Course guide
230585 - PHST-LIDAR - Photonic Systems in Telecommunications: Lidar (Laser Radar)

Last modified: 14/12/2023

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.

Degree: ERASMUS MUNDUS MASTER'S DEGREE IN PHOTONICS ENGINEERING, NANOPHOTONICS AND BIOPHOTONICS (Syllabus 2010). (Optional subject).

Academic year: 2018 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Francesc Rocadenbosch, UPC.

Others: Constantino Muñoz Porcar, UPC.
Michaël Sicard, UPC.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE2. Demonstrate the understanding of the peculiarities of the quantum model for light-matter interaction.
CE4. Demonstrate knowledge of the fundamentals of image formation, propagation of light through different media and Fourier Optics.
CE9. Ability to synthesize and present photonics research results according to the procedures and conventions of scientific presentations in English.

Generical:
CG1. Ability to project, design and implement products, processes, services and facilities in some areas of photonics, such as photonic engineering, nanophotonics, quantum optics, telecommunications and biophotonics.
CG4. Ability to understand the generalist and multidisciplinary nature of photonics, seeing its application, for example, to medicine, biology, energy, communications or industry
CG2. Ability to modeling, calculate, simulate, develop and implement in research and technological centers and companies, particularly in research, development and innovation tasks in all areas related to Photonics.

Transversal:
1. 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.

2. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding how companies are organised and the principles that govern their activity, and being able to understand employment regulations and the relationships between planning, industrial and commercial strategies, quality and profit.

3. 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.

4. SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.

Basic:
CB6. Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context
CB7. Students should know how to apply the knowledge acquired and their problem-solving ability in new or little-known environments within broader (or multidisciplinary) contexts related to their area of ¿¿study.
CB8. Students should be able to integrate knowledge and face the complexity of formulating judgments based on information that, being incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of their knowledge and judgment.
CB10. Students should possess the learning skills that allow them to continue studying in a way that will be largely self-directed or autonomous.

TEACHING METHODOLOGY

- Lectures
- Activities

LEARNING OBJECTIVES OF THE SUBJECT

The course focuses on a tutorial discussion of the main techniques, systems and subsystems related to laser-radar (LIDAR) remote sensing. The course presents the grounds of the technological, physical, and signal-processing keys involved as well as the applications of these remote sensing systems. Present-day fields of application comprise the detection and monitoring of chemical species, atmospheric observation, pollution concentration and physical variables, and others, in the industrial field.
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 research work (computer based) is progressively introduced during course.

BIBLIOGRAPHY:

Guidelines with specific bibliography available at ATENEA web page, https://atenea.upc.edu/moodle/login/index

' Basic
LASER REMOTE SENSING, Takashi Fujii, Tetsuo Fukuchi (Editors), CRC, Taylor&Francis, Florida, 2005.

LASER MONITORING OF THE ATMOSPHERE, E.D. Hinkley (Editor), Springer-Verlag, 1976.

' Advanced
LASER REMOTE SENSING: FUNDAMENTALS AND APPLICATIONS, R. M. Measures, John Wiley& Sons, 1984 (Reprint de Krieger Publishing Company, 1992).

STUDY LOAD

Type	Hours	Percentage
Self study	51,0	68.00
Hours large group	24,0	32.00

Total learning time: 75 h

CONTENTS

1.- Elastic lidar systems.

Description:
1.1.- Foundations and architecture.
1.2.- Basic design parameters: Elastic lidar equation. Optical overlap factor. Background radiance considerations.
1.3.- Examples of real systems.

Full-or-part-time: 4h
Theory classes: 4h

2.- Link budget.

Description:
2.1.-Receiving chain: Opto-electronic conversion. Temporal and spatial resolution. Signal conditioning and acquisition (transient recorders and photon counters).
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).

Full-or-part-time: 4h 30m
Theory classes: 4h 30m

3.- Raman systems.

Description:
3.1.- Raman Lidar. Basics about the Raman effect. Atmospheric probing and system layout (temperature measurement, molecular species (gas) detection, and water-vapor measurement).
3.2.- Elastic-Raman systems (aerosol detection). Problem revision (Sect. 2.5).

Full-or-part-time: 6h
Theory classes: 6h

4.- Wind lidar systems.

Description:
4.1.- Coherent Doppler Lidar: Architecture and design considerations.
4.2.- Direct-detection Doppler systems: Edge technique and double-edge technique. Fringe technique.
4.3.- Wind measurement using incoherent techniques.

Full-or-part-time: 4h
Theory classes: 4h

5.- Lidar data inversion.

Description:
5.1.- Inversion of opto-atmospheric parameters: Elastic data inversion (range-corrected semi-quantitative methods, from the slope method to Klett's method, multi-angle inversion). The combined elastic/Raman lidar technique.
5.2.- Examples: Inversion of physical parameters (atmospheric-boundary-layer height retrieval, ceilometry, chimney-stack emission flux).

Full-or-part-time: 2h
Theory classes: 2h

6.- Other laser-radar systems

Description:
6.1.- DIAL: Detection of molecular pollutants.
6.2.- Other systems.

Full-or-part-time: 2h
Theory classes: 2h

ACTIVITIES

Computer based problem

Full-or-part-time: 2h 18m
Theory classes: 2h 18m

GRADING SYSTEM

- 50 % Final exam (multiple answer test)
- 50 % Guided research work (computer based prob. 2.5 + interview).

Special weight will be given to the continuous assessment of student's progress in the discussion sessions as well as to course attendance (80% minimum).

BIBLIOGRAPHY

Basic:
- Fujii, Takashi; Fukuchi, Tetsuo. Laser remote sensing [on line]. Boca Raton: Taylor&Francis, 2005 [Consultation: 17/06/2016]. Available on: http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10143572. ISBN 0824742567.
- Hinkley, E.D. Laser monitoring of the atmosphere. Berlin: Springer-Verlag, 1976. ISBN 354007743X.

Complementary:
- Measures, Raymond M. Laser remote sensing : fundamentals and applications. Malabar, Fla: Krieger, 1992. ISBN 0894646192.