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
- Individual work (distance)
- Exercises
- Mid-Term Exam
- Final Exam

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.
230600 - DC - Digital Communications

- Ability to use and to characterize the most important pass-band digital modulations.

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

<table>
<thead>
<tr>
<th>1. Introduction: Random Signals and Stochastic Processes</th>
<th>Learning time: 18h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 6h</td>
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<tr>
<td></td>
<td>Self study : 12h</td>
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</tbody>
</table>

### Description:
- Characterization of stochastic processes.
- Stationarity and Ergodicity.
- Random signals in linear systems.
- Real and complex Gaussian processes. Noise.
- Power Spectral Density and Wiener-Khinchine Theorem.
- Pass-Band random signals. Base-band equivalent signal, In-phase and Quadrature components.

<table>
<thead>
<tr>
<th>2. Pulse Amplitude Modulation (PAM)</th>
<th>Learning time: 27h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 9h</td>
</tr>
<tr>
<td></td>
<td>Self study : 18h</td>
</tr>
</tbody>
</table>

### Description:
- Additive White Gaussian Noise (AWGN) channel.
- Detection, matched-filter and signal correlation.
- Nyquist's criterion and band-limited pulse-shaping.
- Symbol and bit error probabilities.
- Inter-symbol interference and performance degradation.

<table>
<thead>
<tr>
<th>3. Signal Space Theory</th>
<th>Learning time: 57h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 15h</td>
</tr>
<tr>
<td></td>
<td>Self study : 42h</td>
</tr>
</tbody>
</table>

### Description:
- Signal Space: Signals and vectors.
- Relevant noise and relevant information.
- Minimum error probability, maximum a-posteriori (MAP) and maximum likelihood criteria (ML). Optimal detection schemes.
- Error probability and union bounds.
- Application cases:
  - ASK
  - PSK
  - QAM
Planning of activities

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

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

Description:
- Bello's channel model and channel transfer matrix.
- Block transmission.
- OFDMA: Orthogonal Frequency Division Multiple Access.

EXERCISES

Description:
Exercises to strengthen the theoretical knowledge.

EXTENDED ANSWER TEST (MID TERM EXAMINATION)

Description:
Mid term control.

EXTENDED ANSWER TEST (FINAL EXAMINATION)

Description:
Final examination.

Qualification system

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

Basic:


