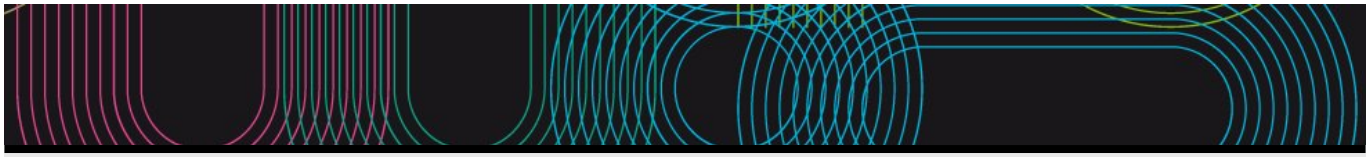

IDENTIFYING DATA				
Power electronics and automatic control				
Subject	Power electronics and automatic control			
Code	V12G320V01501			
Study programme	Degree in Electrical Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	9	Mandatory	3rd	1st
Teaching language	Spanish			
Department	Systems Engineering and Automatisms Electronics Technology			
Coordinator	Delgado Romero, Mª Emma Nogueiras Meléndez, Andres Augusto			
Lecturers	Delgado Romero, Mª Emma Gómez Yepes, Alejandro Nogueiras Meléndez, Andres Augusto			
E-mail	aaugusto@uvigo.es emmad@uvigo.es			
Web	http://faitic.uvigo.es/			
General description	This subject provides the basics of power electronics and automatic control. The first block provides the power electronics knowledge: basic semiconductor devices, protection and driving of semiconductors, and power circuits connected to the AC grid. The second block provides the automatic control knowledge: fundamental tools to analyze, simulate and design continuous and discrete control systems, and deepens the knowledge on the industrial regulators fields. This educational guide is a translation from the Spanish version. In case of any discrepancy, the only one valid is the Spanish version.			

Competencies	
Code	
B3	CG3 Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations.
C12	CE12 Know the fundamentals of automation and control methods.
C25	CE25 Applied knowledge of power electronics.
C26	CE26 knowledge of the principles of automatic regulation and its application to industrial automation.
D2	CT2 Problems resolution.
D3	CT3 Oral and written proficiency.
D6	CT6 Application of computer science in the field of study.
D9	CT9 Apply knowledge.
D10	CT10 Self learning and work.
D16	CT16 Critical thinking.
D17	CT17 Working as a team.

Learning outcomes			
Expected results from this subject	Training and Learning Results		
Applied Knowledge of power electronics	B3	C25	D2 D9 D10

Protection and control of power semiconductors devices	B3	C25	D2 D6 D9 D10
Basic knowledge of electronic power converters connected to the electric grid and its topologies	B3	C25	D2 D6 D9 D10 D17
Basic knowledge of DC/AC electronic power converters	B3	C25	D2 D6 D9 D10 D17
Comprise the systems of regulación automatic realimentados	B3	C12 C26	D9 D10
Capacity to analyse continuous and discreet systems, with special attention in electrical systems	B3	C12 C26	D2 D6 D9 D10 D16 D17
Know the fundamentos of the technicians of design of regulatory discreet	B3	C12 C26	D2 D6 D9 D10 D16 D17
Know tools of simulación of systems of control	B3	C12 C26	D2 D3 D6 D9 D10 D16 D17
Capacity to use practical technicians of adjust of regulatory industrial	B3	C12 C26	D2 D3 D6 D9 D10 D16 D17

Contents	
Topic	
Block 1 - Power Electronics	
Subject 1.1 - Power Semiconductors Devices	Power Diodes MOSFETs IGBTs Thyristors
Subject 1.2 - Protection and control of power semiconductor devices	Thermal and electrical protections Snubber Networks Control circuits of MOSFET and IGBT transistors Thyristor control circuits
Subject 1.3 - Electronic power converters coupled to the electrical network and their topologies	Single-phase and three-phase uncontrolled rectifiers Single-phase and three-phase semi-controlled and controlled rectifiers
Subject 1.4 - DC / AC Electronic power converters	Part 1 Single phase inverter PWM modulation Harmonics and amplitude control Part 2 Three phase inverters Single-phase and three-phase AC-AC converters AC control

Laboratory Block 1 - Power Electronics Laboratory	Session 1.1 - Introduction to the laboratory, analysis of measurements and use of the simulator Session 1.2 - Simulation of single-phase rectifier circuits Session 1.3 - Three-phase rectification Session 1.4 - Simulation of single-phase inverter circuits. PWM modulation. Session 1.5 - Single phase inverter. PWM modulation.
Block 2 - Automatic Control	
Subject 2.1 - Introduction to control systems	Feedback Modeling and simulation Continuous systems
Subject 2.2 - Analysis of continuous-time systems	Time and frequency response Stability and robustness
Subject 2.3 - Industrial regulators	Design goals PID regulators Practical aspects in the implementation of regulators
Subject 2.4 - Analysis of discrete-time systems	Discrete systems and Z transform Sampling and reconstruction Modeling and simulation Time and frequency response Stability and robustness
Subject 2.5 - Synthesis of regulators in discrete time	Design goals Performance evaluation Analytical design through the roots locus and Bode diagram Discretization of continuous regulators
Laboratory Block 2 - Automatic Control Laboratory	Session 2.1 - Modeling and simulation of continuous systems Session 2.2 - Analysis of systems in continuous time Session 2.3 - Industrial regulator I. Operation and parameterization. Session 2.4 - Industrial regulator II. Design and implementation Session 2.5 - Simulation in discrete time. Design and digital Control.

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	0	4	4
Previous studies	0	64	64
Lecturing	36	0	36
Problem solving	16	24	40
Laboratory practices	20	0	20
Autonomous problem solving	0	52	52
Other	0	3	3
Self-assessment	1	0	1
Practices report	3	2	5

*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	Awareness of the previous knowledge necessary to face the subject. In advance of the start of the face-to-face sessions, students will have a detailed list of the knowledge they must have acquired throughout their previous training, which will be necessary to successfully complete the subject.
Previous studies	Previous preparation of the classroom theoretical sessions: In advance of the theoretical sessions, the students will have a series of materials to prepare, since they will cover these sessions. Previous preparation of the practical laboratory sessions: It is absolutely essential that, for a correct use, the student performs a prior preparation of laboratory practice sessions. For this purpose, specific instructions and material will be provided for each session with sufficient advance notice. The student must previously work on the materials provided and must also have prepared the theoretical aspects necessary to address the session. This preliminary preparation will be an element that will be taken into account when evaluating each practical session.

Lecturing	They will be developed in the schedules fixed by the direction of the center. They will consist of an exposition, on the part of the professors, of relevant aspects of the subject that will be related to the materials that previously the students had to work. In this way the active participation of the students is encouraged, who will have the opportunity to express doubts and questions during the session. When it is timely or relevant, we will proceed to solve examples and / or problems that adequately illustrate the problem to be treated. To the extent that the size of the groups allows it, the most active participation possible of the students will be encouraged.
Problem solving	During the lectures, when appropriate or relevant, will proceed to solve examples and / or problems that adequately illustrate the problem to be treated. To the extent that the size of the groups allows it, the most active participation possible of the students will be encouraged.
Laboratory practices	482/5000 They will be developed in the schedules fixed by the direction of the center. The sessions will be supervised by the professors, who will control the attendance and will value the use of them. During the practice sessions the students will carry out activities of the following types: - Simulation of circuits and systems - Calculation, assembly and measurement of circuits and systems At the end of each practice session each group will deliver the corresponding results sheets.
Autonomous problem solving	477/5000 Study of consolidation and review of the master sessions: After each theoretical classroom session the student should systematically carry out a consolidation and review study, where all doubts related to the subject should be resolved. The doubts or unresolved aspects should be exposed to the teacher as soon as possible, so that he / she uses those doubts or questions as an element of feedback of the teaching-learning process.

Personalized attention

Methodologies	Description
Laboratory practices	
Autonomous problem solving	

Assessment

	Description	Qualification	Training and Learning Results

Other	The Final Exam, to be held on the date and time according to the official school calendar, will consist of a written test, with a score of 0 to 10 points, individual and face-to-face. It will correspond to 60% of the final grade of each block. Power electronics block It will consist of four parts EEP1, EEP2, EEP3 and EEP4, with contents EP1, EP2, EP3 and EP4 respectively. Each part may consist of a combination of the following types of exercises: test questions, questions and / or exercises. The first (EEP1), the second (EEP2) and the third (EEP3) part of the Final Exam are compulsory for those students with a grade lower than 5 points in the respective partial tests PEP1, PEP2 and PEP3. Students with a grade equal to or higher than 5 in PEP1, PEP2 and / or PEP3 are exempt from submitting to EEP1, EEP2 and / or EEP3, respectively, provided that in the fourth part of the Final Exam (EEP4) they obtain a higher grade to zero. The fourth part of the Final Exam (EEP4) is mandatory for all students. In case of not presenting to the fourth part of the Final Exam (EEP4), or not to obtain a note superior to zero, the note of the block (BEP) is calculated with the following formula BEP = LEP * 0.2 + PEP1 * 0.067 + PEP2 * 0.067 + PEP3 * 0.067 With a grade higher than zero in the fourth part of the Final Exam (EEP4), the corresponding note of the block (BEP) is calculated with the following algorithm: If PEP1 & gt; = 5, then TEP1 = PEP1 * 0.2; If PEP1 & lt; 5, then TEP1 = EEP1 * 0.133 + PEP1 * 0.067; If PEP2 & gt; = 5, then TEP2 = PEP2 * 0.2; If PEP2 & lt; 5, then TEP2 = EEP2 * 0.133 + PEP2 * 0.067; If PEP3 & gt; = 5, then TEP3 = PEP3 * 0.2; If PEP3 & lt; 5, then TEP3 = EEP3 * 0.133 + PEP3 * 0.067; TEP4 = EEP4 * 0.2 BEP = LEP * 0.2 + TEP1 + TEP2 + TEP3 + TEP4 Automatic regulation block It will consist of three parts ERA1, ERA2 and ERA3, with contents RA1, RA2 and RA3 respectively. Each part may consist of a combination of the following types of exercises: test questions, questions and / or exercises. The first (ERA1) and second (ERA2) parts of the Final Exam are compulsory for those students with a grade lower than 5 points in the respective partial tests PRA1 and PRA2. Students with a grade equal to or higher than 5 in PRA1 and / or PRA2 are exempt from submitting to ERA1 and / or ERA2, respectively, provided that in the third part of the Final Exam (ERA3) they obtain a grade higher than zero. The third part of the Final Exam (ERA3) is compulsory for all students. In case of not attending the third part of the Final Exam (ERA3), or not obtaining a grade higher than zero, the block mark (BRA) is calculated with the following formula BRA = LRA * 0.2 + PRA1 * 0.1 + PRA2 * 0.1 With a grade higher than zero in the third part of the Final Exam (ERA3), the corresponding note of the block (BRA) is calculated with the following algorithm: If PRA1 & gt; = 5, then TRA1 = PRA1 * 0.3; If PRA1 & lt; 5, then TRA1 = ERA1 * 0.2 + PRA1 * 0.1; If PRA2 & gt; = 5, then TRA2 = PRA2 * 0.3; If PRA2 & lt; 5, then TRA2 = ERA2 * 0.2 + PRA2 * 0.1; TRA3 = ERA3 * 0.2 BRA = LRA * 0.2 + TRA1 + TRA2 + TRA3 Minutes of the Minutes The note of the minutes (NA), which comes from the notes in the blocks, is calculated with the following algorithm: If BEP & gt; = 5 & BRA & gt; = 5, then NA = BEP * 0.5 + BRA * 0.5 Yes BEP & lt; 5 or BRA & lt; 5, then NA = MINIMUM (BEP, BRA)	60	B3 C12 D2 C25 D3 C26 D9 D16

Self-assessment	All students will be evaluated continuously throughout the semester. Those students who have been granted the waiver of continuous assessment by the school, the procedure is detailed in the section "Waiver of continuous assessment". Due to the multidisciplinary character of the subject, it has been divided into two blocks: - Block 1 - Power electronics (EP) - Block 2 - Automatic regulation (RA) The evaluation of each of the blocks follows the same methodologies. The note of each one of the blocks will be composed of: - 20% of the internship note (see Internship report) - 80% of theory grade, of which 20% is a continuous assessment grade (Self-assessment) and 60% is the final exam grade (see Other) Each of the blocks ponders in the final grade of the subject to 50%, provided that the grade obtained in each block is approved or higher. If one of the blocks is suspended, the final grade of the subject will be the one obtained in said block. If the two blocks are suspended, the final grade of the subject will be the lowest of those obtained in the blocks. Ordinary Calls Ordinary calls are those of January and June / July Theory evaluation of the power electronics block BEP: block note The theory evaluation note is obtained by the same method in the two calls (January and June / July) The theoretical contents of the Power Electronics block are evaluated in four parts, with a score of 0 to 10 each: - EP1: Topics 1.1 and 1.2 - EP2: Topic 1.3 - EP3: Topic 1.4 part 1 - EP4: Topic 1.4 part 2 The evaluation in partial theory will be carried out during theory class hours. It will consist of three written tests, individual and face-to-face, lasting 20 minutes (approximately) each. It will correspond to 20% of the final grade in the block, and if approved, release the final exam. In the partial test 1 (PEP1) the EP1 content is evaluated, in the partial test 2 (PEP2) the EP2 content is evaluated and in the partial test 3 (PEP3) the EP3 content is evaluated. The tests may consist of a combination of the following types of exercises: test questions, questions and / or exercises. The marks obtained in PEP1, PEP2 and PEP3 will be valid for the calls of January and June of this course. Theory evaluation of the automatic regulation block BRA: block note The theory evaluation note is obtained by the same method in the two calls (January and June / July) The theoretical contents of the automatic regulation block are evaluated in three parts, with a score of 0 to 10 each: - RA1: Themes 1, 2 (content Temporal analysis, Stability, LR) - RA2: Topics 2 (content Frequency analysis), 3 and 4 (discrete Modeling content) - RA3: Topics 4 and 5 The evaluation in partial theory will be carried out during theory class hours. It will consist of two written tests, individual and face-to-face, lasting 20 minutes (approximately) each. It will correspond to 20% of the final grade in the block, and if approved, release the final exam. In the partial test 1 (PRA1) the content RA1 is evaluated, and in the partial test 2 (PRA2) the content RA2 is evaluated. Both tests may consist of a combination of the following types of exercises: test questions, questions and / or exercises. The marks obtained in PRA1 and PRA2 will be valid for the calls of January and June of this course.	20	B3 C12 D2 C25 D9 C26 D10 D16

