Course guides
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: 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: 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

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

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

Symposium: Smart Sensors

Description:
Development (since the beginning of the course) and presentation of a work done by student groups on topics related to smart sensors

Related activities:
Study of the state of the art of some topics of Smart sensor
Public presentation of the work

Full-or-part-time: 19h
Theory classes: 6h
Self study : 13h

Lab 0: Laboratory organizacion

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

Related activities:
Laboratory experiments
Report of the experiments

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

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

Lab 7: Characterization and measurement of an NTC thermistor. Aplicaction to temperature measurement for drift correction

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

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 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 transmision 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:
- 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.
- Pallás Areny, R. Sensores y acondicionadores de señal. 4a ed. Barcelona: Marcombo Boixareu, 2003. ISBN 8426713440.
- 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.

Complementary:
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- Kularatna, N. Digital and analogue instrumentation: testing and measurement. Stevenage, UK: The Institution of Electrical Engineers, 2003. ISBN 0852969996.