Universidad de Alcalá

TEACHING GUIDE

High frequency technologies

Degree in
Telecommunication Technologies Engineering (GITT)
Telecommunication Systems Engineering (GIST)
Telematics Engineering (GIT)
Electronic Communications Engineering (GIEC)

Universidad de Alcalá

Academic Year 2021/2022

3rd Year - 2nd Semester (GITT)

3rd Year - 1st Semester (GIST)

4th Year - 2nd Semester (GIT+GIEC)

Approved by the School Board on July 6, 2021

TEACHING GUIDE

Course Name:	**High frequency technologies**
Code:	**350028 (GITT+GIST+GIT+GIEC)**
Degree in:	**Telecommunication Technologies Engineering (GITT)** **Telecommunication Systems Engineering (GIST)** **Telematics Engineering (GIT)** **Electronic Communications Engineering (GIEC)**
Department and area:	**Teoría de la Señal y Comunicaciones** **Signal Theory and Communications**
Type:	**Compulsory (GITT+GIST)** **Optional (Generic) (GIT+GIEC)**
ECTS Credits:	**6.0**
Year and semester:	**3rd Year - 2nd Semester (GITT)** **3rd Year - 1st Semester (GIST)** **4th Year - 2nd Semester (GIT+GIEC)**
Teachers:	To be defined.
Tutoring schedule:	To be known at the beginning of the term.
Language:	Spanish/English friendly

1. COURSE SUMMARY

Modern communication systems are demanding higher frequencies in the radio electric spectrum. The design and the comprehension of the most important properties of circuits and systems is mandatory for the future graduates.

High Frequency Technologies gives two complementary points of view about those high frequency circuits and systems. On the first hand, the subject gives to the student the basic concepts that allow analyzing and characterizing circuits, systems and guided media in microwave frequencies, as well as the basis of the tools and the measuring equipment needed for it. On the second hand, from that previous knowledge, it is intended that the student will be able to evaluate the behavior of a circuit or system given a manufacturer's brochure.

A practical approach is finally given with some examples of more complex systems, such as microwave transmitter and receivers, phase shifters in antenna arrays, examples of mobile or wireless systems…

So, the tools and the concepts delivered in this course are the basis for those subjects related to telecommunication systems and technologies that comprise microwave techniques, radio links, wireless and mobile networks.

The student, after passing the course, will be able to analyze the components of a transmission system, to select those circuits and systems according to a given technical requirement, as well as the most suitable transmission media.

The syllabus is planned into two blocks with different aims. The first part comprises impedance matching and S parameters and its objective is to explain the basis of the microwave circuit theory. The second block comprises passive circuits, resonators and filters and active devices and it's focused on the practical realization of different elements and their technical properties, practical limits and selection criteria.

The laboratory contents are intended to underline this second block. The student will be able to compare the theoretical and practical performance, emphasizing the capacity to evaluate and select those elements that may be part of more complex systems. Problem lessons are focused to reinforce the analysis and design capacities as a way of evaluate different physical realizations.

Recomendations

It is highly recommended that the student has previously passed the subjects Cálculo I, Cálculo II, Fundamentos Físicos II, Análisis de Circuitos and specially Propagación de Ondas.

A deep knowledge of complex exponentials and logarithms, transmission line equations and their parameters (Characteristic Impedance, propagation constant) and the characterization and parametrization of two port networks is assumed as previous background of the students.

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_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_TR4 - Knowledge for the achievement of measurements, calculations, evaluations, appraisals, examinations, studies, reports, planning of tasks and other similar works in its specific ambience of the telecommunication.

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.

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_CST3 - Ability to analyze components and their specifications for systems of guided and non-guided communications.

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

After succeeding in this subject the students will be able to:

RA1. Solve matching problems using Smith Chart.

RA2. Use Scattering matrix (S parameters) to characterize microwave circuits behaviour and interconnection in a communications system.

RA3. Identify the most common passive circuits, their design parameters and manufacturing technologies and their design trade offs.

RA4. Design microwave filters. Generalize filter design and analysis techniques for the design and analysis of filters at microwave frequencies using different technologies.

RA5. Design and analyze microwave amplifiers and oscillators

RA6. Be able to use the typical instrumentation and simulation tools of a microwave laboratory, as well as to interpretate the measured and simulated results.

