Educational project of the subject

Subject	WIRELESS TELECOMMUNICATION SYSTEMS		
Matter	RADIO COMMUNICATIONS		
Module	SPECIFIC SUBJECTS OF TELECOMMUNICATION ENGINEERING		
Title	DEGREE IN TELECOMMUNICATION TECHNOLOGIES ENGINEERING		
Plan	460	**Code**	45045
Teaching period	2nd SEMESTER	**Type**	OPTIONAL
Level	DEGREE	**Course**	4th
ECTS credits	6 ECTS		
Teaching language	ENGLISH		
Professor in charge	RAMÓN DE LA ROSA STEINZ		
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Department	SIGNAL THEORY, COMMUNICATIONS AND TELEMATIC ENGINEERING		

1. Situation / sense of the subject

1.1 Setting in context

The wireless communication systems or radio systems represent a fascinating subject that comprises a great set of applications. They have evolved at a vertiginous pace with a great impact in the end-user. The satellite communications, the digital broadcasting of radio and television, the mobile telephony applications or the wireless technologies for data transmission are embedded in our daily living activities.

The purpose of this subject is to introduce the wireless systems to the student in a practical manner. The technical characteristics of these systems will be presented, but complemented with applied work in the laboratory. The goal is to settle the underlying concepts and interact with the technologies involved in wireless communications.

The subject is aimed at promoting the skills to find and select technical specifications and reinforce the student's ability to solve applied problems. Thus, a set of tools will be offered to the student, both hardware and software, so they can understand the key concepts so as to tackle the wireless challenges, consequence of the rapid evolution in this technologies.

1.2 Relation with other matters

From the point of view of the official *Telecommunication technologies* degree, this subject is related to the subject *Radio transmission fundamentals*, which gives the extended concepts related to the antenna systems, whose applications will be described in the present subject. In addition, the subjects from the matter *Electronics for telecommunications* are in charge of introducing the electronics involved in wireless systems. The previous matters *Fundamentals on communications* and *Fundamentals on electromagnetic engineering* should have been the responsible ones to describe the basics on electric circuits, the nature of electromagnetics and the techniques to send information by means of electromagnetic waves in radio systems.

1.3 Pre-requirements

From the point of view of students from universities abroad, this subject requires reasonable good skills in English language, both at listening and at writing. The goal of the subject is to review the concepts learnt across the different subjects usually taught at the electrical and electronic engineering degrees or at the telecommunication engineering degrees, integrate them and relate them to current wireless technologies. However, a deep knowledge is not required to attend it as this is a review subject aimed at integrating concepts. Hence, it can be a good opportunity to learn or update some fundamentals related to wireless systems. Nevertheless, It will be very helpful some basic knowledge about electronics to understand schemas, and ability to understand the concept of electromagnetic waves and its location in the radio frequency spectrum. About the applied part of the subject, it will be helpful some basic knowledge of the laboratory of electronics instrumentation (oscilloscope, multimeter, function generator), reasonable manual skills and being resourceful to build small prototypes.

From the point of view of the official *Telecommunication technologies* degree, there are no excluding conditions to attend this subject, although there are some common sense recommendations to take into account. As it is a subject located in the last course of the degree, it is recommended to have studied the matters *Fundamentals on communications* and *Fundamentals on electromagnetic engineering* from the *Basic matters block*. Also, it is recommended to have studied the obligatory subjects from the matter *Electronics for telecommunications*. In addition, it is very recommended to have attended the subject *Radio transmission fundamentals*, located in the third course.

2. Competences

2.1 General

- GBE1 Ability to manage mandatory specifications, regulations and standards.
- GBE2 Ability to apply numeric and analytic methods to problems in the fiend of technical telecommunication engineering.
- GBE3 Ability to solve problems with initiative, creativity and critical reasoning.
- GBE4 Ability to design and implement experiments, analyse them and understand the data.
- GE1 Ability to work in several environments such as laboratories or companies under the supervision of specialised professionals.
- GE4 Ability to develop projects in the field of telecommunications that satisfy the required technical, cosmetic and safety specifications, applying basic elements of financial management of human resources, organisation and project planning.
- GC1 Ability to organise and manage the available time.
- GC2 Ability to communicate knowledge, procedures, results and ideas, both written and spoken, related to telecommunications and electronics. .
- GC3 Ability to work in any context, whether individual or in group, educational or professional, local or international, respecting the fundamental rights of equality, sex, ethnics or religion and the universal accessibility principles, applying a philosophy of peace to each action.

2.2 Specific

- ST1 Ability to build, operate and manage the telecommunication networks, services, processes and applications, understood as systems to pick-up, transport, represent, process, store, manage and display multimedia information, from the point of view of the communications systems.
- ST3 Ability to analyse components and specifications of communication systems, whether guided or not guided systems.
- ST4 Ability to select circuits, subsystems and systems related to radio frequency, microwaves, radio broadcasting, radio links or radio determination.
- ST5 Ability to select antennas, equipment and transmission systems, to deal with the propagation of guided and non-guided electromagnetic waves, whether in the radio frequency or in the optics range, associating it with the radio frequency spectrum management and the involved frequency allocation.

3. Objectives

At the end of the subject, the student must be able to:

- Know the options to experiment in the field of the radio amateur operation.
- Work with regulations related to the radio frequency spectrum management.
- Work with specifications related to radio telecommunication systems.
- Identify transmissions with spectrum analysis equipment.
- Connect the basic parameters that characterise a radio frequency system.
- Interpret the technology involved in the radio telecommunication systems.
- Estimate the radio coverage in point-to-point systems.
- Enumerate and describe the communication systems studied.
- Identify the planning requirements in terms of time and resources to develop projects.

4. Contents and sections

Section 1: Technology of the radio frequency systems

Workload in ECTS credits:	2.4

a. Setting in context and rationale

This section is composed of three themes. It starts with an introductory theme where a review of the required concepts for the subject will be done. The radio frequency spectrum organisation will be reviewed and the radio amateur operation will be presented as a way to experiment. The next two themes will review the antenna systems technology, the transmitters and receiver characteristics and the evolution to the software defined radio (SDR) systems.

b. Learning objectives

At the end of this section, the student must be able to:

- Know the radio amateur possibilities.
- Work with the information that regulates the radio frequency spectrum.
- Connect the basic parameters that characterise a radio frequency system.
- Interpret the technology of the transmitting and receiving equipment.

c. Contents

THEME 1: An introduction to radio

1.1 Objectives.

1.2 Concepts revision. Logarithmic units.

1.3 The radio frequency spectrum.

1.4 Radio amateur operation as a way of experimenting.

1.5 Summary.

THEME 2: Antenna systems technology

2.1 Objectives.

2.2 Review of characteristics and parameters defining the antennas.

2.3 Antenna feeders.

2.4 Antennas applied to communication systems.

2.5 Summary.

THEME 3: Receivers and transmitters

3.1 Objectives.

3.2 Receivers technology.

3.3 Transmitters technology.

3.4 Interpreting transceiver wiring diagrams.

3.5 The evolution of the radio. Software defined radio (SDR).

3.2 Summary.

d. Teaching methods

- Interactive master class.
- Study of cases both at the classroom and at the laboratory.
- Collaborative learning.
- Projects method learning.

e. Work plan

See Annex I.

f. Assessment

The competence acquisition assessment will be based on:

- Attitude and participation assessment during the academic activities.
- On-line assessment through learning course management systems (LCMS) like Moodle.
- Written test and/or on-line test with LCMS tools at the end of the lessons period.

g. Basic references

- I. Poole, *Newnes Guide to Radio and Communications Technology*. Newnes, 2003.

h. Additional references

- S. Winder, J. Carr, *Newnes Radio and RF Engineering Pocket Book*. Newnes, 2002.
- G. Brown, *Radio and Electronics Cookbook*. Newnes 2001.
- T. J. Rouphael, *RF and Digital Signal Processing for Software-Defined Radio: A Multi-Standard Multi-Mode Approach*. Newnes, 2009.
- B. A. Fette, *RF Cognitive Radio Technology*. Academic Press, 2009.
- *The ARRL Handbook*. ARRL.
- *The ARRL Antenna Book*. ARRL.

- J. J. Carr, *Antenna Toolkit*, 2nd. ed. Newnes, 2001.
- J. L. Smith, *Basic NEC with Broadcast Applications*, Focal Press, 2008.
- *Reference Data for Engineers,* 9th. ed. Newnes, 2002.
- J. J. Carr, *RF Components and Circuits*. Newnes, 2002.

i. Required resources

A set of materials will be necessary, most of them supplied by the university or the professor:

- Work environment in the LCMS Moodle, hosted in the *Virtual campus* of the university.
- Technical bibliography in e-book format (.pdf), subscribed by the university library.
- Radio frequency laboratory instrumentation. Spectrum analysers and SDR receivers with accompanying software.
- Radio amateur transceivers, standing wave ratio meters, antennas, dummy loads and other accessories useful to explain a radio communications system.
- Basic electronic hardware (a small radio, spare components and circuits) acquired by the student.
- Recommended: personal computer to work at home, although there are enough computers available to the students at the school during the opening hours.

j. Timing

ECTS WORKLOAD	EXPECTED PERIOD TO CARRY OUT THE PLAN
2.4 ECTS	Weeks 1st to 6th

Section 2: Application to the wireless communication systems

Workload in ECTS credits:	3.6

a. Setting in context and rationale

After reviewing the underlying technology of a wireless system, the most representative applications in wireless telecommunication systems will be studied. Hence, radio broadcasting systems will be seen, but also the terrestrial links, satellite links, cellular telecommunications and the short-range communications.

b. Learning objectives

At the end of this section, the student must be able to:

- Describe the elements and figures involved in a satellite link.
- Estimate the radio coverage in point-to-point systems.
- Describe the modulation schemas that can be applied to several telecommunication systems.
- Enumerate and distinguish the studied systems attending to the application and the technology involved.

c. Contents

THEME 4: Radio broadcasting

4.1 Objectives

4.2 Amplitude modulation (AM) radio broadcasting.

4.3 Frequency modulation (FM) and FM-stereo radio broadcasting.

4.4 Digital broadcasting: RDS y DAB.

4.5 Modulating in DAB. OFDM.

THEME 5: Radio links and satellite communications

5.1 Objectives.

5.2 Introduction and satellite orbits.

5.3 Parameters that influence the communication: the link budget.

5.4 Types of satellites.

5.5 Satellites and radio amateur operation. Related modulating schemas: FSK and PSK.

5.6 Radio links. Coverage estimation with software.

5.7 Summary

THEME 6: Cellular telecommunications

6.1 Objectives.

6.2 Introduction.

6.3 Basic standards.

6.4 Second generation (2G): GSM, GPRS and EDGE.

6.5 Modulations related to 2G. MSK, GMSK.

6.6 Third generation (3G) and subsequent generations. UMTS, LTE, 5G.

6.7 Modulations related to 3G and subsequent generations. Spread spectrum.

6.8 Summary.

THEME 7: Short-range wireless data communications

7.1 Objectives.

7.2 Introduction.

7.3 Bluetooth.

7.4 IEEE 802.11 – ISO/IEC 8802-11 (Wi-Fi).

7.5 Other technologies.

7.8 Summary

d. Teaching methods

- Interactive master class.
- Study of cases both at the classroom and at the laboratory.
- Collaborative learning.
- Projects method learning.

e. Work plan

See Annex I.

f. Assessment

The competence acquisition assessment will be based on:

- Attitude and participation assessment during the academic activities.
- On-line assessment through learning course management systems (LCMS) like Moodle.

