Universidad de Alcalá

ELECTRONIC CONTROL ENGINEERING

Degree in Electronic Engineering and Industrial Automation

University of Alcalá

Academic Year 2019/2020

3rd Year – 2nd Semester

TEACHING GUIDE

Name of the course:	**ELECTRONIC CONTROL ENGINEERING**
Code:	**600020**
Degree:	**Graduate in Electronic Engineering and Industrial Automation**
Department & Area of Knowledge:	**Electronics / Electronic Technology**
	Compulsory
ECTS credits:	**6**
Year & semester:	**3rd year / 2nd semester**
Teachers:	**View website (UAH Virtual Platform)**
Office hours:	**View website (UAH Virtual Platform)**
Language Classes Offered:	**English / Spanish**

1. INTRODUCTION

The aim of this course is twofold. On the one hand, the student completes his training in control engineering, dealing with the analysis and synthesis of multivariable control in the state space domain as well as the understanding of advanced control techniques. On the other hand, the student applies the theoretical knowledge by implementing the electronic controller in a hardware platform. The student thus completes the design cycle in control systems: plant modelling, control design, simulation, electronics implementation and results validation.

The main concepts covered in the course are the following: plant modelling and parameter identification based on experimentation, fundamentals of multivariable control, design of servo-systems and observers based on eigenvalue relocation, basics of optimal control and optimal estimation and electronic control implementation of motion actuators (driving and steering) based on DC motor.

For better understanding of the course, it will be necessary to have prior knowledge acquired in the courses of Control Engineering I and II.

2. COMPETENCES

Competences of generic and professional nature:

This course will enable the student to acquire the following skills, as defined in Section 3 of the Annex to the Order CIN/352/2009:

- TR2**:** knowledge of basic topics and technologies that enable to learn new methods and technologies, as well as providing the student with high capacity to adapt to new situations.

- TR3: Ability to solve problems showing initiative, take decisions, creativity, critical reasoning and knowledge communication, skills and capabilities in the field of Industrial Engineering.

- TR4: Knowledge applicable to make measurements, calculations, estimations, technical valuations, working plans and reports and other similar work.

- TR5 **-** Ability to handle mandatory specifications, regulations and standards.

- TR9: Ability to work in a multilingual and multidisciplinary environment.

Professional competences:

This course will also enable the student to acquire professional skills, as defined in Section 5 of the Annex to the Order CIN/351/2009.

CEI7 - Knowledge and capacity for modeling and simulation.

CEI8 - Knowledge of automatic regulation and control techniques and their application to industrial automation.

CEI11 - Ability to design control systems and industrial automation.

Learning results

LR14 - Recognize techniques of multivariable control and advanced control.

LR15 - Identify digital electronic control systems and their industrial applications.

LR16 - Design electronic control systems.

LR17 - Apply tools to design and implement computer-aided control of real prototypes

3. CONTENTS

Content units	Total class hours (Lec / Lab)
Introduction. Teaching guide: competence, learning outcomes, content and course evaluation.	2 / 0
Identification and electronic control of a real system. Application of modeling and identification techniques on real platforms. Implementation of digital controllers.	4 / 12
Fundamentals of multivariable control (MVC). MVC properties. Representation of systems in the state space. Discretization. Solving the state space system of equations. Stability, controllability and observability.	8 / 0
Design of controllers and observers in the state space. Techniques for MVC by state vector feedback. Regulation. Servosystem. Full and reduced observer.	12 / 8
Advanced control techniques. Reviewing advanced control techniques. Optimal control techniques. Optimal estimation techniques.	4 / 2

Students are also provided, on the **course website** (UAH virtual platform: http://www.uah.es/aula_virtual), with a detailed description of each lesson that includes:

- Contents each in-person classes.
- Available resources for each lesson.
- Work that the students must perform before and after classes in the hours allotted for their work.

Timetable (Indicative)

Week	Content	
	Large Group	Small Group
01st	Introduction. Fundamentals of MVC	Design and implementation tools for control systems assisted by computer
02 nd	Modeling systems in St-Sp domain	Study of actual prototype to be controlled
03 rd	Discretization of systems in St-Sp domain	Modeling a real system
04 th	State equation solution	Identification of a real system
05 th	Stability, controllability, observability	Design of speed PID Control
06 th	Regulation	Computer implementation of PID control (I)
07 th	Tracking reference	Computer implementation of PID control (II)
08 th	PEI1 Mid-term evaluation	EPL1 first deliverable (week limit delivery)
09 th	Full observer	St-Sp modeling and identification of a real plant
10 th	Reduced observer	Servo system design in St-Sp domain
11 th	Introduction to advanced control	Design of observer in St-Sp domain
12 th	Optimal control techniques	St-Sp control implementation for real prototype (I)
13 th	Optimal estimation techniques	St-Sp control implementation for real prototype (II)
14 th	PEI2 Mid-term evaluation	EPL2 second deliverable (week limit delivery)

4 hours/week, 2 theory hours (large group) + 2 laboratory hours (small group)

4. METHODOLOGY OF TEACHING AND LEARNING. TRAINING ACTIVITIES

4.1. Credit distribution

Hours in a classroom setting:	58 hours (52 in-person classes + 4 hours interim tests+ 2 hours final evaluation)
Time of student work on their own:	92 hours
Total:	150 hours

4.2. Methodological strategies, teaching materials and resources

In the teaching-learning process the following training activities will be held:
• Lectures (theoretical classes): large groups
• Practical classes (problems solving): large groups
• Lab classes: small groups
• Tutorships: individual and/or group
• Student work, before and after classes. This work will be supported by the information available for each topic at the website of the course (UAH Virtual platform)

In coordination with the lectures, practical classes oriented to problem solving and lab classes, where students can apply the acquired control concepts to real and/or simulated prototypes, are proposed.

To carry out the practice, the student will have the required material for digital implementation of control solutions: a computer with design/simulation tools, electronic cards and mechatronic platform to be controlled. Plant and controller are linked by an Ethernet network.

Students will be provided throughout the semester with tutorship in group (if requested by the students themselves) or individual. Whether individually or in small groups, this tutorship will resolve doubts and consolidate the acquired knowledge. Also it will help to make appropriate monitoring and assess the proper functioning of the mechanisms of teaching and learning.

Finally, the whole development of the subject will be detailed on the website of the course (UAH Virtual platform). All resources developed for the subject, such as slides, exercise statements and solutions, statements of problems for practices, detailed schedules for each group and class, mid-term exams marks and any other information that teachers consider appropriate for the proper teaching-learning process will be available on the website.

5. ASSESSMENT: Procedures, assessment and marking criteria

Students have two methods of assessment: continuous or final assessment. To optimize the teaching-learning process, teachers of this course urge students to choose the continuous model but respecting the regulations of the University of Alcalá, an alternative final-exam assessment process is offered. Observing these rules, *students will have a period of fifteen days from the course begin to apply their intention to invoke the final assessment model providing relevant reasons. Written applications must be addressed to Polytechnic University School Director***.** The evaluation of the learning process for those students who do not request non-continuous assessment or whose application is refused will be done, by default, according to the model of continuous assessment, described in following paragraphs.

Continuous assessment implies and/or allows for the following:

- The student knows, by means of real and objective tests, his evaluation criteria.
- The student knows regularly the results of his learning process.
- Provide the teacher with objective information about subject evolution
- Intermediate tests release contents from the final test.

According to current UAH regulations (rules governing the processes of learning assessment approved by the Governing Council of March 24, 2011, Article 6, paragraph 4), and, as long as the laboratory module is considered as an essential part to reach the capacities aimed by the Electronic Control Engineering course, **attendance to all the lab practices, as well as successfully completing them, is considered as an essential and also compulsory element** for the course assessment, either under continuous assessment or final evaluation format. **For this reason, lab practices are common and mandatory, both for continuous and final assessment too.**

5.1 Assessment Criteria

Assessment criteria must address the degree of acquisition of learning outcomes by the student. For this purpose the following criteria are defined:

AC1: The student shows ability and initiative for modeling real systems, identifying linear and nonlinear components.

AC2: The student can perform the complete design of reference tracking system for a multivariable plant compensating for external disturbances.

AC3: The student demonstrates his availability to design deterministic observers as part of a complete multivariable control system.

AC4: The student is able to integrate knowledge of electronics, communications and control theory and apply them in real implementation.

AC5: The student has acquired sufficient technical knowledge to compare simulated and experimental results of a multivariable control system.

5.2 Assesment procedure (tools)

The following assessment tools will be used:

1. **Ordinary call:**

   1.a) Continuous assessment: The theoretical part of the course will be evaluated by two mid-term exams (PEI1 and PEI2). The lab part will be evaluated by performing two practices with their corresponding deliverable (EPL1 and EPL2) and individual defense. Students who have passed the PEIs and the EPLs are exempt from the final exam (PEF), obtaining the mark as the average of the PEIs and the Es rating. The final assessment (PEF) of the theoretical part will consist of a final exam, with two components (PEF1,2) to facilitate the recovery of each previous mid-term evaluation. The PEF of the practical part will consist of a single final practice.

   1.b) *Non-Continuous assessment:* The theoretical part will consist of a single exam covering all theoretical learning outcomes set for the course. The practical part will consist of the design and implementation of a final practice covering all practical learning established for the course.

