Linear networks analysis and synthesis

Academic Year: (2019 / 2020) **Review date: 01-06-2015**

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

Coordinating teacher: GARCIA LAMPEREZ, ALEJANDRO

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 outcomes

* Cognitive (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 synthesising 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.
- differentially characterizing, wrt 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 synthesising passive low-, high-, bandpass and suppressed band analog filters using the Butterworth and Chebychev approximations.
- specifying and synthesising said filters in the digital case resorting to analog sinthesis.
- 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 generalisation 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 equalisation. 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

Four different teaching/learning activities will be used: theoretical lectures, problem-solving sessions, problem solving assignment and formative evaluation assessment tests.

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

Theoretical Lectures (3ECTS)
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 group.

PROBLEM SOLVING-SESSIONS AND PROBLEM-SOLVING ASSIGNMENTS(3 ECTS)
For problem-solving sessions, students will be given problem statements in advance. Sometimes they will be required to meet in or off class time with fellow students to made solution easier. Problem solving will include common review of solutions and instructor-led correction. These should help ground knoledge and develop the ability to analyse and transmit information relevant to problem-solving. Common review is expected to improve opinion exchange between instructors and students.

CONTINUAL/FINAL AND EVALUATIVE ASSESSMENT (0,86 ECTS)
They will be held a week past the end of units 1, 2, 3 and 4. Their content will be related to the most important concepts in the last unit. This type of assessment is intended both to provide a continual evaluation scheme, thus it contributes to final assessment, and an evaluative scheme: the aggregate, anonymised results of the assessment tests will be reviewed in class to highlight strong and weak points in the student population for that test (see below).

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. Collective tutoring sessions will be held after evaluative assessment sessions and their marks are made public to provide feedback to the group about the solution and assessment results.

ASSESSMENT SYSTEM

Final assessment will comprise a weighted aggregate of evaluative assessment and final evaluation test. Weights are to be found above. A minimum grade/socre 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

- A.V. Oppenheim and R.W. Shafer Discrete-Time Signal Procesing, Prentice-Hall: Englewood Cliffs NJ, 1989
- Anant Agarwal Foundations of Analog and Digital Electronic Circuits, Elsevier, 2005
- C. K. Tse Linear circuit analysis, Addison-Wesley, 1998
- G.C. Temes and J.W. Lapatra Introduction to Circuit Synthesis and Design, McGraw-Hill: NY, 1977
- J.W. Nilsson and S. Riedel Eletric Circuits, Addison Wesley: Reading MA, 1992
- R. A. DeCarlo Linear Circuit Analysis, Oxford University Press, 2001

ADDITIONAL BIBLIOGRAPHY

- A. Papoulis Circuits and Systems. A modern Approach, Holt, Rinehart & Winston: New York NY, 1980
- F.J. Taylor Principles of Signal and System, McGraw-Hill: New York NY, 1994
- P.R. Adby Applied Circuit Theory Matrix and Computer Methods: Ellis Horwood Series on Electrical and Electronic Engineering, John Wiley & Sons, 1990
- R. Decarlo and P.M. Lin Linear Circuit Analysis Vol. II, Prentice-Hall: Englewood Cliffs NJ, 1995
- S. Karni Applied Circuit Analysis, John Wiley & Sons: New York NY, 1988
- W. M. Siebert Circuits, Signals, and Systems, MIT Press: ISBN: 0262192292, 1985