Course guide
230084 - CSL - Linear Circuits and Systems

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: 2022 ECTS Credits: 6.0 Languages: Catalan, Spanish

LECTURER

Coordinating lecturer: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura
Others: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

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 (Quizzes)
Long answer exams (Control)
Long answer exam (Final Exam)
Laboratory Practice
LEARNING OBJECTIVES OF THE SUBJECT

The main goal of the course is the study of linear circuits as analog processors of electrical signals. With this aim, circuits are studied from both temporal and frequential points of view with special emphasis on the analysis and design of frequency-selective circuits which are extensively used in electronic and communications systems.

To achieve this goal, important concepts presented in all engineering related to information technology and communications, such as network function, the time response, the signal description from a frequency point of view, the frequency response, and the filter concept, are gradually introduced.

Quite a lot of importance to the design of simple circuits is also given, using simulation tools, like Spice, Octave… to validate them and arrive, in some specific cases, at their experimental verification in the laboratory sessions. All this process leans on the use of electronic devices regularly used such as the AO, the BJT. et cetera.

At the course’s end, students will:

* Understand and dominate the basic concepts of linear systems and electrical electronic circuit theory, analysis, and design.

* Perform the tasks on schedule, according to the guidelines set by the teacher or tutor.

* Identify the progress and the degree of accomplishment of learning objectives.

* Correctly raise the problem from the proposed statement and identify options for resolution. Apply suitable resolution method and identify the correction of solutions.

* Know and use correct tools, software tools and applications available at core subjects laboratories and carry out correctly analyzing the data collected.

* Apply studied basic principles to resolve typical engineering problems.

* Know the following basic concepts:
  - Definition of circuit model and circuit element
  - Partial system description: The block diagrams
  - Cascaded connection of circuits and identification/minimization of possible load effects
  - Laplace transformed circuit
  - Impedance and admittance. Network Function
  - First- and second-order circuit dynamics. Stability
  - Sinusoidal steady state. Phasor Domain Circuit
  - Amplification and phase shift
  - Resonance
  - Frequency response
  - Gain (dB) . Bode plots
  - Filtering: Cutoff Frequency, pass-band, and band-reject. Bandwidth and quality factor
  - Periodic signals spectra. Harmonics
  - RMS. Average power and available generator power. (dBm)
  - Impedance matching.
  - Two-port networks characterization

* Be able to implement the following skills:
  - Effectively analyze linear circuits both in transient and steady state
  - Characterize the behavior of a circuit in the time and frequency domains from its network function, and be able to relate the responses in the two domains
  - Make basic circuit designs
  - Validate the results by simulating the circuits
  - Build experimental prototypes from circuitual schematics, do significant measurements using laboratory equipment and interpret the results
**STUDY LOAD**

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self study</td>
<td>85,0</td>
<td>56.67</td>
</tr>
<tr>
<td>Hours large group</td>
<td>52,0</td>
<td>34.67</td>
</tr>
<tr>
<td>Hours small group</td>
<td>13,0</td>
<td>8.67</td>
</tr>
</tbody>
</table>

**Total learning time:** 150 h

**CONTENTS**

**Topic 1. Linear circuits and systems. Conceptual framework.**

**Description:**
Concept of signal. Type of signals.
Modelling and study of components and electrical systems.
- 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:** 14h
Theory classes: 8h
Laboratory classes: 2h
Self study: 4h

**Topic 2. Time response of linear circuits and systems.**

**Description:**
- Time domain analysis of dynamic circuits (Differential equations systems)
- Algebritization techniques:
  - Discretization. Circuit Simulation.
  - Laplace transform.
- Full time-domain circuit response calculation.
- Zero-Input and Zero-State responses.
- Free and forced responses.
- Pole-zero diagram.
- Stability.
- Transient and steady-state responses.
- Step response of first and second order circuits.

**Full-or-part-time:** 36h
Theory classes: 12h
Laboratory classes: 2h
Self study: 22h
### Topic 3. Frequency response of linear circuits and systems.

**Description:**
- Sinusoidal steady-state response calculation.
- Phasor Transformed Circuit. $H(j\omega)$. 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 ($|H|_{\text{max}}$, $\omega_c$, $Q$, ...)
- First and second order passive and active filter design.

**Full-or-part-time:** 66h  
Theory classes: 22h  
Laboratory classes: 4h  
Self study: 40h

### Topic 4. Response to non-sinusoidal periodic signals

**Description:**
- Fourier series for periodic signals. Relevant cases.
- Linear circuits response to periodic signals.
- Simple signal processing examples from the frequency point of view.

**Full-or-part-time:** 14h  
Theory classes: 4h  
Laboratory classes: 2h  
Self study: 8h

### Tema 5: AC Power

**Description:**
- Instantaneous power. Average power.
- Average power in a resistor. Root-mean-square 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:** 14h  
Theory classes: 4h  
Laboratory classes: 2h  
Self study: 8h
Tema 6: Two-port networks

Description:
- Two-port network definition. Need of a parametric characterization.
- Z, Y, T and hybrids parameters. Equivalent models.
- Two-port connections: series, parallel and cascade.
- Study of loaded two-port networks.

Full-or-part-time: 6h
Theory classes: 2h
Self study: 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.
GRADING SYSTEM

The final mark will be obtained from the continuous evaluation (scoring tasks suggested by the teacher throughout the course, and laboratory work) and the final exam, according to the following criteria:

- Professor-proposed scoring tasks: 30%. A non-exclusive list of such activities follows:
  - Moodle Quizzes
  - Synthesis assignments
  - In-classroom exams
  - Other

- Laboratory sessions: 20%.
  (Note: In order to pass the course it is mandatory to have carried out all the laboratory works as well as the preliminary studies and the associated reports with a minimum quality)

- Final exam: 50% (Written test which assesses the knowledge of the whole course)

Students with a continuous assessment greater than or equal to 8 (of 10) may choose not to take the final exam. In this case, the overall rating will be approved 5. However, this score may be completed up to 10 by performing some specific activity at teacher’s discretion.

This course will assess the following generic skills:

- Self learning (Elementary)

In the event that a student takes the reevaluation test, continuous assessment will not be taken into account, and the criteria to calculate the overall mark in this case will be the following:

- Laboratory sessions: 20% The obtained in the completed last quarter within the academic year laboratory grade will remain. (Note: In order to pass the course it is mandatory to have carried out all the laboratory works as well as the preliminary studies and the associated reports with a minimum quality)

- Final exam: 80% (Written test which assesses the knowledge of the whole course)

Nor the laboratory sessions nor the generic skills will be subject to reappraisal.

BIBLIOGRAPHY

Basic:

Complementary:

RESOURCES

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