Practices report	The laboratory practices will be evaluated continuously (session to session) with a score of 0 to 10 each, obtaining the average grade as a laboratory note (LEP or LRA). It will correspond to 20% of the final grade of the block. The evaluation criteria are: - Minimum attendance of 83% (5 of 6 practice sessions per block). - Puntuality. - Previous preparation of the practice. - Delivery of requested exercises. - Attitude and use of the session. - Compliance with the objectives set. The laboratory note for the calls of January and June will be LEP for the block of Power Electronics and LRA for the block of Automatic Regulation. The practical sessions will be carried out in groups. The statements of the practices will be available to students in advance. The students will fill out a set of results sheets, which they will deliver at the end of the practice, and which will justify their attendance and allow them to assess their use.	20	B3	C12 C25 C26	D3 D6 D9 D10 D16 D17

Other comments on the Evaluation

Extraordinary Calls

Students who have passed the laboratory by continuous assessment may maintain the grade previously achieved (LEP and LRA). If they have not done the practices, they are evaluated with zero.

The Examination of the Extraordinary Convocation, to be held on the date and time according to the official calendar of the school, will consist of a written test, with a score of 0 to 10 points, of an individual and face-to-face character. It will correspond to 80% of the final grade of the block.

The power electronics block will consist of four parts EEP1, EEP2, EPP3 and EEP4, with contents EP1, EP2, EP3 and EP4 respectively. Each part may consist of a combination of the following types of exercises: test questions, questions and / or exercises. The EEP note is calculated as:

EEP = EEP1 * 0.2 + EEP2 * 0.2 + EEP3 * 0.2 + EPP4 * 0.2

The automatic regulation block will consist of three parts ERA1, ERA2 and ERA3, with contents RA1, RA2 and RA3 respectively. Each part may consist of a combination of the following types of exercises: test questions, questions and / or exercises. The ERA note is calculated as:

ERA = ERA1 * 0.3 + ERA2 * 0.3 + ERA3 * 0.2

The note of the minutes (NA) is calculated with the following algorithm:

BEP = LEP * 0.2 + EEP

BRA = LRA * 0.2 + ERA

If BEP> = 5 and BRA> = 5, then NA = BEP * 0.5 + BRA * 0.5

If BEP = 5, then NA = BEP * 0.5 + BRA * 0.5

If BEP

Sources of information

Basic Bibliography

Rashid, Muhamad H., **Electrónica de Potencia**, Pearson-Prentice Hall, 2004

Dorf, R.C., Bishop, R.H., **Sistemas de Control Modernos**, Addison-Wesley, 2005

Complementary Bibliography

Barrado Bautista, A. y Lázaro Blanco, A., **Problemas de Electrónica de Potencia**, Pearson-Prentice Hall, 2012

Moreno, L., Garrido, S., Balaguer, C., **Ingeniería de Control: Modelado y Control de Sistemas Dinámicos**, Ariel, 2003

Recommendations

Subjects that it is recommended to have taken before

Computer science: Computing for engineering/V12G320V01203
Mathematics: Algebra and statistics/V12G320V01103
Mathematics: Calculus 1/V12G320V01104
Mathematics: Calculus 2 and differential equations/V12G320V01204
Fundamentals of electronics/V12G320V01404

Other comments

It is very important that the students keep updated the profile in the FAITIC platform. All communications related with this course will be made through this platform. All individual communications will be made through the email listed in this platform.

The students can solve doubts related with the laboratory previous activities in the personal attention hours (tutoring time), or by any other contact procedure available in FAITIC.

The students must meet the deadlines for all the activities.

The translations to Galician and English are for informative purposes. In case of discrepancies, the Spanish version of this guide will prevail.
All the achieved results must be justified, in any of the exams or activities. No result will be considered valid unless an appropriate explanation of how it was found is provided. The selected method for solving a problem is considered when grading the solution.

When writing the solutions and answers in reports and tests, avoid spelling mistakes and unreadable symbols.

Exams lacking some of the sheets will not be graded.

Use of cell phones, notes or books is forbidden during exams.

The translations to Galician and English are for informative purposes. In case of discrepancies, the Spanish version of this guide will prevail.