- Written test and/or on-line test with LCMS tools at the end of the lessons period.

g. Basic references

- I. Poole, *Newnes Guide to Radio and Communications Technology*. Newnes, 2003.

h. Additional references

- *The ARRL Satellite Handbook*. ARRL.
- B. R. Elbert, *The Satellite Communication Applications Handbook*, 2nd. ed. Artech House, 2004.
- J. Everett, *VSATs: Very Small Aperture Terminals*. Peter Peregrinus, 1992.
- I. Poole, *Cellular Communications Explained*, Newnes, 2005.
- C. Braithwaite; M. Scott, *UMTS Network Planning and Development*. Newnes 2003.
- E. Dahlman, S. Parkvall, J. Sköld, P. Beming, *3G Evolution: HSPA and LTE for Mobile Broadband*, Academic Press, 2007.
- E. Dahlman, S. Parkvall, J. Sköld, *4G LTE-LTE-Advanced for Mobile Broadband*, Academic Press, 2011.
- D. M. Dobkin, *RF Engineering for Wireless Networks. Hardware, Antennas, and Propagation*. Newnes, 2005.
- S. Rackley, *Wireless Networking Technology: From Principles to Successful Implementation*. Newnes, 2007.

i. Required resources

A set of materials will be necessary, most of them supplied by the university or the professor:

- Work environment in the LCMS Moodle, hosted in the *Virtual campus* of the university.
- Technical bibliography in e-book format (.pdf), subscribed by the university library.
- Coverage estimation software.
- Ground station to track satellites, located in the school.
- Radio frequency laboratory instrumentation, SDR receivers, software and a computer.
- Basic electronic hardware (a small radio, spare components and circuits) acquired by the student.
- Recommended: personal computer to work at home, although there are enough computers available to the students at the school during the opening hours.

j. Timing

ECTS WORKLOAD	EXPECTED PERIOD TO CARRY OUT THE PLAN
3.6 ECTS	Weeks 7th to 15th

5. Teaching methods and methodological principles

These methods will be applied to give the subject:

- Activities to be present:
  - Theory lessons. Interactive master class supported by the LCMS Moodle (*Campus virtual*) and Internet.
  - Seminars. Study of practical cases guided by the professor.
  - Laboratory. Development of radio electronics experiments and radio communications experiments with the computer. Development of a telecommunication project during the semester. Work will be individual or in reduced groups if resources are limited.
- Activities out of the class:
  - Individual work. Personal study. Solving exercises at the LCMS Moodle (*Campus virual*). Proposed activities to be carried out of the class. Implementation of the semester's project. Study in advance of the laboratory experiments before attending each session.

6. Student's time requirements table

ACTIVITIES TO ATTEND	HOURS	ACTIVITIES OUT OF THE CLASS	HOURS
Theory-practice lessons	30	Individual study and autonomous work	90
Classroom applied lessons	0	Group study and autonomous work	0
Laboratory	20		
Internships, work experience	0		
Seminars	10		
Group tutorials	0		
Assessment (out of the official exams period)	0		
Total attended	**60**	**Total not attended**	**90**

7. Assessment system and characteristics

INSTRUMENT/PROCEDURE	WEIGHT IN THE FINAL MARK	COMMENTS
Semester's activities	10%	Marks will be given from the activities proposed at regular intervals, whether at the classroom or with the LCMS Moodle. The *non fulfilled fraction* of the activities will penalize the final mark.
Semester's project	30%	Marks will be given from the delivered reports and the demonstrations of how it works given.
Final exam (written and/or with the LCMS Moodle or equivalent)	60%	The *final mark* will be calculated from the categories above (*mark* = 10% + 30% + 60%) in this way: *final mark = mark – 2·(non fulfilled fraction)*.

GRADING CRITERIA
• **Ordinary exam:** ○ It is required to attend the 70% of the laboratory lessons in the established schedule to pass the subject. In case of non-compliance, the subject will be graded as *not attended*. • **Extraordinary exam:** ○ Ordinary exam's criteria are kept. In case the official date of the exam is placed before finishing the semester lessons, the final exam mark will grade the 100% of the subject. In this case, the semester's activities and project will not be graded.

8. Final facts

- The Annex I mentioned above, where the detailed planning is described, will be delivered at the beginning of the lessons.