230603 - TSF - Telecommunication Systems Fundamentals

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications
Academic year: 2020
Degree: MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Teaching unit Optional)
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Teaching unit Optional)
ECTS credits: 5

Teaching staff
Coordinator: Perez Romero, Jorge
Others: Gene Bernaus, Juan Manuel
Perez Romero, Jorge

Prior skills
Basic background on Digital Communications, Electromagnetic Radiation and Propagation, Guided EM Waves

Degree competences to which the subject contributes

Specific:
1. Ability to develop radio-communication systems: antennas design, equipment and subsystems, channel modeling, link dimensioning and planning.
2. Ability to implement wired/wireless systems, in both fix and mobile communication environments.
3. Ability to design and dimension transport, broadcast and distribution networks for multimedia signals

Transversal:
4. 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.
5. 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
- Individual homework
- Short answer test
- Extended answer test

Learning objectives of the subject

Learning objectives of the subject:
The aim of this course is to present the basic fundamentals of the communication systems for both wired and wireless systems. In the case of wireless systems this course particularly addresses the study, design and evaluation of the basic features of mobile communication systems. In the case of wired systems this course provides basic background on the field of fiber-optic communication systems. In particular, a brief review of the most fundamental devices, namely optical fibers, laser diodes, photodetectors, optical modulators, and optical amplifiers, will give the students the basic knowhow on their functionalities and operation from a system’s perspective. Another goal of this course is to get the students acquainted with the quality parameters of an optical transmission like signal-to-noise ratio (SNR) or bit error rate (BER).

Learning results of the subject:

- Ability to design and evaluate the fundamental communication techniques for networks, services and applications in mobile telecommunications environments.
- Ability to identify and model complex radio systems.
- Ability to identify the most relevant parameters of optical fibers, laser diodes, photodiodes, optical modulators, and optical amplifiers and to operate such devices.
- Ability to analyse and design a basic fiber-optic communications system, including the estimation of both the SNR and BER for optical data transmission systems.
- Ability to design and develop mobile communication systems, including channel modeling, link budget and dimensioning.
- Ability to design and develop copper-based cable and optical fiber systems for communication purposes.
- Ability to apply advanced knowledge in photonics and optoelectronics.

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group:</th>
<th>39h</th>
<th>31.20%</th>
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<tbody>
<tr>
<td>Hours medium group:</td>
<td>0h</td>
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<tr>
<td>Hours small group:</td>
<td>0h</td>
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<td>Guided activities:</td>
<td>0h</td>
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<tr>
<td>Self study:</td>
<td>86h</td>
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<td>68.80%</td>
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## Content

### 1. Introduction to cable transmission

**Learning time:** 2h  
Theory classes: 1h  
Self study: 1h

**Description:**  
- Evolution of cable telecommunication systems  
- Conductor line technology and applications  
- Evolution of fiber-optic based telecommunication systems

### 2. Optical Fibers

**Learning time:** 17h  
Theory classes: 5h  
Self study: 12h

**Description:**  
- Basic propagation light guiding concepts  
- Single-mode and multimode fibers  
- Attenuation and dispersion  
- Other physical transmission impairments  
- Performance of fiber optics

### 3. Optical Transmitters

**Learning time:** 14h  
Theory classes: 4h  
Self study: 10h

**Description:**  
- Basics on laser semiconductors  
- Lasers for optical fiber communications  
- Modulation of light properties  
- Optical Intensity modulation  
- Carrier modulation formats  
- Optical transceiver modules  
- WDM optical transmitters
<table>
<thead>
<tr>
<th>Module</th>
<th>Learning time</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>4. Optical Receivers</strong></td>
<td>14h</td>
<td><strong>Description:</strong>&lt;br&gt;- Basics on photodetectors&lt;br&gt;- PIN and APD photodetectors&lt;br&gt;- Photodetection noise&lt;br&gt;- Optical detection techniques&lt;br&gt;- Receiver sensitivity</td>
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<td><strong>Learning time:</strong>&lt;br&gt;<strong>Theory classes:</strong> 4h&lt;br&gt;<strong>Self study:</strong> 10h</td>
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<td><strong>5. Optical Amplifiers</strong></td>
<td>7h 30m</td>
<td><strong>Description:</strong>&lt;br&gt;- Semiconductor optical amplifiers (SOA)&lt;br&gt;- Erbium-doped fiber amplifiers (EDFA)&lt;br&gt;- System applications</td>
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<td><strong>Learning time:</strong>&lt;br&gt;<strong>Theory classes:</strong> 2h 30m&lt;br&gt;<strong>Self study:</strong> 5h</td>
</tr>
<tr>
<td><strong>6. Optical Fiber Telecommunication Systems</strong></td>
<td>8h</td>
<td><strong>Description:</strong>&lt;br&gt;- Intensity modulation/direct detection&lt;br&gt;- Coherent systems&lt;br&gt;- Wavelength Division Multiplexed (WDM) networks</td>
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<td><strong>Learning time:</strong>&lt;br&gt;<strong>Theory classes:</strong> 3h&lt;br&gt;<strong>Self study:</strong> 5h</td>
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<td><strong>7. Introduction to mobile communications</strong></td>
<td>2h</td>
<td><strong>Description:</strong>&lt;br&gt;- Definitions&lt;br&gt;- Types of Radiocommunication systems&lt;br&gt;- Mobile communications: Systems and technologies</td>
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<td><strong>Learning time:</strong>&lt;br&gt;<strong>Theory classes:</strong> 1h&lt;br&gt;<strong>Self study:</strong> 1h</td>
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<td>Chapter</td>
<td>Title</td>
<td>Learning time:</td>
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| 8. | Characterisation of the mobile radio channel | 11h | - Introduction  
- Propagation in the mobile environment (Path Loss, Slow fading, Multi-path propagation)  
- Noise  
- Interference |
| 9. | Link Budget and Radio Engineering techniques | 12h 30m | - Quality target  
- Performance model of the radio link  
- Link budget  
- Radio engineering techniques  
  - Power control  
  - Channel coding and interleaving  
  - Diversity  
  - Spatial Multiplexing |
| 10. | Mobile Radio Access | 18h | - Introduction  
- Multiple access techniques (FDMA, TDMA, CDMA, OFDMA)  
- Duplexing techniques (FDD, TDD)  
- Mobile radio access management |
11. Cellular Systems

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<tr>
<th>Learning time: 19h</th>
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<tr>
<td>Theory classes: 6h</td>
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<tr>
<td>Self study: 13h</td>
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**Description:**
- Model of a cellular system
- Control and management of cellular systems
- Dimensioning of a cellular system
- Dimensioning of FDMA/TDMA cellular systems
- Dimensioning of CDMA cellular systems
- Multi-layer cellular structures

**Qualification system**

Delivery of exercises and active participation during lectures: 50%
Mid-term exam: 25%
Final exam: 25%

**Bibliography**

**Basic:**


**Complementary:**