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

LECTURER

Coordinating lecturer:
Consultar aquí / See here:
https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others:
Consultar aquí / See here:
https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

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.

TEACHING METHODOLOGY

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

LEARNING OBJECTIVES OF THE SUBJECT

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.

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>
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</tbody>
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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: