230055 - COMOPT - Optical Communications

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications
Academic year: 2018
Degree: BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN TELECOMMUNICATIONS TECHNOLOGIES AND SERVICES ENGINEERING (Syllabus 2015). (Teaching unit Optional)
ECTS credits: 6

Teaching staff
Coordinator: Josep Prat Gomà
Others:
Ruiz Moreno, Sergio
Soneira Ferrando, María José
Pérez Pueyo, Rosanna
Prat Goma, Josep Joan
Gene Bernaus, Juan Manuel

Teaching languages: Catalan, Spanish

Prior skills
Fundamentals on quantum physics, semiconductors and transmission systems.

Requirements
Digital communications, Electromagnetism

Degree competences to which the subject contributes

Generical:
10 ECI N3. They will have acquired knowledge related to experiments and laboratory instruments and will be competent in a laboratory environment in the ICC field. They will know how to use the instruments and tools of telecommunications and electronic engineering and how to interpret manuals and specifications. They will be able to evaluate the errors and limitations associated with simulation measures and results.

Teaching methodology
Theoretical lectures, application sessions, personal work, laboratory sessions

Learning objectives of the subject
Fundamental understanding of fiber optic communications, both theoretical as well as experimental.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>39h</th>
<th>26.00%</th>
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<tbody>
<tr>
<td>Hours small group:</td>
<td>26h</td>
<td></td>
<td>17.33%</td>
</tr>
<tr>
<td>Self study:</td>
<td>85h</td>
<td></td>
<td>56.67%</td>
</tr>
<tr>
<td>Content</td>
<td>Learning time: 5h 50m</td>
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</table>
| **(ENG) Chapter 1. Introduction** | Theory classes: 2h 30m  
Self study: 3h 20m |
| **Description:** | Optical communications technology evolution.  
Evolution from point-to-point fiber optic systems to all-optical networks.  
Block diagram of an optical communications system.  
Introduction to optical networks. |
| **Specific objectives:** | Historical evolution of optical communications.  
Introductory session, showing the block diagram of a fiber optics communication system. |

<table>
<thead>
<tr>
<th>Content</th>
<th>Learning time: 18h 20m</th>
</tr>
</thead>
</table>
| **(ENG) Chapter 2. Fiber Optics** | Theory classes: 5h 50m  
Self study: 12h 30m |
| **Description:** | Fiber Optics description. From geometric optics to Maxwell equations.  
Signal propagation in optical fibers.  
Dispersion:  
-Modal dispersion  
-Chromatic dispersion  
-Waveguide dispersion  
-Polarization mode dispersion.  
Attenuation.  
Optical fiber types  
Multi-mode: main characteristics.  
Single-mode: main characteristics.  
Non-linear effects in fiber optics propagation.  
Optical fiber for WDM systems.  
Dispersion compensation fibers.  
Special fiber optics.  
Fiber optics connection.  
Optical fiber cables: types and characteristics. |
| **Specific objectives:** | Understanding fiber optics principles and signal propagation in optical fibers. |
### Laboratory: Optical fiber and devices measures

**Description:**
Measuring fiber optic core diameter, numerical aperture, characterizing attenuation by using an OTDR. Optical coupler measures.

**Related activities:**
Chapter 2

**Specific objectives:**
Fiber optics hands-on. OTDR measurements.

### Chapter 3. Optical sources

**Description:**
LED: basic concepts, types and characteristic parameters.

**Specific objectives:**
Understanding the light emission processes (spontaneous and stimulated), the laser diode and its main characteristics, with special emphasis in lasers utilized for fiber optic telecom systems.

### Laboratory: Optical Sources

**Description:**
LED: characteristic parameters measurement.
Laser Diode: characteristic parameters measurement.
### Chapter 4. Optical signal modulation

**Description:**
- Direct intensity (optical power) modulation.
- Analogic and digital modulation
- IM transmitter block diagram
- External optical modulation
  - External modulation transmitter block diagram.
  - Amplitude, frequency and phase modulation.

**Specific objectives:**
Understanding the mechanisms involved in optical carrier modulation

**Learning time:**
- Theory classes: 4h 30m
- Self study: 10h

### Laboratory: Optical transmitters

**Description:**
- LED based optical transmitter: digital transmission main parameters measurement.
- LD based optical transmitter: digital transmission main parameters measurement.

**Learning time:**
- Laboratory classes: 4h
- Self study: 2h 10m

### Chapter 5. Optical detection.

**Description:**
- Opto-electronic conversion.
- Photodetector types.
- Shot noise in optical communications. Ideal receiver.
- Avalanche and thermal noises.
- Direct Detection receiver.
- Signal to noise ratio.

**Specific objectives:**
Understanding the light to current conversion in different types of photo-detectors as well as the different detection techniques.
Review of the optical receiver elements and its behavior.

**Learning time:**
- Theory classes: 5h 40m
- Self study: 12h 30m
## Laboratory: Optical receivers

<table>
<thead>
<tr>
<th><strong>Description:</strong></th>
<th>Digital transmission system optical receiver measures.</th>
</tr>
</thead>
</table>

### Chapter 6. Optical amplifiers

| **Description:** | Semiconductor optical amplifier.  
Doped fiber optical amplifier.  
Noise in optical amplifiers.  
Optically pre-amplified receivers.  
**Specific objectives:** | Understanding optical amplifiers and their characteristics. |
|------------------|-------------------------------------------------------|

### Chapter 7. IM-DD optical communications systems.

| **Description:** | Block diagram. System model.  
BER calculation.  
System performance as a function of type of fiber, bit rate, modulation format, receiver type, amplification.  
**Specific objectives:** | Understanding the performance of the whole system after reviewing its components in previous chapters.  
Design and dimensioning of a practical system with current components. |
|------------------|-------------------------------------------------------|

### Laboratory: Transmission systems modeling and simulation

<table>
<thead>
<tr>
<th><strong>Description:</strong></th>
<th>Fiber optics digital transmission system simulations.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Learning time:</strong></th>
<th>4h</th>
<th>8h 10m</th>
<th>15h 20m</th>
<th>5h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Laboratory classes:</strong></td>
<td>3h</td>
<td>2h 30m</td>
<td>6h</td>
<td>3h</td>
</tr>
<tr>
<td><strong>Self study:</strong></td>
<td>1h</td>
<td>5h 40m</td>
<td>9h 20m</td>
<td>2h</td>
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</tbody>
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**Chapter 8. Future topics**

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 11h 50m</th>
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<tbody>
<tr>
<td>WDM systems.</td>
<td>Theory classes: 4h 50m</td>
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<tr>
<td>Optical networks fundamentals.</td>
<td>Self study: 7h</td>
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<tr>
<td>FTTH networks.</td>
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**Qualification system**

Theory 70% (2 midterm tests, 28% + final exam, 42%), Laboratory 30%

The laboratory practices cannot be re-evaluated.

**Bibliography**

**Basic:**