Course guide
230920 - SM - Measurement Systems

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

Degree: BACHELOR'S DEGREE IN ELECTRONIC ENGINEERING AND TELECOMMUNICATION (Syllabus 2018). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Spanish, 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

Knowledge and solvent use of circuit analysis, basic electromagnetism and the concepts of transfer function, frequency response of a linear system, signal spectral analysis and power spectrum
Knowledge and estimation of the limitations of operational amplifiers and similar integrated circuits, such as instrumentation amplifiers.
Knowledge of the implementation of sinusoidal and relaxation oscillators
Knowledge and application of function calculus. complex variable, basic statistics, stochastic processes and spectral noise density.
Operation and knowledge of the principles of operation of basic measurement instruments.
Knowledge and use of Python

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE23. (ENG) GREELEC: Cpacitat de realitzar l'especificació, implementació, documentació i posada a pount d'equips i sistemes, electrònics, d'unstrumentació i de control, considerant tant els aspectes tècnics com les normatives reguladores corresponents. (Mòdul de tecnologia específica- Sistemes electrònics).
CE28. (ENG) GREELEC: Capacitat per especificar i utilitzar instrumentació electrònica i sistemes de mesura. (Mòdul de tecnologia específica- Sistemes electrònics).
CE29. (ENG) GREELEC: Capacitat d'analitzar i solucionar els problemes d'interferències i compatibilitat electromagnètica. (Mòdul de tecnologia específica- Sistemes electrònics).

Generical:
CG2. (ENG) GEELEC: coneixment, comprensió i capacitat per explicar la legislació necessària durant el desenvolupament de la professió d'enginyer tècnic de telecomunicació i facilitat per al maneig d'especificacions, reglaments i normes d'obligat compliment.
CG5. (ENG) GREELEC: Coneixements per a la realització de medicions, càlculs, taxacions, peritacions, estudis, informes, planificació de tasques i treballs anàlegs en l'ambit específic de la telecomunicació.

Transversal:
CT3. (ENG) GREELEC: COMUNICACIÓ EFICAÇ ORAL I ESCRITA. Comunicar-se de forma oral i escrita amb d'altres persones sobre els resultats de l'aprenentatge, d el'elaboració del pensament i de la presa de decisions, participar en debats sobre el tema de la pròpia especialitat.

Basic:
CB3. (ENG) GREELEC: Que els estudiants tinguin la capacitat de reunir i interpretar dades rellevants (normalment dins de la seva àrea d'estudi) per emetre judicis que incloguin una reflexió sobre temes rellevants de caire social, científic o ètic.

TEACHING METHODOLOGY

Flipped Classroom
Problem-based learning
Hands-on laboratory

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course, the student must:
To be able to analyze, specify and design measurement systemas at a basic level.
Know the main types of sensors and have criteria for the comparison and choice of the various sensors that can measure a certain magnitude.
Efficiently use measurement instruments both in manual mode and under computer control
Be able to estimate the uncertainty in the measure following international recommendations
To be able to evaluate the effect of interferences and noise in measurement and instrumentation systems.
Understand the basic principles of the regulations of compulsory compliance in Electromagnetic Compatibility
Learn basic techniques for the treatment and presentation of measurement results

STUDY LOAD

Type	Hours	Percentage
Hours large group	39,0	26.00
Hours small group	26,0	17.33
Self study	85,0	56.67

Total learning time: 150 h

CONTENTS

Subject Introduction

Description:
Introduction to the subjects and working methodologies of the subject

Full-or-part-time: 3h
Theory classes: 3h

Introduction to measurement systems

Description:
Basic concepts: Definition of measurement, measurement system, sensor, actuator, measurement blocks
Static and dynamic characteristics of measurement systems

Related activities:
Measurement system characteristics exercises

Full-or-part-time: 8h
Theory classes: 3h
Self study : 5h

Measurement uncertainty estimation

Description:
Measurement uncertainty estimation recommendations
Type A and Type B uncertainties
Uncertainty propagation

Related activities:
Problems related to the estimation of the uncertainty in measurements

Full-or-part-time: 8h
Theory classes: 3h
Self study : 5h

Interferences on measurement systems

Description:
Types of interference
Identification of sources of interference
Reduction of interferences

Related activities:
Exercises on electromagnetic interference

Full-or-part-time: 8h
Theory classes: 3h
Self study : 5h

Noise in measurement systems

Description:
Origin of electronic noise
Noise models
Noise analysis techniques

Related activities:
Exercises on noise

Full-or-part-time: 8h
Theory classes: 3h
Self study : 5h

Resistive sensors

Description:
Introduction to resistive sensors
Piezoresistive sensors (strain gages)
Resistive Temperature Detectors (RTDs)
Thermistors
Magnetoresistors
Light-Dependent Resistors (LDRs)
Resistive Hygrometers

Related activities:
Exercises on characteristics, models and technical specifications of sensors

Full-or-part-time: 8h
Theory classes: 3h
Self study : 5h

Signal conditioning of resistive sensors

Description:
Resistor measurement basic principles
Voltage dividers
Wheatstone bridges
Differential and instrumentation amplifiers

Full-or-part-time: 8h
Theory classes: 3h
Self study : 5h

Reactance variation and electromagnetic sensors

Description:
Capacitive sensors
Variable capacitor
Differential capacitor
Inductive sensors
Variable reluctance sensors
Eddy current sensors
Linear variable differential transformers (LVDTs)
Magnetoelastic and magnetostrictive sensors
Electromagnetic sensors
Sensors based on Faraday's law
Hall effect sensors

