Universidad de Alcalá

TEACHING GUIDE

Wireless Technologies

Degree in
Telecommunication Systems Engineering (GIST)

Universidad de Alcalá

Academic Year 2021/2022

4th Year - 1st Semester (GIST)

Approved by the School Board on July 6, 2021

TEACHING GUIDE

Course Name:	**Wireless Technologies**
Code:	**390009 (GIST)**
Degree in:	**Telecommunication Systems Engineering (GIST)**
Department and area:	**Teoría de la Señal y Comunicaciones** **Signal and Communications Theory**
Type:	**Optional (Oriented) (GIST)**
ECTS Credits:	**6.0**
Year and semester:	**4th Year - 1st Semester (GIST)**
Teachers:	David A. de la Mata Moya
Tutoring schedule:	Consultar al comienzo de la asignatura
Language:	Spanish/ English Friendly

1. COURSE SUMMARY

In recent years, the development of the Information Society has led to a greater diversity in the offering of telecommunication services to companies and individuals. This development has been supported, largely, by wireless networks -wide area networks, metropolitan networks, local or personal ones- So, an increase in the number of radio installations to guarantee the levels of quality and coverage required has taken place. The speed of development and implementation of these new services present in the current work, business, culture or leisure environments goes hand in hand which continuously increasing demand for greater capacity and higher transmission speed services.

This course on Wireless Technologies introduces the student to propagation models and radiant systems, as well as transmission technologies and standards used in personal, local, metropolitan or wide area wireless network. In addition, the subject will cover the radio planning of this type of networks.

The tools and concepts analysed in this subject will allow the student to determine the differences between different wireless networks, as well as the main parameters in its design.

Prerequisites and Recommendations:
In order to get the most of the course Wireless Technologies, it is essential to have mastered the concepts and calculation tools presented in the subjects Wave Propagation, Radiation and Radiocommunication, High Frequency Technologies, Communication Circuits and Mobile Communications. All of them are included in the Degree in Telecommunication Systems Engineering.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following generic skills, which are defined in the Section 3 of the Annex to the Orden CIN/352/2009:

en_TR1 - Knowledge, understanding and ability to apply the necessary legislation during the development of the profession of Technical Engineer of Telecommunication and ease of handling specifications, regulations and mandatory rules.

en_TR2 - Knowledge of basic subjects and technologies that enables to learn new methods and technologies, as well as to provide versatility that allows adaptation to new situations.

en_TR3 - Aptitude to solve problems with initiative, decision making, creativity, and to communicate and to transmit knowledge, skills and workmanship, comprising the ethical and professional responsibility of the activity of the Technical Engineer of Telecommunication.

en_TR5 - Easy to handle specifications, regulations and mandatory standards.

en_TR6 - Ability to analyze and assess the social and environmental impact of technical solutions.

en_TR8 - Capacity of working in a multidisciplinary and multilingual team and of communicating, both in spoken and written language, knowledge, procedures, results and ideas related to telecommunications and electronics.

en_TRU1 - Capacity of analysis and synthesis.

en_TRU2 - Oral and written competencies.

en_TRU3 - Ability to manage information.

en_TRU4 - Autonomous learning skills.

Professional Skills

This course contributes to acquire the following professional skills, which are defined in the Section 5 of the Annex to the Orden CIN/352/2009:

en_CST2 - Ability to apply the techniques on which telecommunication networks, services and applications are based, both in fixed and mobile environments, personal, local or at a great distance, with different bandwidths, including telephony, broadcasting, television and data, from the point of view of view of the transmission systems.

en_CST4 - Capacity for the selection of circuits, subsystems and systems of radiofrequency, microwaves, radio broadcasting, radio links and radiodetermination.

en_CST5 - Ability to select antennas, equipment and transmission systems, propagation of guided and unguided waves, by electromagnetic means, radiofrequency or optical and the corresponding radioelectric space management and frequency assignment.

Learning Outcomes

Upon successful completion of this course, students will demonstrate the following learning outcomes:

RA1.Define and manage the fundamental parameters of the different RF devices and equipment involved in the different wireless systems.

RA2. Sizing and designing the radiant elements involved in wireless systems.

RA3. Differentiate the different architectures used in wireless communication systems.

RA4. Formulate the sizing of both indoors and outdoors wireless communication systems and services.

3. CONTENTS

Contents Blocks	Total number of hours
UNIT 1. GENERAL CONCEPTS. Historical review of wireless communications. Current systems (WMAN: WiMax ...; WLAN: WiFi...; WPAN: Bluetooth ... and other wireless technologies: RFID ...). Frequency bands used: free and licensed bands. Normalization of wireless communications.	• 2 hours
UNIT 2. WAVE PROPAGATION IN WIRELESS NETWORKS. Large scale channel models (Outdoors long distance: COST-231, Rec. P-1546, Outdoors short distance: Rec. P-1411 and Indoors: Rec. P-1238-7), medium scale (area coverage) and small scale (multipath fading). Definition of the parameters associated with small scale channel models (delay dispersion, coherence bandwidth and coherence time). Characterization of broadband multipath channels.	• 8 hours
UNIT 3. RADIO TECHNOLOGIES IN WIRELESS NETWORKS. Effects of multipath on broadband signalS (ISI). Widespread spectrum techniques: FH-SS and DS- SS. Systems co-location. Inter-system interference. OFDM technology. OFDM baseband signal. Cyclic prefix. Channel estimation. Coded OFDM.	• 6 hours
UNIT 4. WIRELESS TELECOMMUNICATION SYSTEMS. Study of the physical layer and the MAC layer of WMAN 802.16 metropolitan area network standard. Network specifications: coverage, system capacity, accessibility. System dimensioning. Radio planning.	• 8 hours
UNIT 5. ANTENNA SYSTEMS IN WIRELESS COMMUNICATIONS. Multiple antenna systems. MIMO technology Estimation techniques for the direction of arrival.	• 4 hours

Laboratory Contents Blocks	Total number of hours
Lab exercise 1. Estimation of large-scale losses and measurement of RSSI in WIFI systems.	• 6 hours
PROJECT: Analysis of an 802.16 wireless network distributed in the following lab exercises: • Simulating the propagation channel in an 802.16 network • Simulating OFDM techniques in an 802.16 network • Simulating COFDM techniques in an 802.16 network • Simulating MIMO techniques in an 802.16 network	• 16 hours
Lab exercise 2. Evaluation of Direction of Arrival Estimation Techniques	• 6 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	58 hours (56 hours on-site +2 exams hours)
Number of hours of student work:	92
Total hours	150

4.2. Methodological strategies, teaching materials and resources

The teaching strategy is based on a series of activities that allow addressing the objectives established by the skills described above:

Teaching in large groups:

The classroom will be the place where the main concepts of the subject will be presented. The main goal is to introduce the student to the theoretical foundations of wireless communications, its architectures, devices to be used, general and regulatory characteristics, as well as the applications these technologies may have in different situations. This introduction will be done in a guided, sequential and reflective way. The support with teaching materials will be key to create reflective learning environments, where students and teachers can undertake a critical analysis that allows the student to relate concepts autonomously.

The order of presentation of the contents will evolve from the most general to the most particular aspects of each of the systems. In this way, the student will be able to deduce how to apply the general concepts to specific scenarios. It is also very convenient to establish links with other subjects of the curriculum during the classroom sessions, and provide experiences on the contents, which will help to attract the attention of the student and encourage their interest in the subject.

Individual Activities:

- Content evaluation tests: During the development of the course, interim tests will be carried out to detect achievements and gaps in the learning process.
- Pre-class quizzes: Before attending to class, the students may answer a quiz that helps them to prepare for the class in advance.

Group activities:

The following group activities will be carried out in small groups of two or three students throughout several working sessions. In these sessions, students must work as a team.

- Laboratory exercises: The main goal is getting the students to acquire the most relevant practical knowledge in the radio area of wireless networks.

  The objectives to be achieved in each one of the lab exercises will be established in advance, along with a basic bibliography (magazines, recommendations, books). At the end of each one of the lab exercises a report in which the students record the procedures used, the results obtained and some critical conclusions about them must be presented.

- Project: The aim of the project is providing the student with the proper learning environment to analyse 802.16 wireless network coverage. The project will unfold throughout several small group sessions. In these sessions, students will work as a team and will simulate both propagation channels and technologies associated with the standard. Students will also generate a report that reflects their evolution in the acquisition of knowledge and the final achievement of the goals established.

- Case study: The goal is analysing the physical and MAC layer operation of an 802.16 communication network. For this purpose, students will take into account their prior knowledge of the standard.
  Through the dimensioning and analysis of an specific network, key radio parameters for dimensioning and operating the network will be discovered.

5. ASSESSMENT: procedures, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Regulations for the Regulation of Teaching Learning Processes, NRPEA, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Regulations for the Evaluation of Apprenticeships (approved by the Governing Council on March 24, 2011 and modified in the Board of Directors). Government of May 5, 2016) as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

Ordinary Call

Continous Assessment:

The student continuous work will be assessed as follows:

- Laboratory exercises and Project:
  - A unique report will be delivered for each lab exercise and project by each of the groups of students.
  - An interim test covering the contents worked on the lab exercises will be carried out.

- Case study:
  - Interim individual tests covering the theoretical concepts related to the case study will be carried out. The aim is to consolidate basic concepts related to the technologies used in wireless networks, as well as basic concepts related to 802.16 standard in order to successfully address the case study.
  - In addition, each group of students will carry out a presentation of their work at the end of the semester.

- Pre-class quizzes: Before attending to class, the students may answer a quiz that helps them to prepare for the class in advance.
- Final assessment test: It will be carried out at the end of the semester. This test is presented to the student as a way to improve the grades obtained previously in the interim assessment tests. It will

also help him to master the new concepts studied along the semester.

Assessment through final exam:

In case the student renounces continuous assessment, they will be assessed as follows:

- A written final test related to the contents developed in the lab exercises and the laboratory project. The student must previously submit the lab exercises and project reports.
- A written final test related to the theoretical contents. It will consist of theoretical and practical questions related to the concepts developed throughout the course.

Extraordinary Call

The procedure will be the same as the one described for assessment through final exam in the ordinary call.

5.2. EVALUATION

EVALUATION CRITERIA

Evaluation criteria measure the level of competence the students have acquired. For that purpose, the following are defined:

CE1. The student shows the ability to manage the fundamental parameters of RF devices and RF equipment in wireless systems.

CE2. The student can analyse and characterize the antenna systems involved in the wireless system.

CE3. The student demonstrates they can differentiate the different transmission technologies used in wireless communication services.

CE4. The student is capable of analysing and dimensioning wireless networks.

CE5. The student is able to work with international standards, specifications and recommendations related to wireless services.

CE6: The student is able to work in a group, in a multilingual environment and can present their learning results in written and oral manner.

GRADING TOOLS

The work of the student is graded according to the assessment criteria defined above. For that purpose the following grading tools are used:

1. Lab reports **(E1-E2)**. Reports with the results and conclusions obtained during the lab exercises. Each lab group will summit one report for each lab exercise.
2. Project report **(E3)**. Report with the results and conclusions for the lab project. Each project group will summit one report.
3. Intermediate assessment tests **(PEP1-2)**:
    a. Interim assessment test **(PEP1).** It will cover the concepts related to topics 2 and 3.
    b. Interim assessment test **(PEP2):** It will cover the concepts necessary for the lab exercises and the project.
4. Pre-class quizzes **(E4-E5)**. Quizzes results carried out before and during the case study.

5. Delivery associated to case study **(E6)**. Combinated mark assigned to the report and the individual performance in its presentation by each member of the group.

