Automatic Control Systems

<table>
<tr><th>module title
module code</th><th colspan="3">level of module</th><th>year of study</th><th>semester/trimester when the module is delivered</th></tr>
<tr><td>Automatic Control Systems
EN-SplC 602-6</td><td colspan="3">1st (undergraduate)</td><td>3rd</td><td>SPRING</td></tr>
<tr><th rowspan="2">Name / e-mail of lecturer(s)</th><th colspan="2">Weekly Hours</th><th rowspan="2">ECTS</th><th rowspan="2">module type (comp., opt.)</th><th rowspan="2">mode of delivery (face to face, distance learning)</th></tr>
<tr><th>Lect.</th><th>Lab.</th></tr>
<tr><td>Prof. Maria RANGOUSSI
(mariar@teipir.gr)
Lecturer Kleanthis PREKAS
(prekas@teipir.gr)</td><td>4</td><td>2</td><td>7</td><td>compulsory</td><td>face to face</td></tr>
<tr><td>module web Page</td><td colspan="5">http://electronicstaff.teipir.gr/rangoussi/index.php/en/teaching/undergraduate-courses/automatic-control-systems/lectures.html
and
http://labpower.teipir.gr/index_hl.htm</td></tr>
<tr><td>learning outcomes</td><td colspan="5">Upon successful completion of the course, the student possesses advanced knowledge, skills and competences that enable him/her to:
1. Describe all basic ACS structures by block diagrams.
2. Translate readily a time-domain ACS description into a frequency-domain one and vice-versa; select the appropriate and simpler possible form for the problem at hand.
3. Use software system simulation tools to compute the ACS output in the time and in the frequency domains. Assess the quality of the output with respect to given specifications and estimate the error between actual and desired output.
4. State and apply the algebraic and the graphics ACS stability criteria, simulate each criterion in software, interpret the results; assess and characterize an ACS using the results and thus perform a full ACS stability study.
5. Analyze a realistic problem that requires controller / compensator design, judge and select the appropriate among alternative controller architectures taught in the course; design the controller in block diagram level and simulate the ACS including the controller in software.
6. Collaborate with fellow students in a team, in order to thoroughly address complex controller design problems (analysis – synthesis) under realistic conditions and to critically evaluate alternative solutions, leading to decisions as to the feasibility of hardware implementations.</td></tr>
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	Keywords: Feedback, Closed system, Steady-state and transient response, Steady-state errors, Stability criteria, Routh criterion, Root Locus, System compensation, Bode/Nyquist/Nichols diagrams, PID control, Controller / compensator design, Phase lead / lag controllers.
prerequisites and co-requisites:	None
recommended optional programme components	
module description	<u>*Lectures*</u> **UNIT I: Introduction to closed-loop systems and block diagram simplification** 1. Open- and closed-loop systems, Feedback (positive and negative), Impulse Response and Transfer function descriptions of Linear Systems, Transfer function extraction examples. 2. Block diagrams; simplification of a block diagram into a simpler equivalent one using equivalence rules. Generalization from 1-by-1 to M-by-N I/O systems. **UNIT II: Time domain response of 1^{st} and 2^{nd} order systems – Errors in the Steady-state.** 1. Computation of the time response of 1^{st} and 2^{nd} order systems for basic input waveforms (sinusoidal, step, ramp, parabolic). 2. Error signal definition, Limiting value theorem, Error constants and steady-state error computation for polynomial inputs. **UNIT III: Closed-loop system stability – Definitions and Criteria - Algebraic (Routh) and graphics (Root Locus).** 1. Linear system stability: Definitions and Criteria (algebraic – graphics). 2. The Routh Criterion and its parametric forms. Conditional stability. 3. Root locus – Drawing, interpretation, ACS characterization, complete 1-by-1 ACS stability study. **UNIT IV Bode, Nyquist, Nichols Diagrams and Gain / Phase Margins.** 1. Bode diagram: Drawing, interpretation, stability study using the associated criterion. Definition, meaning and uses of gain and phase margins in conjunction with the Bode diagram. 2. Nyquist and Nichols diagrams and associated stability criteria. Critical frequency, Niquist point. **UNIT V: System compensation and controller design – general**

	principles. PID controllers and parameter setting. 1. Introduction to the system compensation, aims and controller types. Series and parallel controllers. 2. PID controllers – applications and parameter setting (Ziegler-Nichols empirical rules). **UNIT VI: Phase lead / lag controllers and hybrid solutions.** 1. Phase lead / lag controller design for series compensation. Applications on the basis of given specs and software simulation. 2. Parallel system compensation (velocity, acceleration). Comparative assessment of series and parallel design solutions. *Laboratory* 1. Time response of 1st and 2nd order linear systems. 2. Frequency domain response and frequency plots (Bode, Nyquist, Nichols Diagrams). 3. Steady-state Errors in the ACS output. 4. PID controllers. 5. Velocity control ACS (hands-on plus computer simulation, accessed remotely). 6. Liquid level control ACS (hands-on plus computer simulation, accessed remotely). 7. Position Control ACS. 8. Sinusoidal waveform generation – 2nd order ACS (PLL). 9. Programmable Logic Controllers (PLCs). *10.* Telemetric Systems based on GSM modem.
recommended or required bibliography:	*Essential reading* 1. DORF, R.C., BISHOP, R.H., Modern Control Systems, Prentice-Hall, 2000. 2. Schaum's Outline Series on Feedback and Control Systems, 2nd Ed., McGraw-Hill Professional Publishing. 3. Laboratory notes by Kl. Prekas: http://labpower.teipir.gr/index.htm *Recommended Books* 1. CHEN, C.-T., Linear System Theory and Design, HRW, 1981. 2. OGATA, K., Modern Control Engineering, Prentice Hall Inc., New Jersey, 1997. 3. KUO, B.C., Automatic Control Systems, Prentice-Hall Inc., New Jersey, 1995.

4. KAILATH, TH., Linear System Theory, Prentice-Hall, 1980.

planned learning activities and teaching methods:

Learning Activities Plan

Learning activity	Load (hours)
Lectures	104
Laboratory experiments	26
Student technical report on lab part	26
Student technical report on lecture part (possibly as a team member)	26
Study and preparation for exam	28
TOTAL COURSE LOAD	***210***

Teaching Methods Employed

- Face to face teaching with the aid of powerpoint transparencies and multimedia (audio) material.
- Simulation software for the simulation study and stability study of ACS, in the lectures part of the course.
- Virtual Lab through the use of simulation software for the simulation study of ACS, for telemetric / telecontrol applications and for remote realization of experiments (Remote Lab), in the lab part of the course.
- Teaching support and study material (lecture notes, lab notes, solved examples, solved past exams) through the course webpage.
- Electronic communication with the students enrolled in the course, through the course webpage.

assessment methods and criteria:

Final course grade =

Lectures part grade x 60% + Laboratory part grade x 40%, analyzed as follows:

Lectures part grade:

Homework assignments – 2 per semester (20%)

Final written exam – 2 hours (80%)

Final written exam covers all taught material. During the exam, students may consult a list of formulae provided by the examiner as a reminder. Students must prove mastery of the material through stating and interpreting definitions of all quantities, handling relations among quantities and solving of design problems based on specs.

	<u>Laboratory part grade:</u> Lab part grade is the average of all (10) individual Lab Experiment Grades achieved by the student during the semester. Lab Experiment Grade = Oral exam in class (60%) plus written test in class (40%), on the subject of the current Experiment. A written preparatory homework is assigned each week, on the subject of the Experiment scheduled for next week.
language of instruction:	Greek and English