Universidad de Alcalá

TEACHING GUIDE

Electronic Control Engineering

Degree in Industrial Electronics and Automatics Engineering

Universidad de Alcalá

Academic Year 2024/2025

3rd Year - 2nd Semester

Approved by the EPS School Board on June 14th, 2024

TEACHING GUIDE

Course Name:	**Electronic Control Engineering**
Code:	**600020**
Degree in:	**Industrial Electronics and Automatics Engineering**
Department and area:	**Electrónica** **Electronic Technology**
Type:	**Compulsory**
ECTS Credits:	**6.0**
Year and semester:	**3rd Year, 2nd Semester**
Teachers:	View website (UAH Virtual Platform)
Tutoring schedule:	View website (UAH Virtual Platform)
Language:	English

1. COURSE SUMMARY

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 modeling, control design, simulation, electronics implementation, and validation. The main concepts covered in the course are the following: plant modeling 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 a better understanding of the course, it will be necessary to have prior knowledge acquired in the courses of Control Engineering I and II.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following generic skills, which are defined in the Section 3 of the Annex to the Orden CIN/351/2009:

en_TR2 - Knowledge in basic and technological subjects, which enables them to learn new methods and theories, and gives them versatility to adapt to new situations.

en_TR3 - Ability to solve problems with initiative, decision making, creativity, critical reasoning and to communicate and transmit knowledge, skills and abilities in the field of Industrial Engineering.

en_TR4 - Knowledge to carry out measurements, calculations, assessments, appraisals, appraisals, studies, reports, work plans and other similar works.

en_TR5 - Ability to handle specifications, regulations and mandatory standards.

en_TR9 - Ability to work in a multilingual and multidisciplinary environment.

en_TRU1 - Capacity of analysis and synthesis.

en_TRU2 - Oral and written competencies.

en_TRU3 - Ability to manage information.

en_TRU4 - Autonomous learning skills.

en_TRU5 - Team work.

Professional Skills

This course contributes to acquire the following professional skills, which are defined in the Section 5 of the Annex to the Orden CIN/351/2009:

en_CEI7 - Knowledge and capacity for modeling and simulation of systems.

en_CEI8 - Knowledge of automatic regulation and control techniques and their application to industrial automation.

en_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
Introduction. Teaching guide: competence, learning outcomes, content, and course evaluation.	2 hours
Identification and electronic control of a real system. Application of modeling and identification techniques on real platforms. Implementation of digital controllers.	16 hours
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 hours
Design of controllers and observers in the state space. State vector feedback for MVC. Regulation. Servosystem. Full and reduced observer.	20 hours
Advanced control techniques. Reviewing advanced control techniques. Optimal control techniques. Optimal estimation techniques.	6 hours

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

Timetable.

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

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

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	58 hours (56 hours on-site +2 exams hours)
Number of hours of student work:	92
Total hours	150

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 a mechatronic platform to be controlled. Plant and controller are linked by an Ethernet network.
Students will be provided throughout the semester with tutorship in groups (if requested by the students themselves) or individually. 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, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Learning Assesment Guidelines, LAG, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Learning Assesment Guidelines as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

Ordinary Call

Continuous Assessment:

The theoretical part of the course will be evaluated by one mid-term exam **PEI)** and one final exam (**PEF**). The lab part will be evaluated by performing two practices with their corresponding deliverable (**EPL1** and **EPL2**) and individual defense. The final subject assessment will result from the weighted average of the theoretical part (PEI-PEF) and the practical part (EPLs).

Assessment through final exam:

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.

The final course assessment will result from the weighted average of the theoretical part and the practical one.

Extraordinary Call

The procedure will be the same as that described for the assessment by means of a final exam in the ordinary call.

5.2. EVALUATION

EVALUATION 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 a 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 the 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.

GRADING TOOLS

This section specifies the evaluation instruments that will be applied to each one of the Evaluation criteria

- **Partial evaluation (PEI)** and **final one (PEF).** They consist of theoretical exams that may include:
  - Multiple-choice questions on basic aspects of the contents developed in class.
  - Exercises related to the analysis and design of controllers.
- **Deliverables of laboratory practices (EPL1** and **EPL2)**. The deliverables consist of a memory that collects the work done by the student in the laboratory sessions, including the critical analysis of results. Each student will be evaluated individually with questions associated with the deliverables.

GRADING CRITERIA

In the ordinary call-continuous assessment the relationship between the skills, learning results, evaluation criteria, and grading tool is as follows.

Skill	Learning Results	Evaluation Criteria	Grading Tool	Contribution to the final mark
TR2, TR3,TR5 CEI7,CEI8, CEI11	LR15, LR16	AC1, AC2, AC3	PEI	17,5%
			PEF	32,5%
TR4,TR5, TR9, CEI11	LR14, LR17	AC1, AC4, AC5	EPL1	25%
			EPL2	25%

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** (PEI and PEF). It means that a student satisfactorily achieves the results of theoretical learning if the global rating obtained on the set of theoretical exams is equal to or greater than 50% of the maximum possible score.
- Have successfully passed **laboratory practices** (EPLs). 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 (PEI, PEF, EPL1, EPL2) shall be considered submitted (presented) in the ordinary call.

In the ordinary call-final evaluation, the relationship between the skills, learning results, evaluation criteria, and grading tool is as follows.

Skill	Learning Results	Evaluation Criteria	Grading Tool	Contribution to the final mark
TR2, TR3,TR5 CEI7,CEI8, CEI11	LR15, LR16	AC1, AC2, AC3	PEF-Theory	50%
TR4,TR5, TR9, CEI11	LR14, LR17	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.

Extraordinary call

Skill	Learning Results	Evaluation Criteria	Grading Tool	Contribution to the final mark
TR2, TR3,TR5 CEI7,CEI8, CEI11	LR15, LR16	AC1, AC2, AC3	PEF-Theory	50%
TR4,TR5, TR9, CEI11	LR14, LR17	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.

6. BIBLIOGRAPHY

6.1. 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.
- Equipment guides, instrumentation, and software tools used in laboratory Electronic Control Engineering.

6.2. Additional Bibliography

- 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. Addison Wesley.
- An introduction to the Kalman Filter. Authors: G. Welch and G. Bishop. TR95-041. May. 23, 2003.
- Análisis, diseño y realización de sistemas electrónicos de control discreto. Autores: F.J. Rodríguez y otros. Servicio de publicaciones, Universidad de Alcalá.
- System Identification: Theory for the User. 2nd Edition. Author: Lennart Ljung. Prentice-Hall 1999.

Disclosure Note

During the evaluation tests, the guidelines set out in the Regulations establishing the Rules of Coexistence of the University of Alcalá must be followed, as well as the possible implications of the irregularities committed during said tests, including the consequences for committing academic fraud according to the Regulation of Disciplinary Regime of the Students of the University of Alcalá.