Course guide
230643 - IS - Instrumentation and Sensors

Last modified: 28/06/2022

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

Degree: **Academic year:** 2022 **ECTS Credits:** 5.0
Languages: English

LECTURER

Coordinating lecturer: PERE JOAN RIU COSTA

Others:

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

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

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

Introduction

Description:
-Introduction to the subject. Objectives, metholologies, activities, grading system, etc

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

- 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:

- Ratcliffe, C; Ratcliffe, B. Doubt-Free Uncertainty In Measurement [on line]. Cham: Springer, 2015 [Consultation: 07/09/2022]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-319-12063-8. ISBN 9783319120638.
- Pallás-Areny, R.; Webster, J.G. Sensors and signal conditioning [on line]. 2nd ed. New York: John Wiley and Sons, 2001 [Consultation: 03/02/2021]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?docID=4747125. ISBN 0471332321.
- D'Antona, G; Ferrero, A. Digital Signal Processing for Measurement Systems. Theory and Applications [on line]. New York, NY: Springer, 2006 [Consultation: 07/09/2022]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/0-387-28666-7. ISBN 9781281334732.
- Wang, P; Liu, Q. Biomedical Sensors and Measurement [on line]. Heidelberg ; New York : Hangzhou: Springer, 2011 [Consultation: 07/09/2022]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-642-19525-9. ISBN 9787308082693.
- Sawan, M. Handbook of Biochips : Integrated Circuits and Systems for Biology and Medicine [on line]. New York, NY: Springer, 2022 [Consultation: 07/09/2022]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/referencework/10.1007/978-1-4614-3447-4. ISBN 9781461434474.

Complementary:

- Putten, A.F.P.V. Electronic measurement systems: theory and practice. 2nd ed. Bristol ; Philadelphia: IOP Publishing, 1996. ISBN 978-0750303408.
- Dargie, W.; Poellabauer, C. Fundamentals of wireless sensor networks: theory and practice [on line]. Chichester: John Wiley & Sons, 2010 [Consultation: 17/07/2017]. Available on: http://onlinelibrary.wiley.com/book/10.1002/9780470666388. ISBN 9780470666388.