Linear networks analysis and synthesis

Academic Year: (2019 / 2020) **Review date: 01-05-2019**

Department assigned to the subject: Department of Signal and Communications Theory

Coordinating teacher: LLORENTE ROMANO, SERGIO

Type: Compulsory ECTS Credits : 6.0

Year : 2 Semester : 2

STUDENTS ARE EXPECTED TO HAVE COMPLETED

Linear Algebra (1º)
Systems and Circuits (1º)
Linear Systems (2º)
Ampliación de matemáticas (2º)
Electronic Components and Circuits (2º)

COMPETENCES AND SKILLS THAT WILL BE ACQUIRED AND LEARNING RESULTS.

1. Transversal/Generic learning outcomes (Be capable of...)

- Solving mathematical analysis and synthesis problems.
- Apply scientific and technical knowledge to practical situations.
- Solve problems stated mathematically.
- Integrate theoretical knowledge into the solution of problems.

2. Specific learning cognitive outcomes (be capable of stating...)

- Deciding and stating the advantages of using mesh or node analysis for a particular network.
- Identifying matrices of mesh and node methods and tell whether they belong to reciprocal systems.
- Naming and identifying the different types of system functions/transfer functions for stable causal linear networks and the relationships between responses in the Laplace, real frequency and time domains.
- Describing part of a network as a two-port.
- Name the different types and manifestations of power in a network with two-ports.
- Stating the maximal power transfer theorems for generators and loads with and without an interposing two-port.
- State the concept of conjugate matching.
- Relating natural and logarithmic power units.
- Stating the conditions for a network to be reciprocal and/or symmetrical
- Describing the filter synthesis process.
- Graphing the analog filter prescription functions in modulus and attenuation.
- Stating the difficulties in synthesizing an ideal low-pass transfer function.
- Stating Approximation Theory for the design of low-pass LC analog filters.
- Mathematically describing frequency transforms for high-pass, band-pass and suppressed-band filters.
- State the advantages of working in normalized frequency, impedance, resistance, inductance and capacitance.
- Deferentially characterizing, with respect to the analog version, the transfer function in the Z domain of digital filters both for infinite and finite impulse responses (IIR & FIR)
- Stating a discrete-time domain response from a difference equation.
- Sketching direct architectures for digital filters.

* Procedural/instrumental (e.g. Be capable of working out...)

- Stating and solving analysis equations for linear networks with mesh and node methods both in stationary sinusoidal and in stationary and transient regimes with the unilateral Laplace transform.
- Same with two-ports included in them.
- Describing two-ports by their impedance, admittance, power transfer and image parameters.
- Specifying and synthesizing passive low-, high-, bandpass and suppressed band analog filters using the Butterworth and Chebychev approximations.
- Specifying and synthesizing said filters in the digital case resorting to analog synthesis.

- Simulating analog filters digitally.

DESCRIPTION OF CONTENTS: PROGRAMME

Unit 1: Systematic Linear Network analysis in stationary sinusoidal regimes with mesh and nodal analysis.

1.1. Description of RLC components in SSR.(PO a, PO e, PO g, PO k)
1.2. Using systematic methods for linear network analysis
    1.2.1. Mesh analysis
    1.2.2. Nodal analysis
1.3. Networks with mutual inductance and transformers
1.4. Real, reactive, and apparent powers. Complex conjugate matching.

Unit 2: Linear Network analysis using the unilateral Laplace transform. (PO a, PO e, PO g, PO k)

2.1. The unilateral Laplace transform
2.2. The generalization of analysis theorems to the Laplace domain. Use in network analysis: free, driven, stationary and transient regimes.
2.3. Transfer functions. Frequency response. Phase and amplitude response.

Unit 3: Two-port network analysis PO a, PO e, PO g, PO k)

3.1. Two-port description: [z], [y] and [F] parameters.
3.2. Two-port interconnection.
3.3. Image parameters.
3.4. Loaded two-ports. Insertion and transmission losses. Matched two-ports. Conjugate matching. Logarithmic measurement units: Nepers and decibels.

