# Course guide
# 230924 - CTR - Control Systems

**Last modified:** 11/04/2025

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| **Unit in charge:** | Barcelona School of Telecommunications Engineering |
| **Teaching unit:** | 710 - EEL - Department of Electronic Engineering. |

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| **Degree:** | BACHELOR'S DEGREE IN ELECTRONIC ENGINEERING AND TELECOMMUNICATION (Syllabus 2018). (Compulsory subject). |

**Academic year:** 2025 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish, English

## LECTURER

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| **Coordinating lecturer:** | DOMINGO BIEL SOLE |
| **Others:** | Primer quadrimestre:<br>DOMINGO BIEL SOLE - 11, 12, 13<br>MANUEL MARIA DOMINGUEZ PUMAR - 11, 12<br>XAVIER MANYOSA I VILARDELL - 13 |

## PRIOR SKILLS

Circuit theory.
Signal processing.
Basic electronics.

## DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

### Specific:
CE26. (ENG) GREELEC: Capacitat per a comprendre i utilitzar la teoria de la realimentació i els sistemes electrònics de control. (Mòdul de tecnologia específica- Sistemes electrònics).

### Basic:
CB2. (ENG) GREELEC: Que els estudiants sàpiguen aplicar els coneixements adquirits al seu treball o vocació d'una forma professional i tinguin las competències que solen desmostrar-se per mitjà de l'elaboració i defensa d'arguments i la resolució de problemes dins de la seva àrea d'estudi.

## TEACHING METHODOLOGY

Expository method / Lecture
Laboratory practice
Autonomous work

## LEARNING OBJECTIVES OF THE SUBJECT

. To get the capability to set the control specifications.
. To get the ability to design and verify the proper performance of a control system.
. To design the proper controllers to verify specifications in both time domain and frequency domain

## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Self study | 85,0 | 56.67 |
| Hours large group | 52,0 | 34.67 |
| Hours small group | 13,0 | 8.67 |

**Total learning time:** 150 h

## CONTENTS

### 1. Introduction

**Description:**
1.1. What is a control system? Basic components of a control system, reference, control, output and disturbance signals.
1.2. Control system goals.
1.3. Continuous-time control and discrete-time control. Examples.

**Full-or-part-time:** 5h
Theory classes: 2h
Self study : 3h

### 2. System Modelling

**Description:**
2.1. Dynamic systems classification: linear and nonlinear systems, time-varying and time-invariant systems.
2.2. State space models.
2.3. SISO and MIMO Systems.
2.4. Nonlinear system linearization. Examples.

**Full-or-part-time:** 8h
Theory classes: 4h
Self study : 4h

### 3. Dynamic behaviour

**Description:**
3.1. Autonomous and non-autonomous systems.
3.2. Equilibrium points, invariant sets and limit cycles.
3.3. Stability. Lyapunov stability analysis.

**Full-or-part-time:** 19h
Theory classes: 9h
Self study : 10h

## 4. Linear Systems

**Description:**
4.1. Linear system state space representation.
4.2. The matrix exponential. Eigenvalues. Transient and steady-state time-response of linear systems.
4.3. Transfer function for SISO systems.
4.4. First and second-order systems.
4.5. Transient response characterization: settling time, maximum overshoot, etc.
4.6. Higher order systems: transient response approximation through dominant poles and zero-pole cancellation.
4.7. Routh-Hurtwitz stability criteria.
4.8. Steady-state error.

**Full-or-part-time:** 22h
Theory classes: 9h
Self study : 13h

## 5. State Feedback

**Description:**
5.1. Reachability.
5.2. Stabilization by state feedback. Poles-placement design through state feedback. Ackermann's formula.
5.3. Integral action.
5.4. Observability.
5.5. State observer design.

**Full-or-part-time:** 26h
Theory classes: 10h
Self study : 16h

## 6. Output Feedback

**Description:**
6.1. Control design in SISO systems through root locus. First and second-order controllers. PID controllers.
6.2. Implementation issues of PID controllers.

**Full-or-part-time:** 23h
Theory classes: 8h
Self study : 15h

## 7. Frequency-domain control design

**Description:**
7.1. Frequency response of SISO system. Nyquist diagram and Bode diagram.
7.2. Nyquist stability criterion.
7.3. Relative stability: gain margin and phase margin.
7.4. Frequency-domain specifications: relative stability margins and bandwidth of a control system.
7.5. Frequency domain control design. Lead-lag and phase-lag compensations.

**Full-or-part-time:** 21h
Theory classes: 10h
Self study : 11h

## Experience 1: Control Systems Introduction

**Description:**
Control system description. Control goals. Characteristic signals. Numerical simulation results.

**Full-or-part-time:** 4h
Laboratory classes: 2h
Self study : 2h

## Experience 2: System identification

**Description:**
System identification using numerical tools.

**Full-or-part-time:** 4h
Laboratory classes: 2h
Self study : 2h

## Experience 3: PID controller design

**Description:**
PID control design implemented by means of electronic circuitry.

**Full-or-part-time:** 12h
Laboratory classes: 6h
Self study : 6h

## Experience 4: Discrete-time control systems introduction

**Description:**
Discrete-time control systems introduction

**Full-or-part-time:** 6h
Laboratory classes: 3h
Self study : 3h

## GRADING SYSTEM

The course grade will be obtained from two marks, the laboratory mark (LAB) and the theory mark. The theory mark considers two exams, a midâ□□term exam (ME) and a final exam (FE). The final mark (FM) will be FM=0.2*LAB + 0.8*max(FE, 0.65*FE + 0.35*ME). The laboratory is not re-evaluable.

## BIBLIOGRAPHY

**Basic:**
- Åström, K.J.; Murray, R.M. Feedback systems: an introduction for scientists and engineers. Princeton: Princeton University, 2008. ISBN 9780691135762.
- Ogata, K. Modern control engineering. 5th ed. Boston: Pearson, 2010. ISBN 9780137133376.
- Khalil, H.K. Nonlinear systems. 3rd ed., international ed. New Jersey: Pearson Education, 2014. ISBN 9781292039213.

**Complementary:**
- Golnaraghi, F.; Kuo, B.C. Automatic control systems. 10th ed. New York: McGraw-Hill Education, 2017. ISBN 9781259643835.

- Slotine, J.-J.E.; Li, W. Applied nonlinear control. Englewood Cliffs, NJ: Prentice-Hall, 1991. ISBN 0130408905.