor for biotechnological applications)*

**Full-or-part-time:** 23h  
Theory classes: 5h  
Laboratory classes: 3h  
Guided activities: 15h

### Circuit architecture for sensor system acquisition

**Description:**
- System architecture alternatives
- Analog front-end
- System-on-chip approaches

**Full-or-part-time:** 28h  
Theory classes: 5h  
Laboratory classes: 3h  
Guided activities: 20h
Sensor data analysis and processing

Description:
Sensor signal processing
Model fitting
Physical variables extraction

Full-or-part-time: 28h
Theory classes: 4h
Laboratory classes: 3h
Guided activities: 21h

ACTIVITIES

LABORATORY

Description:
Development of a sensor based on impedance spectroscopy for biotechnological application.
- Assessment of the effective resolution of the oscilloscope and methods to improve it
- Codification of a software-defined broadband vector voltmeter.
- Construction and characterization of the sensor

Full-or-part-time: 12h
Laboratory classes: 12h

GRADING SYSTEM

- Final / half-term written exam: 40%
- Individual works, written: 10%
- Group Project presentation, oral and written: 20%
- Group Project development, including lab: 30%

EXAMINATION RULES.

In written exams, no devices with wireless communication capabilities or the ability to store textual or graphical information, including programmable calculators, will be allowed.
BIBLIOGRAPHY

Basic:

Complementary: