Application for Beatriz Galindo´s Call (Junior Grant)

Proposed by Prof. Dr. Manuel López-Amo Sainz. Head of the Optical Communications and Electronics Applications group and Member of the Smart Cities Institute of Universidad Pública de Navarra (UPNA).

Kind of grant: Junior

- Teaching profile: Teaching in sensors and sensors networks applied in renewable energies and environmental protection. Teaching proposed for the Master's degree in Telecommunications Engineering and in open teaching in newly created MOOC subjects
- Research profile: Photonic systems for sustainable applications

Teaching project

The teaching project, in line with the research project, is focused on making use of the knowledge in fibre optic sensors and Smart Cities, to update the teaching given at the UPNA. To this end, we have consulted with the head of the Higher Educational Innovation Centre, who stressed the lack of open network subjects at our university. These subjects not only mean a reinforcement for the students of our degrees, but also a way to publicize the studies of our university, as it has been done by prestigious universities such as Harvard and Stanford.

Therefore, in this teaching project, two subjects are proposed. One of them, a new on-line one. The other one, an updated existing one, with new contents, for the Master's Degree in Telecommunication Engineering. Specifically, it is proposed to update the contents of the second year course of the master's degree "Design of optical networks" and the generation of a MOOC subject (Online course offered in open and free access) that would complement the aforementioned and it would be the first subject of these characteristics offered by Universidad Pública de Navarra.

The teaching guides of these subjects are included below. In them are described the planning, contents, methodology for their teaching, competencies, and proposed evaluation method. The corresponding regulations of the university will fix the number of students.

Connection between the teaching project and the objectives of the International Excellence Campus "Iberus".

This teaching project (and the research one, as will be mentioned later) focuses on teaching fibre optic sensors. This type of sensors are being successfully used in the monitoring of renewable energy generation and transport systems: wind turbines, photovoltaic panels, heating monitoring of high voltage cables and others.

Therefore, in the proposed subjects, special emphasis will be placed on the applicability of this technology for the measurement and supervision of sustainable energy systems. This target is the first specialization area of the campus "Iberus"

In addition, the MOOC subject designed to studied on-line also wants to meet the objectives of the strategic plan of the campus "Iberus" 2017-2020, specifically with the challenge 2- goal 07: Implement a successful model of e-learning.

http://www.campusiberus.es/resumen-ejecutivo/#2

Connection between the teaching project and the research project.

Both, the teaching and the research projects focus on optical fibres. Specifically on fibre optic sensors. So, the connection is clear. The experience acquired in the research to be carried out, will be used to improve and update the teaching material of both proposed subjects. The time balance between research and teaching will be the 30% and 70% respectively.

Proposed Subjects

1. **Subject: 73087 Optical networks design (Second year of the Master's degree in Telecommunications Engineering) 6 ECTS**

Corresponding module / matter

ME1. Specialty module in Advanced Communications.

Matter: Advanced communications.

Descriptors

Fibre optic communications, high capacity communications networks, FTTH (fibre to the home), optical network switching, fibre optic Ethernet networks, underwater fibre optic networks, free-space optical networks, sensors and fibre optic sensor networks. Fibre optic as a technological base of innovative business ideas and development projects in the new digital economy.

Skills

BASIC SKILLS

CB6 – To possess and understand knowledge that provides a basis or an 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 ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.

CB8 – Students should be able to integrate knowledge, facing the complexity of making judgments based on information. That information, that can be incomplete or limited, includes reflections on social and ethical responsibilities linked to the application of their knowledge

CB9 - Students should know how to communicate their conclusions and the knowledge to specialized and non-specialized audiences in a clear and unambiguous way.

CB10 - Students should have the learning skills that allow them to continue studying in a way that can be self-directed or autonomous.

GENERIC SKILLS

CG1 - Ability to project, calculate and design products, systems and facilities in all areas of telecommunications engineering.

CG8 - Ability to understand the ethical responsibility and professional deontology of the activity of the Telecommunications Engineer profession.

CG10 - Knowledge, understanding and ability to apply the corresponding legislation in the exercise of the profession of Telecommunications Engineer.

SPECIFIC SKILLS

CCA5: Ability to analyze the challenges of current optical devices and networks, and future trends, following an independent technical judgment. Students should take into account also the political and socio-economic implications involved in this technology.

CCA6: Knowledge of emerging communications networks and services and the ability to develop value-added applications in this context.

CCA7: Ability to deepen autonomously in other technologies and aspects of interest related to communications.

