



## IDENTIFYING DATA

### Physics: Analysis of Linear Circuits

|                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                 |      |            |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------|------------|
| Subject             | Physics: Analysis of Linear Circuits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                 |      |            |
| Code                | V05G300V01201                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                 |      |            |
| Study programme     | (*)Grao en Enxeñaría de Tecnoloxías de Telecomunicación                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                 |      |            |
| Descriptors         | ECTS Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Choose          | Year | Quadmester |
|                     | 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Basic education | 1st  | 2nd        |
| Teaching language   | Spanish                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                 |      |            |
| Department          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                 |      |            |
| Coordinator         | Sánchez Sánchez, Enrique                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                 |      |            |
| Lecturers           | Díaz Otero, Francisco Javier<br>García Mateo, Carmen<br>García-Tuñón Blanca, Inés<br>Gómez Araújo, Marta<br>Prol Rodríguez, Miguel<br>Sánchez Sánchez, Enrique                                                                                                                                                                                                                                                                                                                                                                     |                 |      |            |
| E-mail              | enrique.sanchez@uvigo.es                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                 |      |            |
| Web                 | <a href="http://www.faitic.uvigo.es">http://www.faitic.uvigo.es</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                 |      |            |
| General description | The course introduces the fundamentals of the lumped circuit principles and abstractions on which the design of electronic systems is based. These include lumped circuit models for sources, resistors, inductors, and capacitors. It intends to present some techniques to analyze (to determine currents and voltages) such systems: conventional analysis (integer-differential analysis, phasors and impedances in sinusoidal regime) and linear systems theory based analysis (by using the Laplace and Fourier transforms). |                 |      |            |

## Competencies

|      |                                                                                                                                                                                                                                                                                                                                          |
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| Code |                                                                                                                                                                                                                                                                                                                                          |
| A3   | CG3: The knowledge of basic subjects and technologies that capacitates the student to learn new methods and technologies, as well as to give him great versatility to confront and update to new situations                                                                                                                              |
| A4   | CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.                                                                                     |
| A13  | CE4/FB4: Comprehension and command of basic concepts in linear systems and their related functions and transforms; electric circuits theory, electronic circuits, physical principles of semiconductors and logical families, electronic and photonic devices, materials technology and their application to solve Engineering problems. |

## Learning aims

| Expected results from this subject                                                              | Training and Learning Results |
|-------------------------------------------------------------------------------------------------|-------------------------------|
| To know the elements and laws involved in lumped circuit analysis.                              | A13                           |
| To show the ability to analyse linear circuits in different circumstances.                      | A4                            |
| - to know how to choose among different alternatives when solving a problem.                    | A13                           |
| - to know simplifying techniques, their constraints, and how to decide which ones must be used. |                               |
| To translate the time domain into the transformed domains, by using transforms basic concepts.  | A13                           |
| To be able to qualitatively justify the role played by circuit elements and their interactions. | A3                            |
|                                                                                                 | A13                           |
| To master the language and symbolism of the discipline                                          | A3                            |

## Contents

| Topic |
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|                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I: Introduction                       | <p>Fundamental and derived magnitudes.</p> <p>Active and passive elements and their functional relationships.</p> <p>Kirchhoff's laws.</p> <p>Simplifying techniques; Thévenin and Norton equivalent circuits.</p> <p>Analysis by the technique of mesh voltages. Analysis by the techniques of node currents.</p>                                                                                                                                                                                                                                                        |
| II: Transient Response                | <p>Transient and steady-state regimes.</p> <p>Transient regime origin.</p> <p>Conditions of study (transient between two steady-state continuous regimes, two reactive elements as a maximum).</p> <p>Inductors and capacitors in steady-state continuous regime.</p> <p>Single reactive element networks: time expression, time constant.</p> <p>Two reactive elements networks: types of responses, time expressions, damping coefficient, angular resonant frequency.</p> <p>Networks changing in several time values.</p> <p>Partially coupled elements networks.</p> |
| III: Steady-state sinusoidal response | <p>Definition and parameters.</p> <p>Concepts of phasor and impedance.</p> <p>Mesh and node analysis of steady-state sinusoidal regime networks.</p> <p>Autoinductance and mutual inductance.</p> <p>Linear and ideal transformers.</p> <p>Power expressions: instantaneous power, complex power, average power, reactive power.</p> <p>Thévenin and Norton equivalent circuits.</p> <p>Frequency response.</p> <p>Using the superposition principle.</p>                                                                                                                 |
| IV: Two-ports                         | <p>Definition of a two-port circuit.</p> <p>Characteristic parameters.</p> <p>Sets of characteristic parameters.</p> <p>Characteristic parameters determination.</p> <p>Combining two-ports.</p> <p>A two-port in a circuit.</p>                                                                                                                                                                                                                                                                                                                                          |
| V: Signals and systems                | <p>Classes of signals.</p> <p>Some relevant signals: step function, unit impulse function, exponential function, sinusoidal function.</p> <p>Classes of systems.</p> <p>System properties; linear, time invariant systems; response to impulse.</p>                                                                                                                                                                                                                                                                                                                       |
| VI: Laplace transform                 | <p>Definition.</p> <p>Direct transforms.</p> <p>Inverse transform determination.</p> <p>Application to linear circuits.</p> <p>The transference function.</p> <p>Steady-state response in a circuit.</p> <p>Response for a sinusoidal input.</p> <p>Application of the superposition principle.</p>                                                                                                                                                                                                                                                                       |
| VII: Fourier transform                | <p>Fourier series expansion.</p> <p>Expressions of Fourier series expansion.</p> <p>Amplitude and phase spectra.</p> <p>Frequency response.</p> <p>Fourier transform.</p> <p>Fourier transform expressions.</p> <p>Properties: linearity, symmetry, time displacement, time/frequency scaling, modulation.</p>                                                                                                                                                                                                                                                            |
| VIII: Filters.                        | <p>Filter concept.</p> <p>Filter classes.</p> <p>Ideal and real filters.</p> <p>Low pass prototype based design.</p> <p>Filter responses.</p>                                                                                                                                                                                                                                                                                                                                                                                                                             |

## Planning

|                                    | Class hours | Hours outside the classroom | Total hours |
|------------------------------------|-------------|-----------------------------|-------------|
| Introductory activities            | 1           | 0                           | 1           |
| Master Session                     | 24          | 48                          | 72          |
| Laboratory practises               | 21          | 21                          | 42          |
| Forum Index                        | 0           | 5                           | 5           |
| Troubleshooting and / or exercises | 5           | 15                          | 20          |

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

| Methodologies           |                                                                                                                                                                                                                                                                                |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                         | Description                                                                                                                                                                                                                                                                    |
| Introductory activities | Presentation of the course: syllabus, bibliography, teaching methodology, and assessment and grading procedures.                                                                                                                                                               |
| Master Session          | The goal of this methodology is the presentation of the theoretical contents and the practical assessment about students learning abilities.<br>In 3 of these sessions, written quizzes will be conducted of 55 minutes each as a maximum.                                     |
| Laboratory practises    | Circuit simulation exercises will be done by using PSpice and Matlab software packages for 20 hours (in 3 of them evaluation exercises will be conducted). During 6 additional hours circuit implementation and measurement tasks will be done, with two evaluation exercises. |
| Forum Index             | The course web site is hosted in UVIGO e-learning platform ( <a href="http://fatic.uvigo.es">http://fatic.uvigo.es</a> ). It includes all the information related to the course. Forums for ideas interchanging and comments will be available.                                |

### Personalized attention

| Methodologies        | Description                                                                                                                                                                                                                                                                                                                                |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Master Session       | Personal attention will be carried out under student demand, at the professor room and/or at the laboratories, during the time schedules established and posted by the instructors at the beginning of the course. Additionally, discussion forums at the web site will be used as communication channel between instructors and students. |
| Laboratory practises | Personal attention will be carried out under student demand, at the professor room and/or at the laboratories, during the time schedules established and posted by the instructors at the beginning of the course. Additionally, discussion forums at the web site will be used as communication channel between instructors and students. |
| Forum Index          | Personal attention will be carried out under student demand, at the professor room and/or at the laboratories, during the time schedules established and posted by the instructors at the beginning of the course. Additionally, discussion forums at the web site will be used as communication channel between instructors and students. |

### Assessment

|                                                          | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Qualification |
|----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Troubleshooting and / or exercises                       | 3 exercises to be done during the time schedule for lecture sessions. Each one is referred to one or two of the most relevant topics in the course. Each exercise consists of two or more questions. Maximum qualifications of 1, 2, and 2.5 points will be assigned, respectively.<br>Capabilities A4 and A13 are evaluated by means of these tests.                                                                                                                                 | 55            |
| Practical tests, real task execution and / or simulated. | 5 evaluation exercises will be done along the semester. They will be conducted in medium-size groups. 3 of them will concern circuit simulation, 0.75, 1 and 1.25 points, respectively, being assigned. The 2 remaining exercises will refer to circuit implementing and testing (with maximum qualifications of 0.5 and 1 points, respectively). In these exercises skills concerning join work will be evaluated.<br>Capabilities A3 and A13 are evaluated by means of these tests. | 45            |

### Other comments on the Evaluation

Additionally to the evaluation system above described, the student may choose to do a final exam. This exam will have the same characteristics than exercises named "Solving problems and/or exercises ", being evaluated among 0 and 10 points.

The student, in agreement to the official academic-year schedule, will have two opportunities during the academic year to pass the course.

**1. First opportunity at the end of the semester (end of semester).** The student is free to choose the continuous evaluation system above described, without excluding the possibility to do a final exam. Possible cases:

- Students only doing the continuous evaluation: they are graded with the points obtained in the evaluation.
- Students doing both the continuous evaluation and the exam: they are graded with the best of both qualifications.
- Students only doing the final exam: they are graded with the points obtained in the exam.

**2. Extraordinary exam.** Students not passing the course at the end of the semester may do a final exam like the aforementioned. Points reached in it (among 0 and 10) will be the final grade.

**Additional comment:** Doing 4 or more tests and/or the final exams will prevent the student to get the "Not presented" mark.

**Re-scheduling of tests.** In case of missing a test, instructors have not any compulsion to rescheduling.

**Test results.** Before each test, the date and revision procedure of assigned grading marks will be indicated. Such dates will imply a reasonable delay (in general, not greater than three weeks) between the date of test and the release of the grading marks.

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### Sources of information

James W. Nilsson, **Electric Circuits**,

Enrique Sánchez, Carmen García Mateo, **Material docente**, Página web,

J.H. McClellan, R.W. Schafer, M.A. Yoder, **Signal Processing First**,

J. W. Nilsson's book will be the basic course reference. It is a book covering all the course content in more extension and by using a very clear language. It includes a number of exercises, both proposed and solved. A number of editions are available, in general with little differences among them. It is recommended to the students to use the English editions.

Additionally, the students will have available in the course web site some teaching material (extended lectures notes, practice handbooks, exam examples).

McClellan et al. book is mentioned as a complementary reference, specially indicated for signal processing and filtering lessons. This book will be used in a second year course devoted to digital signal processing.

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### Recommendations

#### Subjects that continue the syllabus

Physics: Fundamentals of Electronics/V05G300V01305

Digital Signal Processing/V05G300V01304

Signal Transmission and Reception Techniques/V05G300V01404

Microwave Circuits/V05G300V01611

Radio Frequency Circuits/V05G300V01511

Analogue Electronics/V05G300V01624

Engineering of Electronic Equipment/V05G300V01523

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#### Subjects that are recommended to be taken simultaneously

Mathematics: Calculus II/V05G300V01203

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#### Subjects that it is recommended to have taken before

Mathematics: Linear Algebra/V05G300V01104

Mathematics: Calculus I/V05G300V01105

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### Other comments

It is strongly recommended that students are familiar with complex numbers, trigonometric functions, linear equation system solving, elemental function derivatives and computation of simple integrals.