Course guide
230084 - CSL - Linear Circuits and Systems

Last modified: 18/06/2024

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.

Degree: BACHELOR'S DEGREE IN TELECOMMUNICATIONS TECHNOLOGIES AND SERVICES ENGINEERING (Syllabus 2015). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: ORESTES MIQUEL MAS CASALS

Others:
Primer quadrimestre:
JORGE GARCIA MATEOS - 11, 13, 41
ORESTES MIQUEL MAS CASALS - 41

Segon quadrimestre:
ALBERTO ALONSO GONZÁLEZ - 11, 13, 31, 33
NURIA DUFFO UBEDA - 21, 22, 23, 24
JORGE GARCIA MATEOS - 21, 22, 23, 24, 41, 43
CARLOS LOPEZ MARTINEZ - 31, 33
ANIOL MARTÍ ESPELT - 41, 43
ORESTES MIQUEL MAS CASALS - 11, 13

PRIOR SKILLS

Resolution of algebraic equations; Basic trigonometric relations and operations; Complex number arithmetic; Logarithmic and exponential functions; Basic resistive circuit analysis; Skills, measurements and instrumentation of the electronics' laboratory.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Transversal:
1. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with recommended information sources according to the guidelines set by lecturers.

TEACHING METHODOLOGY

Lectures
Laboratory sessions
Group work (distance learning)
Individual work (distance learning)
Short answer exams
Long answer exams

LEARNING OBJECTIVES OF THE SUBJECT

The main objective of the course is the study of linear circuits as analog processors of electrical signals. With this goal in mind, circuits are examined from both a temporal and a frequency perspective, with particular emphasis on the analysis and design of frequency-selective circuits widely used in electronic and communication systems.

To accomplish this objective, important concepts are gradually introduced that are essential in all engineering fields related to information technology and communications. These include network function, time response, frequency-based signal description, frequency response, and the concept of filters.

Significant importance is also placed on the design of simple circuits using simulation tools such as Spice and Octave, in order to validate them. In some specific cases, experimental verification is conducted during laboratory sessions. This entire process is supported by the use of commonly employed electronic devices such as operational amplifiers (AOs) and bipolar junction transistors (BJTs), among others.

Upon completing the course, the student will be able to:

• Understand and master the basic concepts of linear systems and the theory, analysis, and design of electrical/electronic circuits.

• Perform assigned tasks within the given timeframe, following the guidelines provided by the professor or tutor.

• Identify the progress and degree of achievement of learning objectives.

• Properly formulate the problem based on the given statement and identify options for its resolution. Apply the appropriate problem-solving method and validate the solution.

• Acquire knowledge of and correctly use the available tools, instruments, and software applications in the laboratories of the core subjects. Successfully analyze the collected data.

• Apply the studied basic principles to solve engineering-related problems.

• Acquire knowledge of the following fundamental concepts:
  - Concept of circuit model and circuit element.
  - Partial descriptions of systems: Block diagrams.
  - Cascading of circuits and identification/minimization of possible loading effects.
  - Laplace-transformed circuit.
  - Impedance and admittance. Network function.
  - Dynamics of first and second-order circuits. Stability.
  - Sinusoidal steady-state (SSS). Phasor-transformed circuit.
  - Amplification and phase shift.
  - Resonance.
  - Frequency response.
  - Gain (dB). Bode plots.
  - Filtering: Cutoff frequency, passbands and stopbands. Bandwidth and quality factor.
  - Frequency representation of signals. Phasor diagrams. Spectra. Spectrum of periodic signals. Harmonics.
  - Power in the SSS. Average power and RMS value. Available power of a generator. dBm.
  - Impedance matching.
  - Two-port characterization.

• Apply the following skills:
  - Effectively analyze linear circuits in both transient and steady-state regimes.
  - Characterize the behavior of a circuit in the time and frequency domains based on its network function and relate the responses in both domains.
  - Perform basic circuit designs.
  - Validate results by simulating circuits.
  - Assemble experimental prototypes based on circuit diagrams, perform meaningful measurements using laboratory equipment, and interpret them.

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STUDY LOAD

Type	Hours	Percentage
Hours small group	13,0	8.67
Hours large group	52,0	34.67
Self study	85,0	56.67

Total learning time: 150 h

CONTENTS

Topic 1. Linear circuits and systems. Conceptual framework.

Description:
- Scope of application. Circuit definition. Linear and nonlinear circuits.
- Passive and active circuit elements. Relationship with the modelled physical phenomena.
- Concept of signal. Signal types.
- Modelling and study of electronic components and systems.
- Block diagrams, cascade connection and load effects.
- Introduction to computer-aided analysis and simulation of circuits and systems.

Full-or-part-time: 8h
Theory classes: 8h

Topic 2. Time response of linear circuits and systems.

Description:
- Time domain analysis of circuits with dynamic elements.
- Algebritzation techniques:
  - Discretization. Circuit Simulation.
  - Laplace transform.
- Laplace transformed circuit. Concepts of Impedance and Admittance.
- Full time-domain circuit response calculation.
- Zero-Input and Zero-State responses.
- Network function. Relationship with impulse response. Circuit order.
- Pole-zero diagrams of circuits and functions.
- Free and forced responses.
- Stability.
- Transient and steady-state responses.
- Step response of first and second order circuits.

Full-or-part-time: 12h
Theory classes: 12h

Topic 3. Frequency response of linear circuits and systems.

Description:
- Frequency descriptions of sinusoidal signals: Phasors and Phasor diagrams. Spectra.
- Sinusoidal steady-state response calculation.
- Concepts and measures of amplification/attenuation and phase shift. Oscillogram reading and interpretation.
- Phasor Transformed Circuit. H(jω). Impedance and Admittance in SSS.
- Series/parallel inmitance models.
- Resonance.
- Frequency description of circuits. Magnitude and phase curves.
- Definition of filter and its associated concepts: Band, pass- and stop-bands, cutoff frequency, and bandwidth.
- Detailed study of some first and/or second order filters: lowpass, highpass, bandpass, bandstop and allpass characteristics.

Specific parameters (|H|max, ωc, Q,...)
- Bode plots. Logarithmic scales. Concepts of decade, octave and bel/decibel. Computation from pole/zero diagram of H(s).
- First and second order passive and active filter design.
- Filtering of non-sinusoidal periodic signals.
- Introduction to two-port networks.

Full-or-part-time: 24h
Theory classes: 24h

Tema 4: AC Power

Description:
- Instantaneous power. Average power.
- Average power in a resistor. Root-mean-saquare value (rms)
- Relationship between dBm and dB.
- Maximum power transfer. Maximum available power of a generator. Impedance matching. Solutions based on LC networks and transformers.

Full-or-part-time: 4h
Theory classes: 4h

Observations:

Description:
The proposed topics order is indicative and may be modified according to the needs of the course or other courses taught in parallel.
The examples used in the development of the different subjects include devices like the Operational Amplifier, transistors MOS and BJT and transformers. Their circuit models as well as the specific features that arise in the analysis are treated when they are needed and have therefore transversal presence in the different topics of CSL.

ACTIVITIES

Practical sessions

Description:
Six laboratory sessions corresponding to the practical application of the topics covered in the course.

Full-or-part-time: 22h
Self study: 10h
Laboratory classes: 12h

Assignments throughout the course

Description:
Various tasks to deepen the topics covered up to the moment.

Related competencies :
07 AAT N1. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with recommended information sources according to the guidelines set by lecturers.

Full-or-part-time: 20h
Guided activities: 20h

Quizzes

Description:
Quizzes

Full-or-part-time: 12h
Self study: 12h

Self-learning activities

Description:
Resolution of linear circuit problems with circuit simulation and numerical mathematics software and other activities.

Related competencies :
07 AAT N1. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with recommended information sources according to the guidelines set by lecturers.

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

Partial exam

Description:
Individual and written control test, conducted around mid-course.

Full-or-part-time: 16h
Self study: 14h
Theory classes: 2h

Final exam

Description:
The final exam is a written, in-person, and individual test that covers all the concepts worked on in any area of the course, including theory, practices, assignments, quizzes, and other activities. This exam serves a dual purpose: on one hand, it contributes to the final grade along with continuous assessment, but on the other hand it acts as a comprehensive test for those students who do not wish to/cannot participate in continuous assessment.

Full-or-part-time: 24h
Self study: 21h
Laboratory classes: 1h
Theory classes: 2h

GRADING SYSTEM

The course assessment is based on 2 main components: Continuous Assessment (CA) and Final Exam (FE). In turn, continuous assessment is subdivided into several Assessable Tasks (AT) and Laboratory Practices (LP), being:

• AT: Assessable activities proposed by the professor. A non-exclusive list of possible tasks includes:
  - Moodle quizzes
  - Synthesis Assignments
  - Partial exams
  - Others (exercises, self-learning activities, etc.)

• LP: Laboratory practices: To pass the course, it is essential to have completed all laboratory work and the corresponding preliminary studies.

• FE: The Final Exam (see the "activities" section).

The Final Grade (FG) of the subject will be calculated as follows:

FG1 = 0.5*CA + 0.5*FE = (0.2*LP + 0.3*AT) + 0.5*FE ; FG2 = 0.2*LP + 0.8*FE

FG = MAX(FG1, FG2)

Observations and exceptions:

• Students who achieve a continuous evaluation score equal to or higher than 8 (out of 10) and who had passed the midterm exam, may choose not to take the final exam. In this case, the overall grade will be a passing grade of 5. However, it is possible to increase this grade up to 10 by completing some specific activity individually as determined by the professors.

• If, due to a duly justified major reason, a student is unable to take the final exam on the scheduled date, they have the right to take an extraordinary test within the period established by the school. In this case, the format of the test may differ from the regular exam.

• The course's practical sessions are mandatory. Attending all sessions and completing the corresponding preliminary studies are necessary conditions for passing the course. Otherwise, the final grade for the course will be "0, Not Presented". However, if a student cannot attend one or more practical sessions due to justified and documented reasons, the faculty may arrange alternative dates or measures to complete them.

Course reevaluation:

• In the event that a student takes the reevaluation exam (REEX), the grade from continuous assessment will not be considered, and the criteria for calculating the reevaluation grade (RG) in this case will be as follows:

RG = 0.2*LP + 0.8*REEX

• Laboratory practices will not be subject to reevaluation; instead, the laboratory grade obtained in the last completed semester within the academic year will be maintained.

BIBLIOGRAPHY

Basic:
- Thomas, R.E.; Rosa, A.J.; Toussaint, G.J. The analysis and design of linear circuits. 7th ed. Hoboken, NJ [etc.]: John Wiley & Sons, 2012. ISBN 9781118065587.

Complementary:
- Davis, A.M. Linear Circuit Analysis. Mason, OH: Cengage Learning, 1998. ISBN 9780534950958.

RESOURCES

Other resources:
https://circuits.upc.edu