Course guide
230742 - QOC - Quantum Optical Communications

Last modified: 21/06/2024

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: 2024 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Consultar aquí / See here:

Others: Consultar aquí / See here:

PRIOR SKILLS

Basic background on digital communications and signal processing.

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

Transversal:
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.

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.

TEACHING METHODOLOGY

- Theoretical lectures
- Exercises
- Tests

LEARNING OBJECTIVES OF THE SUBJECT

Quantum communications is a new research field while optical communications is the most used technology nowadays. The combination of the two seems to be the next natural step.
The main objective is to review the optical communications systems under the perspective of quantum mechanics which provides a much deeper understanding. In particular, quantum information theory provides new tools in designing a communications system being quantum key distribution (QKD) its most paradigmatic application.
The abilities to be acquired after the course's completion are:
• To be able to understand the fundamentals of quantum information theory.
• To be able to analyze a quantum optical communications system.
• To be able to design an optical quantum key distribution (QKD) system.

STUDY LOAD

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

Total learning time: 125 h

CONTENTS

1. Introduction

Description:
1. Introduction
1.1. Course Objectives and Methodology
1.2. Brief Introduction to the Quantum Realm

Full-or-part-time: 3h
Theory classes: 2h
Self study : 1h

2. Elements of Quantum Mechanics

Description:
2. Elements of Quantum Mechanics
2.1. Dirac's Notation
2.2. Hilbert Spaces
2.3. Schrödinger Equation
2.4. Quantum Measurements

Full-or-part-time: 22h
Theory classes: 7h
Self study : 15h

3. Discrete-Variable QOC

Description:
3. Discrete-Variable QOC
3.1. Review of Classical Optical Communications
3.2. Quantum Decision Theory
3.2.1. Pure States: Kennedy's Theorem
3.2.2. Mixed States: Holevo's Theorem
3.3. Quantum Communications Systems
3.3.1. Noiseless
3.3.2. With Thermal Noise
3.4. Quantum Optical Communications Systems
3.4.1. Fiber-optic Communications
3.4.2. Free-space Communications

Full-or-part-time: 50h
Theory classes: 15h
Self study : 35h

4. Continuous-Variable QOC

Description:
4. Continuous-Variable QOC
4.1. Overview of Entanglement
4.2. Fundamentals of Continuous Variables
4.2.1. The Harmonic Oscillator
4.2.2. Gaussian States
4.3. Classical and Quantum Information Theory
4.3.1. Classical and Quantum Entropies
4.3.2. Shannon Capacity
4.3.3. The Holevo Bound
4.4. Applications
4.4.1. Quantum Key Distribution (QKD)
4.4.2. Quantum Internet

Full-or-part-time: 50h
Theory classes: 15h
Self study : 35h

GRADING SYSTEM

- Partial exams: 60%
- Final exam: 40%

BIBLIOGRAPHY

Basic:
- Gianfranco Cariolaro. Quantum Communications. Springer, 2015. ISBN https://doi.org/10.1007/978-3-319-15600-2.

Complementary:
- J.J. Sakurai and Jim Napolitano. Modern Quantum Mechanics. Cambridge University Press, 2020. ISBN https://doi.org/10.1017/9781108587280.- Michael A. Nielsen and Isaac L. Chuang. Quantum Computation and Quantum Information. Cambridge University Press, 2010. ISBN https://doi.org/10.1017/CBO9780511976667.- Emmanuel Desurvire. Classical and Quantum Information Theory: An Introduction for the Telecom Scientist. Cambridge University Press, 2009. ISBN

https://doi.org/10.1017/CBO9780511803758.- Christopher Gerry, Peter Knight, and Peter L. Knight. Introductory Quantum Optics. Cambridge university press, 2005. ISBN https://doi.org/10.1017/CBO9780511791239.- Rodney Loudon. The Quantum Theory of Light. Oxford University Press, 2000. ISBN https://doi.org/10.1093/oso/9780198501770.001.0001.