



## Course guides

# 230647 - ACWS - Advanced Communications for Wireless Systems

Last modified: 29/04/2020

**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:** 2020    **ECTS Credits:** 5.0    **Languages:** English

### LECTURER

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**Coordinating lecturer:** Vazquez Grau, Gregori

**Others:** Riba Sagarra, Jaume  
Vazquez Grau, Gregori

### REQUIREMENTS

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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](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/guidocent/pdf/ing/230018>) and 'Advanced Digital Communications' ([http://infoteleco.upc.edu/documents/guia\\_docent/assignatures/all/ang/230051.pdf](http://infoteleco.upc.edu/documents/guia_docent/assignatures/all/ang/230051.pdf)).

### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**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

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- Lectures
- Application classes
- Individual work (distance)
- 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

Type	Hours	Percentage
Self study	86,0	68.80
Hours large group	39,0	31.20

**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 OFDMA 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

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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

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### Basic:

- Viterbi, A.J.; Omura, J.K. Principles of digital communication and coding. New York: Dover, 2009. ISBN 9780486469010.
- Tse, D.; Viswanath, P. Fundamentals of wireless communication. Cambridge: Cambridge University Press, 2005. ISBN 9780521845274.

### Complementary:

- Benedetto, S.; Biglieri, E. Principles of digital transmission: with wireless applications [on line]. New York: Kluwer Acad./Plenum PWB, 1999 [Consultation: 22/09/2020]. Available on: <http://link.springer.com/book/10.1007/b117711/page/1>. ISBN 0306457539.
- Goldsmith, A. Wireless communications. Cambridge ; New York: Cambridge University Press, 2005. ISBN 0521837162.
- Gallager, R.G. Information theory and reliable communication. New York: John Wiley & Sons, 1968. ISBN 0471290483.
- Cover, T.M.; Thomas, J.A. Elements of information theory. 2nd ed. New York: John Wiley & Sons, 2006. ISBN 0471241954.