UAB
Universitat Autònoma de Barcelona

Communication Theory

Code: 102696
ECTS Credits: 9

2024/2025

Degree	Type	Year
2500898 Telecommunication Systems Engineering	OB	3

Contact

Name: Gonzalo Seco Granados

Email: gonzalo.seco@uab.cat

Teachers

Rafael Terris Gallego

Teaching groups languages

You can view this information at the end of this document.

Prerequisites

This subject can be considered as the continuation of the 102714 Communication Foundations, therefore, it is recommended to have passed and passed 102714 Foundations of Communications.

It is also recommended to have a good knowledge of 102690 Foundations of Signals and Systems, and 102712 Signals and Discrete Systems.

Objectives and Contextualisation

A communications system in general consists of the following blocks: source, source encoder, channel encoder, modulator, channel, demodulator, channel decoder, source decoder and recipient. During the Foundations of Communications course, the emphasis was placed on the study of the modulator, channel and demodulator. In this course, first of all, they will be remembered and some new aspects of modulation and demodulation will be seen, but above all the other blocks of the system will be studied in depth, paying special attention to the characterization of the sources at the level of Information theory, compression using source codes and correction of errors introduced by the channel through channel encoding.

The specific objectives are to:

- Consolidate the knowledge about modulations and demodulations, and describe some more advanced techniques than the previous courses.
- Dimension communication systems from the point of view of probability of error (coding).
- Analyze the flow of information throughout the communications system using the concepts of information theory.
- Understand the fundamental limits given by the theory of information.

- Encode fonts to reduce redundancy.
- Become knowledgeable of the main methods of channel coding and its operating principles.

Competences

- Apply deterministic and stochastic signal processing techniques to the design of communication subsystems and data analysis.
- Communication
- Design and dimension multiuser communication systems using the principles of communication theory under the restrictions imposed by the specifications and the need to provide a quality service.
- Develop personal attitude.
- Develop personal work habits.
- Develop thinking habits.
- Draft, develop and sign projects in the field of telecommunications engineering that, depending on the speciality, are aimed at the conception, development or exploitation of telecommunication and electronic networks, services and applications.
- Learn new methods and technologies, building on basic technological knowledge, to be able to adapt to new situations.
- Resolve problems with initiative and creativity. Make decisions. Communicate and transmit knowledge, skills and abilities, in awareness of the ethical and professional responsibilities involved in a telecommunications engineer's work.
- Work in a multidisciplinary group and in a multilingual environment, and communicate, both in writing and orally, knowledge, procedures, results and ideas related with telecommunications and electronics.
- Work in a team.

Learning Outcomes

1. Autonomously associate new knowledge and techniques that are adequate for conceiving, developing or exploiting telecommunication systems and services, with special emphasis on data transmission.
2. Be able to analyse, encode, process and transmit multimedia information employing analogue and digital signal processing techniques.
3. Classify the advantages and disadvantages of different technological alternatives for deploying or implementing communication systems in terms of digital source compression, channel coding and security mechanisms.
4. Combine different technological alternatives to propose data transmission systems that are optimised for features of the application scenario.
5. Communicate efficiently, orally and in writing, knowledge, results and skills, both professionally and to non-expert audiences.
6. Critically evaluate the work done.
7. Describe, develop, analyse and optimise the different blocks of a data transmission system.
8. Develop critical thinking and reasoning.
9. Develop curiosity and creativity.
10. Develop independent learning strategies.
11. Develop scientific thinking.
12. Develop the capacity for analysis and synthesis.
13. Differentiate and classify the main source coding and compression algorithms.
14. Differentiate the blocks and functionalities of a complete data transmission system.
15. Discuss and apply cryptography systems designed to improve the security of a communication system.
16. Distinguish the fundamental parameters of a complete data transmission oriented communications system.
17. Efficiently use ICT for the communication and transmission of ideas and results.
18. Identify the minimum requirements for the communication of reliable and secure digital data.
19. Interpret the fundamental limits of information theory.
20. Judge and criticise, both orally and in writing, different reliable and secure concepts, methods and techniques for digital data transmission.

21. Manage available time and resources.
22. Plan the design process as part of a digital communication systems team with emphasis on source compression, data coding and secure message transmission.
23. Prevent and solve problems.
24. Recognise different multiuser access techniques and choose the best solutions in accordance with the communication scenario.
25. Understand and illustrate the main methods of channel coding and its operative principles.
26. Use communication and computer applications (office automation, databases, advanced calculation, project management, display, etc.) to support the design of data transmission systems and facilitate posterior technological transfer.
27. Use the concepts of systems of data source code compression and secure digital message transmission in single-user and multiuser systems.
28. Work autonomously.
29. Work cooperatively.
30. Work in an organised manner.

Content

1. Definitions and basic properties to the theory of information

- Introduction to data transmission systems
- Detection and need of source and channel codings.
- Logical channel
- Entropy, relative entropy, mutuall information.
- Inequality of data processing. Fano inequality.
- Property of asymptotic equipartition.

2. Source coding and data compression

- Type of source codes and properties.
- Source coding theorem (1st Shannon theorem).
- Huffman coding.
- Shannon-Fano-Elias coding.
- Lemple-Ziv coding.

3. Channel capacity

- Type and characterization of the channel. Channel capacity.
- Channel coding theorem (2nd Shannon theorem).
- Differential entropy.
- Gaussian channel capacity.

4. Block codes

- Properties of linear block codes. Systematic codes.
- Generating and parity matrices.
- Basic block codes (Hamming, repetition, maximum length, BCH, Reed-Salomon).
- Decoding and probability of error.
- Cyclic codes.
- Concatenation of codes and advanced codification (LDPC).

5. Convolucional codes

- Properties of convolutional codes.
- Representation and description of codes. States diagram and trellis.
- Types of codes. Systematic codes. Recursive codes.
- Probability of error and performance. Free distance. BER.

- Optimum decoding (MLSE). Viterbi algorithm.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Laboratory sessions	15	0.6	1, 6, 3, 4, 25, 5, 7, 11, 10, 12, 9, 8, 14, 13, 15, 16, 17, 21, 18, 19, 20, 22, 23, 24, 2, 29, 28, 30, 26, 27
Problem-solving lectures	15	0.6	1, 6, 3, 4, 25, 7, 11, 10, 12, 9, 8, 14, 13, 15, 16, 17, 21, 18, 19, 20, 22, 23, 24, 2, 29, 28, 30, 26, 27
Theory lectures	39	1.56	1, 3, 4, 25, 7, 11, 10, 12, 9, 8, 14, 13, 15, 16, 18, 19, 20, 22, 24, 26, 27
Type: Supervised			
Tutoring	6	0.24	1, 3, 4, 25, 5, 7, 11, 10, 12, 8, 14, 13, 15, 16, 21, 18, 19, 20, 22, 24, 2, 28, 26, 27
Type: Autonomous			
Student's individual work	143	5.72	1, 6, 3, 4, 25, 7, 11, 10, 12, 9, 8, 14, 13, 15, 16, 21, 18, 19, 20, 22, 23, 24, 2, 28, 30, 26, 27

Classroom activities

- Theory classes: presentation of the theoretical contents
- Classes of problems: solving problems related to theory, with the participation of the students themselves.
- Laboratory sessions: application of the techniques presented to the theory classes to different real systems and implementation with different simulation softwares.
- Partial and recovery exams.

Autonomous activities

- Study of the theoretical and practical contents of the subject. Resolution of problems and preparation of deliveries of some sets of problems. Preparation of the exams.
- Laboratory activities: realization and deepening of laboratory exercises. Preparation of the report of each laboratory session.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes

Follow-up Activities	Up to 10%, if it increases the final grade.	1	0.04	1, 6, 3, 4, 25, 5, 7, 11, 12, 9, 8, 14, 13, 15, 16, 17, 21, 18, 19, 20, 22, 23, 24, 2, 30, 26, 27
Partial Exam 2	32 %	2	0.08	1, 3, 4, 25, 5, 7, 11, 10, 12, 9, 8, 14, 13, 15, 16, 21, 18, 19, 20, 22, 23, 24, 2, 28, 27
Partial exam 1	48 %	2	0.08	1, 3, 4, 25, 5, 7, 11, 10, 12, 9, 8, 14, 13, 15, 16, 21, 18, 19, 20, 22, 23, 24, 2, 28, 27
Practices	20 %	0	0	1, 6, 3, 4, 25, 5, 7, 11, 10, 12, 9, 8, 14, 13, 15, 16, 17, 21, 18, 19, 20, 22, 23, 24, 2, 29, 28, 30, 26, 27
Recovery Exam	80 %	2	0.08	1, 3, 4, 25, 5, 7, 11, 10, 12, 9, 8, 14, 13, 15, 16, 21, 18, 19, 20, 22, 23, 24, 2, 28, 27

Principles of evaluation

The assessment is structured so that students can choose a format of continuous evaluation or a format where most of the weight of the assessment is concentrated at the end of the course (which can also be used as a recovery mechanism for the continuous evaluation). This allows the student to adapt the pace of completion of the assessment elements to their needs and preferences.

Evaluation elements

There will be the following evaluation elements:

- Follow-up activiites
- Practices
- Partial Exam 1
- Partial Exam 2
- Recovery Exam

The follow-up activities (NS) will consist of participation in class, carrying out problems or tests in class and/or submitting problems outside of class. The follow-up note will only be used to raise the final grade (maximum of 10%).

The grade of practices (NP) will be evaluated based on the reports that must be submitted at the start and / or end of the practice sessions, the work and possible exercices done during or after the sessions, and the possible additional exercises deliveries. It is not necessary to approve each practice individually. Laboratory sessions are an activity that is not recoverable.

The Partial Exam 1 (ExP1) will be held approximately halfway through the course. It does not release matter why the contigunts of this course are cumulative; that is to say, they must master the first issues to be able to follow the last ones.

The Partial Exam 2 (ExP2) will be carried out approximately the last week of face-to-face activities (theoretical classes).

The Recovery Exam (ExR) will be carried out once the face-to-face activities have been finalized, during the time period specifically devoted to examinations.

Calculation of the final grade

- Continuous assessment note: AC = max {0.4*ExP1 + 0.6*ExP2, ExP2}

- Overall note of the exams (NE):

- NE = AC if the recovery exam is not peformed.

- NE = ExR if the recovery exam is performed.

- The final grade (NF) of the subject is: NF = max {0.8 x NE + 0.2 x NP, 0.9 x (0.8 x NE + 0.2 x NP) + 0.1 x NS}

- To approve it is necessary that NF >= 5.

Repeating students

You can keep the Lab Grade from previous years. It is the option that is considered by default if they do not go back to doing the practices.

Honor grades

Granting an Honor qualification is a decision of the faculty responsible for the subject. Honors will be awarded only to students who have shown a great level of excellence in the subject, and not bydefault to those who have removed the highest marks. The regulations of the UAB indicate that Honors can only be awarded to students who have obtained a final grade of 9.00 or more. It can be granted MH up to 5% of the total number of students enrolled.

Consideration of "Not Evaluable"

The final grade will be "Not Evaluable" only when the student is not present at any exam, neither of the continuous evaluation nor recovery exam.

Consideration in case of copy or plagiarism

Notwithstanding other disciplinary measures that are deemed appropriate, and in accordance with the current academic regulations, the evidenceorreports where the student has committed irregularities (eg plagiarism, deception, copying, the fact to leave copy, etc.) that could lead to a variation of the qualification.

Communication

The Virtual Campus will be the communication platform with the students.

Bibliography

Basic

- Cover, T. M.; Thomas, J. A. Elements of Information Theory. Wiley, 2nd edition, 2006.
- Proakis, J.; Salehi, M.; Digital Communications. McGraw-Hill, 5th edition, 2008.

Complementary

- Artés Rodríguez, A.; Pérez González, F.; Cid Suero, J.; López Valcarce, R.; Mosquera Nartallo, C.; Pérez Cruz, F.; Comunicaciones Digitales, http://www.tsc.uc3m.es/~antonio/libro_comunicaciones/El_libro_files/comdig_artes_perez2.pdf
- Ha, T. T., Theory and Design of Digital Communication Systems. Cambridge University Press, 2011.
- Glover, I. A.; Grant, P. M., Digital Communications. Prentice Hall, 3rd edition, 2010.

Advanced

- Proakis, J.; Salehi, M.; Commnications Systems Engineering, Prentice-Hall, 2nd edition, 2001.
- Du, K.-L.; Swamy, M. N., Wireless Communication Systems. From RF Subsystems to 4G Enabling Technologies. Cambridge University Press, 2010.
- Madhow, U., Fundamentals of Digital Communication. Cambridge University Press, 2008.
- Lin, S.; Costello, D. J., *Error Control Coding.* Prentice-Hall, 2nd Edition, 2004.
- Gallager, R. G., *Principles of Digital Communication.* Cambridge University Press, 2008.
- Moon, T. K., *Error Correction Coding: Mathematical Methods and Algorithms.* Wiley-Interscience, 2005.

- Roman, S., *Introduction to Coding and Information Theory.* Springer, 1996
- Abramson, N., *Information Theory and Coding*. McGraw-Hill, 1963.
- Blahut, R., *Algebraic Codes for Data Transmission*. Cambridge University Press, 2003.
- Hamming, R. W., *Coding and Information Theory.* Prentice-Hall, 1980.
- Gitlin, R.D.; Hayes, J.F.; Weinstein, S.B. Data communications principles. Plenum Press, 1992.
- Adamec, J., *Foundations of Coding: Theory and Applications of Error-Correcting Codes with an Introduction to Cryptography and Information Theory.* Wiley-Interscience, 1991.
- Sklar, B.; *Digital Communications: Fundamentals and Applications,* Prentice Hall, 2nd edition, 2001.
- Goldsmith, A.; *Wireless Communications,* Cambridge University Press, 2005.
- Molisch, A. F.; *Wireless Communications,* Wiley, 2nd edition, 2011.

Software

During the practical sessions, MATLAB software will be used.

Likewise, MALTAB will also be used as a support for the theoretical and problem classes.

Language list

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	331	Spanish	second semester	morning-mixed
(PAUL) Classroom practices	332	Spanish	second semester	morning-mixed
(PLAB) Practical laboratories	331	Catalan	second semester	morning-mixed
(PLAB) Practical laboratories	332	Catalan	second semester	morning-mixed
(PLAB) Practical laboratories	333	Catalan	second semester	morning-mixed
(TE) Theory	330	Spanish	second semester	morning-mixed