ANX-PR/CL/001-01
LEARNING GUIDE

SUBJECT
93000812 - Fiber optics communications

DEGREE PROGRAMME
09AQ - Master Universitario en Ingenieria de Telecomunicacion

ACADEMIC YEAR & SEMESTER
2017/18 - Semester 2
Index

Learning guide

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1. Description

1.1. Subject details

<table>
<thead>
<tr>
<th>Name of the subject</th>
<th>93000812 - Fiber optics communications</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of credits</td>
<td>6 ECTS</td>
</tr>
<tr>
<td>Type</td>
<td>Optional</td>
</tr>
<tr>
<td>Academic year of the programme</td>
<td>Second year</td>
</tr>
<tr>
<td>Semester of tuition</td>
<td>Semester 4</td>
</tr>
<tr>
<td>Tuition period</td>
<td>February-June</td>
</tr>
<tr>
<td>Tuition languages</td>
<td>English</td>
</tr>
<tr>
<td>Degree programme</td>
<td>09AQ - Master Universitario en Ingenieria de Telecomunicacion</td>
</tr>
<tr>
<td>Centre</td>
<td>Escuela Tecnica Superior de Ingenieros de Telecomunicacion</td>
</tr>
<tr>
<td>Academic year</td>
<td>2017-18</td>
</tr>
</tbody>
</table>

2. Faculty

2.1. Faculty members with subject teaching role

<table>
<thead>
<tr>
<th>Name and surname</th>
<th>Office/Room</th>
<th>Email</th>
<th>Tutoring hours *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ignacio Esquivias Moscardo</td>
<td>B-115</td>
<td><a href="mailto:ignacio.esquivias@upm.es">ignacio.esquivias@upm.es</a></td>
<td>Sin horario. Concertar hora previa</td>
</tr>
<tr>
<td>(Subject coordinator)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miguel Angel Muriel Fernandez</td>
<td>B-118</td>
<td><a href="mailto:m.muriel@upm.es">m.muriel@upm.es</a></td>
<td>Sin horario. Concertar hora previa</td>
</tr>
</tbody>
</table>
3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

- Sistemas de comunicaciones
- Redes de comunicaciones

3.2. Other recommended learning outcomes

- Fundamentals of optical communication systems
4. Skills and learning outcomes *

4.1. Skills to be learned

CE13 - Capacidad para aplicar conocimientos avanzados de fotónica y optoelectrónica, así como electrónica de alta frecuencia.

CE3 - Capacidad para implementar sistemas por cable, línea, satélite en entornos de comunicaciones fijas y móviles.

4.2. Learning outcomes

RA67 - Capacidad de utilizar dispositivos e instrumentos relacionados con comunicaciones ópticas avanzadas

RA66 - Capacidad de analizar, diseñar, implementar y caracterizar sistemas avanzados de comunicaciones ópticas

RA68 - Compresión de los procesos físicos que afectan las prestaciones de los sistemas avanzados de comunicaciones ópticas

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

The general objective of the subject is to provide students with the ability to understand, analyze, and design, as well as the associated knowledge, in present fiber optic communications systems and in recent technological advances defining the future evolution.

To achieve this general objective, the different types of components and current systems will be studied (new modulation formats, coherent communications, high spectral efficiency, etc.) with emphasis on their behavior from the point of view of optical signal and their performance in link length and binary rate.

1. THEORETICAL LECTURES: These lectures will be used for the presentation of the contents, based on the
resources provided to the students through the Moodle platform.

2. PROBLEM SESSIONS: During the sessions the lecturer will propose problems that the student should solve as a personal work. Later, some of the proposed problems will be solved in the classroom, with the active participation of the students, clarifying the doubts.

3. LABORATORY SESSIONS: In the laboratory the concepts of optical communications seen in the face-to-face lectures are developed in a practical way.

5.2. Syllabus

1. Introduction to present Optical Communication Systems
   1.1. Historical perspective
   1.2. Ethernet and Optical Transport Networks (OTN)
   1.3. Basic concepts in photonics systems and networks

2. Optical Signal Generation
   2.1. Single-frequency Lasers
   2.2. Tunable lasers
   2.3. Optical Modulators
   2.4. Modulation Formats
   2.5. Multicarrier signal generation

3. Signal propagation in optical fibers
   3.1. Propagation in singlemode fibers
   3.2. Propagation in multimode fibers
   3.3. Non-linear Effects
   3.4. Multi-core and few-mode Fibers

4. Optical Amplification
   4.1. Semiconductor Optical Amplifiers
   4.2. Doped Fiber Optical Amplifiers
   4.3. Raman and Brillouin Optical Amplifiers
5. Signal recovery and noise

5.1. Noise types

5.2. Receiver parameters

5.3. Signal impairments

5.4. Coherent digital receivers

6. Advanced Systems

6.1. O-OFDM (Optical-Orthogonal Frequency Division Multiplexion) Systems

6.2. MIMO (Mutiple Input Multiple Output) optical communications

7. Channel Capacity and Energy Efficiency

7.1. Limits if Channel Capacity

7.2. Energy-efficient Optical Transmision

8. Laboratory Sessions

8.1. Session 1: Spectral Characterization of optical emitters

8.2. Session 2: Characterization of an EDFA

8.3. Session 3: Mode Propagation in fiber

8.4. Session 4: Link characterization with OTDR

8.5. Session 5: Optical link design and simulation
# 6. Schedule

## 6.1. Subject schedule*

<table>
<thead>
<tr>
<th>Week</th>
<th>Face-to-face classroom activities</th>
<th>Face-to-face laboratory activities</th>
<th>Other face-to-face activities</th>
<th>Assessment activities</th>
</tr>
</thead>
</table>
| 1    | Chapter 1: Introduction to Optical Communications  
Duration: 02:00  
Lecture  
Chapter 2: Optical Signal Generation  
Duration: 02:00  
Lecture | | | |
| 2    | Chapter 2: Optical Signal Generation  
Duration: 02:00  
Lecture  
Chapter 2: Optical Signal Generation  
Duration: 02:00  
Problem-solving class | | | |
| 3    | Chapter 2: Optical Signal Generation  
Duration: 02:00  
Problem-solving class  
Chapter 3: Signal propagation in optical fibers  
Duration: 02:00  
Lecture | | | |
| 4    | Chapter 3: Signal propagation in optical fibers  
Duration: 02:00  
Lecture  
Chapter 3: Signal propagation in optical fibers  
Duration: 02:00  
Problem-solving class | | | |
| 5    | Chapter 3: Signal propagation in optical fibers  
Duration: 02:00  
Problem-solving class  
First partial exam  
Written test  
Continuous assessment  
Duration: 02:00 | | | |
| 6    | Chapter 4: Optical Amplification  
Duration: 02:00  
Lecture  
Chapter 4: Optical Amplification  
Duration: 02:00  
Problem-solving class | | | |
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Description</th>
<th>Duration</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Chapter 4: Optical Amplification</td>
<td>Lecture</td>
<td>01:00</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Chapter 5: Signal Recovery and Noise Sources</td>
<td>Lecture</td>
<td>02:00</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Chapter 5: Signal Recovery and Noise Sources</td>
<td>Problem-solving class</td>
<td>02:00</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Chapter 6: Advanced Systems</td>
<td>Lecture</td>
<td>02:00</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Chapter 6: Advanced Systems</td>
<td>Problem-solving class</td>
<td>02:00</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Chapter 7: Channel Capacity and Energy Efficiency</td>
<td>Lecture</td>
<td>02:00</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Chapter 7: Channel Capacity and Energy Efficiency</td>
<td>Problem-solving class</td>
<td>02:00</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Second partial exam</td>
<td>Written test</td>
<td>03:00</td>
<td>Laboratory assignments</td>
</tr>
<tr>
<td>15</td>
<td>Lab Exam</td>
<td>Problem-solving test</td>
<td>01:00</td>
<td>Continuous assessment</td>
</tr>
<tr>
<td>16</td>
<td>Final Exam</td>
<td>Written test</td>
<td>03:00</td>
<td>Final examination</td>
</tr>
<tr>
<td>17</td>
<td>Final Lab Exam</td>
<td>Problem-solving test</td>
<td>01:00</td>
<td>Final examination</td>
</tr>
</tbody>
</table>
The independent study hours are training activities during which students should spend time on individual study or individual assignments.

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The subject schedule is based on a previous theoretical planning of the subject plan and might go through experience some unexpected changes along throughout the academic year.
### 7. Activities and assessment criteria

#### 7.1. Assessment activities

##### 7.1.1. Continuous assessment

<table>
<thead>
<tr>
<th>Week</th>
<th>Description</th>
<th>Modality</th>
<th>Type</th>
<th>Duration</th>
<th>Weight</th>
<th>Minimum grade</th>
<th>Evaluated skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>First partial exam</td>
<td>Written</td>
<td>Face-to-face</td>
<td>02:00</td>
<td>40%</td>
<td>4 / 10</td>
<td>CE3, CE13</td>
</tr>
<tr>
<td>14</td>
<td>Second partial exam</td>
<td>Written</td>
<td>Face-to-face</td>
<td>02:00</td>
<td>40%</td>
<td>4 / 10</td>
<td>CE3, CE13</td>
</tr>
<tr>
<td>14</td>
<td>Lab Exam</td>
<td>Problem-solving test</td>
<td>Face-to-face</td>
<td>01:00</td>
<td>20%</td>
<td>4 / 10</td>
<td>CE3, CE13</td>
</tr>
</tbody>
</table>

##### 7.1.2. Final examination

<table>
<thead>
<tr>
<th>Week</th>
<th>Description</th>
<th>Modality</th>
<th>Type</th>
<th>Duration</th>
<th>Weight</th>
<th>Minimum grade</th>
<th>Evaluated skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Final Exam</td>
<td>Written</td>
<td>Face-to-face</td>
<td>03:00</td>
<td>80%</td>
<td>4 / 10</td>
<td>CE3, CE13</td>
</tr>
<tr>
<td>17</td>
<td>Final Lab Exam</td>
<td>Problem-solving test</td>
<td>Face-to-face</td>
<td>01:00</td>
<td>20%</td>
<td>4 / 10</td>
<td>CE3, CE13</td>
</tr>
</tbody>
</table>

##### 7.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.
7.2. Assessment criteria

The final grade in the **continuous evaluation** consists of the marks obtained in the two Partial Exams and in the Lab. Exam, weighted as follows:

Final grade = 40% First Partial Exam + 40% Second Partial Exam + 20% Lab Exam

The minimum qualification in each exam to be able to pass is 4 points out of 10.

For those students wishing to be evaluated by means of a **final exam**, it will have theoretical and lab parts, weighted in the following way

Final grade = 80% Theoretical Final Exam + 20% Laboratory Exam

**Extraordinary call**

The extraordinary call will consist of a theoretical examination, and a practical evaluation, weighted in the following way:

Final grade = 80% Theoretical Final Exam + 20% Laboratory Exam

"The evaluation by means of final test will use the same types of evaluative techniques that are used in the continuous evaluation (EX, ET, TG, etc.), and it will be done in the dates and hours of final evaluation approved by the School Board for the present course and semester, except those activities of evaluation of learning results of difficult qualification in a final exam, in which case, such evaluation activities may be carried out throughout the course "
# 8. Teaching resources

## 8.1. Teaching resources for the subject

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slides</td>
<td>Web resource</td>
<td>Slides and problems with solutions available in Moodle</td>
</tr>
<tr>
<td>Laboratorio Brigadier Mathé</td>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>Sala de trabajo en grupo: Laboratorio</td>
<td>Equipment</td>
<td></td>
</tr>
</tbody>
</table>