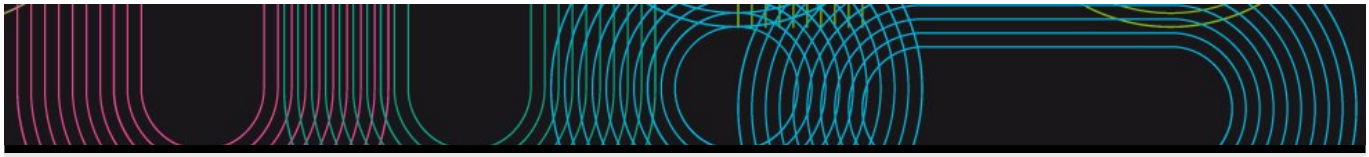

IDENTIFYING DATA				
Power electronics and automatic control				
Subject	Power electronics and automatic control			
Code	V12G320V01501			
Study programme	Grado en Ingeniería Eléctrica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	9	Mandatory	3rd	1st
Teaching language	Spanish			
Department				
Coordinator	Delgado Romero, Mª Emma Gómez Yepes, Alejandro			
Lecturers	Delgado Romero, Mª Emma Gómez Yepes, Alejandro			
E-mail	emmad@uvigo.es agyepes@uvigo.es			
Web	http://moovi.uvigo.gal/			
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.			

Training and Learning Results	
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.

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
Practical Block 1 - Laboratory of electronics of power	Practice 1.1 - Introduction to the simulation with PSIM. Practice 1.2 - Introduction to the laboratory of electronics of power. Practice 1.3 - Simulation of circuits rectifiers no controlled. Practice 1.4 - Three phase rectifiers. Practice 1.5 - Simulation of single-phase inverter circuits and PWM modulation . Practice 1.6 - Single-phase inverter and 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
Practical Block 2 - Laboratory of automatic regulation	Practice 2.1 - Modelling and simulation of continuous systems with Simulink of Matlab Practical 2.2 - Modelling and simulation of continuous systems with Control System Toolbox of Matlab Practical 2.3 - Analysis in the time domain of continuous systems time 2.4 - Frequency response and graphics Practical 2.5. Analyses in frequency domain with Sisotool of Matlab Practical 2.6 Digital Systems: simulation and analysis with Z transform.

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 practical	20	0	20
Autonomous problem solving	0	52	52
Self-assessment	1	0	1
Report of practices, practicum and external practices	3	2	5
Objective questions exam	0	2	2
Essay questions exam	0	1	1
*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 practical	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 assistance

Methodologies	Description
Laboratory practical	
Autonomous problem solving	

Assessment

	Description	Qualification	Training and Learning Results

Self-assessment	All the students will be evaluated of continuous form along the course. Those students to which have been them conceded the renunciation to the continuous evaluation by part of the school, the procedure finds detailed in the section "Continuous evaluation waivers". Because of the multidisciplinary character of the subject, has divide the same in two blocks: - Block 1 - The electronics of power (EP) - Block 2 - The automatic regulation (RA) The evaluation of each one of the blocks follows the same methodologies. The note of each one of the blocks will be composed by: - 20% of the note of practices (see Report of practices) - 80% of note of theory, in which in the case of the block EP 44,5% is note of continuous evaluation and 35,5% is the note of the final examination (see Examination of objective questions), and in the case of the block RA 40% is note of continuous evaluation and 40% is the note of the final examination (see Examination of objective questions). Each one of the blocks pound in the final note of the subject to 50%, whenever the note obtained in each block was approved or upper. If it suspends one of the blocks, the final note of the subject will be the obtained in said block. If they suspend the two blocks, the final note of the subject will be the minor of the obtained in the blocks. Ordinary announcements consider ordinary announcements the one of January and June/Julio. Evaluation of theory of the block of electronics of power BEP: note of the block The note of evaluation of theory obtains by the same method in the two announcements (January and June/Julio) The theoretical contents of the block of Electronics of Power evaluate in three parts, with a punctuation of 0 to 10 each one: - EP1: Subjects 1.1 and 1.2 - EP2: Subject 1.3 - EP3: Subject 1.4 The continuous evaluation of the theory will do in partial of theory and will correspond to 35.5% of the final note of the block. It will consist in three proofs written, of individual and face-to-face character, of length 25 minutes (roughly) each one. In the partial proof 1 (PEP1) evaluates the content EP1, in the partial proof 2 (PEP2) evaluates the content EP2 and in the partial proof 3 (PEP3) evaluates the content EP3. The partial proofs PEP1 and PEP2 will carry out in schedule of classes of theory, and in case to approve , free matter of the final examination. The partial proof PEP3 will make in the week enabled by the school for proofs of continuous evaluation of the course and is compulsory for all the students. In case of not to present to the third partial (PEP3), or not obtaining an upper note to zero, the note of the block (*BEP) calculates with the following formula: BEP = LEP * 0,2 + PEP1 * 0,089 + PEP2 * 0,089 where LEP is the note of laboratory of the block (See Report of practices). The proofs will be able to consist of a combination of the following types of exercises: questions of type test, questions and/or exercises. The notes obtained in PEP1, PEP2 and PEP3 will be valid for the announcements of January and June of this course. Evaluation of theory of the block of automatic regulation BRA: note of the block The note of evaluation of theory obtains by the same method in the two announcements (January and June/July) The theoretical contents of the block of automatic regulation evaluate in three parts, with a punctuation of 0 to 10 each one: - RA1: Subjects 1, 2 (part) - RA2: Subjects 2 (part), 3 and 4 (part) - RA3: Subjects 4 (part) and 5 The continuous evaluation of the theory will do in partial of theory. It will consist in three proofs written, of individual and face-to-face character, of length 25 minutes (roughly) each one. It will correspond to 40% of the final note of the block. In the partial proof 1 (PRA1) evaluates the content RA1, in the partial proof 2 (PRA2) evaluates the content RA2 and in the partial proof 3 (PRA3) evaluates the content RA3. The partial proofs PRA1 and PRA2 will carry out in schedule of classes of theory, and in case to approve , free matter of the final examination. The partial proof PRA3 will make in the week enabled by the school for proofs of continuous evaluation of the course and is compulsory for all the students. In case of not to present to the third partial (PRA3), or not obtaining an upper note to zero, the note of the block (BRA) calculates with the following formula: BRA = LRA * 0,2 +PRA1 * 0,1 + *PRA2 * 0,1 where LRA is the note of laboratory of the block (See Report of practices). The proofs will be able to consist of a combination of the following types of exercises: questions of type test, questions and/or exercises. The notes obtained in PRA1, PRA2 and PRA3 will be valid for the announcements of January and June of this course.	40	B3	C12 C25 C26	D2 D9 D10 D16

Report of practices, practicum and external practices	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
Objective questions exam	The Final Exam is composed by the Objective questions exam and the Essay questions exam, This exam will be held on the date and time according to the official school calendar, with a score of 0 to 10 points, individual and face-to-face. It will correspond to 40% of the final grade of each block. Power Electronics Block It will consist of two parts EEP1 and EEP2 , with contents EP1 and EP2 respectively. Each part may consist of a combination of the following types of exercises: test questions, questions and / or exercises. The first part (EEP1) and the second part (EEP2) of the Final Exam are compulsory for those students with a grade lower than 5 points in the respective partial tests PEP1 and PEP2. Students with a grade equal to or higher than 5 in PEP1 and / or PEP2 are exempt from submitting to EEP1 and / or EEP2, respectively, provided that in the third part of partial exam (PEP3) they obtain a higher grade to zero. The third part of the partial Exam (PEP3) is mandatory for all students. In case of not presenting to the third part of the partial Exam (PEP3), or not obtaining a mark superior to zero, the note of the block (BEP) is calculated with the following formula: BEP = LEP * 0,2 + PEP1 * 0,089 + PEP2 * 0,089 With a grade higher than zero in the third part of the Final Exam (EEP3), the corresponding note of the block (BEP) is calculated with the following algorithm: If PEP1 >= 5, then TEP1 = PEP1 * 0.267; If PEP1 < 5, then TEP1 = EEP1 * 0,178 + PEP1 * 0,089; If PEP2 >= 5, then TEP2 = PEP2 * 0,267 ; If PEP2 < 5, then TEP2 = EEP2 * 0,178 + PEP2 * 0,089; TEP3 = PEP3 * 0,267 BEP = LEP * 0,2 + TEP1 + TEP2 + TEP3 Automatic Regulation Block It will consist of two parts ERA1 and ERA2, with contents RA1 and RA2 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 partial Exam (PRA3) they obtain a grade higher than zero. In case of not attending the third part of the partial Exam (PRA3), 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 partial Exam (PRA3), the corresponding note of the block (BRA) is calculated with the following algorithm: If PRA1 >= 5, then TRA1 = PRA1 * 0.3; If PRA1 < 5, then TRA1 = ERA1 * 0.2 + PRA1 * 0.1; If PRA2 >= 5, then TRA2 = PRA2 * 0.3; If PRA2 < 5, then TRA2 = ERA2 * 0.2 + PRA2 * 0.1; TRA3 = PRA3 * 0.2 BRA = LRA * 0.2 + TRA1 + TRA2 + TRA3 Final Score on the Subject Act The note of the subject act (NA), which comes from the notes in the blocks, is calculated with the following algorithm: If BEP >= 5 and BRA >= 5, then NA = BEP * 0.5 + BRA * 0.5 If BEP < 5 or BRA < 5, then NA = MINIMUM(BEP, BRA)	40	B3	C12 C25 C26	D2 D9 D16

Essay questions exam	See the explanation on the previous point: Objective questions exam	0	B3 C12 D3 C25 D9 C26 D16	

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 three parts EEP1, EEP2 and EEP3, with contents EP1, EP2 and EP3 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 * 0.267 + EEP2 * 0.267 + EEP3 * 0.267

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.