Optical Communications

Code: 102691
ECTS Credits: 9

2025/2026

Degree	Type	Year
Telecommunication Systems Engineering	OB	3

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

Basic concepts of semiconductors, electromagnetic fields and telecommunication systems. The knowledge and abilities that the student should have previously achieved in order to be able to follow the subject appropriately are: to know and be able to use the basic principles of calculation of one or more variables; Use and solve differential equations and differential equations in partial derivatives; Capacity to analyze functions of complex variable; Ability to understand and use vectorial and numerical analysis; Ability to solve linear and invariant systems and related functions and transformations; Understand and use the principles of probability, the concepts of random variable and its application to telecommunications; Ability to understand and master the concept of oscillation and the general laws of electromagnetic waves; Know theoretical and practical concepts of electricity and magnetism, as well as the ability to analyze the electromagnetic fields; Understand and use the concepts of guided and non-guided propagation in the domain of time and frequency; Understand the physical principle of semiconductors.

Objectives and Contextualisation

1. To Acquire an advanced level of knowledge of the main blocks that constitute an optical communications link, the integral components (optical fibers, light emitters, photodetectors and other photonic devices), and the basic principles of the digital transmission of optical signals.
2. Skills: the ability to calculate the most important parameters in the context of digital optical links, to use high-performance optical device and system simulation software (VPI TransmissionMaker), solve problems and write reports, work in small groups of two people.
3. Competences: To have the mathematical and physical foundations necessary to interpret, select, evaluate, and possibly propose concepts, theories, use the technological developments related to optical communications and their application. Ability to analyze photonic devices, and understand their use in optical telecommunications.

Competences

- Analyse components and specifications for communication systems that are guided or non-guided by electromagnetic, radiofrequency or optical means.
- Apply the necessary legislation in the exercise of the telecommunications engineer's profession and use the compulsory specifications, regulations and standards.

- Communication
- Develop personal attitude.
- Develop personal work habits.
- Develop thinking habits.
- Learn new methods and technologies, building on basic technological knowledge, to be able to adapt to new situations.
- Select and devise communication circuits, subsystems and systems that are guided or non-guided by electromagnetic, radiofrequency or optical means to fulfil certain specifications.
- Work in a team.

Learning Outcomes

1. Analyse components and specifications of optical communication systems.
2. Apply the national and international regulations and standards to the field of optical communications.
3. Apply the techniques on which, in the field of optical communications and from the point of view of transmission systems, networks, services and applications are based.
4. Communicate efficiently, orally and in writing, knowledge, results and skills, both professionally and to non-expert audiences.
5. Develop curiosity and creativity.
6. Develop scientific thinking.
7. Develop systemic thinking.
8. Efficiently use ICT for the communication and transmission of ideas and results.
9. Evaluate the advantages and disadvantages of different technological options for the deployment or implementation of optical communication systems.
10. Make one's own decisions.
11. Manage available time and resources.
12. Prevent and solve problems.
13. Select transmission equipment and systems by optical means.
14. Use computer applications to support the development and exploitation of networks, services and applications based on optical communications.
15. Work cooperatively.

Content

Content

(T: theory, S: problems or seminars, PS: preparation of problems or seminars, L: laboratories, PP: lab work preparation, E: study, AA: other activities, all these activities have required times specified in hours.)

1. Optical fibers

T	S	PS	L	E	PP	AA	Total
9	3	3	6	9	6		36

General introduction. Basic concepts of Optics. Guided optical radiation. Singlemode and multimode fibers. Step index fibers and graded index fibers. The optical properties of fibers. Fiber losses, the scattering of Rayleigh, Mie, Brillouin and Raman. Chromatic dispersion, modal dispersion. Transmission characteristics. Special fibers: zero dispersion, displaced dispersion, flattened dispersion. Modelling parameters.

2. Optical Emitters

T	S	PS	L	E	PP	AA	Total
9	3	3	6	9	6		36

The basis of light emission. Emission of light in semiconductors. Double heterojunction structure. LED rate equation. Characteristics: spectral line width, step response, modulation response, bandwidth. Fabry-Perot Resonator. Bragg reflectors. Semiconductor laser, types and properties. Laser rate equations, threshold current, step response, modulation response, bandwidth dependence with current. Modeling parameters with rate equations, life time carriers and photons, coefficient of damping, confinement factor.

3. Optical receivers

T	S	PS	L	E	PP	AA	Total
9	3	3	6	9	6		36

Light detection in p-n junctions. PIN and APD diodes. Equivalent circuit, transimpedance amplifier. Responsivity, dark current. Thermal noise, shot noise, avalanche factor. Consequences of converting optical power to electric current: electrical beat noise S-ASE and ASE-ASE. Bandwidth in actual devices. Modeling parameters: noise spectral density, M, k.

4. Optical Amplifiers

T	S	PS	L	E	PP	AA	Total
9	3	3	6	9	6		36

Importancein WDM systems. Optical semiconductor amplifiers, two-level system, electric pumping. Introduction to rate equations. Small signal gain, saturation power, noise dependence with gain. ASE noise, dependence with gain. Fiber amplifiers, three-level system, photonic pumping, EDFA doped fiber amplifiers, RAMAN fiber amplifiers with high bandwidth. Modeling parameters.

5. Optical communications digital links 9

T	S	PS	L	E	PP	AA	Total
9	3	3	6	6		36	

Transmission of digital signals, IIDD intensity modulation, direct detection. Parameter Q, BER. Thermal noise, "shot" noise. ASE optical noise influence: electric beating noise, S-ASE, ASE-ASE. Interference between symbols (ISI), dispersion. Passive components: isolator, MZ modulator, optical filters. Balance of power and time. Impulse response of the link.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Laboratory practices (labwork)	18	0.72	1, 3, 9, 6, 7, 8, 11, 10, 12, 13, 15, 14
Problem classes	18	0.72	1, 3, 9, 6, 7, 13, 14
Theory classes (lectures)	39	1.56	1, 3, 9, 6, 7, 13
Type: Supervised			
Tutorials	18	0.72	12
Type: Autonomous			
Literature search	9	0.36	2, 9, 13, 14
Preparation of laboratory sessions and completion of the report	36	1.44	3, 4, 14
Problem solving and case preparation	18	0.72	6, 7, 11
Reading of books, articles and cases	9	0.36	3
Study	50	2	1, 3, 9, 6, 7, 11, 13

Theory classes (objectives 1 and 3) and problems, both are presencial and are linked chronologically with 6 practical modules of laboratory work. Problem-based learning (APB): individual labwork related problems and questions for each student in each module (objective 2).

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Examinations	67%	6	0.24	1, 2, 3, 9, 4, 6, 7, 11, 10, 12, 13
Work module in the laboratory and corresponding reports	33%	4	0.16	1, 2, 3, 9, 4, 6, 7, 5, 8, 11, 10, 12, 13, 15, 14

OPTCOM evaluation

a) Processes and scheduled evaluation activities, with the indication of the value assigned to the continuous assessment and to the final tests.

• Exam 67%. The test will consist of three compulsory partial exams (OB) and two optional recovery exams (OP) applicable only to the first two parts. Each partial exam will last 60 minutes and will consist of answering 12 test questions (four options that subtract 1/3 of the grade in erroneous cases).

1. The first EP1 test covers the first 37,5% of the course (OB).

2. The second EP2 test covers the next 37,5% of the course (OB).

3. The third EP3 test covers the final 25% of the course (OB).

4. The recovery exam will consist of two parts (EF1 + EF2), each lasting one hour, corresponding to EP1 and EP2. When the grade in EP1 is less than 5, the EF1 exam is compulsory. When the grade of EP2 is less than 5, the EF2 exam is compulsory.

• LAB laboratory work of six modules (3 hours) in small groups of two people, continuous assessment (30%). The LAB work is mandatory.

• Six PROB problem modules: individual work, continuous evaluation (3%). The PROB work is mandatory.

The indicators that will be used to grade the learning achieved: interpretation, selection, evaluation, and use of concepts, theories, technological developments related to optical communications.

The final EX exam grade will be the maximum value of (0.375*EP1+0.375*EP2+0.25*EP3) or (0.375*EF1+0.375*EF2+0.25*EP3). To pass, EX must exceed the minimum grade of 5 points and the grade in parts [max (EF1, EP1); max (EF2, EP2)] must exceeds 4 points. The global evaluation NF = 0.67 * EX + 0.30 * LAB + 0.03 * PROB, is based on the EX exam grade (67%), the LAB practice grade (30%), and the PROB problem grade (3%) . In the case that the EX theory grade is less than 4 points out of 10, but the overall NF grade exceeds 5 points, the student will be failed with a grade of 4.5 points.

b) Schedulingofevaluation activities.

The evaluation schedule:

• Continuous evaluation of Laboratory Practices, every two weeks.

• Continuous evaluation of problems, every two weeks (PROB).