CCA8: Ability to be involved in research lines associated with communications

Learning results

When the teaching ends, the student should:

• Understand scientific or commercial texts of medium or advanced difficulty on the physical level of optical networks (layers 1 and 2 of the OSI model). Know the devices and subsystems used in these networks (R1)

• Know how to apply the phenomena involved in the transmission of the signal through optical networks (R2)

• Have a perspective on the history of broadband networks and future trends, as well as the role that fibre optics plays in them (R3)

• Know the topologies of private fibre data networks, access networks, metropolitan, extended area, underwater and non-guided, their technological alternatives and the characteristics that are specific to each one (R4)

• Have acquired theoretical knowledge and practical skills on the instrumentation used in optical networks and characterization techniques (R5)

• Have developed an independent technical judgment about optical solutions in communication networks (R6)

• Have acquired theoretical knowledge and practical skills on fibre optic sensor networks and fibre optic networks for lighting (R7)

Methodology

Activity - methodology	Classroom hours	Non-classroom hours
A-1 Theory lectures/participatory classes	20 h	5 h
A-2 laboratory work	10 h	
A-3 discussions, pooling, tutoring groups	2 h	
A-4 development of projects	5 h	50 h
A-5 readings of material		20 h
A-6 individual study		30 h
A-7 exams, assessment tests	3 h	
A-8 individual tutoring		5 h
Total	40 h	110 h

Relationship skills-training activities

Skill	Training activity
CB6, 7, 8, 9, 10	A1 to A8
CG1, 8, 10	A2 and A4
CCA5, 6, 7, 8	A4, 5, 6

Language

Spanish, with some books and teaching materials in English.

Evaluation

Result of learning	Evaluation system	Weight (%)	Recoverable character
Understand commercial or scientific texts of medium difficulty on the physical level of optical networks (layers 1 and 2 of the OSI Model). Learn about devices and subsystems used in these networks (R1)	Oral or written test	15	Yes
Learn to apply the physical phenomena involved in the transmission of the signal over optical networks (R2)	Oral or written test / reports and presentations	15	Yes
A perspective of the history of broadband networks and future development trends, as well as the role of optical fibre in them (R3)	Oral or written test / reports and presentations	10	Yes
Learn about optical fibre private data networks, access networks, Metropolitan, wide area networks, underwater and not guided, their technological alternatives and characteristics which they own to each (R4)	Oral / written test	15	Yes
Acquiring theoretical knowledge and practical skills on the instrumentation used in optical networks and the techniques of their characterization (R5)	Practice tests	20	No
Having developed an independent technical judgment on optical solutions in communication networks (R6)	Reports and presentations	10	Yes
Acquiring theoretical knowledge and practical skills on fibre optic sensor networks and networks of optical fibre for lighting (R7)	Oral / written test	15	Yes

Contents

This subject aims to provide a global vision of emerging communications technologies. Thus, its contents will be necessarily updated based on the technological evolution. An initial list of contents is the one presented below.

• Emerging optical transport networks (submarine intercontinental networks, WAN networks and MAN networks).

• Optical access and local area networks.

• Instrumentation for the characterization of optical networks.

• IR wireless optical networks

• Sensors and fibre optic sensor networks

• Lighting with fibre optics

Program of the subject

The theoretical and practical contents of this subject are intended to prepare the student for the performance of their profession in the specific field of fibre optic networks.

Theoretical contents:

Topic 1. Advanced topics of optical network design: access and transport. (8h)

Topic 2. Phases, organization and realization of real Fibre Optic projects. Execution of real FTTH deployment projects. (10 h)

Topic 3. IR Wireless optical networks (2 h)

Topic 4. Fibre optic sensors and sensor multiplexing networks. Application in renewable energies. Specialty fibres and their applications. (8 h)

Practical contents:

Instrumentation and techniques for the design of optical networks: Experimentation with electro-optical instrumentation used for the analysis of fibre optic telecommunication networks and the characterization of associated devices. For example, optical time domain reflectometers (OTDR) and multifunction equipment for measuring optical losses (OLTS). They will use them for locating events through the network, determination of the link length, insertion losses and return loss of network sections, etc. In addition, they will use optical spectrum analyzers for the characterization of optical sources and passive and active optical components used in fibre networks. In addition, it will be analyzed the quality of the transmission in optical networks with digital or analog signal modulation. Material to be used: various types of light sources, optical receivers and passive devices (couplers, multiplexers, fibre Bragg gratings (FBGs)), Signal generators, digital oscilloscope, data generator, electric spectrum analyzer and optical amplifiers. (5h)

Fibre sensors: Experimentation and characterization of fibre optic sensors and sensor multiplexing networks. Implementation of a distance sensor. Also, a refractive index one. Multiplexing of two ring sensor structures. Material used: various types of sources and optical receivers and passive devices (couplers, multiplexers...), signal generator, optical power meter, semiconductor laser in the network header. Laboratory star network, oscilloscope, He-Ne laser. Use of advanced equipment for measuring point and distributed fibre optic sensors. Application to temperature measurements in electrical systems. Used material: FBGs, point and distributed sensors interrogators. Optical fibre cables. FBGs (5h)

Bibliography

Basic books:

• Optical Networks, R. Ramaswami and K.N. Sivarajan, Morgan Kaufmann Publishers, Inc., 1998

• Fibre Optic Test and Measurement, D. Derickson, Prentice Hall, 1998

• Handbook of Optical fibre sensing technology, J.M. Lopez Higuera (Ed) Wiley (2002)

Additional reading:

• Broadband Optical Access Networks and Fibre-to-the-Home: Systems Technologies and Deployment Strategies, John Wiley and Sons, 2006

• Fibre to the Home, the new empowerment, Paul E. Green, John Wiley & Sons, 2005

• Fibre Optics Technicians Manual, Jim Hayes, Delmar, 2005

• WDM Technologies: Optical Networks, Achyut K. Dutta, Academic Press, 2002

• FTTX Concepts and Applications, Gerd Keizer, John Wiley & Sons, 2006

• Optical communications. Component and systems. J.H. Franz, V.K. Jain, Ed. Narosa, 2000

• Fibre Network Service Survivability, Tsong-Ho Wu, Artech House, 1992

• Survivable Optical WDM Networks, Canhui Ou, Springer-Verlag New York Inc., 2005

On-line resources:

The website of the subject in the Virtual Classroom of the UPNA offers a collection of electronic materials that students will use intensively during the course. These include the slides that the teachers show during their presentations, the text of the practical lab work, links to different websites (technical magazines, etc.) and complementary materials that specifically support the activities of the course. In addition, the page includes forums for students to request information

and assistance. Access from the web to recordings of guest lectures to the subject of previous years. Specifically, the next lectures are available: Description of the optical local network of the UPNA, alternative solution for the access network and the FON experiment, the TELENA network of the Government of Navarra, the MAN/WAN network of Telefónica, Example of sensors and networks of fibre optic sensors in civil works and energy applications.

A 12-hour course on optical networks taught by BT also is available with the following contents: design of WDM networks, management and control of optical networks, recovery from faults of optical networks, considerations in the deployment of optical networks, and vision of BT about the optical access of the future.

Additional material

During the practical sessions in the laboratory, students will use the advanced optical and opto-electronic equipment of the Department of Electrical and Electronic Engineering of the UPNA.

Teaching place

Classroom and Optical Communications and Television lab of the Public University of Navarra

2. MOOC Subject: Sensors and optical fibre sensor networks (3 ECTS)

Descriptors

Fibre optic sensors. Classification. Manufacturing, measurement methods and applications. Optical fibre sensor networks. Types and applications in the Energy and Civil Work sector. Design and measurement in fibre optic sensor networks.

Skills (collected in the memory of the University Master's Degree in Telecommunications Engineering of the UPNA)

BASIC SKILLS

CB6 – To 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 ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.

CB8 – Students should be able to integrate knowledge, facing the complexity of making judgments based on information. That information, that can be incomplete or limited, includes reflections on social and ethical responsibilities linked to the application of their knowledge

CB10 - Students should have the learning skills that allow them to continue studying in a way that can be self-directed or autonomous.

GENERAL SKILLS

CG1 - Ability to project, calculate and design products, systems and facilities in all areas of engineering.

SPECIFIC SKILLS

CCA1: Ability to analyse the challenges of current optical sensors and sensor networks, and their future trends, following an independent technical judgment. Students should take into account also the political and socio-economic implications involved in this technology.

CCA6: Knowledge of emerging optical sensor networks and services (smart cities, remote systems) and the ability to develop value-added applications in this context.

CCA3: Ability to deepen autonomously in other technologies and aspects of interest related to optical fibre sensors.

Learning results

When the training ends, the student should be able to:

• Understand scientific or commercial texts of medium or advanced difficulty in the field of fibre optic sensors. (R1)

• Have a perspective on the history and evolution of fibre optic sensors and sensor networks (R2)

• Know the topologies of fibre optic sensor networks, their technological alternatives and the characteristics that are specific to each one (R3)

• Have acquired theoretical knowledge and practical skills on the instrumentation used for manufacturing, interrogation and characterization of sensors and their networks. (R4)

• To have developed an independent technical judgment about optical solutions in sensor networks (R5)

Methodology

Activity - methodology	Classroom hours	Non-classroom hours
A-1 on-line teaching		20 h
A-2 discussions, pooling, tutoring groups		2 h
A-3 development of projects		20 h
A-4 material reading		18 h
A-5-individual study		10 h
A-6 exams, assessment tests		1 h
A-7 individual tutoring		4 h
Total		75 h

Language

English.

Evaluation

Result of learning	Evaluation system	Weight (%)	Recoverable character
R1, R2, R3, R4, R5	Online test at the end of the teaching	40	Yes
R3, R4, R5	Individual design of a sensors network for a specific application	60	Yes

Contents and Agenda

This subject aims to give a global vision of optical fibre sensors and sensor networks. So, its contents will necessarily be updated as a function of technological evolution. An initial proposal of contents is the one presented below.

- Fibre optic sensors: Types, manufacturing, measurement and applications
- Optical fibre sensor networks: Types, topologies, multiplexing formats.
- Design of optical fibre sensor networks.
- Practical applications of fibre optic sensors and their networks

Theoretical contents:

Introduction: Fibre optic sensors in energy applications, civil works and sustainability and the environment. Examples of application of fibre optic sensors and historical development. (1 hour)

Types of fibre optic sensors: point sensors, quasi-distributed and distributed. Characteristics and basic structures (interferometers, diffraction gratings and others). (3 h)

Basic components and structures for fibre optic sensors and sensor networks: Optical fibres, couplers and splitters, optical switches, isolators and circulators, selective wavelength devices (filters and mux/demux), optical modulators, light sources and detectors. (3 h)

Distributed sensors: Use of Rayleigh, Brillouin and Raman scattering for distributed measurements using optical fibres. (1 h)

Multiplexing of point and quasi-distributed sensors: Dependence on distance, wavelength, number of sensors and power budget. Dependence on the network design on the fibre optic sensors to be multiplexed (1h)

Interrogation techniques for multiplexing networks (including modulation, demodulation and self-reference techniques) (3 h)

Topologies: linear, ring, star, mesh, tree and ladder networks. Hybrid topologies (1h)

Passive multiplexing networks: TDM, WDM, FDM, SDM, coherence division multiplexing (CDM) in passive networks. Hybrid multiplexing (3h)

Amplified multiplexing networks (active): Gain and noise in multiplexing networks. Limitations. Remote multiplexing networks. (1h)

Protection techniques for sensor networks: Robust networks. Self-healing Networks (1h)

Applications: examples of application of the most common multiplexing networks: multiplexing networks of intensity sensors, interferometric and FBG, among others (2h)

Practical contents:

Supervised design of a fibre optic sensors network (20 h)

Bibliography

Basic books:

Handbook of Optical fibre sensing technology, J.M. López Higuera (Ed) Wiley (2002)

Fibre Optic Sensors: Fundamentals and Applications, Fourth Edition. David A. Krohn; Trevor W. MacDougall; Alexis Mendez. Spie Press Book (2015)

Additional reading:

B. Culshaw, "Optical Fibre Sensor Technologies: Opportunities and - Perhaps - Pitfalls," J. Lightwave Technol., vol. 22, pp. 39-50, 2004.

Y. J. Rao and S. Huang, Fibre Optic Sensors, Chapter 10, Applications of Fibre Optic Sensors, pp. 397-434, Ed. by S. Yin, P. B. Ruffin, F. T. S. Yu, 2008.

B. Lee, "Review of the present status of optical fibre sensors," Optical Fibre Technology, vol. 9, pp. 57-79, 2003.

R. Kashyap, Fibre Bragg Gratings, (Academic Press, New York, 1999)

Grattan, K. T., & Meggitt, B. T. (Eds.). (1995). Optical fibre sensor technology (Vol. 1). London: Chapman & Hall.

Lee, B. H., Kim, Y. H., Park, K. S., Eom, J. B., Kim, M. J., Rho, B. S., & Choi, H. Y. (2012). Interferometric fibre optic sensors. Sensors, 12(3), 2467-2486.

On-line resources:

The website of the subject in the UPNA Virtual Classroom will offer a collection of electronic materials that students will use intensively during the course. These include the slides with narration and explanatory videos in which the teachers show the operation of the fibre optic sensors and their measuring equipment along 20 hours. The summaries of the practical work of previous students, links to Internet sites of interest (technical journals, etc.) and complementary material of support to the activities of the course will be preserved as well. In addition, the page includes forums for students to request information and assistance. Access from the web to recordings of guest lectures to the subject of previous years.

Teaching place

On-Line subject available on the Public University of Navarra´s website