6. Final evaluation test **(PEF)**: It will consist of theoretical-practical issues related to the different technologies and standards developed throughout the semester, both in the classroom and in the lab:

    a. In the ordinary call-continuous evaluation, this test is aimed at students who want to improve the qualifications of some of the interim tests carried out throughout the semester.

    b. In the ordinary call-final evaluation and in the extraordinary call this test will consist of two parts: one related to the theoretical contents **(PEF-Theory)** and another focused on the lab work **(PEF-Laboratory).**

GRADING CRITERIA

In ordinary call-continuous assessment the relationship between skills, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
TR5, TR8, TRU2, TRU3, CST2, CST4, CST5	RA1,RA2, RA4	CE1, CE2, CE4, CE5, CE6	E1-E2	12%
TR5, TR8, TRU2, TRU3, CST2, CST4, CST5	RA1,RA2, RA4	CE1, CE2, CE4, CE5, CE6	E3	18%
TR5, TRU2, TRU3, TRU4, CST2, CST4, CST5	RA1, RA2, RA3, RA4	CE1, CE2, CE3, CE4, CE5	PEP1-2	25+20=45%
TR5, TR8, TRU2, TRU3, CST2, CST4	RA1, RA3, RA4	CE1, CE3, CE4, CE5, CE6	E4-E5	5 + 5 =10%
TR5, TR8, TRU2, TRU3, CST2, CST4	RA1, RA3, RA4	CE1, CE3, CE4, CE5, CE6	E6	15%
TR5, TRU2, TRU3, TRU4, CST2, CST4, CST5	RA1, RA2, RA3, RA4	CE1, CE2, CE3, CE4, CE5	PEF	45%

(*) It's possible for students, as described in section GRADING TOOLS, re- examinate at the end of the course, in order to upgrade their marks on PEP1-3 interim test. The new mark will only be taken into account if it is higher than the previous one. The percentage assigned to the PEF is the same as the PEPs, because this test is aimed at those students who want to improve the PEP score after the entire academic learning process.

Students will be considered as not showing up in the ordinary call if they do not participate in the teaching-learning process as it is established in this teaching guide in terms of assistance, completion and delivery of learning and assessment activities. Students not submitting 75% of the assessable activities within the first month of continuous assessment process will be also considered as they have not shown up in the ordinary call.

In the ordinary call- assessment through final exam, the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
TR5, TR8, TRU2, TRU3, CST2, CST4, CST5	RA1,RA2, RA4	CE1, CE2, CE4, CE5, CE6	E1-E3/ PEF-Lab	54%
TR5, TRU2, TRU3, TRU4, CST2, CST4, CST5	RA1, RA2, RA3, RA4	CE1, CE2, CE3, CE4, CE5	PEF-Theory	46%

Extraordinary call

The same percentages established for the evaluation through final exam will be applied for the extraordinary call. In this case, the student will have the choice of doing a lab test or keeping the mark obtained in the ordinary call.

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- Perahia, E. and Stacey, R. Next Generation Wireless LANs, Second Edition. Ed Cambridge University Press 2013
- Eklund C.; Marks, R. B.; Ponnuswamy, S.; Stanwood, K. L. and Van Waes, N. J.M. WirelessMAN®: Inside the IEEE 802.16™ Standard for Wireless Metropolitan Area Networks. Ed. The Institute of Electrical and Electronics Engineers, Inc, 2011.
- Andrews, Jeffrey G. Fundamentals of WiMAX: Understanding BroadbandWireless Networking. Ed Prentice Hall, 2007.
- Hanzo, Lajos L.; Akhtman, Y.; Wang, L. and Jiang, M. MIMO-OFDM for LTE, WiFi and WiMAX: Coherent versus Non-coherent and Cooperative Turbo Transceivers. Ed. Wiley-IEEE Press, 2010.

6.2. Additional Bibliography

- Belding-Royer, E.M.; Al Agha, K. and Pujolle, G. ((2005). Mobile and wireless communication networks. Springer.
- Carr, J.J. Microwaves & wireless communicationstechnologies. Newnes, 1996.

Disclosure Note

The University of Alcalá guarantees to its students that, if due to health requirements the competent authorities do not allow the total or partial attendance of the teaching activities, the teaching plans will achieve their objectives through a teaching-learning and evaluation methodology in online format, which will return to the face-to-face mode as soon as these impediments cease.