• EP1 (60 minutes), approximately week 6-7

• EP2 (60 minutes), approximately week 11-13

• EP3 (60 minutes), approximately week 16-18 (School of Engineering exam schedule)

• Recovery exams (EF1 60 minutes, EF2 60 minutes), approximately week 16-18 (School of Engineering exam schedule).

c) Recovery process. The EP1 and EP2 tests (50,25% of the global evaluation) can be recovered in the corresponding exams (EF1, EF2). The fifth test consists of the partial exam EP3 (16,75% global evaluation) is not recoverable. In accordance with the coordination of the Degree and the management of the School of Engineering, the following activities cannot be recovered: Practices (1-6, 5% each), PROB modules (1-6, 0,5% each).

d) Grade review procedure. For each assessment activity, a place, date and time of review will be indicated in which the student can review the activity with the teacher. In this context, claims may be made about the grade of the activity, which will be evaluated by the teachers responsible for the subject. If the student does not appear in this review, this activity will not be reviewed later.

e) Special Grades: Not Assessable: A student will be considered non-assessable (NA) if he has not submitted to any of the activities. Enrollment of honor: Awarding a qualification of enrollment of honor was decided by the teachers responsible for the subject. UAB regulations indicate that MH can only be granted to students who have obtained a final grade equal to or greater than 9.00. Up to 5% MH of the total number of students enrolled can be awarded.

f) Irregularities on the part of the student, copying and plagiarism. Without prejudice to other disciplinary measures deemed appropriate, and in accordance with current academic regulations, irregularities committed by the student that may lead to a change in the grade of an act of evaluation willbe rated with a zero. Therefore, plagiarizing, copying or copying a practice or any other evaluation activity will imply suspending with a zero and it will not be recoverable in the same academic year. If this activity has an associated minimum grade, then the subject will be suspended.

g) Evaluation of repeating students.

In line with article 117 of the UAB Academic Regulations, from the second enrollment (specifically, for students who are NOT in their first enrollment and who have passed both LAB and PROB tests with a grade of 5), the assessment of The subject or module will consist of a synthesis test, which allows the evaluation of the learning results foreseen in the teaching guide of the subject. In this case, the grade of the subject will correspond to the grade of the synthesis test. For the synthesis test, the exams (0.375*EP1+0.375*EP2+0.25*EP3) or (0.375*EF1+0.375*EF2+0.25*EP3 will be used. However, students who have not passed both LAB and PROB work with a grade of 5, in each case, are required to have repeated the LAB and / or PROB work not passed.

In this course, the use of Artificial Intelligence (AI) technologies is permitted as an integral part of the development of the work, provided that the final result reflects a significant contribution from the student in terms of analysis and personal reflection. The student must clearly identify which parts have been generated using this technology, specify the tools used, and include a critical reflection on how these have influenced the process and the final outcome of the activity. Lack of transparency in the use of AI will be considered academic dishonesty and may result in a penalty in the activity grade, or more severe sanctions in serious cases.

This course does not permit a one-time evaluation.

Bibliography

Basic bibliography (Spanish)

1. Fundamentos De Comunicaciones Ópticas, José Capmany, Francisco Javier Fraile-Peláez; Javier Martí; (Sintesis), 2ª Edición (ISBN84-7738-599-8)
2. Problemas de Comunicaciones Ópticas, José Capmany, Daniel Pastor, Beatriz Ortega, Salvador Sales, 2003 (ISBN: 84-9705-381-8)

Complementary bibliography

1. Sistemas Y Redes Opticas De Comunicaciones; Martin Pereda, Jose A., Pearson Educacion, 1ª Edición, Madrid, 2004, ISBN: 8420540080
2. Optical fiber communication systems ; Leonid Kazovsky, Sergio Benedetto, Alan Willner, Artech House, 1996 , ISBN: 0-89006-756-2
3. Optical Fiber Communications: Principles and Practice. J.M. Senior, Prentice-Hall International. Series in Optoelectrónics. Londres, 1993. Segunda Edición.

Software

VPI Transmission Maker

Excel

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	331	English	second semester	morning-mixed
(PAUL) Classroom practices	332	English	second semester	morning-mixed
(PLAB) Practical laboratories	331	English	second semester	morning-mixed
(PLAB) Practical laboratories	332	English	second semester	morning-mixed
(PLAB) Practical laboratories	333	English	second semester	morning-mixed
(PLAB) Practical laboratories	334	English	second semester	morning-mixed
(TE) Theory	330	English	second semester	morning-mixed