Course guides
230704 - ORS - Optical Remote Sensing: Lidar (Laser Radar)

Last modified: 14/05/2020

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

Degree: MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).

Academic year: 2020 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Francesc Rocadenbosch, UPC.

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

PRIOR SKILLS

Basic knowledge of remote-sensing radar systems and signal processing foundations is of advantage. Good knowledge is gained during the course.

REQUIREMENTS

No previous requirements.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE2. (ENG) Màster en Fotònica:
Demostrar que comprende las peculiaridades que comporta el modelo cuántico para la interacción luz-materia.
CE4. (ENG) Màster en Fotònica:
Demostrar que conoce los fundamentos de la formación de imagen, de la propagación de la luz a través de los diferentes medios y de la Óptica de Fourier.
CE9. (ENG) Màster en Fotònica:
Capacidad para sintetizar y exponer los resultados de investigación en fótonica según los procedimientos y convenciones de las presentaciones científicas en inglés.

Generical:
CG1. (ENG) Màster en Fotònica:
Capacidad para proyectar, diseñar e implantar productos, procesos, servicios e instalaciones en algunos ámbitos de la fotónica como los relacionados con la ingeniería fotónica, la nanofotónica, la óptica cuántica, las telecomunicaciones y la biofotónica

CG4. (ENG) Màster en Fotònica:
Capacidad para entender el carácter generalista y multidisciplinario de la fótonica viendo su aplicación por ejemplo a la medicina, biología, energía, comunicaciones o la industria
CG2. (ENG) Màster en Fotònica:
Capacidad para la modelización, cálculo, simulación, desarrollo e implantación en centros de investigación, centros tecnológicos y empresas, particularmente en tareas de investigación, desarrollo e innovación en todos los ámbitos relacionados con la Fotónica.

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. (ENG) Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación
CB7. (ENG) Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.
CB8. (ENG) Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicio.
CB10. (ENG) Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

TEACHING METHODOLOGY

- Lectures
- Activities: Simulation project, problems

LEARNING OBJECTIVES OF THE SUBJECT

The course addresses the main techniques, systems and subsystems related to remote-sensing laser-radar sensors (LIDAR). The Foundations of Remote Sensing, Technological and Systems Architecture are presented with emphasis on the different types of laser radars, transmission equation, signal processing and retrieval of data products, as well as applications in atmospheric observation from terrestrial and space LIDARs. Examples comprise the detection and monitoring of chemical species in the industry field as well as atmospheric observation and monitoring of pollution, gases (water vapor) and temperature, among others.

The subject combines expository classes with application classes, where the different types of lidar systems are simulated and discussed taking into account present technological state of the art. The course also addresses a transversal objective of lidar systems software simulation of as a guided intensification work.

STUDY LOAD

Type	Hours	Percentage
Self study	86,0	68.80
Hours large group	39,0	31.20

Total learning time: 125 h

CONTENTS

1.- Elastic lidar systems.

Description:
1.1.- Foundations and architecture.
1.2.- Basic design parameters: Lidar equation. Optical overlap factor. Background radiance .
1.3.- Examples of terrestrial and air- and satellite-borne systems.

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

2.- Link budget and SNR: Foundations and simulation.

Description:
2.1.- Lidar receiver: Opto-electronic conversion and reception chain. Temporal and spatial resolution. Signal conditioning and acquisition (analog-to-digital conversion and and photon counters).
2.2.- Generalised Signal-to-Noise Ratio (SNR). Noise-dominant modes.
2.3.- Problem I: Elastic lidar.
2.4.- Lidar range estimation.
2.5.- Simulation project (problem II): Power budget and SNR for an elastic-Raman lidar system.

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

3.- Raman systems.

Description:
3.1.- Raman Lidar: Foundations.
3.2.- Atmospheric probing and system design (I): temperature measurement.
3.3.- Atmospheric probing and system design (II): molecular species detection (gases, water vapor).
3.4.- Elastic-Raman systems. Simulation project revision (Sect. 2.5).

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

4.- Wind lidar systems.

Description:
4.1.- Doppler Wind Lidar: foundations, applications and detection techniques.
4.2.- Coherent Doppler Lidar: link budget, architecture and signal processing. Practical examples of systems and recent developments.
4.3.- Direct-detection Doppler Lidar: detection techniques and developments. Practical examples of systems and recent developments.

Full-or-part-time: 7h 30m
Theory classes: 7h 30m

5.- Lidar inversion: Retrieval of atmospheric products.

Description:
5.1.- Atmospheric aerosols/particles.
5.2.- Inversion of atmospheric optical properties: Inversion of backscatter lidar data (slope method, Klett's, lidar ratio estimation by combining solar photometer and lidar sensors). Inversion of Raman lidar and High Spectral Resolution Lidar (HSRL) data. Two-dimensional methods.
5.3.- Inversion of physical products: Aerosol microphysical properties. Atmospheric structural properties (boundary layer, clouds, ...).
5.4.- Applications: Cooperative instrumentation. Examples of interest.

Full-or-part-time: 7h 30m
Theory classes: 7h 30m

6.- DIAL and other laser-radar systems

Description:
6.1.- DIfferential Absoprtion Lidar (DIAL): Detection of chemical contaminant species.
6.2.- Other laser radar systems and industrial applications.

Full-or-part-time: 3h
Theory classes: 3h

ACTIVITIES

Computer-based simulation of lidar systems.

Full-or-part-time: 3h
Theory classes: 3h

GRADING SYSTEM

- 50 % Final exam (multiple answer test)
- 50 % Guided research work (computer-based project/problem nos. 1-2 + Interview).
Course attendance (80% minimum).

BIBLIOGRAPHY

Basic:
- Hinkley, E.D. Laser monitoring of the atmosphere. Berlin: Springer-Verlag, 1976. ISBN 354007743X.
- 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.

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