Unit 4: An introduction to the synthesis of passive, analog filters. (PO a, PO c, PO e, PO g, PO k)

4.1. Filtering. Phase and group delay. Phase equalization. Filter types. Filter specification.
4.2. Filter characterization functions.
4.3. Low-pass filter approximation theory. Parameter normalization. Frequency transformations.
4.4. Butterworth and Chebychev filter synthesis: low-pass, high-pass, band-pass and suppressed band.

Unit 5: An introduction to the synthesis of digital filters. (PO a, PO c, PO e, PO g, PO k)

5.1. A comparison with analog filters.
5.2. Z domain transfer functions with infinite and finite impulse responses. Difference equations. Direct architectures. Stability.
5.2. FIR filter synthesis from analog synthesis.
5.3. Analog filter simulation with digital filters.

LEARNING ACTIVITIES AND METHODOLOGY

Three different teaching/learning activities will be used: theoretical lectures, problem-solving sessions and problem solving.

ECTS credits include in all cases an allotment for personal work and team problem-solving work.

THEORETICAL LECTURES (2,48 ECTS)
Theoretical lectures will include the use of blackboard and slide material to illustrate main concepts in subject. The explanation of theoretical concepts will be complemented with exercises and problem solution sketches. These lectures will require personal initiative and research plus theoretical study: he/she might be asked to develop particular concepts or apply them to specific problem instances either individually or in the group.

PROBLEM SOLVING-SESSIONS AND PROBLEM-SOLVING ASSIGNMENTS (2,64 ECTS)
For problem-solving sessions, students will be given problem statements in advance. Problem solving will include common review of solutions and instructor-led correction. These should help ground knowledge and develop the ability to analyze and transmit information relevant to problem-solving. The common review is expected to improve opinion exchange between instructors and students.

LABORATORY TESTS (0.86 ECTS)
It is intended to carry out two "software" laboratory in computer classroom where the student can simulate the circuits that have been analyzed or designed in the theoretical sessions. With these simulations, students can evaluate the success of the analysis and design techniques learned in class.

Individual tutoring sessions are intended to involve specific, clearly defined aspects. Appointments will be managed through the learning management system being used during the course. If required, collective tutoring sessions will be held to provide feedback to the group about the solution and assessment results.

ASSESSMENT SYSTEM

Final assessment will comprise a weighted aggregate of evaluative labs and final evaluation test. Weights are to be found above.

A minimum grade/score of 4.0 will be needed in the final test.

The final evaluation test will comprise both theoretical questions and problems resembling those of the formative evaluation tests, about all the units in the subject.

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

BASIC BIBLIOGRAPHY

- Alan V Oppenheim, R. W. Schafer J. R. Buck Discrete-time signal processing., Prentice Hall, 1999
- Anant Agarwal Foundations of Analog and Digital Electronic Circuits, Elsevier, 2005
- C. K. Tse Linear circuit analysis, Addison-Wesley, 1998
- J.W. Nilsson Electric Circuits, Prentice Hall, 2008
- L. E. García Castillo, A. García Lampérez, S. Llorente Romano, M. Salazar Palma Problemas de Análisis y Diseño de Circuitos, Copy Red, S.A., 2016
- R. A. DeCarlo Linear Circuit Analysis, Oxford University Press, 2001

ADDITIONAL BIBLIOGRAPHY

- P. R. Adby Ellis Horwood Series: Electrical and Electronic Engineering, Applied Circuit Theory. Matrix and Computer Methods, John Wiley & Sons, 1990
- R. Decarlo, P. M. Lin Circuit Analysis, vol. 2 Prentice-Hall, 1995.
- A. Papoulis Circuits and Systems: A Modern Approach, Rinehart & Winston, 1980.
- F. J. Taylor Principles of Signal and Systems, McGraw-Hill, 1994.
- G. C. Temes, J. W. Lapatra Introduction to Circuit Synthesis and Design, McGraw-Hill, 1977
- S. Karni Applied Circuit Analysis, John Wiley & Sons, 1988..
- W. M. Siebert Circuits, Signals and Systems, MIT Press, 1985.