230600 - DC - Digital Communications

**Coordinating unit:** 230 - ETSETB - Barcelona School of Telecommunications Engineering

**Teaching unit:** 739 - TSC - Department of Signal Theory and Communications

**Academic year:** 2019

**Degree:**
- MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Teaching unit Optional)
- MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Teaching unit Optional)

**ECTS credits:** 5

**Teaching languages:** English

### Teaching staff

**Coordinator:** Vazquez Grau, Gregori

**Others:** Riba Sagarra, Jaume

Vazquez Grau, Gregori

### Prior skills

Students are required to certify that they have previously followed an introductory course on communications with a similar content as the undergraduate subject ‘Introduction to Communications’ ([https://www.upc.edu/content/grau/guiadocent/pdf/ing/230018](https://www.upc.edu/content/grau/guiadocent/pdf/ing/230018))

**Basic concepts on signal and systems:**
- Time domain and frequency domain analysis of deterministic and random signals and linear systems.
- Characterization of random signals (stochastic processes).
- Stationarity and Ergodicity.
- Real and complex Gaussian processes. Thermal noise.
- Power spectral density.

**Basic concepts on digital communications:**
- Additive White Gaussian Noise (AWGN) channel.
- Matched filter and signal detection.
- Time and frequency domain Nyquist’s criterions.
- Band-limited pulse shaping. Nyquist’s pulses.
- Symbol and bit error probabilities in PAM modulations.
- Frequency selective channels and inter-symbol interferences.

### 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.
Learning objectives of the subject:

The aim of this course is to provide the fundamental concepts on digital communication systems. The course must habilitate students coming from heterogeneous different disciplines for being able to follow advanced studies in this field. Fundamental concepts on signals and systems, probability, base-band and pass-band random processes will be reviewed. Pulse-Amplitude Modulation (PAM) will be the basic tool for introducing important concepts as optimal detection, matched filtering, pulse-shaping, symbol and bit error probabilities, power spectral density and inter-symbol interference. The course will be concluded with the theory needed to understand more sophisticated modulations based on the Signal Space concept, the MAP/ML optimal detection theory, diversity concept and Orthogonal Frequency Division Multiplexing (OFDM). Most important pass-band modulations (ASK, PSK, QAM) will be studied as case examples.

Learning results of the subject:

- To achieve a basic background on signals and systems, probability, random processes and digital communications concepts and theory.
- Ability to use and to understand a vectorial and matrix representation of signals and multidimensional modulations.
- Ability to use and to characterize the most important pass-band digital modulations.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group: 39h</th>
<th>31.20%</th>
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<tr>
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<td>Hours medium group: 0h</td>
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<tr>
<td></td>
<td>Hours small group: 0h</td>
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<td>Guided activities: 0h</td>
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<td>Self study: 86h</td>
<td>68.80%</td>
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## Content

### 2. Frequency Flat-Fading Channels

**Learning time:** 57h  
Theory classes: 15h  
Self study: 42h

**Description:**  
- Channel models. Bello’s model.  
- Delay-spread and coherence-bandwidth. Doppler-spread and coherence-time.  
- Rayleigh and Rice fading channels.  
- Spatial Diversity: SIMO, MISO, MIMO. Diversity gain vs array gain.  
- Temporal diversity: Interleaving, time-codes and maximum product distance.  
- Case study: Rotational codes.  
- Space-Time coding: Alamouti’s scheme.

### 1. Signal Space and Optimal Detection

**Learning time:** 45h  
Theory classes: 15h  
Self study: 30h

**Description:**  
1. Transmission in AWGN channels  
- Signal Space  
- Optimal MAP receiver  
- Union Bound.  
- Basic modulations (ASK, PSK, FSK, QAM).

### 3. Frequency-Selective Channels: Orthogonal Frequency Division Multiplexing (OFDM)

**Learning time:** 23h  
Theory classes: 9h  
Self study: 14h

**Description:**  
- Bello’s channel model and the channel matrix.  
- Block transmission and SVD solution.  
- OFDMA: Orthogonal Frequency Division Multiple Access.
### Planning of activities

<table>
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<th>EXERCISES</th>
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| **Description:**
Exercises to strengthen the theoretical knowledge. |

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<th>EXTENDED ANSWER TEST (MID TERM EXAMINATION)</th>
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| **Description:**
Mid term control. |

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<tr>
<th>EXTENDED ANSWER TEST (FINAL EXAMINATION)</th>
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| **Description:**
Final examination. |

### Qualification system

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

### Bibliography

**Basic:**