2. **Extraordinary call:**

   2.a) Theoretical part. It will consist of a single exam covering all theoretical learning outcomes set for the course.

   2.b) Practical part. It will consist of the design and implementation of a final practice covering all practical learning established for the course.

5.3 Assessment procedure (marking criteria)

Continuous assessment, ordinary call

<table>
<tr><th>Competences</th><th>Learning results</th><th>Assessment criteria</th><th colspan="3">Assessment tool</th><th>Evaluation weights</th></tr>
<tr><td rowspan="4">TR2, TR3, TR5, CEI7, CEI8, CEI11</td><td rowspan="4">LR15, LR16</td><td rowspan="4">AC1, AC2, AC3</td><td rowspan="2">PEI1</td><td>Test</td><td rowspan="4">$PEF_{1,2}$</td><td>7,5%</td></tr>
<tr><td>Exercises</td><td>17,5%</td></tr>
<tr><td rowspan="2">PEI2</td><td>Test</td><td>7,5%</td></tr>
<tr><td>Exercises</td><td>17,5%</td></tr>
<tr><td rowspan="2">TR4, TR5, TR9 CEI11</td><td rowspan="2">LR14, LR17</td><td rowspan="2">AC1, AC4, AC5</td><td colspan="2">E1</td><td rowspan="2">PEF_{LAB}</td><td>25%</td></tr>
<tr><td colspan="2">E2</td><td>25%</td></tr>
</table>

Students shall be deemed to have passed the course (demonstrating the achievement of the theoretical and practical learning outcomes) following continuous assessment if these requirements are met:

• Have successfully passed the **theoretical exams** (PEIs and PEF if required). It means that a student satisfactorily achieves the results of theoretical learning if its rating on the set of theoretical exams is equal to or greater than 50% of the maximum possible score having obtained a minimum score in each of the parties, PEI1-PEF_1 and PEI2-PEF_2 of at least 40% of the maximum score.

• Have successfully passed **laboratory practices** (EPLs and PEF). It means that a student successfully acquires the results of practical learning, if he/she attends at least 80% of the laboratory sessions, completes all practices and his/her related exam score is equal to or greater than 50% of the maximum obtainable score.

• The **final mark**, having passed the theoretical part and the practical part will result from the weighted average of both.

• Students who follow the model of continuous assessment and are evaluated on two or more exams of the four possible (2 PEI, 2 EPL) shall be considered submitted (presented) in the ordinary call.

Final assessment, ordinary call

Competences	Learning results	Assessment criteria	Assessment tool	Evaluation weights
TR2, TR3, TR5, CEI7, CEI8, CEI11	LR2, LR3	AC1, AC2, AC3	PEF_{THEORY}	50%
TR4, TR5, TR9, CEI11	LR1, LR4	AC1, AC4, AC5	PEF_{LAB}	50%

Students shall be deemed to **have passed the course** (demonstrating the achievement of the theoretical and practical learning outcomes) if both parts, theory and laboratory, are independently overcome. The final mark is the average of the scores of both parts.

Final assessment, extraordinary call

Competences	Learning results	Assessment criteria	Assessment tool	Evaluation weights
TR2, TR3, TR5, CEI7, CEI8, CEI11	LR2, LR3	AC1, AC2, AC3	PEF_{THEORY}	50%
TR4, TR5, TR9, CEI11	LR1, LR4	AC1, AC4, AC5	PEF_{LAB}	50%

As for the ordinary call, students shall be deemed to **have passed the course** (demonstrating the achievement of the theoretical and practical learning outcomes) if both parts, theory and laboratory, are independently overcome. The final mark is the average of the scores of both parts.

6. BIBLIOGRAPHY

Basic bibliography

- Documentation developed by the teachers of the course.
- Sistemas de Control en Tiempo Discreto. 2ª Edición. Autor: K. Ogata. Editorial: Prentice Hall.
- Multivariable feedback control. Analysis and design. Autor: S. Skogestad and I. Postlehwaite. Editorial John Wiley & Sons.
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Complementary bibliography

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- Modern Control Systems. 12 edition. Authors: R. Dorf and R.H. Bishop. Edit Pearson 2011.
- Digital Control Engineering. Analysis and design. Author: M. Sam Fadali. Edit. Elsevier. 2009.
- The Art of Control Engineering. Authors: K. Dutton y otros. Edit. AddisonWesley.
- An introduction to the Kalman Filter. Authors: G. Welch and G. Bishop. TR95-041. May. 23, 2003.
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- System Identification: Theory for the User. 2nd Edition. Author: Lennart Ljung. Prentice-Hall 1999.