Related activities:
Exercises on characteristics, models and technical specifications of sensors

Full-or-part-time: 8h
Theory classes: 3h
Self study : 5h

Signal conditioning for reactance variation sensors

Description:
Issues and alternatives in reactance measurements
AC bridges
Pseudobridges
AC amplifiers and power decoupling
AC to DC converters
Coherent Detection
Detection based on Oscillators

Related activities:
Exercises on sensor conditioning circuits and systems

Full-or-part-time: 8h
Theory classes: 3h
Self study : 5h

Self-Generating and Semiconductor Junction Sensors

Description:
Thermocouples
Piezoelectric sensors
Semiconductor junction sensors

Related activities:
Exercises on characteristics, models and technical specifications of sensors

Full-or-part-time: 8h
Theory classes: 3h
Self study : 5h

Signal conditioning for self-generating sensors

Description:
Low-drift amplifiers
Electrometer and transimpedance amplifiers
Charge amplifiers

Related activities:
Exercises on sensor conditioning circuits and systems

Full-or-part-time: 8h
Theory classes: 3h
Self study : 5h

Problem solutions recap

Description:
Summary of the solved problems along the course

Related activities:
Team activities presentations

Full-or-part-time: 6h
Theory classes: 6h

Lab 0: Laboratory organizacion

Description:
Laboratory introduction including instruments and how the laboratory lessons are organized.
Creation of teams of students

Full-or-part-time: 2h
Laboratory classes: 2h

Lab 1:Introduction to the instrumentation laboratory

Description:
Laboratory workplace first contact
Use of LabView for signal simulation

Related activities:
Laboratory experiments
Preliminary study of the experiments
Report of the experiments

Full-or-part-time: 5h
Laboratory classes: 2h
Self study : 3h

Práctica 2: The digital multimeter: Measurement principles, instrument drivers and measurement automation

Description:
Automatic digital multimeter measurements
Trade-off speed-accuracy.
Integration time relevance

Related activities:
Laboratory experiments
Preliminary study of the experiments
Report of the experiments

Full-or-part-time: 5h
Laboratory classes: 2h
Self study : 3h

Lab 3: Type A uncertainty estimation in frequency measurements using digital multimeters

Description:
Estimation using the digital multimeter while measuring the frequency of some signal sources

Related activities:
Laboratory experiments
Preliminary study of the experiments
Report of the experiments

Full-or-part-time: 5h
Laboratory classes: 2h
Self study : 3h

Lab 4: Automated measurements with digital oscilloscopes

Description:
Automated measurement of the frequency response of a filter

Related activities:
Laboratory experiments
Preliminary study of the experiments
Report of the experiments

Full-or-part-time: 5h
Laboratory classes: 2h
Self study : 3h

Lab 5: Interfence effect on resistance measurements

Description:
Capacitive and inductive interference effect reduction when measuring resistance using a digital multimeter

Full-or-part-time: 4h
Laboratory classes: 2h
Self study : 2h

Lab 6: Amplifier noise characterization

Description:
RMS value and spectrum of the noise of an amplifier

Full-or-part-time: 4h
Laboratory classes: 2h
Self study : 2h

Lab 7: Characterization and measurement of an NTC thermistor.

Description:
Basic conditioning circuit for a Pt-100
Characterization and callibration of the measurement system

Related activities:
Laboratory experiments
Preliminary study of the experiments
Report of the experiments

Full-or-part-time: 7h
Laboratory classes: 4h
Self study : 3h

Lab 8: Load cell calibration

Description:
Load cell conditioning
Calibration curve

Related activities:
Laboratory experiments
Preliminary study of the experiments
Report of the experiments

Full-or-part-time: 4h
Laboratory classes: 2h
Self study : 2h

Lab 9: Capacitive sensor conditioning

Description:
Capacitive angle sensor conditioning circuits comparison
Signal acquisition using Arduino
Automatic angle measurement system

Related activities:
Laboratory experiments
Preliminary study of the experiments
Report of the experiments

Full-or-part-time: 12h
Laboratory classes: 6h
Self study : 6h

GRADING SYSTEM

40% Final exam
30% Flipped classroom activities
30% Hands-on laboratory reports
The contents associated with the laboratory are not reassessed
To pass the subject it is a requirement to make the laboratory associated tasks

BIBLIOGRAPHY

Basic:
- Fraden, J. Handbook of modern sensors: physics, designs, and applications [on line]. 5th ed. Cham: Springer International Publishing, 2016 [Consultation: 15/07/2019]. Available on: http://dx.doi.org/10.1007/978-3-319-19303-8. ISBN 9783319193038.
- Pallàs Areny, Ramon; Webster, John G. Sensors and signal conditioning. Second Edition. New York: John Wiley & Sons, Inc, [2001]. ISBN 9780471332329.

Complementary:
- Pérez García, M.A. Instrumentación electrónica. Madrid: Paraninfo, 2014. ISBN 9788428337021.
- Northrop, R.B. Introduction to instrumentation and measurements [on line]. 3a ed. Bosa Roca, US: CRC Press, 2014 [Consultation: 15/07/2019]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=1609198. ISBN 9781466596795.
- Regtien, P.P.L. Measurement science for engineers [on line]. London: Kogan Page Science, 2004 [Consultation: 15/07/2019]. Available on: https://www.sciencedirect.com/science/book/9781903996584. ISBN 9781903996584.