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: 2016

Degree: MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Teaching unit Optional)
DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 1992). (Teaching unit Optional)
DEGREE IN ELECTRONIC ENGINEERING (Syllabus 1992). (Teaching unit Optional)
MASTER'S DEGREE IN INFORMATION AND COMMUNICATION TECHNOLOGIES (Syllabus 2009). (Teaching unit Optional)
MASTER'S DEGREE IN NETWORK ENGINEERING (Syllabus 2006). (Teaching unit Optional)
MASTER'S DEGREE IN NETWORK ENGINEERING (Syllabus 2009). (Teaching unit Optional)
MASTER'S DEGREE IN ELECTRONIC ENGINEERING (Syllabus 2013). (Teaching unit Optional)

ECTS credits: 2,5 Teaching languages: English

Teaching staff

Coordinator: Francesc Rocadenbosch

Others: 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.

Teaching methodology

- Lectures
- Application classes
- Individual work
- Exercises
- Oral presentations
- Other activities: End-to-end simulation, visit to the UPC multi-spectral lidar station (European Infrastructure, OPTIONAL ACTIVITY upon operational time-slot availability of the station, number of students, and course schedule).
- Extended answer test (Final Exam)

The teaching and learning methodology combines expositive classes with more interactive ones, where systems and case problems are simulated and/or discussed based on literature reviews. A guided simulation mini-project (computer based) is progressively introduced during course.

Exercises:
- Description: Exercises to strengthen the theoretical knowledge and with a focus to guide the computer-based mini-project.
Oral presentation/interview*:
- Description: Presentation of the link-budget simulation mini-project (session 19).
(*) Depending on the total number of students enrolled.
Extended answer test (Final examination):
- Description: Final examination (multiple-answer test, session 20).

Learning objectives of the subject

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.

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Study load

Total learning time: 62h 30m	Hours large group:	20h	32.00%
	Self study:	42h 30m	68.00%

Content

1. BACKSCATTER LIDAR SYSTEMS	Learning time: 15h Theory classes: 4h 30m Self study : 10h 30m

Description:
1.1. Foundations and Architecture
    1.1.1. Basic design parameters: Elastic lidar equation
        1.1.1.1. Optical (OVF, background radiance)
    1.1.2. Signal conditioning and acquisition
        1.1.2.1. Signal conditioning: Receiving Chain
        1.1.2.2. Acquisition systems: Photon counters
1.2. Examples of real systems

2. SYSTEM LINK BUDGET: END-TO-END SIMULATION	Learning time: 16h 30m Theory classes: 0h 30m Practical classes: 4h Self study : 12h

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)

3. RAMAN SYSTEMS	Learning time: 9h Theory classes: 2h Practical classes: 1h Self study : 6h

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)

4. WIND-LIDAR SYSTEMS	Learning time: 6h Theory classes: 2h Self study : 4h
Description: 4.1. Coherent Doppler Lidar 4.1.1. Architecture 4.1.2. Design considerations 4.2. Direct-detection Doppler systems	

5. OTHER LASER-RADAR SYSTEMS	Learning time: 6h Theory classes: 2h Self study : 4h
Description: 5.1. DIAL: Detection of gas species 5.2. Other laser-radar systems	

6. EVALUATION	Learning time: 10h Theory classes: 4h Self study : 6h
Description: 6.1 Oral presentation/interview (2h) 6.2 Final exam (2h)	

Qualification system

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

Bibliography

Basic:

Fujii, T.; Fukuchi, T. Laser remote sensing [on line]. Boca Raton [etc.]: Taylor & Francis, 2005 [Consultation: 12/05/2015]. Available on: <http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10143572>. ISBN 0824742567.

Others resources:

E.D. Hinkley (Editor), R.T.H. Collis, H. Inaba, P.L. Kelley, R.T. Ku, S.H. Melfi, R.T. Menzies, P.B. Russell, V.E. Zuev. LASER MONITORING OF THE ATMOSPHERE. Springer-Verlag, 1976.