Course guide
300032 - CET - Electronic Circuits for Telecommunications

Last modified: 06/06/2024

Unit in charge: Castelldefels School of Telecommunications and Aerospace Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.

Degree: BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2009). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 4.5 **Languages:** Catalan

LECTURER

Coordinating lecturer: Definit a la infoweb de l'assignatura.

Others: Definit a la infoweb de l'assignatura.

PRIOR SKILLS

· Analyze the voltage-current relationships in the ideal passive electronic components.
· Analyze linear circuits, both with resistive and reactive components, obtaining both the evolution over time and the frequency response of any of the electrical variables.
· Circuit analysis with ideal operational amplifiers and other active components (ideal diode, ideal transistor)
· Identify the types of filters that exist based on their response in the time and frequency domains
· Know the basic operation of elementary digital circuits: truth table, logic levels, multiplexers
· Know the basic architectures and subsystems that make up telecommunication systems.

REQUIREMENTS

Pre-requisite:
Electronic circuits aln supply systems
Co-requisite:
Emissors and receptors

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. CE 24 SIS. Capacidad para la selección de circuitos, subsistemas y sistemas de radiofrecuencia, microondas, radiodifusión, radioenlaces y radiodeterminación. (CIN/352/2009, BOE 20.2.2009.)

Generical:
4. EFFICIENT USE OF EQUIPMENT AND INSTRUMENTS - Level 1: Using instruments, equipment and software from the laboratories of general or basic use. Realising experiments and proposed practices and analyzing obtained results.

Transversal:
2. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with recommended information sources according to the guidelines set by lecturers.
3. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.
5. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 1. Identifying information needs. Using collections, premises and services that are available for designing and executing simple searches that are suited to the topic.
6. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

TEACHING METHODOLOGY

Considering the architecture of electronic systems for telecommunications as a leitmotif, the subject develops key concepts in high-frequency electronic design in both a theoretical and practical way. The teaching methodology is based on the following axes:
1. Prior preparation of some topics of theory (autonomous work)
2. Doubt resolution and application activities, carried out by students in theory class (face-to-face)
3. Consolidation activities, in the form of solving exercises (autonomous)
4. Activities of practical application, in the form of resolution of a project to develop along the term (autonomous work in hours out of class, and face-to-face in hours of laboratory class)
The syllabus is distributed in weekly videos that students must study independently, prior to each theoretical session (autonomous learning competence). The theory sessions will consist of a first activity to discuss the topics, where students will resolve all doubts regarding the previously prepared concepts. Then it will follow an activity of application of concepts, where the professor will propose a series of exercises to solve within class, with subsequent discussion of results. These activities will break the monotony of the explanations by making the student actively participate in the class, and will serve so that the student can have immediate information of his degree of achievement of objectives.
The material of the subject is mostly in English and students will be encouraged to present their work in English as well (third language competence).
The lab sessions are aimed at developing a project where many of the concepts studied will have to be applied, as well as integrating previous skills indicated at the beginning of this guide and looking for information regarding circuit solutions in each block of the project. (solvent use of information resources). Students will work in stable pairs during the semester (teamwork competence), and will document the whole project process: objectives, design, experiments, validation and discussion of results. This documentation will be done in an online lab notebook (via Google Docs). Teachers will be able to give feedback to each working couple using this tool. During the realization of these laboratory sessions will deepen in the knowledge of the typical instrumentation of the laboratories of communications and electronics (competition on the correct use of equipment and instrumentation).
The consolidation activities aim to revise, expand and apply the concepts that appeared in the classes and facilitate their assimilation. These are problems, reading and searching for information (autonomous learning skills and solvent use of information resources).

LEARNING OBJECTIVES OF THE SUBJECT

Upon completion of the subject Electronic Circuits for Telecommunications, students must be able to:
1. Identify the technologies and devices used in telecommunication systems, and be able, based on their specifications, to select the optimal one for each application.
2. Identify the design alternatives of high frequency circuits for both linear and nonlinear analog processing in telecommunication systems.
3. Identify the limitations of high frequency analog active and passive circuits.
4. Identify the different techniques of other frequency digitization and their relationship with the specifications and architecture of high frequency analog-to-digital converters.
5. Know different alternatives for generating analog signals.
6. Identify techniques to improve signal integrity in high frequency circuits.
7. To use in a methodical and critical way the usual instrumentation in the telecommunication laboratories.

STUDY LOAD

Type	Hours	Percentage
Guided activities	10,5	9.33
Self study	63,0	56.00
Hours large group	19,5	17.33
Hours small group	19,5	17.33

Total learning time: 112.5 h

CONTENTS

Introduction to high frequency electronic systems

Description:
As an introduction to the subject, the student is given an overview of the architecture of electronic systems for telecommunications detailing the subsystems that make them up. From these subsystems, in this content a brief review is made of the basic concepts of signal digitization, signal multiplexing, analog signal processing circuits for signals and high frequency sensors, such as piezoelectric, complementing knowledge of previous subjects. Tools such as Bode diagrams are introduced, which will be used to describe the frequency response of passive and active components working at high frequencies.

Related activities:
Preparation activities
Classroom activities
Consolidation activities
Laboratory project
Control 1
Half-term exam

Full-or-part-time: 17h
Theory classes: 1h 30m
Laboratory classes: 3h
Guided activities: 1h
Self study : 11h 30m

High processing linear analog processing

Description:
The frequency response of VFA and CFA operational amplifiers, common in audio, video, and RF applications, is described. Its main advantages and limitations are identified as elements of analog processing within the signal chain. On the other hand, amplifiers with fully differential amplifiers and their frequency limitations are studied. There is also an introduction to the noise models of these amplifiers, and how to analyze them. The design of active (based on operational amplifiers) and passive analog filters is studied.

Related activities:
Preparation activities
Classroom activities
Consolidation activities
Laboratory project
Half-term exam

Full-or-part-time: 47h 30m
Theory classes: 9h 30m
Laboratory classes: 9h
Guided activities: 3h
Self study : 26h

A/D and D/A converters for telecommuniations

Description:
Based on the basic knowledge of A-D conversion, we delve into oversampling techniques to improve SNR and subsampling in telecommunication systems, as well as the design of anti-Asian filters. The specifications of ac converters are introduced: SNR, SFDR, SINAD, THD, and their impact on the design of signal chains for telecommunication receivers. The main architectures of high-frequency analog-to-digital converters are introduced. As for high-frequency digital-to-analog converters, their ac specifications, architectures, and techniques for generating high-frequency carriers, including DDS, are studied. The main architectures and the application of softening filters to improve the SFDR are also studied.

Related activities:
Preparation activities
Classroom activities
Consolidation activities
Laboratory project
Control 2
Final semester exam

Full-or-part-time: 26h 30m
Theory classes: 6h
Laboratory classes: 3h
Guided activities: 1h
Self study : 16h 30m

Non-linear analog processing

Description:
The concepts to be treated will complement that of linear analog processing. We will study low- and high-frequency logarithmic amplifiers for telecommunications applications, diode-based circuits, multipliers, demodulators, and comparators.

Related activities:
Preparation activities
Classroom activities
Consolidation activities
Laboratory project
Final semester exam

Full-or-part-time: 21h 30m
Theory classes: 4h
Laboratory classes: 3h
Guided activities: 1h
Self study : 13h 30m

ACTIVITIES

Classroom activities

Description:
At the beginning of each theory session, we will begin solving the doubts identified during the preparation activities. Then, 2 application exercises will be proposed for students to work on. The professor will discuss possible solutions to these exercises

Specific objectives:
· Apply the concepts studied previously
· Involve the student actively during the theory sessions
· Resolve doubts about the concepts covered.
· Observe the level of follow-up of the student.

Material:
Exercises published on the Atenea page.

Delivery:
None

Full-or-part-time: 11h
Theory classes: 11h

Deliveries (consolidation activities)

Description:
Each content will have one or two proposed problems to deliver weekly, to be developed out of class. It is a question of demonstrating the assimilation of the studied matter, complementing it with the search of information in the web pages of the main semiconductor manufacturers, as well as of the use of tools of design online (filters, amplifiers, ADCs and DACs).

Specific objectives:
· Revise, extend and apply the concepts studied and facilitate their assimilation.
· Acquire individual work and self-learning skills.

Material:
· Documentation available on the Athena page
· Complementary bibliographic material, published in Atenea
· Documentation available in the library
· Documentation available online

Delivery:
The teacher will indicate a deadline for submitting the problems and they will be evaluated in the 'Works' section.

Full-or-part-time: 19h
Self study: 19h

Prior activities

Description:
These activities take place outside the classroom. You will study of the videos that will contain the explanations of the theoretical concepts and some examples of application. Each week, students will have to do their study independently before the respective session in the classroom (large group) identifying the doubts that arise from their study.

Specific objectives:
· Understand the new theoretical contents, weekly, autonomously and actively
· Identify doubts about the concepts studied.

Material:
Videos and additional documents published on the Atenea page

Full-or-part-time: 20h 30m
Self study: 20h 30m

Performance and preparation of exams

Description:
Students will be assessed using individual face-to-face exams, one mid-semester (mid-semester exam) and one end-of-semester exam (end-of-semester exam).

Specific objectives:
· Evaluate the level of assimilation of the concepts studied
· Provides feedback to students on their learning process
· Demonstrate individual work skills.

Material:
· Documentation available at Atenea.
· Bibliography of the subject.
· Documentation available in the library.
· Documentation available online.

Delivery:
Face-to-face

Full-or-part-time: 8h
Self study: 8h

Application project

Description:
Students will receive guidance and instructions during the first lab session. In addition to the application of the theoretical concepts covered, signal integrity in high frequency electronic circuits will be studied. For this reason, the concepts of impedance in real passive components and their models and values for high-frequency electronic circuits will be presented, as well as the effect of these impedances on the interconnection of the designed systems. The transients present in digital circuits and their reduction will be studied; the ground connection of the circuits and the capacitive and inductive coupling models, which allow to analyze the presence of interferences in the circuit, as well as the methods to reduce them.

Material:
Guide published in Atenea, and follow-up notebook in Google Docs
Components given by the professor

Delivery:
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Full-or-part-time: 54h
Self study: 30h
Laboratory classes: 24h

GRADING SYSTEM

Grade criteria will be published at the course's web

EXAMINATION RULES.

BIBLIOGRAPHY

Basic:
- Zumbahlen, H. Linear circuit design handbook. Amsterdam: Ed. Elsevier, 2008. ISBN 9780750687034.
- Moreira, J. An engineer's guide to automated testing of high-speed interfaces [on line]. Boston: Ed. Artech House, 2010 [Consultation: 22/11/2023]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=4845579. ISBN 9781607839835.

Complementary:
- Malaric, K. EMI protection for communication systems. Boston: Ed. Artech House, 2010. ISBN 9781596933132.
- Kester, W. High speed design techniques [on line]. Ed. Analog devices, 2006 [Consultation: 20/04/2020]. Available on: https://www.analog.com/en/education/education-library/high-speed-design-techniques.html#. ISBN 9781566199094.
- Kester, W. The data conversion handbook [on line]. Ed. Elsevier, 2005 [Consultation: 20/04/2020]. Available on: https://www.analog.com/en/education/education-library/data-conversion-handbook.html#. ISBN 0750678410.