230315 - LIDAR - Lidar Remote Sensing

**Coordinating unit:** 230 - ETSETB - Barcelona School of Telecommunications Engineering

**Teaching unit:** 739 - TSC - Department of Signal Theory and Communications

**Academic year:** 2015

**Degree:**
- MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Teaching unit Optional)
- DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 1992). (Teaching unit Optional)
- MASTER'S DEGREE IN ELECTRONIC ENGINEERING (Syllabus 2013). (Teaching unit Optional)
- MASTER'S DEGREE IN INFORMATION AND COMMUNICATION TECHNOLOGIES (Syllabus 2009). (Teaching unit Optional)
- MASTER'S DEGREE IN NETWORK ENGINEERING (Syllabus 2009). (Teaching unit Optional)
- DEGREE IN ELECTRONIC ENGINEERING (Syllabus 1992). (Teaching unit Optional)

**ECTS credits:** 2.5

**Teaching languages:** English

**Teaching staff**

**Coordinator:** Francesc Rocadenbosch

**Degree competences to which the subject contributes**

**Specific:**
- CE1. Ability to apply information theory methods, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing to communication and audiovisual systems.
- CE13. Ability to apply advanced knowledge in photonics, optoelectronics and high-frequency electronic
- CE14. Ability to develop electronic instrumentation, as well as transducers, actuators and sensors.
The course focuses on a tutorial discussion of the main techniques, systems and subsystems, and applications related to LIDAR (laser-radar) remote sensing. The course presents the grounds of the technological, physical, and data-retrieval keys involved in relation to the applications of these remote sensing systems in the ground-based and space-borne contexts. Present-day application fields comprise atmospheric observation (pollution concentration and physical-variables monitoring), wind remote sensing (e.g., eolic farms), detection and monitoring of chemical species, and others, in the industrial field.

Learning results of the subject:
- Ability to develop LIDAR (laser-radar) remote-sensing systems for atmospheric sensing and chemical-species detection in the context of both ground-based and satellite-based systems.
- Ability to specify, analyse, and evaluate the performance of different types of LIDAR systems using end-to-end software simulation.
- Ability to model and interpret retrieved lidar data in terms of level-1 products (atmospheric reflectivity, attenuation) and level-2 products (pollution content and transport, gas-species concentration, and wind velocity).
- Ability to understand and forecast a wide range of LIDAR applications including pollution monitoring and gas detection in the environmental/regulatory field, wind retrieval in relation to eolic farms, telemetry, 3-D imaging and scanning in architecture, and bathymetry (sea surface and submarine investigation).
- Knowledge exposure to continental and world-wide network initiatives concerning both active and passive optical remote sensing instruments.
- Ability to develop laser-radar/optical-active remote-sensing systems: telescope ("optical antenna") and opto-electronic receiver design, equipment and subsystems, channel modeling, link budget, and architecture specification.
- Ability to design laser-radar remote sensing systems (LIDAR) for atmospheric environmental sensing (pollution) and chemical-species detection, either as ground-based or satellite-based systems.
- Ability to integrate Telecommunication Engineering technologies and systems, as a generalist, and in broader and multidisciplinary contexts, such as remote sensing, atmospheric probing, and imaging.
- Ability to develop signal processing methods and algorithms for data retrieval and interpretation in atmospheric,
environmental and industrial LIDAR remote sensing.

<table>
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<tr>
<th>Study load</th>
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<tbody>
<tr>
<td><strong>Total learning time:</strong> 62h 30m</td>
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<tr>
<td>Hours large group:</td>
<td>20h</td>
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<tr>
<td>Self study:</td>
<td>42h 30m</td>
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## Content

### 1. BACKSCATTER LIDAR SYSTEMS

**Description:**
1.1. Foundations and Architecture  
   1.1.1. Basic design parameters: Elastic lidar equation  
   1.1.2. Signal conditioning and acquisition  
2. Examples of real systems

**Learning time:** 15h  
- Theory classes: 4h 30m  
- Self study: 10h 30m

### 2. SYSTEM LINK BUDGET: END-TO-END SIMULATION

**Description:**
2.1. Receiving chain: OE conversion and resolution (review)  
2.2. Generalised signal-to-noise ratio (noise-dominant modes)  
2.3. Example problem I  
2.4. Lidar range estimation: Simulation  
2.5. Elastic-Raman link budget (problem proposal)

**Learning time:** 16h 30m  
- Theory classes: 0h 30m  
- Practical classes: 4h  
- Self study: 12h

### 3. RAMAN SYSTEMS

**Description:**
3.1. Raman Lidar  
   3.1.1. Basics about the Raman effect  
   3.1.2. Atmospheric probing and system layout  
      3.1.2.1. Temperature measurement  
      3.1.2.2. Molecular species (gas) detection  
      3.1.2.3. Water-vapor measurement  
3.2. Elastic-Raman systems: End-to-end-simulation (problem revision)

**Learning time:** 9h  
- Theory classes: 2h  
- Practical classes: 1h  
- Self study: 6h
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#### 4. WIND-LIDAR SYSTEMS

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<tbody>
<tr>
<td>4.1. Coherent Doppler Lidar</td>
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<tr>
<td>4.1.1. Architecture</td>
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<td>4.1.2. Design considerations</td>
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<td>4.2. Direct-detection Doppler systems</td>
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| Learning time: 6h |
| Theory classes: 2h |
| Self study: 4h |

#### 5. OTHER LASER-RADAR SYSTEMS

<table>
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<th>Description:</th>
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<tbody>
<tr>
<td>5.1. DIAL: Detection of gas species</td>
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<tr>
<td>5.2. Other laser-radar systems</td>
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| Learning time: 6h |
| Theory classes: 2h |
| Self study: 4h |

#### 6. EVALUATION

<table>
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<tbody>
<tr>
<td>6.1 Oral presentation/interview (2h)</td>
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<td>6.2 Final exam (2h)</td>
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| Learning time: 10h |
| Theory classes: 4h |
| Self study: 6h |

### Qualification system

- Final examination: 50%
- Oral presentation*: 50%
  (* Guided Link-budget program)

### Bibliography

#### Basic:


#### Others resources: