Course guide
230647 - ACWS - Advanced Communications for Wireless Systems

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). (Compulsory subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).

Academic year: 2022  ECTS Credits: 5.0  Languages: English

PRIOR SKILLS

Students are required to certify that they have previously followed courses on digital communications with similar technical contents than the master adaptation course ‘Digital Communications’ (http://infoteleco.upc.edu/documents/guia_docent/assignatures/all/ang/230600.pdf) or as for the undergraduate subjects ‘Introduction to Communications’ (https://www.upc.edu/content/grau/guiadocent/pdf/ing/230018) and ‘Advanced Digital Communications’ (http://infoteleco.upc.edu/documents/guia_docent/assignatures/all/ang/230051.pdf).

Concepts on signal and systems:
- Time domain and frequency domain analysis of deterministic and random signals and linear systems.

Concepts on digital communications:
- Signal Space and optimal detection in Additive White Gaussian Noise (AWGN) channels.
- Time and frequency domain Nyquist’s criterions. Band-limited pulse shaping. Nyquist’s pulses.
- Digital modulations: PAM, QAM, ASK, PSK, FSK and orthogonal modulations.
- Discrete and continuous Bello’s Model.
- Frequency-Flat Fading and Frequency Selective channels: Coherence-Time, Coherence-Bandwidth, Delay-Spread and Doppler-Spread.
- Channel models: Rayleigh and Rician Channels.
- Multicarrier modulations: OFDM.
- Space diversity techniques: Beamforming and Maximum-Ratio Combining.
- Space-Time diversity techniques: Alamouti’s Code.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. 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.
**Transversal:**

2. 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.

3. 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.

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**TEACHING METHODOLOGY**

- Lectures
- Application classes
- Exercises
- Mid-Term Exam
- Final Exam

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**LEARNING OBJECTIVES OF THE SUBJECT**

The aim of this course is to present advanced concepts on digital communication systems. The course is divided in two main sections, that is, the point-to-point communication theory and the extension to multiuser scenarios. From a definition and a measure of information, the course develops the theory associated to the important concept of channel capacity. Impact of frequency-flat fading channels and frequency selective channels are analyzed. Performance degradations are mitigated through the use of transmission and reception diversity techniques. The extension of all the former concepts to a multiuser framework is done, providing a more rich and interesting context for current and future communication networks.

Learning results of the subject:

- To achieve a solid background on fundamental concepts of digital communications and information theory.
- Ability to understand the physical layers of modern advanced communication systems in point-to-point and multiuser networks.
- Ability to analyze, characterize and develop the physical layers of modern advanced communication systems in point-to-point and multiuser networks.

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**STUDY LOAD**

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Self study</td>
<td>86,0</td>
<td>68.80</td>
</tr>
<tr>
<td>Hours large group</td>
<td>39,0</td>
<td>31.20</td>
</tr>
</tbody>
</table>

Total learning time: 125 h
## CONTENTS

### 1. Introduction: A Definition of Information.

**Description:**
- Discrete memoryless sources and source entropy.
- Discrete memoryless channels, mutual Information and channel capacity.
- Continuous time-amplitude channels. The Gaussian channel.
- Water-pouring and bit-loading approaches.

**Full-or-part-time:** 42h  
Theory classes: 12h  
Self study: 30h

### 2. Additive White Gaussian Channel (AWGN).

**Description:**
- Signalling and optimal detection.  
Performance bounds and case studies.

**Full-or-part-time:** 7h  
Theory classes: 3h  
Self study: 4h

### 3. Frequency-Flat-Fading Channels: the wireless channel.

**Description:**
- Statistical Models.  
- Performance degradation and diversity schemes.  
- Use of the channel-state information.  
- Slow-fading: Outage Probability and Outage Capacity.  
- Fast-fading: Ergodic Capacity.

**Full-or-part-time:** 16h  
Theory classes: 6h  
Self study: 10h

### 4. Frequency-Selective Channels: the multipath channel.

**Description:**
- Bello’s channel model and channel transfer matrix.  
- SVD and optimal communication schemes.  
- OFDMA: Orthogonal Frequency Division Multiple Access.  
- Hybrid SVD on OFDM solutions.

**Full-or-part-time:** 20h  
Theory classes: 6h  
Self study: 14h
5. Multiple-Access Channel.

Description:
- Ahiswede-Liao multiple-access capacity region.
- Multiple-access schemes and capacity regions: TDMA, FDMA-OFDMA, CDMA.
- Multiuser detection.
- Uplink fading channel.
- Downlink fading channel.
- Multiuser diversity.

Full-or-part-time: 40h
Theory classes: 12h
Self study: 28h

Activities

EXERCISES

EXTENDED ANSWER TEST (MID TERM EXAMINATION)

EXTENDED ANSWER TEST (FINAL EXAMINATION)

Grading System

Mid-Term examination: 40 %
Final examination: 60 %
Final Grade: The final grade is the maximum between the Final Exam mark and the weighted former mark.

Bibliography

Basic:

Complementary: