Course guides
230920 - SM - Measurement Systems

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: 2020  ECTS Credits: 6.0  Languages: Catalan, Spanish

LECTURER

Coordinating lecturer: Garcia Gonzalez, Miquel Angel

Others:

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: Capacit de realitzar l'especificació, implementació, documentació i posada a punt d'equips i sistemes, electrònics, d'instrumentació 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).

General:
CG2. (ENG) GREELEC: coneixement, 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

Participatory class
Cooperative learning
Resolution of exercises and problems
Problem-based learning
Flipped classroom

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course, the student must:
To be able to analyze, specify and design measurement systems 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

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<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Self study</td>
<td>85,0</td>
<td>56.67</td>
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<tr>
<td>Hours large group</td>
<td>39,0</td>
<td>26.00</td>
</tr>
<tr>
<td>Hours small group</td>
<td>26,0</td>
<td>17.33</td>
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</table>

Total learning time: 150 h

CONTENTS

Introduction to measurement systems

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

Related activities:
Questionnaires and tasks at home related to measurement systems and characteristics of measurement systems
Homework related to the estimation of uncertainty in the measure
Advanced activities in the classroom for characterization, calibration and modeling of measurement systems
Advanced activities in the classroom to estimate the uncertainty in the measure
Study of self-learning materials

Full-or-part-time: 15h
Theory classes: 6h
Self study: 9h
## Noise and interferences in measurement systems

**Description:**
- Types of interference
- Identification of sources of interference
- Reduction of interferences
- Origin of electronic noise
- Noise models
- Noise reduction techniques

**Related activities:**
- Questionnaires and homework on electromagnetic interference
- Questionnaires and homework on noise
- Advanced classroom activities on characterization and interference reduction
- Advanced classroom activities on characterization and noise reduction
- Study of self-learning materials

**Full-or-part-time:** 15h  
Theory classes: 6h  
Self study: 9h

## Sensors

**Description:**
- Modulating sensors: Resistive, capacitive and inductive sensors
- Generating sensors

**Related activities:**
- Homework on characteristics, models and technical specifications of sensors
- Advanced activities in the classroom on characteristics, models and technical specifications of sensors
- Study of self-learning materials

**Full-or-part-time:** 23h  
Theory classes: 9h  
Self study: 14h

## Signal conditioning

**Description:**
- Resistive sensor conditioning
- Reactive sensor conditioning
- Generating sensor conditioning

**Related activities:**
- Homework on sensor conditioning circuits and systems
- Advanced activities in the classroom on sensor conditioning circuits and systems
- Study of self-learning materials

**Full-or-part-time:** 23h  
Theory classes: 9h  
Self study: 14h
Lab 0: Laboratory organization

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: 4h
Laboratory classes: 2h
Self study : 2h

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: 4h
Laboratory classes: 2h
Self study : 2h

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: 4h
Laboratory classes: 2h
Self study : 2h
<table>
<thead>
<tr>
<th>Lab 4: Automated measurements with digital oscilloscopes</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
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<tr>
<td>Automated measurement of the frequency response of a filter</td>
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<td><strong>Related activities:</strong></td>
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<tr>
<td>Laboratory experiments</td>
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<tr>
<td>Preliminary study of the experiments</td>
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<tr>
<td>Report of the experiments</td>
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<tr>
<td><strong>Full-or-part-time:</strong></td>
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<tr>
<td>4h</td>
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<tr>
<td>Laboratory classes: 2h</td>
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<td>Self study : 2h</td>
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<tr>
<th>Lab 5: Load cell calibration</th>
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<td><strong>Description:</strong></td>
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<tr>
<td>Load cell conditioning</td>
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<tr>
<td>Calibration curve</td>
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<tr>
<td><strong>Related activities:</strong></td>
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<tr>
<td>Laboratory experiments</td>
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<tr>
<td>Preliminary study of the experiments</td>
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<tr>
<td>Report of the experiments</td>
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<tr>
<td><strong>Full-or-part-time:</strong></td>
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<td>4h</td>
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<tr>
<td>Laboratory classes: 2h</td>
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<td>Self study : 2h</td>
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<tr>
<th>Lab 6: Characterization and measurement of a Pt-100. Temperature measurement</th>
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<tr>
<td><strong>Description:</strong></td>
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<tr>
<td>Basic conditioning circuit for a Pt-100</td>
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<tr>
<td>Characterization and calibration of the measurement system</td>
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<tr>
<td><strong>Related activities:</strong></td>
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<tr>
<td>Laboratory experiments</td>
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<tr>
<td>Preliminary study of the experiments</td>
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<tr>
<td>Report of the experiments</td>
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<tr>
<td><strong>Full-or-part-time:</strong></td>
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<tr>
<td>4h</td>
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<tr>
<td>Laboratory classes: 2h</td>
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<td>Self study : 2h</td>
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</table>
Lab 7: Characterization and measurement of an NTC thermistor. Application to temperature measurement for drift correction

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

**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 8: Acquisition and estimation of temperature using Arduino.

**Description:**
Arduino connection to the developed temperature measurement circuits
Signal acquisition of the conditioning circuits
Data transmission to a PC
Data conversion to temperature

**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
Lab 10: Digital pressure sensor acquisition using I2C communication

Description:
Acquisition using Arduino and I2C protocol
Data transmission to PC
Data conversion with temperature compensation to pressure

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

Full-or-part-time: 8h
Laboratory classes: 4h
Self study: 4h

GRADING SYSTEM

15% Final exam
20% Activities at classroom
20% Self-study activities
15% Symposium work
20% Laboratory work and reports
10% Preliminary laboratory studies

BIBLIOGRAPHY

Basic:

Complementary: