Last update: 06-05-2019

# 230475 - TCTRL - Control Theory

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering
Academic year: 2019
Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Teaching unit Compulsory)
ECTS credits: 6 Teaching languages: Catalan, Spanish

## Teaching staff

Coordinator: Doria Cerezo, Arnau

Others: Olm Miras, Josep Maria
Biel Sole, Domingo

## Opening hours

Timetable: By appointment

## Degree competences to which the subject contributes

Specific:
1. Knowledge of control theory. Knowledge of feedback procedures. Ability to design a process control system.

Generical:
1. ABILITY TO IDENTIFY, FORMULATE, AND SOLVE PHYSICAL ENGINEERING PROBLEMS. Planning and solving physical engineering problems with initiative, making decisions and with creativity. Developing methods of analysis and problem solving in a systematic and creative way.
7. They will have acquired knowledge related to experiments and laboratory instruments and will be competent in a laboratory environment in the ICC field. They will know how to use the instruments and tools of telecommunications and electronic engineering and how to interpret manuals and specifications. They will be able to evaluate the errors and limitations associated with simulation measures and results.

Transversal:
2. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
3. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 3. Communicating clearly and efficiently in oral and written presentations. Adapting to audiences and communication aims by using suitable strategies and means.
4. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.
5. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.
6. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.

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## Teaching methodology

There will be three theoretical and two practical weekly sessions. The theoretical lectures will be devoted to a careful presentation of the basic concepts and the main results which will be illustrated with some examples. The practical sessions will be devoted to the solution of a variety of exercises and problems.

## Learning objectives of the subject

* To understand the basic concepts related to feedback systems in both continous-time and discrete-time
* To apply the root locus technique and the Routh and Jury stability criteria in the analysis of feedback control systems
* To design the proper controllers to verify specifications in both time domain and frequency domain

## Study load

| | | | |
|---|---|---|---|
| Total learning time: 150h | Hours large group: | 65h | 43.33% |
| | Self study: | 85h | 56.67% |

## Content

| 1. Introduction | Learning time: 5h<br>Theory classes: 2h<br>Self study : 3h |
|---|---|

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.

| 2. System modelling | Learning time: 11h<br>Theory classes: 2h<br>Practical classes: 2h<br>Self study : 7h |
|---|---|

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.

| 3. Dynamic behaviour | Learning time: 24h<br>Theory classes: 5h<br>Practical classes: 4h<br>Self study : 15h |
|---|---|

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

| 4. Linear systems | Learning time: 10h<br>Theory classes: 3h<br>Practical classes: 1h<br>Self study : 6h |
|---|---|

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. Transient response characterization: settling time, maximum overshoot, etc.

| 5. State feedback | Learning time: 33h<br>Theory classes: 8h<br>Practical classes: 5h<br>Guided activities: 3h<br>Self study : 17h |
|---|---|

Description:
5.1. Reachability.
5.2. Stabilization by state feedback. Poles-placement design through state feedback. First and second-order systems. Higher order systems: transient response approximation. Ackermann's formula.
5.3. Integral action.

| 6. Output feedback | Learning time: 42h<br>Theory classes: 12h<br>Practical classes: 8h<br>Self study : 22h |
|---|---|

Description:
6.1. Observability.
6.2. State observer design.
6.3. Transfer function characterization. Block diagrams. Routh-Hurtwitz stability criteria. Control design in SISO systems through root locus. Steady-state error.
6.4. First and second-order controllers. PID controllers.
6.5. Implementation issues of PID controllers.

| 7. Frequency-domain control design | Learning time: 25h<br>Theory classes: 7h<br>Practical classes: 4h<br>Self study : 14h |
|---|---|

Description:
7.1. Frequency response of SISO system. Nyquist diagram and Bode diagram.
7.2. Nyquist stability criterion.
7.3. Application of the Nyquist criterion to systems with non-linearities: the describing function.
7.4. Relative stability: gain margin and phase margin.
7.5. Frequency-domain specifications: relative stability margins and bandwidth of a control system. Frequency-domain control design. Lead-lag and phase-lag compensations.

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## Qualification system

There will be a final exam (EF)
and a partial exam (EP).
The students' participation in practical sessions will be also taken into account (P).

The final score will follow from max{EF, 0.65*EF+0.30*EP+0.05*P}

## Bibliography

### Basic:

Aström, K.J.; Murray, R.M. Feedback systems: an introduction for scientists and engineers. Princeton: Princeton University, 2008. ISBN 978-0-691-13576-2.

Ogata, K. Modern control engineering. 5th ed. Boston: Pearson, 2010. ISBN 9780137133376.

### Complementary:

Golnaraghi, F.; Kuo, B.C. Automatic control systems. 9th ed. New York: John Wiley & Sons, 2010. ISBN 978-0470048962.

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