Course guide
230653 - EIO - Electronic Instrumentation and Optoelectronics

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: 2022  ECTS Credits: 5.0  Languages: English

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
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 tested 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

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self study</td>
<td>86,0</td>
<td>68.80</td>
</tr>
<tr>
<td>Hours small group</td>
<td>13,0</td>
<td>10.40</td>
</tr>
<tr>
<td>Hours large group</td>
<td>26,0</td>
<td>20.80</td>
</tr>
</tbody>
</table>

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 conditioning 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: 7h
Theory classes: 2h
Self study: 5h

8. Carriers: Recombination, emission, and absorption

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

Full-or-part-time: 7h
Theory classes: 2h
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: 7h
Theory classes: 2h
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: 7h
Theory classes: 2h
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: 6h
Theory classes: 1h
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:** 7h
Theory classes: 2h
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:** 7h
Theory classes: 2h
Self study: 5h

### 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
The course is divided into 2 parts: Instrumentation and Optoelectronics. Each part has a weight of 50% in the final score.
The Instrumentation qualification (100 %) takes account:
- 20 % lab work
- 20% optoelectronics work and or exercises
- 60 % final exam Instrumentation
The Optoelectronics qualification (100 %) takes account:
- 40 % continuous assessment or exam control in the middle of the course
- 60 % continuous assessment or final exam

BIBLIOGRAPHY
Basic:

Complementary: