Universidad Zaragoza

**Academic Year/course: 2021/22**

# 29624 - Control Engineering

## Syllabus Information

**Academic Year:** 2021/22
**Subject:** 29624 - Control Engineering
**Faculty / School:** 110 - Escuela de Ingeniería y Arquitectura
**Degree:** 430 - Bachelor's Degree in Electrical Engineering
**ECTS:** 6.0
**Year:** 3
**Semester:** First semester
**Subject Type:** Compulsory
**Module:**

## 1. General information

### 1.1. Aims of the course

The subject and its expected results respond to the following approaches and goals:

There are two different types of goals:

Theoretical: It is intended that the student knows and manages with ease theoretical contents that support systems control using the computer. At the end of the subject the student will be able to:

- Understand the role of the computer as an element of control.
  Represent the behavior of systems and continuous signals in discrete domain, as well as the transformation between one domain to the other.
- Analyze and simulate the behavior of single or multi-variable systems in the discrete-time domain.
- Design and implement control algorithms and variables estimation.
- Understanding of the significance of distributed control and automation systems.
- Understanding architectures, buses and industrial communication networks.

Practical:

- The aim is for the student to be able to work with ease in a real control environment, applying and analyzing the practical scope of the theoretical learned contents. At the end of the subject the student will be able to:
- Simulate discretized single and multi-variable systems.
- Program controllers and estimators of single and multi-variable systems.
- Experiment with the systems to be controlled and with their corresponding models.
- Learn to experiment and use industrial controllers.

These approaches and goals are aligned with some of the Sustainable Development Goals, SDG, of the 2030 Agenda ( https://www.un.org/sustainabledevelopment/) and certain specific goals, in such a way that the acquisition of the Learning outcomes of the subject provides training and competence to the student to contribute to a certain extent to their achievement:

- Goal 7: Ensure access to affordable, reliable, sustainable and modern energy
  Target 7.3 By 2030, double the global rate of improvement in energy efficiency
- Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation
  Target 9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities

### 1.2. Context and importance of this course in the degree

Control engineering is a subject from specific technologies branch.
In this context, the advanced concepts of control of continuous systems are presented, addressing theoretical, programming

and implementation aspects as well as practical application.
The background of the students includes Mathematics, Physics, Electrical Engineering, Computer Science, and Automatic Systems. This subjects are requisites to understand the basic principles of the subject.

In this subject, the student learns how to analyze and design computer control systems managing continuous systems with techniques based on both external and internal representation.

At the end of the course the student is able to understand the advantages of systems control, its importance in industrial processes from the technical, economic and environmental point of view, as well as its analysis and design.

In the aforementioned Automatic Systems, students have learned to model simple discrete events systems and how to implement it using programmable logic controllers (PLCs).

However, the functioning of data networks, and of industrial networks in particular, is unknown.

In this subject, supervisory control and data acquisition systems (SCADA) and manufacturing control systems (MES) are introduced, as a bridge, from plant production systems, to business management systems (ERP type and similar).

### 1.3. Recommendations to take this course

In this course concepts and techniques of computer control of continuous systems are presented. Also, the discrete systems and two modeling formalisms for these are studied: deterministic finite automaton and Petri nets. At the end of the course, the student is able to model systems, analyze their behavior, design control schemes, and implement them using conventional language and commercial industrial controllers.

For pedagogical and content reasons it is advisable to have studied Mathematics I, II, III, Physics I, II, Electrical Engineering and Analysis of electrical circuits, Fundamentals of Electronics, Computing, Automatic Systems. The previous study of these subjects provides the student the basic tools to develop, analyze, simulate and control a real system.

## 2. Learning goals

### 2.1. Competences

The obtained competences and skills after completing the subject are:

Generic competences:

1. Ability to solve problems and make decisions with initiative, creativity and critical reasoning (C4)
2. Ability to apply information and communication technologies in Electrical Engineering (C5)
3. Ability to use the techniques, skills and tools of electrical engineering necessary to practice it (C7)

Specific competences:

1. Ability to know and understand the basic concepts about the use and programming of computers, operating systems, databases and computer programs with application in engineering (C14)
2. Ability to understand the principles of automatic regulation and its application to industrial automation (C37).

### 2.2. Learning goals

To overcome the subject, the student must demonstrate the following outcomes:

1. Design and implement the computer control of a system, selecting the most appropriate technique according to the control requirements and the context in which they arise.
2. Applies systems identification techniques in order to extract mathematical models suitable for use in control.
3. Simulates the behavior of dynamic systems using computer tools suitable for this purpose.
4. Design a hierarchy of distributed control, resolving both the communication needs between the different elements of the control, as well as the computerized supervision of the whole.

