Universidad Rey Juan Carlos

TEACHING GUIDE

ANALOG AND DIGITAL ELECTRONICS

GRADO EN INGENIERÍA BIOMÉDICA (INGLÉS) (3º y 4º curso) (2374)

ACADEMIC YEAR 2026-27

Q2803011B UNIVERSIDAD REY JUAN CARLOS
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I.-Subject Identification	
Type	OBLIGATORIA
Teaching period	2 course, 2Q semester
Nº of credits	6
Language in wich the subject is taught	English

II.-Presentation

In this subject, the fundamental tools and concepts of Electronics are described for the understanding and design of electronic circuits used in biomedical signal processing. Two major contents are treated: i) Analog Electronics, in which electrical signals (voltages or currents) are continuous function of time (in *analogy* with naturally perceived experiences) and ii) Digital Electronics, in which time continuous signals are sampled and coded in binary *digits*.

Analog Electronics: we first recall the basics of linear electrical circuits, e.g. Thevenin and Norton equivalences, voltage and current dividers, and then introduce non-linear elements, i.e. diodes and transistors. Low pass and high pass, first order, frequency filters will be introduced and presented and their spectral response and Bode representation will be described. Sensors and transducers will be described, considering practical example of biomedical instrumentation circuitry. Operational amplifiers (OpAmp) are described in depth in open loop and with negative feedback, with several operational circuits, such as inverting, non-inverting amplifiers, adder, subtractor and more. Comparators and oscillators with positive feeback are also presented.

Digital Electronics: Sampling and coding concepts will be described. Boolean Algebra, the theoretical basis of digital signal processing, will be presented in detail. Logical functions and mathematical tools for their simplification will be described. Basic logic ports and combinational circuits, such as comparators, multiplexers, coder/decoder, arithmetical operators, will be introduced and the design rules for digital circuit realization, from a given logic function, will be presented in detail.

III.-Learning outcomes

CG02. Use computational and experimental tools for the analysis and quantification of biomedical engineering problems
CB5 . That students have developed the learning skills needed to undertake further studies with a considerable degree of autonomy.
CE16. Understand the basic concepts of linear systems and related functions and transforms, theory of electrical circuits, electronic circuits, the physical principle of semiconductors and logic families, electronic devices, and their application to solve problems in biomedical engineering.
CE17. Designing instruments for medical applications
CE18 .Use sensors, controllers and biomedical signal acquisition systems for the evaluation and design of biomedical devices and systems

- Key for degrees not adapted to RD 822/21: **CB** - basic competences, **CG** - generic competences, **CE** - specific competences, **CT** - transversal competences.
- Key for degrees adapted to RD 822/21: **CON** - knowledge, **COM** - competences, **HAB** - skills.

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IV.-Contents

IV.A.-Syllabus

1. Linear Electronic Circuits (Review)
1.1 Basic Components
1.2 Kirchhoff's Laws
1.3 Voltage and Current Divider
1.4 Superposition Theorem
1.5 Thévenin's and Norton's Theorems
2. Diodes
2.1 Semiconductor Materials
2.2 The PN Junction
2.3 Junction Diode: Shockley Equation, Piecewise Linear Approximation, Operating Point and Load Line
2.4 Zener Diode
2.5 Circuit Configurations: Rectifier Circuits, Clipping Circuits, and Full-Wave Rectifier
3. Transistors
3.1 Bipolar Junction Transistor (BJT)
3.1.1 Fundamentals and working principle
3.1.2 Biasing Circuits
3.1.3 BJT Circuit Configurations: Common Emitter (Inverter), Common Collector (Voltage Follower), Common Base (Current Follower)
3.2 FET Transistors
3.2.1 MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor)
3.2.2 Types of MOSFETs: Depletion and Enhancement Mode NMOS and PMOS
3.2.3 MOSFET Circuit Configurations
4. Frequency Response and Filters
4.1 Inductors and Capacitors: I-V Characteristics (Review)
4.2 Time Domain: Transient Analysis
4.3 Steady-State Sinusoidal Regime
4.4 Phasors and Phasor Circuits
4.5 Frequency Domain Analysis: Impedances
4.6 Behavior at Multiple Frequencies
4.7 Frequency Analysis of Circuits: Bode Diagrams
5. Operational Amplifiers
5.1 Introduction: Ideal Op-Amp Approximation
5.2 Open-Loop Operational Amplifier
5.3 Closed-Loop with Negative Feedback
5.4 Closed-Loop with Positive Feedback
6. Sensors and Actuators
6.1 The concept of transducer
6.2 Sensors
6.2.1 Movement sensors. Piezoelectrics
6.2.2 Light sensors. Photodiodes and Charge-Coupled Devices (CCDs)
6.2.3 Temperature sensors. RTD, Thermocouples, Thermistors
6.2.4 Stretching sensors. Resistive, inductive, capacitive
6.2.5 Chemical concentration. Resistive, electrolytic, FET
6.3 Actuators
6.3.1 Movement actuators. Piezoelectrics. Servomechanisms
6.3.2 Light emitters. Light emitting diodes
7. Boolean Algebra and Digital Circuits
7.1 Introduction to Digital Electronics: Digital Signals, Sampling, and Representation
7.2 Logic Operators and Functions: Logic Gates and Logic Circuits
7.3 Fundamentals of Boolean Algebra

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7.4 Simplification of Boolean Functions: Karnaugh Maps
7.5 Implementation of Functions Using NAND and NOR Gates
7.6 Combinational Circuits: Comparator, Multiplexor, Adders

IV.B.-Training activities

Type	**Title**
Academic tutorials	AF2_Tutorials carried out individually or in groups, at the students' request, on specific concepts of the subject.
Theoretical sessions	AF1_Lectures imparted by the teacher. The students will be prompted to actively participate into the lectures through questions designed to evaluate their current comprehension on the topic under study, or by requesting them to ask their own questions and engage in their discussion.
Resolution of exercises, problems, case studies	AF7_Resolution of exercises proposed during practical classes, individually or in groups.
Experimental and/or technological laboratories	AF7_Laboratory practices where the theoretical knowledge learned in the classroom is applied and hands-on experience in working with circuits is acquired.
Experimental and/or technological laboratories	AF9_Preparation of the practical laboratory classes prior to each laboratory session.
Test and/or exams	AF5_Asynchronous online tests on specific theoretical concepts and fundamental ideas of each topic.
Test and/or exams	AF5_A midterm exam to evaluate the knwoledge and skills aquired by the students up to that point.

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V.-Student workload	
Theoretical sessions	26
Resolution of exercises, problems, case studies, etc.	22
Practical sessions in experimental, technological and clinical laboratories, fieldwork, etc.	8
Tests and/or exams	4
Academic tutorials	30
Related activities: conferences, seminars, etc.	18
Preparation of theoretical sessions and self-study	25
Preparation of practical tasks, exercises, case studies, projects, etc.	25
Preparation for tests and/or exams	22
Total student workload	180

VI.-Methodology and academic programme		
Type	**Period**	**Content**
Theoretical sessions	Week 1 to Week 15	MD1. Lectures that will include a high practical degree in terms of interaction and problem resolution due to the characteristics of the topic.
Resolution of exercises, problems, case studies	Week 1 to Week 15	MD2. In-class exercice and problem solving, either by the teacher or the students, individually or in groups.
Experimental and/or technological laboratories	Week 3 to Week 15	MD3. Laboratory sessions aimed at confronting the student with an specific application problem. The students will have to apply their theoretical knowledge to solve it, making decisions based on what has been learned.

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VII.-Assessment methods

The general assessment method is continuous as established in the *Regulation for the Assessment of Learning Outcomes* of Rey Juan Carlos University.
All the assessment systems established in the degree report must be employed, except for those that have a minimum weight of 0%, which can be used by professors in the academic years they consider relevant. Each assessment system may be applied through one or more assessment activities, consistent with the system. No assessment activity can exceed individually 60% of the overall grade for the subject.
The sum of non re-evaluable activities cannot exceed 40% of the overall grade for the subject and, in general, should not have an established minimum grade (except for practical activities in which, strictly speaking, the conditions of the ordinary call cannot be reproduced in the extraordinary call).
Those students who do not manage to pass the subject in the ordinary call, or do not attend this first call, may attend the extraordinary call only for failed re-evaluable assessment activities.
The distribution and characteristics of the assessment activities are described below.

VII.A.-Description and weight of the assessment activities

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The evaluation of the students' performance during the course and the knowledge acquired will be carried out through a series of Evaluation Activities that are detailed below:

SE2_Individual exams: Two exams will be conducted throughout the course: a midterm exam (between weeks seven and nine) and a final exam, at the end of the course (Ordinary call exam). Each exam accounts for 35% of the final grade in the course (for a total of 70%). The midterm exam will evaluate the contents taught up to that moment in the subject (first block of the syllabus), while the final exam will evaluate the remaining contents (second block of the syllabus). **In order to pass the course it is a requirement to have obtained at least a 5.0 out of 10 in both exams**. The midterm exam can be retaken during the final exam, in which case both blocks will be evaluated. Both exams can be retaken in the Extraordinary call.

SE2_Online tests: A series of online tests will be administered through the Virtual Classroom, featuring basic and general questions on the course content. The final grade of the tests will account for 5% of the overall course grade, with no minimum score required. This evaluation activity cannot be retaken and the grade obtained during the ordinary call will also be used in the extraordinary call to compute the final grade. This activity cannot be retaken because it is designed to support the student learning thoughout the course, focusing on common missconceptions and non-obvious concepts derived from the contents covered during the lectures, and therefore its utility is lost in the Extraordinary call.

SE5_Laboratory practices: Four laboratory sessions will be carried out in pairs, and will be evaluated taking into account the achievement of the milestones marked in the practice scripts and the reports submitted for each practical session. The partial or total plagiarism of a report will cause the failure of that practice with the minimum grade (0 out of 10). In case of copying of reports among classmates, the same penalty as in the case of plagiarism will be applied to all students involved, regardless of who submitted the original report and who the copied one. Attendance to the laboratory sessions is compulsory. The final grade obtained in this activity will account for 25% of the overall course grade, and **a minimum score of 5 out of 10 is required to pass the course**. Due to the practical nature of this activity it is not possible to retake it in the Extraordinary call, meaning that failling to pass this activity in the ordinary call will automatically cause the failure of the extraordinary call. The importance of acquiring proper practical experience on circuit handlign and writting the corresponding reports require the students to pass this activity in order to pass the course.

Evaluation	Can be retaken?	Weight percentage	Minimum degree	Date	Contents
S2_Midterm exam	YES	35%	5 out of 10	Between weeks 7th and 9th	Block I
S2_Final exam	YES	35%	5 out of 10	May	Block II
S2_Online tests	NO	5%	None	During the whole duration of the course	All, grouped by topics
S5_Laboratory	NO	25%	5 out of 10	During the whole duration of the course	Reports and milestones

Ordinary call: The final grade of the course will be computed as the weigthed sum of all activities (each one with its own weight as indicated above), **if, and only if all Evaluation Activities with a required minimum score have been passed**. Otherwise, the highest grade of the failed activities with minimum required score will be used instead as the final grade.

Extraodinary call: Failed midterm **and/or** final exams (evaluating Blocks I and II respectively) can be retaken **separetly** during the Extraordinary call. This call will consist on a single exam divided into the two Blocks of contents defined in the Ordinary call. Each student will only have to undertake the failed Blocks in this exam (Block I, Block II or both). The final grade of the Extraordinary call will be computed in the exact same maner as in the Ordinary call.

Advanced call: students may request to advance the evaluation of **one of the two calls** (ordinary or extraordinary) to September, as long as they meet the requirements established in the URJC Learning Outcomes Evaluation Regulations, and **only if they passed the Laboratory Practices during the course 2025/2026**. The evaluation in this case, will consist of a written exam with a required minium score of 5 out of 10 which, if passed, will account for 75% of the final grade. The remaining 25% will be accounted by the grade obtained in the Laboratory during the course 2025/2026.

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VII.B. Assessment of students with academic exemption from class attendance

Having Academic Exemption from Class Attendance (DAAC) does not imply that students are automatically exempt from participating in the continuous assessment activities or in the training activities of compulsory attendance as established in the teaching guide. Once the exemption has been granted, students must contact the subject's teaching staff, who will propose the adaptations he/she may consider relevant, as long as they guarantee the acquisition and adequate assessment of the learning goals established. Students must maintain adequate communication with the teaching staff so that they may provide information on the dates for training and assessment activities, if these are not established in the programme and available for students at the time of achieving the exemption.
Subject with possibility of academic exemption: Yes.

VII.C. Review of assessment activities

In accordance with the Regulation for the Assessment of Learning Outcomes of Rey Juan Carlos University.

VII.D.-Students with a disability or special educational needs

In order to guarantee equal opportunities, non-discrimination, universal accessibility and academic success, students with disabilities or especial education needs may request curricular adaptations to follow their studies. These adaptations will be provided by the Unit of Attention to People with Disabilities of Rey Juan Carlos University, in accordance with the regulation which regulates the service for the Attention of People with Disabilities at the University. This Unit will issue a report for curricular adaptations, so that students with disabilities or special education needs must contact the service (at e-mail discapacidad.programa@urjc.es) in order to provide relevant information for different educational alternatives.

VII.E.-Academic behaviour, academic integrity and honesty

Rey Juan Carlos University is fully committed to the highest standards of academic integrity and honesty, so studying at the URJC means assuming and subscribing to the values of integrity and academic honesty set out in the University's Ethical Code. To support this process, the University has Rey Juan Carlos University's Academic Conduct Regulation as well as different tools (anti-plagiarism, supervision...) that offer a collective guarantee for the full development of these essential values.

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VIII.-Teaching resources and materials
Basic bibliography
Analog Electronics: - *Electronics: a systems approach*. Neil Storey. 4th ed. Pearson Education (2009) **- *Microelectronic Circuits and Devices*. M. N. Horenstein 2 ed. Prentice Hall (1997)** - *Microelectronic Circuits: Theory and Applications*. Sedra-Smith. 7th Ed. Oxford. (2009) - *Circuitos Microelectrónicos*. Sedra-Smith. 5ª Ed. McGraw Hill (2006) - *Principios de Electrónica*. A. P. Malvino Mc.Graw-Hill, (2007). - *Sensores y acondicionadores de señal*. Ramón Pallás Areny. Ramón Pallás Areny. 4ª ed . Barcelona : Marcombo (2003) **Digital Electronics:** - *Fundamentos de los Sistemas Digitales* T.H. Floyd. 9th Ed. Pearson / Prentice-Hall. (2006) - *Digital Design: Principles and Practices*. J. F. Wakerly. 4th Ed. Pearson (2005) - *Diseño Digital. Principios y Prácticas*. J.F.Wakerly Prentice Hall. 3ª Edición.
Consultation bibliography

IX.-Professors	
Name and surname	ANTONIO ROSARIO CONSOLI BARONE
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Department	Teoría de la Señal y Comunicaciones y Sistemas Telemáticos y Computación
Campus	Fuenlabrada
Category	Titular de Universidad
Academic degree	Doctor
Person responsible for the subject	No
Tutorial timetable	Para consultar las tutorias póngase en contacto con el/la profesor/a a través de correo electrónico
Number of quinquennia	2
Number of sexennia	3
No. of positive evaluations by Docentia	2
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Campus	Fuenlabrada
Category	Titular de Universidad

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Academic degree	Doctor
Person responsible for the subject	Yes
Tutorial timetable	Para consultar las tutorias póngase en contacto con el/la profesor/a a través de correo electrónico
Number of quinquennia	2
Number of sexennia	2
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Category	Titular de Universidad
Academic degree	Doctor
Person responsible for the subject	No
Tutorial timetable	Para consultar las tutorias póngase en contacto con el/la profesor/a a través de correo electrónico
Number of quinquennia	1
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No. of positive evaluations by Docentia	1
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Campus	Fuenlabrada
Category	Profesor/a Ayudante Doctor/a
Academic degree	Doctor
Person responsible for the subject	No
Tutorial timetable	Para consultar las tutorias póngase en contacto con el/la profesor/a a través de correo electrónico

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