Course guide
230653 - EIO - Electronic Instrumentation and Optoelectronics

Last modified: 04/06/2025

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

Degree: MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Compulsory subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).

Academic year: 2025 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: ALEXANDRA BERMEJO BROTO - JUAN JOSE RAMOS CASTRO

Others: Primer quadrimestre:
ALEXANDRA BERMEJO BROTO - 11
JUAN JOSE RAMOS CASTRO - 11
FRANCISCO JAVIER ROSELL FERRER - 11

PRIOR SKILLS

Basic analog and digital electronics. Fundamentals of Physics and mathematics, differential equations

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Ability to apply advanced knowledge in photonics, optoelectronics and high-frequency electronic
2. Ability to develop electronic instrumentation, as well as transducers, actuators and sensors.

Transversal:
3. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

4. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

TEACHING METHODOLOGY

- Lectures
- Application classes
- Theory classes
- Laboratory classes
- Exercises
- Tests

LEARNING OBJECTIVES OF THE SUBJECT

Learning objectives of the subject:

The aim of the Electronic Instrumentation part is to understand the principles of measurement theory to specify and use electronic instruments and measuring systems. There will be considered also technical and regulatory standards. Moreover, it will be described and analyzed the different types of sensors for measuring physical quantities related to Information Communication Technologies. The signal conditioning circuits for the sensors will be mounted and test in the laboratory classes. Finally the characteristics of data acquisition systems to register the signals obtained from the sensors will be studied and applied to laboratory classes.
The aim of the Optoelectronics subject is to know optoelectronic devices from a semiconductor point of view. Each device is described in its basic form, and then various improvements and drive circuitry are indicated. First objective is to understand basic semiconductor physics and metal-semiconductor and PN junction performance. Next aims are know the light emission process in LEDs and LASERs devices and their operating parameters, and to understand basic performance of light sensor/receivers as Photoconductors, Solar Cells, Photodiodes and Charge Coupled Devices. Finally other optoelectronics and high frequency devices are also briefly studied and fabrication technology is showed visiting UPC laboratories.

Learning results of the subject:

- Ability to specify, design and use electronic instrumentation and measurement systems.
- Ability to understand the sensors characteristics and its applications
- Ability to design signal conditioning circuits and actuators
- Ability to understand and to explain as semiconductor devices are able to convert electrical current in light and light in electrical current.
- Ability to relate, to quantify, and to characterize the light and the electrical current produced in optoelectronic semiconductor devices.
- Ability to understand materials and geometries used in the construction of optoelectronic devices.
- Ability to analyse and to compare optoelectronic devices from their operating parameters
- Ability to analyse basic operation circuits for optoelectronic devices.

STUDY LOAD

Type	Hours	Percentage
Hours large group	26,0	20.80
Hours small group	13,0	10.40
Self study	86,0	68.80

Total learning time: 125 h

CONTENTS

1. Introduction to measurement theory

Description:
- Instrumentation system topology
- Basic terminology
- Sources of uncertainty and categories
- Uncertainty evaluation and management in measurements

Full-or-part-time: 9h
Theory classes: 2h
Self study : 7h

2. Basic instruments

Description:
- Measurement of electrical magnitudes
- Time and frequency estimators
- Measurement instruments basics
- Programmable instrumentation system

Full-or-part-time: 11h
Theory classes: 2h
Laboratory classes: 4h
Self study : 5h

3. Sensor technologies

Description:
- Modulating sensors
- Generating sensors

Full-or-part-time: 8h
Theory classes: 1h
Laboratory classes: 2h
Self study : 5h

4. Signal conditioning circuits

Description:
- Signal conditinoning circuits for modulating sensors (DC & AC)
- Signal conditioning circuits for generating sensors

Full-or-part-time: 11h
Theory classes: 1h
Laboratory classes: 2h
Self study : 8h

5. Data acquisition systems

Description:
- Signal multiplexing
- A/D D/A conversión

Full-or-part-time: 11h
Theory classes: 1h
Laboratory classes: 2h
Self study : 8h

6. Smart sensors

Description:
- Concept
- Digital processing algorithms
- Field buses
- IEEE 1451 standard

Full-or-part-time: 8h
Theory classes: 1h
Laboratory classes: 2h
Self study : 5h

7. Semiconductor basics

Description:
1. Semiconductor fundamentals
2. Semiconductor crystal structures
3. Energy bands

Full-or-part-time: 5h 30m
Theory classes: 0h 30m
Self study : 5h

8. Carriers: Recombination, emission, and absortion

Description:
1. Carrier fundamentals
2. Density of states and carriers distribution
3. Carrier concentrations
4. Carrier recombination and generation

Full-or-part-time: 5h 30m
Theory classes: 0h 30m
Self study : 5h

9. Carrier transport

Description:
1. Carrier electrical currents
2. Drift transport and mobility
3. Diffusion transport
4. Conductivity and resistivity
5. Drift?diffusion model

Full-or-part-time: 5h 30m
Theory classes: 0h 30m
Self study : 5h

10. Junctions

Description:
1. Equilibrium PN homojunction.
2. Bias PN homojunction
3. Diode I?V equation
4. Transient and small?signal PN homojunction
5. Heterojunctions
6. Metal?semiconductor junctions

Full-or-part-time: 6h
Theory classes: 1h
Self study : 5h

11. LEDS

Description:
1. Principles
2. Basic Structures
3. Output Spectrum
4. Efficiencies
5. Modulation Effects
6. LED examples

Full-or-part-time: 6h
Theory classes: 1h
Self study : 5h

12. LASERS

Description:
1. Principles
2. Heterostructure Laser Diodes
3. Quantum Well Laser Diodes
4. Other Semiconductor Laser Diodes
5. Basic Semiconductor Laser Diode Characteristics

Full-or-part-time: 5h 30m
Theory classes: 0h 30m
Self study : 5h

13. Photodiodes

Description:
1. Semiconductor Light Absorption
2. Photoconductive parameters
3. PN Junction photodetection modes
4. PN Junction Photodiode
5. Quantum Efficiency and Responsivity
6. PIN Photodiode
7. APD Avalanche Photodiode
8. Photodiode Circuits

Full-or-part-time: 6h
Theory classes: 1h
Self study : 5h

14. Solar Cells

Description:
1. Semiconductor light absorption
2. Solar radiation spectrum
3. Photovoltaic performance
4. Equivalent circuit
5. Photovoltaic parameters
6. Solar cell structures

Full-or-part-time: 5h 30m
Theory classes: 0h 30m
Self study : 5h

15. Other Devices

Description:
Optofluidic devices

Full-or-part-time: 1h
Theory classes: 1h

Project

Description:
content english

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

ACTIVITIES

LABORATORY

Description:
- Software for programmable instrumentation.
- Signal conditioning circuits and sensors for weather station.
- Data acquisition and processing
- Small project

Related competencies :
CE14. Ability to develop electronic instrumentation, as well as transducers, actuators and sensors.
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

Full-or-part-time: 34h 20m
Practical classes: 13h
Guided activities: 8h 20m
Self study: 13h

EXERCISES

Description:
Exercises to strengthen the theoretical knowledge.

SHORT ANSWER TEST (CONTROL)

Description:
Mid term control.

EXTENDED ANSWER TEST (FINAL EXAMINATION)

Description:
Final examination.

GRADING SYSTEM

Laboratory (40%): 10% introduction to Lab+30% Project Technical Results
Theory: (60%): 40% on class individual exams + 10% Project presentation

If the exams theory assessemnt is bigger or equal to 5, it will not be necessary to take the final exam.

BIBLIOGRAPHY

Basic:

- Pallás-Areny, R.; Webster, J.G. Sensors and signal conditioning [on line]. 2nd ed. New York: John Wiley and Sons, 2001 [Consultation: 03/02/2021]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?docID=4747125. ISBN 0471332321.
- Kasap, S.O. Optoelectronics and photonics : principles and practices. 2nd ed. Boston, [etc.]: Pearson, 2013. ISBN 9780273774174.
- Pierret, R.F. Advanced semiconductor fundamentals. Rearding, MA: Addison, 1987. ISBN 0201053381.

Complementary:

- Prasad, S.; Schumacher, H.; Gopinath, A. High-speed electronics and optoelectronics: devices and circuits [on line]. Cambridge: Cambridge University Press, 2009 [Consultation: 21/04/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=451912. ISBN 9780511579080.
- Fraden, J. Handbook of modern sensors: physics, designs, and applications [on line]. 5th ed. Cham: Springer International Publishing, 2016 [Consultation: 07/07/2020]. Available on: https://dx.doi.org/10.1007/978-3-319-19303-8. ISBN 9783319193038.
- Webster, J.G.; Eren, H. (eds.). Measurement, instrumentation and sensors handbook : electromagnetic, optical, radiation, chemical, and biomedical measurement [on line]. 2nd ed. Boca Raton: CRC Press, 2014 [Consultation: 17/03/2021]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=1407945. ISBN 9781138072183.