### 2.3. Importance of learning goals

The knowledge that the student acquires in Control Engineering covers the advanced aspects of the control and automation of systems and processes. The control of industrial operations is carried out by industrial regulators, industrial computers, programmable logic controllers, specific controllers, robots ... The advanced understanding of the processes and the techniques of automatic control can bring great improvements in working conditions, in the environment, in the quality of the product and in the competitiveness. With this subject the student will be able to analyze and design complex control systems.

The learning outcomes of this subject give students the ability to analyze real industrial process control situations and enable them to propose schemes and calculate the appropriate control parameters for the operating requirements. These results, and the capacities and abilities derived from them, have a great importance in the industrial environment, where the control of processes and systems is a key and fundamental part for the development of the product, allowing to reduce costs, both economic and environmental, and increasing the final quality of the product.

## 3. Assessment (1st and 2nd call)

### 3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

The student must demonstrate that he has achieved the expected learning outcomes through the following assessment activities

In accordance with the regulations of the University of Zaragoza, the evaluation of this subject is established as "Global rate". Given the relevance of the practical skills in the subject, practical work will also be evaluated throughout the course. This evaluation includes previous studies, development of practical work, resolution of the questions and presentation.

In each call, the evaluation will comprise two parts:

1. Individual written test (80%). Rated between 0 and 10 points (CT). It will be done during the exam period. In it the student will be evaluated from the set of learning outcomes from the theoretical point of view and problem solving.
2. Evaluation of practical work (20%). Qualified between 0 and 10 points (CP), can be overcome throughout the course (gradual test). In any case, a specific individual test will be carried out during the evaluation period for students who have not passed it during the course. In it the student will be evaluated from the set of learning outcomes from the point of view of practical work.

To pass the subject is essential to obtain the two grades (CT and CP) greater than or equal to 4 points out of 10. Only in this case, the overall grade of the subject will be (0.20 * CP + 0.80 * CT). In another case, the overall rating will be the minimum between 4 and the result of applying the previous formula.

To overcome the subject an overall score of at least 5 points out of 10 is needed.

## 4. Methodology, learning tasks, syllabus and resources

### 4.1. Methodological overview

This course is divided into two main parts:

(1) Digital control of continuous systems and

(2) Modeling, analysis and design of discrete event systems. The teaching process will involve three main activities: lectures, problem resolution, and laboratory classes.

- During the lectures, theoretical and methodological concepts will be presented by using practical examples.
- During the problem resolution classes, different problems will be developed with the participation of students.
- Practical sessions will be developed individually or in groups of two students, where students will put into practice the concepts of interest, implement control systems on real systems and simulate using the computers the evolution of systems.

### 4.2. Learning tasks

The course includes the following learning tasks:

1) Lecture classes (type T1) (30 hours).
Lecture sessions of theoretical and practical content. The concepts of digital control of continuous systems and modeling, analysis and control of discrete event systems are introduced by using real examples. Student participation through questions and brief discussions is encouraged.

2) Classes of problems and resolution of use cases (type T2) (15 hours).
Problems and case studies with student participation, coordinated at all times with the theoretical contents are developed. Students are encouraged to work on the problems previously.

3) Laboratory sessions (type T3) (15 hours).
The student performs simulation, design, and implements control systems on real systems. The sessions consist of a preliminary study and a practical realization. The preliminary study should be done prior to practice.

4) Study (type T7) (86 hours).
Student personal study of theoretical concepts and implementation problems. The ongoing work of the student is encouraged by the homogeneous distribution throughout the semester of the various learning activities. This includes tutorials, direct student care, identification of learning problems, guidance on the subject, attention to exercise and doubts.

5) Evaluation exams (T8) (4 hours).
In addition to the qualifying function, evaluation is also a learning tool with which the student checks the degree of understanding and assimilation reached.

### 4.3. Syllabus

The course will address the following topics:

? Topic 1: Introduction

? Topic 2: Digital control of continuous systems

- Discrete-time signals
- Z transform: definition, properties, tables
- Description of sampled systems
- Discretization of continuous systems
- Sampled Systems Analysis
- Design of digital controllers
- Practical aspects of implementation

? Topic 3: Discrete (event) systems

- Preliminary considerations and definition
- Formalisms to represent the DES and interest in engineering
- Deterministic Finite Automaton (DFA)
  - Mealy and Moore models. Transformations and minimization
  - Limitations of DFA
- Petri nets
  - Concept, typical structures and modeling methodology
  - Some properties, analysis and implementation techniques

Five laboratory sessions will be performed.

### 4.4. Course planning and calendar

All classes are scheduled by EINA and are available on its website (https://eina.unizar.es/).

Each teacher publishes its schedule of office hours.

The other activities are planned depending on the number of students and are available at http://add.unizar.es

### 4.5. Bibliography and recommended resources

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=29624&Identificador=14507