1. COURSE TITLE

Control Systems

1.1. Course number

18484

1.2. Course area

Electronic Systems

1.3. Course Type

Specific Technology in Electronic Systems

1.4. Course level

Graduate

1.5. Year

3rd

1.6. Semester

1st

1.7. Credit allotment

6 ECTS

1.8. Prerequisites

It is advisable to have finished the course “Filter design”.

1.9. Minimum attendance requirement

Needed for “continuous” evaluation method, not for “non-continuous” evaluation.

1.10. Faculty data

Theory:

Dr. Ángel de Castro Martín
Dep. Tecnología Electrónica y de las Comunicaciones
Escuela Politécnica Superior
Office: C-236
Tlf: +34 914972802
e-mail: angel.decastro@uam.es

Practice:

Dr. Ángel de Castro Martín
Dep. Tecnología Electrónica y de las Comunicaciones
Escuela Politécnica Superior
Office: C-236
Tlf: +34 914972802
e-mail: angel.decastro@uam.es

Dr. Fernando J. López Colino
Dep. Tecnología Electrónica y de las Comunicaciones
Escuela Politécnica Superior
Office: C-219
Tlf: +34 914973613
e-mail: fj.lopez@uam.es

1.11. Course objectives

In this course, the main control concepts are introduced: open loop, closed loop, design techniques for closed loop, error compensation, stability. PID regulators are studied along with their implementation.

Competences:
SE3: Specification, implementation, documentation of electronic, instrumentation and control systems and equipment.
SE6: Comprehend and use feedback theory and electronic control systems.

GENERAL OBJECTIVES	
G1	Analyze the response of linear systems, including continuous and discrete ones, and their transfer functions.
G2	Advantages and drawbacks of open and closed loop.
G3	Design a PID regulator and analyze closed loop stability.
G4	Implement a discrete regulator using fixed point notation.
G5	Complete implementation of a closed loop system, including analog to digital interface.

UNIT BY UNIT SPECIFIC OBJECTIVES	
UNIT 1.- Continuous linear systems	
1.1.	Describe a continuous linear system by its “s” transfer function.
1.2.	Laplace transform.
1.3.	Impulse and step response.
1.4.	Real system approximation to “s” transfer function.
1.5.	First and second order systems, and higher order by approximation to the previous ones.
UNIT 2.- Sequences and discrete systems	
2.1.	Z transform for sequences and/or discrete systems.
2.2.	Impulse and step response.
2.3.	Real system approximation to “z” transfer function.
2.4.	Conversion between “s” and “z” transfer functions.
UNIT 3.- Discrete regulator design	
3.1.	Open and closed loop: advantages and drawbacks.
3.2.	Closed loop transfer function.
3.3.	Regulator design in the continuous domain and discretization, or direct discrete design.
3.4.	PID regulator design using root locus.
3.5.	Closed loop stability.
UNIT 4.- Digital control implementation	
4.1.	Difference equation from “z” transfer function and vice versa.
4.2.	Implementation of a “z” transfer function in fixed point notation (QX.Y).
4.3.	Synchronization between sensors and regulator.
4.4.	Complete closed loop system implementation.

UNIT 5.- Analog to digital interface	
5.1.	Digital to analog conversion architectures.
5.2.	Analog to digital conversion architectures.
5.3.	Electronics for the control and interface between continuous and discrete domains.

1.12. Course contents

1. **Continuous linear systems**
   1.1. Convolution
   1.2. Laplace transform
   1.3. “s” transfer function
   1.4. Transfer functions of real systems
   1.5. First and second order systems, and higher order approximation to first and second order
2. **Sequences and discrete systems**
   2.1. Numeric sequences and discrete systems
   2.2. Z transform
   2.3. Discrete convolution and “z” transfer function
   2.4. Difference equation
   2.5. Conversion between “s” and “z” transfer functions
3. **Discrete regulator design**
   3.1. Open and closed loop
   3.2. Closed loop transfer functions
   3.3. Continous regulator design and its discretization
   3.4. Direct discrete design. Comparison
   3.5. Root locus
   3.6. Stability analysis
   3.7. PID regulators
4. **Digital control implementation**
   4.1. “z” transfer function and difference equation. Conversions.
   4.2. Fixed point notation (QX.Y). Operations in fixed point.
   4.3. Synchronization between sampling and regulator calculus
5. **Analog to digital interface**
   5.1. Digital to analog architectures
   5.2. Analog to digital architectures
   5.3. Electronics for the interface between continuous and discrete domains (analog and digital electronics)

1.13. Course bibliography

1. R. Aracil Santonja, A. Jiménez Avelló, “Sistemas discretos de control”, UPM-ETSII Sección de Publicaciones.
2. E. Andrés Puente, “Regulación Automática I”, UPM-ETSII Sección de Publicaciones.
3. Katsuhiko Ogata, "Discrete-Time Control Systems", Upper Saddle RiverPrentice-Hall, 1994.
4. Katsuhiko Ogata, "Sistemas de control en tiempo discreto", Pearson: Prentice-Hall Hispanoamericana, 1996.
5. Katsuhiko Ogata, "Ingeniería de control moderna", Pearson educación: Prentice Hall, 2003.
6. Katsuhiko Ogata, "Problemas de ingeniería de control utilizando MATLAB: [un enfoque práctico]", Prentice Hall, D.L. 2006.
7. Allen J. Stubberud, "Schaum's Outline of theory and problems of Feedback and Control Systems: continuous (analog) and discrete (digital)", McGraw-Hill, 1990.