Course guide to Sinais e Sistemas Electrónicos

(41945)

Year 2022/2023

2º year, 2º semester
Classes (hours/week): 2 theory + 2 labs;
ECTS credit units: 6

Graduation:

8240 – Mestrado Integrado em Engenharia de Computadores e Telemática;
8302 – Mestrado Integrado em Engenharia Biomédica;
8285 – Mestrado Integrado em Engenharia Física;
8316 – Licenciatura em Engenharia de Computadores e Informática;
8317 – Licenciatura em Engenharia Biomédica;
8320 – Licenciatura em Engenharia Física;
8312 – Licenciatura em Engenharia de Automação Industrial
8258 – Licenciatura em Física (opção).

1- Course synopsis

Sinais e Sistemas Electrónicos (SSE) is an introductory course on electrical circuits and electronics in the analogue and digital domains.
In the theoretical-practical component, the fundamental aspects of direct current and sinusoidal circuits are studied. Concepts about signals and the corresponding response of circuits in the time and frequency domains are introduced. The program also includes notions about the constitution, operation and use of basic electronic devices such as diodes, transistors and operational amplifiers.
The practical component provides a first contact with the electronics laboratory and the use of the respective equipment. Involves the assembly and testing of simple, electrical and electronic circuits with the aim of providing students with a practical perspective of the concepts acquired in the theoretical classes.

2- Prerequisites

Students should have completed successfully courses on Algebra, Calculus and Electromagnetic Theory.

3- Qualifications to develop with the course

This course aims at providing students with the following abilities:

- Understand the elementary concepts of electrical circuits;
- Know well the main techniques of analysis of linear circuits and their limitations;
- Know how to characterize the response of elementary circuits in the time and frequency domains;

- Identify elementary electronic devices and know their main physical limitations;
- Analyze simple electronic circuits based on diodes and transistors, in analog and digital applications;
- Analyze and dimension elementary circuits with operational amplifiers;
- Correctly use the most common electronics laboratory instruments and know their limitations;
- Appropriately consult a data sheet to obtain technical information on electronic components;
- Properly assemble and test simple circuits in a laboratory environment.

4- Theory lectures

Teaching in SSE combines the usual expository approach with students' autonomous work. The theoretical-practical classes, lasting 120 minutes each, are supported by powerpoint presentations and complemented with exercises done on the board.

4.1- Classes and schedules

TP1	TP2
tuesday, 9 – 11h	wednesday, 14 – 16h
Anf. IV	Anf. 23.1.7

Number of lectures: *14*

4.2- Syllabus

Chapter 1: Foundations

Electric current and potential difference; Basic electrical circuit: hydraulic analogy; Conductors, insulators and electrical resistance; Elements of circuits: physical devices and mathematical models; Reference polarity and reference direction of current; Power in electrical circuits; Ohm's Law; Resistivity; Kirchhoff's Current Law and Voltage Law; Analysis of simple circuits with a single loop or two nodes; Combination of resistors; Voltage and current dividers.

Chapter 2: Circuit analyses techniques

Nodal analysis; Calculation examples; Nodal analysis with super nodes; Thevenin theorem; Thevenin equivalent: Universal Method.

Chapter 3: Capacitance and inductance

Redefinition of active and passive elements; Capacitor and capacity; RC circuit transient response; Coil and inductance; Combination of coils and combination of capacitors; Linearity; Duality.

Chapter 4: Sinusoidal steady-state analysis

Forced response to a sinusoidal function; Complex forcing function; Phasors; Phasor relations for R, L and C; Extension of analysis techniques to circuits in sinusoidal regime; Impedance; Sinusoidal power; RMS value.

Chapter 5: Signals and systems

Signals: definition and classification; Signals in the time and frequency domains; Frequency response; Low-pass RC circuit; The decibel (dB); Amplitude and phase response; High-pass RC circuit; Bode Diagrams; Step response; Rise time; Tilt.

Chapter 6: Operational amplifiers

Operational amplifier: fundamentals; Simplified equivalent model; Feedback: inverter configuration; Gain calculation; OpAmp's ideal model; Concept of virtual short-circuit at the input; Non-inverting configuration; Limits of the ideal model; Input resistance and output resistance in a voltage amplifier; Other basic OpAmp circuits: Voltage follower and its usefulness; Summing amplifier; Integrating amplifier; Voltage comparators.

Chapter 7: Diodes and applications

Diode physics; pn junction in equilibrium, inversely and forward biased; Diode current/voltage characteristic; Most important device parameters; Simplified models for circuit analysis; Rectifiers: half wave and full wave; Filtering; Zener diode and applications; LED diode and photo diode.

Chapter 8: The MOS transistor

Physical structure and basic operation of the MOSFET; Quadratic model of the NMOS transistor; P-channel MOSFET; MOSFET in DC; MOSFET as an amplifier; MOSFET as an electronic switch; Applications of MOSFET as a switch: Power switch and analog switch; Digital circuits; Intrinsic capacities of the MOSFET.

5- Laboratory classes

These classes consist of seven laboratory assignments, lasting one to two classes each, where some of the theoretical themes of the syllabus are addressed. The objectives include the consolidation of knowledge about circuit analysis techniques, the fundamental aspects of the electronic devices studied and their application, and also the familiarization with the measuring and testing equipment often found in the electronics laboratory. Whenever possible, the works are carried out by groups of two students. All elements relevant to the work, namely measurements and results, must be recorded by students.

5.1- Classes and schedules

	P8	**P7**
monday	16 – 18h	18 – 20h
	4.3.20	4.3.03

Number of lectures: *13*

	P5	**P1**	**P6**	**P12**
tuesday	14 – 16h	16 – 18h	17 – 19h	18 – 20h
	4.3.03	4.3.03	4.3.20	4.3.03

Number of lectures: *14*

	P2	**P3**	**P11**	**P14**	**P10**	**P9**
thursday	9 – 11h	9 – 11h	11 – 13h	11 – 13h	14 – 16h	17 – 19h
	4.3.19	4.3.20	4.3.19	4.3.17	4.3.20	4.3.20

Number of lectures: *14*

	P13
friday	14 – 16h
	4.3.20

Number of lectures: *13*

5.2- Lab assignements

1 – Introduction to the electronics lab
Introduction to the equipment and basic components of the electronics laboratory. Using the breadboard, power supply and multimeter. Simple DC circuits. Assembly and measurements.

2 – Voltage-current characteristic of a simple electronic device
Voltage vs Current in a resistor. Ohm's Law. Comparison with the V/I characteristic of a given non-linear device. Concept of dynamic resistance.

3 – Concepts of circuit analysis in practice
Assembly and study of DC circuits. Use of two voltage sources. Practical demonstration of the Superposition Principle and Thévenin's Theorem.

4 – The RC circuit and the oscilloscope
Exploring the basic functionality of the oscilloscope. Using the function generator. Influence of oscilloscope input impedance on measurements. Study of RC circuit response in the time and frequency domains.

5 – Operational amplifiers: basic circuits
Main characteristics of a commercial operational amplifier. Design of inverting and non-inverting configurations. Basic characterization of these configurations in the laboratory.

6 – Junction diode and applications
Assembly and testing of circuits with diodes. Half-wave rectifier with filtering. Zener diode as voltage regulator. Circuit with photo-diode.

7 – Electronics in real applications (optional)
Design, assembly and test of small projects that illustrate the application of electronics to real-world problem solving.

5.3- Planning

Assignements	# classes
1 – Introduction to the electronics lab	2
2 – Voltage-current characteristic of a simple electronic device	1
3 – Concepts of circuit analysis in practice	1
4 – The RC circuit and the oscilloscope	3
5 – Operational amplifiers: basic circuits	1.5
6 – Junction diode and applications	1.5
Lab tests	2

5.4- Electronics lab kit

To carry out practical work in the laboratory, students must have an Electronics lab kit. This Kit, which is considered a personal teaching object, must include, at a minimum, a breadboard, three banana wires, one oscilloscope probe and cutting pliers. A lab kit with this set of tools can be purchased at DETI.

6- Bibliography

- Hayt, W. H.; Kemmerly, J. E.; Durbin, S. M. – "Engineering Circuit Analysis", McGraw-Hill, 7th edition, 2007;
- Sedra, Adel S.; Smith, Kenneth C. – "Microelectronic Circuits", Oxford University Press, 7th edition, 2016;
- Neamen, Donald A. – "Microelectronics: Circuit Analysis and Design", McGraw-Hill, 4th edition, 2010;
- Hayes, Thomas C. – "Learning the Art of Electronics: A Hands-On Lab Course", Cambridge University Press, 2016;
- Oliveira, Pedro Guedes e Santos; Dinis M. – "Electrónica: Uma Visão de Projecto", Universidade do Porto, 2018.

Documentation on the course website: http://elearning.ua.pt/

Includes: this course guide, Lab Works Guide, Component data sheets, Handouts from the theory lectures, assorted info for the lab classes and exercise sheets.

7- Assessment

The course assessment is divided into two components: the theoretical component, with a weight of 60% in the final grade, and the practical component, with a weight of 40%. The minimum grade for approval purposes is, in the theoretical component, 7.5 points.

7.1- Theoretical component

The assessment of the theoretical component will be carried out through a single written test, to be carried out during the exam period, which covers all the subjects taught in TP classes.

7.2- Practical component

The practical component grade is rounded to one decimal place and results from the following two assessment elements and their respective weights:

- Lab test 1 – 40%
- Lab test 2 – 60%

Lab tests: Held in groups, in two practical classes of the semester, on the dates indicated below. It consists in the execution of assessment laboratory works that should focus on any of the themes addressed in the work carried out so far.

Lab tests	
1	17, 18, 20 and 21 April
2	1, 2, 5 and 6 June

8- Absence registration

Theoretical classes: Attendance is free, with no room for marking absences.
Lab classes: There will be room for marking absences. The limit of unexcused absences is 20% of the total number of classes (3 classes)

9- Teachers

	office	**email**	**Class(es)**
Ernesto Martins	DETI – 4.2.38	evm@ua.pt	TP1, TP2, P6 e P8
Alexandre Mota	DETI – 4.2.41	alex@ua.pt	P1 e P5
Armando Rocha	DETI – 4.3.39	arocha@ua.pt	P10, P11 e P13
João Nuno Matos	DETI – 4.3.26	matos@ua.pt	P3 e P14
Luís Nero Alves	IT1 – 2.27	nero@ua.pt	P9
Rui Escadas Martins	DETI – 4.2.46	rmm@ua.pt	P2
Vinicius Oliveira	DETI – 4.2.46	viniciusuchoa@ua.pt	P7 e P12
