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).
(A 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: Capacita 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, 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, i 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'estudis) per emetre jutjats que incloguin una reflexió sobre temes rellevants de caire social, científic o étic.

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>
</tr>
</thead>
<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>
</tr>
</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: 14 h
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

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# 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

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# 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

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

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 6: Characterization and measurement of a Pt-100. Temperature measurement

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

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**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

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**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

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**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: