Course guide
230643 - IS - Instrumentation and Sensors

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

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

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Ability to integrate instrumentation systems on mobile devices.
2. Ability to evaluate the quality and safety of electronic products including reliability, physical testing, electrical safety and electromagnetic compatibility.
3. Ability to deploy distributed instrumentation systems and advanced sensor networks including self-powered systems based on energy harvesting from the environment.
4. Ability to design, implement and operate high performance laboratory electronic instrumentation, with emphasis on error analysis, calibration and virtual control.

Transversal:
5. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

6. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

TEACHING METHODOLOGY

- Lectures
- Application classes
- Laboratory practical work
- Exercises
- Short answer test (Control)
- Extended answer test (Final Exam)
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, advanced sensor conditioning methods, smart sensor systems and error analysis. Also reliability, electrical safety and electromagnetic compatibility issues are covered.

Learning results of the subject:

- Ability to understand the physical principles and manufacturing technologies of advanced sensors.
- Know how to design and manage instrument and sensor networks and associated synchronization problems.
- Knowledge of various techniques of collecting energy from the environment.
- Ability to understand the technical specifications of high-sensitivity and high frequency measurement equipment.
- Knowledge of the basic principles of the calibration of instruments and the techniques used to carry it out.
- Ability to design virtual instrumentation and automatic test systems.
- Knowledge for integrating instrumentation systems on mobile devices.
- Ability to interpret the regulations affecting electronic products.
- Knowledge of the various tests required to verify electronic products.

STUDY LOAD

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

Total learning time: 125 h

CONTENTS

Introduction

-Introduction to the subject. Objectives, methodologies, activities, grading system, etc

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

Advanced Uncertainty Analysis

- 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
- Smart-sensor structure and standards
- Sensor networks
- Energy harvesting techniques for sensor systems

**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  
Practical 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  
Self study : 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  
Self study : 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
Self study: 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

EXERCISES

Description:
- Exercises to strengthen the theoretical knowledge
- Guided study of sensors, instruments and methods related materials

SHORT ANSWER TEST (CONTROL)

Description:
Mid term control.

EXTENDED ANSWER TEST (FINAL EXAMINATION)

Description:
Final examination.

GRADING SYSTEM

Final examination: 50%
Exercises: 20%
Laboratory assessments: 30%
BIBLIOGRAPHY

Basic:

Complementary: