Universitat Autònoma de Barcelona

2021/2022

Multidisciplinary Applications in Telecommunications I

Code: 102695
ECTS Credits: 6

Degree	Type	Year	Semester
2500898 Telecommunication Systems Engineering	OT	4	0

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

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Use of Languages

Principal working language: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

Other comments on languages

The slides will be mainly in English

External teachers

Serni Ribó

Prerequisites

Although there are no formal prerequisites to enroll this course, it is recommended that the student has good knowledge of fundamentals of signals and systems, digital signal processing and design of digital receivers.

Objectives and Contextualisation

A telecommunication system is composed of three main blocks: transmitter, communication channel and receiver, through which the exchange of information between the source (transmitter) and destination (receiver) is carried out. In previous courses the student has acquired the knowledge and tools for the design and analysis of these blocks, typically in an independent manner. This course intends to provide an end-to-end view focusing on a particular application of telecommunications, such as satellite-based positioning. For this purpose, the course will address in detail the so-called global navigation satellite systems (GNSS), among which we can find the American GPS system and the European Galileo system.

The objectives of this course are:

- To know the fundamentals of satellite-based positioning.
- To know the GNSS system architecture.
- To know the signals adopted by GNSS systems, putting emphasis on GPS and Galileo.
- To understand the operation of a GNSS receiver at signal processing and observable level.
- To be able to solve the user's position based on the observables provided by a GNSS receivers.
- To understand the operation of a GNSS.

- To process both real signals and GNSS observables, and to analyze the results.
- To know the fundamentals of precise positioning.
- To know the possible applications of GNSS systems, both at commercial and scientific level.

Competences

- Communication
- Develop personal attitude.
- Develop personal work habits.
- Develop thinking habits.
- 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 engineers work.
- Work in a team.

Learning Outcomes

1. "Reason inductively and deductively; i.e. infer general conclusions from private observations, and take on board the general concepts covered in other courses for specific applications."
2. Apply conceptual, theoretical and practical telecommunication tools, as well as those of telecommunication systems and services to the development and exploitation of applications in a variety of different areas.
3. Communicate efficiently, orally and in writing, knowledge, results and skills, both professionally and to non-expert audiences.
4. Communicate solutions to problems in a thorough and concise manner. Write using formal mathematical language.
5. Critically evaluate the work done.
6. Demonstrate a pragmatic and flexible attitude for efficient implementation of telecommunications in developing and operating in areas of various kinds.
7. Develop critical thinking and reasoning.
8. Develop curiosity and creativity.
9. Develop independent learning strategies.
10. Efficiently use ICT for the communication and transmission of ideas and results.
11. Manage available time and resources.
12. Mathematically formulate a problem from the basis of a descriptive statement.
13. Work autonomously.
14. Work cooperatively.

Content

1. Introduction to GNSS systems

- Motivation.
- Arquitecture and segments.
- Applications.

2. User position computation

- Observables.
- Navigation equation and error sources.
- Navigation solution.
- Performance.
- Differential positioning.

3. GNSS signals

- Fundamentals of spread spectrum modulation.
- Characteristics of GNSS signals.
- Navigation message.
- Modernized signals.

4. GNSS receivers

- Receiver architecture.
- Signal conditioning.
- Acquisition of visible satellites.
- Tracking.
- Demodulation.

5. Scientific applications

- International GNSS Service (IGS).
- Survey and geodesy
- Reflectometry.
- Radio-occultation.

Methodology

The work of the student will be reflected in different activities such as tests, writing laboratory reports, generation of matlab code.

There will be three types of activities:

- Autonomous activities:

    1. *Students' individual work*: Study of the theoretical and practical contents of the subject. Preparation of problems and exams. To carry out this task the student will have at his/her disposal an extensive bibliography as well as the possibility of tutorials with the professor to solve their doubts and / or extend their knowledge of the subject.
    2. *Laboratory reports*: Throughout the course, different laboratory sessions will be held in order to apply the concepts learned in the lectures in different practical situations. Specifically, there will be 4 laboratory sessions splited into 2 different practices. The student must dedicate time to finish the work of the laboratory sessions and prepare the corresponding reports.

- Teaching activities:

    1. *Expository lectures*: The student will acquire the basic knowledge during the classes scheduled during the course. The classes will consist mainly of theoretical sessions taught by the teachers of the subject. When the syllabus requires it, the teachers will solve some practical problem in the classroom.
    2. *Laboratory lectures: The student will perform the various laboratory sessions scheduled during the course. The teacher will be available in these sessions to guide and supervise the work of the students.*

- Supervised activities:

    1. *Tutoring:* Some of the hours scheduled during the course will be devoted to the preparation of the different study cases to be investigated in the subject. The teacher will be available to answerany questions and guide the students in order to successfully completethe study cases.

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.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Expository lectures	36	1.44	1, 2, 6, 8, 7, 12
Laboratory lectures	12	0.48	1, 2, 5, 4, 6, 9, 8, 7, 10, 12, 11, 14, 13
Type: Supervised			
Tutoring	10	0.4	1, 2, 5, 4, 9, 8, 7, 12, 11, 13
Type: Autonomous			
Laboratory reports	32	1.28	1, 2, 5, 4, 9, 7, 10, 12, 11, 14, 13
Student's individual work	58	2.32	1, 2, 5, 4, 6, 9, 8, 7, 12, 11, 13

Assessment

The course is based on three evaluation activities:

- PLAB: Laboratory (40%).
- PP1: Intermediate test 1 (30%).
- PP2: Intermediate test 2 (30%).

The laboratory will be evaluated based on the reports that will be delivered by the student at the beginning and/or the end of the laboratory sessions, on the work carried out during these sessions and on possible additional activities. Due to the practical orientation and the use of specific equipment, the laboratory sessions cannot be recovered later on.

On the other hand, the intermediate tests 1 and 2 are short tests that intend to assess whether the student is successfully progressing in his learning process. The first test will be carried out around the mid point of the semester while the second test will be carried out at the end of the semester. The marks for both tests should be >= 3.5 for the student to be eligible to have all his/her marks averaged out.

The final mark of the course will be computed as follows:

if (Mark_PP1>=3.5 and Mark_PP2>=3.5) --> Final_Mark = 0.4 x Mark_PLAB + 0.3 x Mark_PP1 + 0.3 x Mark_PP2

if (Mark_PP1<3.5 or Mark_PP2<3.5) --> Final_Mark = min(Mark_PP1, Mark_PP2)

Second chance

In order to pass the course it is required that Final_Mark >= 5. Students whose Final_Mark < 5 can attend a second chance exam that will be carried out within the calendar of exams published by the School. Except for the laboratory sessions, for which there is no second chance, the student can recover the remaining 60% of the course mark by doing the second chance exam that will evaluate all topic of the course.

Consideration of "Not evaluable"

Students who do not attend the two intermediate tests, nor the case study, nor the second chance exam, will be declared as "not evaluable".

Additional considerations

Without prejudice of additional disciplinary measures that may be deemed, and according to the current regulations, any irregularity conducted by the student within the scope of an evaluation activity will lead to this activity to be qualified with a mark equal to zero. Therefore, copying or letting other copy a laboratory exercise, report, or any other activity will imply to fail that activity with a mark equal to zero. For those activities with a minimum required mark, this means that the course will be failed.

Correctness of the written language in reports and exams will also be taken into account at evaluation.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Intermediate test 1	30%	1	0.04	1, 4, 9, 8, 7, 12, 11, 13
Intermediate test 2	30%	1	0.04	1, 4, 9, 8, 7, 12, 11, 13
Laboratory	40%	0	0	2, 5, 3, 4, 6, 8, 7, 10, 11, 14, 13

Bibliography

Basic bibliography:

- P. Misra, P. Enge, *Global positioning system: signals, measurements, and performance*, Ganga-Jamuna Press, 2nd ed., 2011. ISBN: 978-0-97095442-8.
- E. Kaplan, C. Hegarty, *Understanding GPS: Principles and Applications*, Artech House, 2nd ed., 2005. ISBN: 978-1-58053894-7.
- F. van Diggelen, *A-GPS: Assisted GPS, GNSS, and SBAS*, Artech House, 1st ed., 2009. ISBN: 978-1-59693374-3.
- P. J.G. Teunissen, O. Montenbruck (Eds.), *Handbook of Global Navigation Satellite Systems*, Springer International Publishing AG 2017. ISBN: 978-3-319-42926-7.

Complementary bibliography:

- B. W. Parkinson, J. J. Spilker (Eds.), *Global Positioning System: Theory and Applications*, AIAA, 1996. ISBN: 978-1-56347106-3.
- A. Bensky, *Wireless Positioning Technologies and Applictions*, Artech House, 2008. ISBN: 978-1-59693130-5.
- G. Seco-Granados, J. A. López-Salcedo, D. Jiménez-Baños, G. López-Risueño, "Challenges in indoor global navigation satellite systems", IEEE Signal Processing Magazine, Vol. 29, no 2, pags. 108-131, 2012.

Software

The software 'octave' will be used for the practical exercises.