Course guide
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: 2022  ECTS Credits: 6.0  Languages: Spanish

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: 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) GEELEC: coneixement, comprehensió 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 inclogui una reflexió sobre temes rellevants de caire social, científic o ètic.

TEACHING METHODOLOGY
Participatory class
Resolution of exercises and problems
Problem-based learning

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

<table>
<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>
</tr>
<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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</tbody>
</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:
Measurement system characteristics exercises
Measurement uncertainty exercises

Full-or-part-time: 14h
Theory classes: 6h
Self study: 8h
## 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:**
Exercises on electromagnetic interference  
Exercises on noise

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

## Sensors

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

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

**Full-or-part-time:** 32h  
Theory classes: 12h  
Self study: 20h

## Signal conditioning

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

**Related activities:**
Exercises on sensor conditioning circuits and systems

**Full-or-part-time:** 32h  
Theory classes: 12h  
Self study: 20h

## 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: 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> Automated measurement of the frequency response of a filter</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> 4h</td>
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<tr>
<td>Laboratory classes: 2h</td>
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<tr>
<td>Self study: 2h</td>
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<thead>
<tr>
<th>Lab 7: Characterization and measurement of an NTC thermistor. Application to temperature measurement for drift correction</th>
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<tbody>
<tr>
<td><strong>Description:</strong> 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> 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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<tbody>
<tr>
<td><strong>Description:</strong> 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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<td><strong>Related activities:</strong></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> 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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Lab 8: Acquisition and estimation of temperatura 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 5: 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:** 15h  
Laboratory classes: 8h  
Self study: 7h

**GRADING SYSTEM**

40% Final exam  
20% Solving of proposed problems  
25% Laboratory work and reports  
15% Preliminary laboratory studies

The contents associated with the laboratory are not reassessed  
To pass the subject it is a requirement to make the laboratory associated tasks
EXAMINATION RULES.

BIBLIOGRAPHY

Basic:

Complementary: