Last update: 04-07-2019

230705 - OSEN - Optical Fiber Sensor Technologies

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

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

Academic year: 2019

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

ECTS credits: 5 Teaching languages: English

Teaching staff

Coordinator: Junyent Giralt, Gabriel

Others: Junyent Giralt, Gabriel
Comellas Colomé, Jaume

Opening hours

Timetable: Any time is possible by appointment email.

Degree competences to which the subject contributes

Specific:

CE11. Knowledge of hardware description languages for high-complex circuits.

CE3. Ability to implement wired/wireless systems, in both fix and mobile communication environments.

CE15. Ability to integrate Telecommunication Engineering technologies and systems, as a generalist, and in broader and multidisciplinary contexts, such as bioengineering, photovoltaic conversion, nanotechnology and telemedicine.
CE6. Ability to model, design, implement, manage, operate, administrate and maintain networks, services and contents
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.

Transversal:

CT4. 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.
CT5. 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.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Teaching methodology

Lectures (3h/week)
Group work or Individual work (distance):Technical Report (work-technical report on a subject related to Optical fiber Sensors)
Presentations of Technical Reports.
Final Exam: Extended answer test

Learning objectives of the subject

The objective of this course is to train students in the methods of studying, analyzing, designing and evaluating the technologies-applications of optical sensors implemented with optical fibers. First, we consider the evolution of optical sensors in general, the importance of fiber optic sensors, their main technologies, and key devices, components and subsystems that allow the implementation of fiber sensor systems. A first chapter is the one dedicated to the analysis and design of the OTDR subsystem that will allow to know the exact distance in the fiber optic segment where the distributed fiber sensors perform the measure (temperature, vibration, etc.).Then the main distributed optical fiber sensors (Rayleigh, Raman and Brillouin) will be analyzed. Because fiber optics can behave like a distributed sensor, the practical application of such sensors is now very relevant for sensing applications in tens of kilometers with a single interrogator at one end. For measurements at discrete points, fiber sensors with Bragg Grating (FBG) are the most widely used for their simplicity and performance. Finally, the industrial applications of these sensors will be analyzed, commenting on the applications of the low-cost sensors based on plastic fibers, and the applications of the optical sensors for the technology and the development of Smart-Cities.

Learning results of the subject:
-Ability to analyze, specify, design optical sensors (and sensor networks) implemented with optical fiber: distributed, non-distributed, quasi-distributed and discrete.
-Ability to develop solutions and applications for different types of fiber sensors: temperature, voltage-deformation, vibration, acoustic, etc.
-Ability to analyze and design the interrogation systems for different types and applications of sensors.
-Ability to analyze and design a key subsystem: Optical Time Domain Reflectometer (OTDR
-Ability to analyze the importance of optical sensors for the development of technologies related to "Smart Cities" and Energy Efficiency.

Study load

Total learning time: 125h	Hours large group:	39h	31.20%
	Hours medium group:	0h	0.00%
	Hours small group:	0h	0.00%
	Guided activities:	0h	0.00%
	Self study:	86h	68.80%

Content

I.Introduction

Learning time: 10h

Theory classes: 4h
Self study : 6h

Description:
I.1.- Optical sensors: A historical perspective
I.2.- Fiber-Optic Sensors: Fundamentals and Applications
I.3.- Optical fibre technology:
Fiber optics
Components, Devices and Subsystems
I.4.- Types of optical fiber sensors:
Quasi-distibuted sensing networks
Distributed fiber optic sensing
Fiber Bragg Grating sensors
Interferometric sensing

II.Optical Time Domain Reflectometry (OTDR)

Learning time: 19h 30m

Theory classes: 8h 30m
Self study : 11h

Description:
II.1.- OTDR: Applications for Distributed Optical Fiber Sensors
II.2.- OTDR: Operating Principles
II.3.- OTDR: Limitations
II.4.- OTDR: Alternatives for High-Performance Long-Haul
II.5.- OTDR: Signal Averaging
II.6.- OTDR: Correlation Techniques
II.7.- OTDR: Complementary Codes
II.8.- OTDR: Correlation Gain
II.9.- Phase-OTDR
II.10.- OTDR: Appendix
II.11.- OTDR: References

III.Raman-Distributed Temperature Sensors (Raman-DTS)	Learning time: 14h Theory classes: 6h 30m Self study : 7h 30m

Description:
III.1.- Raman-DTS
III.2.- Raman scattering
III.3.- Raman-DTS: Temperature measurements
III.4.- Raman-DTS System
III.5.- Raman-DTS Performances
III.6.- Raman-DTS with Loop Configuration
III.7.- Raman-DTS: Long-Range (LR) with Hybrid Configuration
III.8.- Raman-DTS: LR with Coded-OTDR and Discrete Raman Amplification
III.9.- Raman-DTS: Anti-Stokes Raman with Rayleigh Loss Correction
III.10.- Raman-DTS: Dual Sources separated by two Stokes Shifts
III.11.- Raman-DTS: Applications
III.12.- Raman-DTS: References

IV.Brillouin-Distributed Fiber Sensors (Brillouin-DFS)	Learning time: 13h Theory classes: 6h Self study : 7h

Description:
IV.1- Brillouin Scattering
IV.2- Brillouin-DFS
IV.3- Brillouin-DFS: Interrogation Techniques
IV.4- Brillouin-DFS System Performances
IV.5- Brillouin-DFS: Applications
IV.6- Brillouin-DFS: References

V.Fiber Bragg Grating (FBG) Sensors	Learning time: 22h Theory classes: 9h Self study : 13h

Description:
V.1- Bragg Gratings in Optical Fibers
V.2- Fiber Bragg Gratings: Temperature and Strain Sensors
V.3- FBG Interrogator System
V.4- High Capacity FBG-WDM Sensing System
FBGs in multicore fiber for curvature sensing
V.5- FBG Sensors with High Birefringent Optical Fibers
V.6- FBG Sensors: Benefits and Applications
V.7- Appendix: Strain definitions
V.8- FBG Sensors References

VI.Distributed Acoustic Sensing (DAS)	Learning time: 12h 40m Theory classes: 7h Self study : 5h 40m

Description:
VI.1- DAS: Introduction
VI.2- DAS: Interrogation Techniques
VI.3-DAS: Signal Processing
VI.4- DAS: Applications
VI.5- DAS: References

VII.Applications of Fiber Optic Sensors	Learning time: 9h Theory classes: 5h Self study : 4h

Description:
VII.1.- Applications of Distributed Temperature Sensors (DTS)
VII.2.- Distributed Strain Sensors (DSS): practical issues, solutions and applications
VII.3.- Applications of Distributed Acoustic Sensors (DAS)
VII.4.- Applications of Distributed Vibration Sensors (DVS)
VII.5.- Applications of Fiber Bragg Grating Sensors (FBG-Sensors)
VII.6.- Applications of Plastic Fiber-Optic Sensors (PFOS)
VII.7.- Applications to IoT and Smart Cities
VII.8.- Applications of New Optical Fibers (SDM and FMF) to sensing technologies

Planning of activities

TECHNICAL REPORT	Hours: 29h Theory classes: 0h Self study: 29h

Description:
Technical Report: This activity involves the preparation of a Technical Work, in groups of 2 or 3 students, which must be delivered in PowerPoint format and presented to the class at the end of the course.
Oral Presentation: Oral presentation of Technical Report (30 minutes)
Final exam (90 minutes)

Support materials:
For this course ATENEA will be the virtual teaching support tool. From there the students will be able to download all the documents (slides, related papers, etc.) related to the course.

Descriptions of the assignments due and their relation to the assessment:
Technical Report:1 week before the end of course

Specific objectives:
Evaluate technical research done in group on a subject related to the course.

ORAL PRESENTATION	Hours: 0h 45m Laboratory classes: 0h 45m

Description:
Technical Report Presentation of a work group

Support materials:
Power point presentation

Specific objectives:
To evaluate the ability to present oral in group and individually results of the technical report

FINAL EXAM	Hours: 1h 30m Theory classes: 1h 30m

Description:
Final Exam

Qualification system

Final examination: 40%
Individual assessment: 10%
Technical Report (group technical work): 50%

Regulations for carrying out activities

On the final exam students will be able to bring all kinds of technical information (slides, books, related papers of the course, etc.)

Bibliography

Basic:

Hartog, Arthur H.. An Introduction to distributed optical fibre sensors [on line]. CRC Press, 2017 [Consultation: 14/07/2017]. Available on: <http://site.ebrary.com/lib/upcatalunya/detail.action?docID=11390035>. ISBN 9781351645300.

Patil, Supriya; Shjaligram, Arvind. Fiber optic sensors : design to prototype. Lap Lambert Academic Publishing, 2016. ISBN 9783659887666.

Complementary:

Rao, Yun-Jiang ; Ran, Zeng-Ling; Gong, Yuan. Fiber-Optic Fabry-Perot Sensors: An Introduction [on line]. CRC Press, 2017 [Consultation: 14/07/2017]. Available on: <http://site.ebrary.com/lib/upcatalunya/detail.action?docID=11379968>. ISBN 9781498736947.

Mulualem, Yelkal. FPGA Architecture design for distributed optical fiber sensors. Lap Lambert Academic Publishing, 2016. ISBN 9783659892233.

Others resources:

Hyperlink

Nom recurs

For this course ATENEA will be the virtual teaching support tool. From there the students will be able to download all the documents (slides, related papers, etc.) of the course.