3. CONTENTS

Contents Blocks	Total number of hours
Block 1. Introduction and matching techniques. Frequency bands, transmission media. Smith chart. Matching networks: narrow band and broad band networks.	8 hours
Block 2. Scattering parameters. Description of a microwave circuit. Impedance and admittance matrix. S parameters matrix: properties and measurement.	8 hours
Block 3. Passive devices. Attenuators. Phase shifters. Power dividers and directional couplers. Designs with planar transmission lines and waveguides. Non reciprocal devices: isolators and circulators. Characterization and applications.	10 hours
Block 4. Resonators and filters Resonators using transmission lines. Resonant cavities. Dielectric resonators. Introduction to microwave filters. Microstrip filter examples.	6 hours
Block 5. Active Devices. Linear small signal amplifiers: stability, gain and noise. Oscillators: conditions. Negative resistance oscillators. Oscillators using transistors.	6 hours

Laboratory Blocks	Total number of hours
Block 1. Simulation of microwave circuits using ANSYS HFSS	10 hours
Block 2. Measurement of microwave circuits	6 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	58 hours (54 hours on-site +4 exams hours): 28 hours for Theory Lessons 16 hours for laboratory experiments 10 hours for problem solving lessons 4 hours for asessments.
Number of hours of student work:	92
Total hours	150

4.2. Methodological strategies, teaching materials and resources

The teaching strategy of the course is divided into 3 sections: classroom learning, learning in small groups and finally the working sessions in the laboratory.

Sessions of large group in the classroom:

Working sessions in the classroom, in large groups, will consist of lectures where the main concepts of the theory of circuits will be presented. The aim is to introduce students to the theoretical foundations of circuit analysis in a guided and reflective way. The understanding of these concepts will culminate with the use of them in both the laboratory and the problem solving sessions in small groups.

Teaching materials will be essential to create reflective learning environments, where students and teachers can undertake a critical analysis that allows the student to autonomously relate concepts.

The order of presentation of the contents will evolve from the simple to the complex, in order to avoid a high degree of abstraction that might cause a student lack of interest in the course. In any case, it is very convenient, during the working sessions in the classroom, to establish linkages with other subjects in the curriculum, and to provide possible experience on the contents, which will help to attract students' attention and will encourage their interest in the subject.

Sessions of small groups in the classroom:

These small group solving problems lessons are focused on giving the students the tools to face the resolution of microwave circuits analysis and design problems.

Student participation is a key factor. The lessons intend to create a systematic approach to solve this kind of problems: previous study, best solution option and discussion of the problem solution.

TIC tools may be used in some of the lessons such as Blackboard or Socrative.

Sessions of small groups in the Laboratory:

Laboratory practice will be organized into groups. The objective is that the student may test, using the experiments and lab guides, the main theoretical ideas of the subject.

Lab guide should be studied before and some previous questions may be answered by the students. Simulation experiments will be done using CST Studio Suite.

After the lab experiment, every team must give to the teacher a report about the practice development and conclusions.

Self-learning through the performance of individual /group tasks.

Students will carry out tasks related to subject contents. The objective is to deelop skills related to information search, bibliography management, and report generation about the proposes topics.

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:

Full details about contents and scheduling will be given in the subject presentation. The main assessment tools will be:

1. Intermediate evaluation assessment (PEI): Full details will be given the first day at the presentation.
2. Laboratory skills (PL): Group reports and questions about laboratory experiments (PL1). Students must attend 100% of the laboratory sessions and deliver the required reports to all laboratory practices. Recovery sessions will be enabled for those students who have not attended any of the sessions and justify it documentary. The students, as a group, may be required to deliver the reports of the laboratory practices following the established schedule. These practices will be evaluated by the professor responsible for the laboratory group, to assess if the objectives indicated in the script of the same have been met. Laboratory evaluation assessment (PL2): the student will be informed about the objectives and format of this assessment the fist day.
3. Individual or group problems and tasks. (T) Other tasks proposed to the students. Full details will be given the first day at the presentation.
4. Final evaluation assessment (PEF): Problems resolution about microwave theory and applications.

Assessment through final exam:

In the case of evaluation through final exam, the evaluation elements will be the following:

1. Final evaluation assessment including theory questions and problems resolution about microwave theory and applications, and practical assessment about measurement techniques and results interpretation.

2. Laboratory assesment.

Although in this case it is not mandatory to attend the laboratory sessions, it is strongly recommended. Students that have attended the laboratory sessions, delivered the assocciated reports (PL1), performed the laboratory assessment (PL2) and delivered the individual/group problems and tasks (T), could choose betweeen two options:

- To perform the Final evaluation assessment and the Final Laboratory Assessment.

- To perform only the Final evaluation assessment, maintaining the marks obtained in PL1, PL2 and T.

Extraordinary Call

The procedure will be the same as that described for the assessment by means of a final exam in the ordinary call.

5.2. EVALUATION

EVALUATION CRITERIA

The assessment criteria measure the level in which the competences have been acquired by the

student. For that purpose, the following are defined:

CE1. Know the elements of a microwave communication system and their design, implementation and measurement techniques

CE2. Be able to select RF and microwave circuits. Solve typical microwave problems.

CE3. Be able to use the Smith Chart to design and characterize devices and matching networks.

CE4. Understand the meaning of the S parameters and be able to use them in the design and characterization of microwave networks.

CE5. Know the most common microwave passive circuits and filters and their design parameters.

CE6. Understand the behaviour and limits of microwave amplifiers.

CE7. Be able to use microwave measurement and simulation tools.

CE8. Be able to work into class groups and explain and discuss the obtained results.

GRADING TOOLS

The work of the student is graded in terms of the assessment criteria above, through the following tools:

1. Ordinary call, continuous evaluation:
   - Final Evaluation Assessment (PEF).
   - Intermediate Evaluation Assessment (PEI).
   - Other proposed individual or group tasks (if no aditional tasks are planned, this percentage will be included into PEI block) (T)
   - Laboratory Skills (PL1).
   - Laboratory Assessment (PL2)
2. Ordinary call, final evaluation:
   - Final Evaluation Assessment (PEF).
   - Laboratory Assessment (PL)
3. Extraordinary call.
   - Final Evaluation Assessment (PEF).
   - Laboratory Assessment (PL)

The qualification of "Not Submitted" will be awarded to the student who, having opted for the continuous assessment procedure, has failed to meet at least 60% of the sessions of laboratory practices and/or problems, or has not delivered 60% of the proposed tasks.

When the student has exceeded the limits of attendance or delivery of works mentioned in the previous paragraph, regardless of their participation in the partial or final tests, they will not be eligible for the "Not Submitted" grade.

The qualification of "Not Submitted" can not be obtained, independently of what is expressed in the previous paragraphs, when the student is submitted to the partial test (PEI) or to the final test (PEF).

In the final evaluation (ordinary call) and the extraordinary call, students that have attended the laboratory sessions, delivered the assocciated reports (PL1), performed the laboratory assessment (PL2) and delivered the individual/group problems and tasks (T), defined for the continuous evaluation, could choose betweeen two options:

- To perform the Final evaluation assessment and the Final Laboratory Assessment.

- To perform only the Final evaluation assessment, maintaining all the marks obtained in PL1, PL2 and T.

GRADING CRITERIA

Ordinary call-continous

In the ordinary call-continuous assessment the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows. In the case that, no aditional task will be proposed, its percentage will be included in the Intermediate Evaluation Assessment (PEI).

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
TR2-3, CST3-5	RA1-RA5	CE1-CE6	PEF	40%
TR2-3, CST3-5	RA1-RA5	CE1-CE6	PEI	20%
TR2-4, TR8, CST3-5	RA1-RA5	CE2-CE6, CE8	T	10%
TR2-4, TR8, CST3-5	RA6	CE2-CE8	PL1	15%
TR2-4, TR8, CST3-5	RA6	CE2-CE8	PL2	15%

Ordinary call-final and extraordinary call

In the ordinary call-final evaluation and extraordinary call, 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
TR2, TR3, CST3-5	RA1-RA5	CE1-CE6	PEF	65%
TR2-4, TR8, CST3-5	RA6	CE7	PL	35%

In the case of the ordinary call with final evaluation and the extraordinary call, students can make the PL with a contribution of 35%, or maintain the marks obtained in PL1+PL2+T (defined for the continuous evaluation) according to their decision. If they decide to maintain PL1+PL2+T marks from the continuous evaluation, the criteria and evaluation instruments will be as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
TR2, TR3, CST3-5	RA1-RA5	CE1-CE6	PEF	60%
TR2-4, TR8, CST3-5	RA6	CE7	T+PL1+PL2	40%

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- Alpuente Hermosilla, J.; Jarabo Amores, M.P.; López Espí, P.L. y Pamies Guerrero, J.A. (2001):- Líneas de Transmisión y Redes de Adaptación en Circuitos de Microondas.- Servicio de Publicaciones de la Universidad de Alcalá.
- Sanchez Montero, R.; López Espí, P. L.; Jarabo Amores, M. P.; Alpuente Hermosilla, J. – (2004) Teoría de Circuitos de Microondas. Parámetros S. Servicio de Publicaciones de la Universidad de Alcalá.

6.2. Additional Bibliography

- Collin, R.E. (1992).- Foundations for Microwave Engineering.-McGraw-Hill International.
- Pozar, D.M. (1998).- Microwave Engineering.- John Wiley & Sons.
- Rizzi, P.A. (1988).- Microwave Engineering. Passive Circuits.- Prentice Hall.
- Alejandro Delgado Gutiérrez, Juan Zapata Ferrer, (1988) - Circuitos de alta frecuencia. Servicio de Publicaciones de la E.T.S. de Ingenieros de Telecomunicación. (U.P.M.)
- Guillermo González, (1996) - Microwave transistor Amplifier. Prentice Hall

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.