UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Escola Tècnica Superior d'Enginyeria de Telecomunicació de Barcelona

telecos BCN

230733 – ELECTRONIC MEASUREMENT SCIENCE AND TECHNOLOGY

Credits: 5 ECTS

LECTURER

Coordinating lecturer: / Pere J Riu

Others: Ramon Bragós

PRIOR SKILLS

Analog functions design, basic analog and digital filter design, basic electronic instruments knowledge, 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:

- Implement distributed instrumentation systems and advanced sensor networks including self-sufficient systems based on the harvesting of energy from the environment.

- Design, implement and operate high-performance electronic laboratory instrumentation, with emphasis on error analysis, calibration and virtual control.

- Evaluate the suitability of measurement methods and estimate the associated uncertainty.

- Design and implement sensor-based and application-oriented systems.

Transversal:

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

TEACHING METHODOLOGY

- Lectures

- Application classes

- Project Based Learning

- Laboratory practical work

- Exercises

- Short answer test

- Extended answer test

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, 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

Hours large group: 26

Hours small group: 13

Hours self-study: 86

CONTENTS

1. **Advanced uncertainty analysis**
   Limits of GUM
   Non Gaussian variables
   Combining different classes of errors

   Large Group: 4 h
   small Group: 1 h
   Self study : 10 h

2. **Noisy environments**
   Optimal estimators for DC signals
   Optimal estimators for vector (AC) signals
   Noise analysis
   Interference analysis

   Large Group: 4 h
   small Group: 2 h
   Self study : 10 h

3. **Standards and Calibration. Time standards**
   Codification of information in time-domains
   Universal counters
   Standard oscillators

   Large Group: 4 h
   Small Group: 1 h
   Self study : 10 h

4. **Application-based sensor systems design**
   Case study of a specific sensor application **
   Requirements and specifications extraction

   Large Group: 5 h
   Small Group: 3 h
   Self study : 15 h

5. **Circuit architecture for sensor system acquisition**
   System architecture alternatives
   Analog front-end
   System-on-chip approaches

   Large Group: 5 h
   Small Group: 3 h
   Self study : 20 h

6. **Sensor data analysis and processing**
   Sensor signal processing
   Model fitting
   Physical variables extraction

   Large Group: 4 h
   Small Group: 3 h
   Self study : 21 h

* The order of the content topics does not imply a chronological order of lectures
** The case study well be an Electrical Impedance Spectroscopy based sensor for biotechnological applications.

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%

BIBLIOGRAPHY

Basic

C. Ratcliffe and B Ratcliffe, **Doubt-Free Uncertainty In Measurement**, Springer, 2015. ISBN: 978-3-319-36447-6

Gabriele D'Antona, Alessandro Ferrero**. Digital Signal Processing for Measurement Systems. Theory and Applications**. Springer, 2006. ISBN: 978-1-4419-3762-9

Ping Wang, Qingjun Liu. **Biomedical Sensors and Measurement**. Springer , 2011. ISBN 978-3-642-19525-9

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.

Reference Materials

Ekbert Hering, Gert Schönfelder (Eds.) **Sensors in Science and Technology. Functionality and Application Areas**, Springer, 2022. ISBN: 978-3-658-34920-2

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.