COURSE DESCRIPTION CARD - SYLLABUS

Course name

Design of control systems

Course

Field of study
Automatic Control and Robotics

Area of study (specialization)

Level of study
First-cycle studies

Form of study
part-time

Year/Semester
3/5

Profile of study
general academic

Course offered in
Polish

Requirements
elective

Number of hours

Lecture
8

Laboratory classes
18

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

3

Lecturers

Responsible for the course/lecturer:
Maciej Marcin Michałek, PhD, DSc, Prof. of PUT email: maciej.michalek@put.poznan.pl phone: 665-2848
Faculty of Control, Robotics and Electrical Engineering
Piotrowo 3A Street, Poznań

Responsible for the course/lecturer:

Prerequisites

A student should know fundamentals on the design, analysis, and implementation (at least in the Matlab-Simulink environment) feedback control systems for SISO plants in the context of classical control tasks, should have basic knowledge on structures, utilization, and properties of basic regulators and linear filters, should have skills in using the Laplace and Laurent transformations, skills in description of dynamics in a state space and as an input-output system. A student should also know and be able to apply basic stability criteria for linear and nonlinear systems, and should be able to approximate nonlinear systems by its Taylor (local) linear dynamics, should be able to implement and test block schemes of dynamical systems in the Matlab-Simulink environment. Moreover, a student should be able to use basic information-communication tools, acquire information from selected sources, and be ready to cooperate in a team.

Course objective

Systematization and extension of the control design problems, including selection of a control structure, tuning of control parameters, selection of appropriate functional blocks for control systems with dynamical linear and nonlinear plants in the context of various control tasks defined under practical conditions; presentation of fundamental limitations concerning the design problem of feedback control systems; derivation and explanation of applicability of selected design methods for selected control tasks; development of skills for conscious and constructive utilization of the considered design methods for various control tasks, development of skills for critical assessing a quality of the desined control systems.

Course-related learning outcomes

Knowledge

1. Systematization and deepen knowledge on designing a structure and functional blocks of automatic feedback-feedforward control systems for various types of control tasks, in the context of various quality criteria defined accounting for practical working conditions. [K1_W1],[K1_W14],[K1_W17] 2. Familiarization with fundamental limitations of feedback control design process and their consequences for achievable control performance. [K1_W12], [K1_W14] 3. Extended knowledge on selected methods of model-based design of functional blocks of a control system, and extended knowledge on the implementation of basic functional block of control systems. [K1_W1],[K1_W17] 4. Knowledge of practical techniques used for modification of control properties and functionalities of control loops using the add-on methodology. [K1_W17],[K1_W19]

Skills

1. Distinguising between types of control tasks being formulated in practical control systems based on a stated control problem, and ability of determining and critical assessment of quality requirementsfor these tasks. [K1_U24] 2. Selection/derivation of a control system structure and its functional blocks for a posed control task and upon a selected dynamics of a plant; assessment of practical dificulties in implementation and limitations of a designed control system and conscious selection of compromise solutions. [K1_U22],[K1_U24],[K1_U19] 3. Implementation of a designed control system on a fast-prototyping testbed and assessment of achieved control performance upon various quality measures. [K1_U9],[K1_U24]

Social competences

1. Capability of working in a team, and consciousness of non-technical effects of design decisions made

in the area of control systems. [K1_K2],[K1_K3] 2. Consciousness of a neccessity of professional approach to the technical problems and critical assessment of design selections. [K1_K5],[K1_K1]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:
A) For lectures: Verification of the results with a final selection-test written by students. The test comprises 20-30 questions, evary one with A,B,C,D answers, where two of theam are correct and other two are false. A student earns maximally 1 point for a question if he/she selects two correct answers. One correct answer selected and one empty answer left results in 0.5 point. Other possibilities result in 0 points for a question. A positive mark from the test needs earning more than a half of a maximal possible number of points. The result determines the mark OT which, together with a mark OL from laboratory classes, detemine (after rounding) the final mark OK computed as follows: OK = OT*0.7 + OL*0.3. The result OK < 3.0 leads to a negative mark from the course. B) For laboratory classes: Verification of the results is performed by a current check of the development progress of particular students, and also by a final assessment of a working quality of a designed control system, assessment of a final report from the design task, and by assessment of answers to questions formulated by an instructor with a relation to a control-design task given to students.

Programme content

The program of the course includes: - classification of control tasks and objectives stated for automatic control systems in practical conditions; properties and practical examples of control systems (stabilization and set-point control, reference following control, trajectory tracking control, extremal control), - control quality criteria in the context of practical control problems; comparison methods of control systems; stability and robustness and control performance; robustness measures of control systems, - analysis of technical and non-technical consequences of incorrect/wrong selection of a control structure and design parameters, - designing/selection of a control system structure and its functional blocks upon a formulated control task and properties of a controlled plant (cascade systems, feedforward control, input and output filters, measurement filters, estimators of unmeasured signals, anti-windup loop, D-block vs. Tacho-feedback); critical assessment of potential effects of design selections, - dynamics difficult to control (with dominating delay, with zeros in the RHP, unstable with zeros in RHP, with lightly damped oscillatory modes, of higher-order dynamics, highly nonlinear) and control methods for this type of systems, - fundamental limitations in control design (sensitivity and complementary sensitivity functions, Bode integral and the 'waterbed' effect, effectiveness of feedforward control in the presence of uncertainties, control limitations caused by measurement noises corrupting a feedback loop, limitations of control inputs and state constraints), - selected techniques and methods for control design and parametric synthesis of control systems (conscious selection of functional blocks of linear regulators, the half-rule of a model reduction, the IMC/SIMC method, regulators for delay-dominating dynamics, 2DOF regulator in the R-S-T structure, pole placement method and reduction of zeros of closed-loop dynamics, autotuning of regulators, design of feedforward control – full and partial), - design and implementation of reference signals generators using the add-on methodology, - basic design and implementation rules for discrete-time controllers for continuous-time plant dynamics, - selected topics on the on-line signal estimation in a control system, - examples of solving the control design problems.

Teaching methods

A) Lectures: presentation of slides illustrated by examples provided and analyzed on a blackboard. B) Laboratory classes: programing, simulation, and fast-prototyping tasks performed in teams of 2-3 students in the areas defined by an instructor.

Bibliography

Basic

[1] Control system design, G. C. Goodwin, S. F. Graebe, M. E. Salgado, Prentice Hall 2001 [2] Advanced PID control, K. J. Astrom, T. Hagglund, ISA, 2006 [3] Feedback control. Linear, nonlinear and robust techniques and design with industrial applications, S. J. Doods, Springer, 2015

Additional

[4] Multivariable control design. Analysis and design, S. Skogestad, I. Postlethwaite, Wiley, 2005 [5] Computer-controlled systems. K. J. Astrom, B. Wittenmark, Prentice Hall, 1997

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3
Classes requiring direct contact with the teacher	26	1,0
Student's own work (literature studies, preparation for laboratory classes, testing of the studied control systems after classes, preparation of the final report from the second part of classes, preparation for the final examination and attandance the final test) [1]	49	2,0

[1] delete or add other activities as appropriate