COURSE DESCRIPTION CARD - SYLLABUS

Course name
Design of control systems [N1AiR2>PUR]

Course

Field of study
Automatic Control and Robotics

Year/Semester
4/7

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
part-time

Requirements
compulsory

Number of hours

Lecture
20

Laboratory classes
20

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

5,00

Coordinators

prof. dr hab. inż. Maciej Michałek
maciej.michalek@put.poznan.pl

Lecturers

Prerequisites

A student should know fundamentals on the analysis and implementation (in the Matlab-Simulink environment) feedback control systems for single-input-single-output plants in the context of basic control tasks, should have basic knowledge on building, utilization, and properties of linear regulators and linear filters, should have skills in using the Laplace and Laurent transforms, 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 dynamical systems, know basic feedback-control objectives and quality criteria for feedback control performance assessment; should be able to approximate nonlinear systems by the 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 indicated sources, and be ready to cooperate in a team.

Course objective

The objectives of the course are: systematization and extension of the control design issues, including selection of a control structure, selection of control parameters, selection of appropriate functional blocks of control systems for the 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; introduction of selected control design methods for selected control tasks and discussion of conditions for their applicability; development of skills for conscious and constructive utilization of the considered design methods for various control tasks, development of skills for critical assessing of the designed control sys- tem performance.

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, every one with A,B,C,D answers, where two of theam are correct and the 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 tab left with no answer results in 0.5 point. Other possibilities result in 0 points for a question. In order to obtain a positive mark from the test one needs to earn more than a half of a maximal possible number of points.

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 on-line by an instructor with a relation to the control-design task given to students.

Programme content

The course covers the following topics:
- determination of the control system design problem,
- practical consequences of poorely/incorrectly designed control system,
- types and properties of the regulation tasks,
- mathematical models of processes and plants,

- selected structures of automatic control systems,
- selected design methods and examples of their application,
- simulation and experimental verification of selected control systems,
- fundamental limitations of the control system design.

Course topics

A program of the lectures covers:
- introductory issues (what it is the control system design problem, the main design purpose, robustness of a control system, practical aspects of the control system design, consequences of incorrect designing the control systems),
- classification of control tasks and objectives stated for automatic feedback control systems in practical conditions; properties and practical examples of control systems (stabilization / set-point control, reference following control, trajectory tracking control, extremal control),
- control quality criteria in the context of practical control problems; methodology of control systems comparison; stability, robustness, and control performance; robustness measures of control systems,
- analysis of technical and non-technical consequences of incorrect 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 control systems, feedforward control from a disturbance and from a reference signal, 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,
- dynamical plants difficult to control (with a time delay, with zeros in RHP, unstable with zeros in RHP, with multiple lightly damped oscillatory modes, of higher-order dynamics, highly nonlinear) and control design methods for these types of systems,
- fundamental limitations in automatic control design (sensitivity and
complementary sensitivity functions, Bode integral and the 'waterbed' effect, effectiveness of feedforward control in the presence of model uncertainties, control limitations caused by measurement noises corrupting a feedback loop,
limitations of a control input and their consequences for control),
- selected techniques and methods for automatic control design and parametric synthesis of control systems (conscious selection of functional blocks for linear regulators, the half-rule of a model reduction, the IMC / SIMC design method, regulators for time-delayed dynamics, 2DOF regulator in the
R-S-T structure, pole placement method and compensation of zeros of closed-loop dynamics, design of feedforward control – full and partial),
- design and implementation of reference signals generators,
- basic design and implementation rules for discrete-time controllers applicable to continuous-time plant dynamics,
- selected issues of the on-line signal estimation in a control system,
- examples of solving the control design problems.

During the laboratory classes teams of the students implement and test selected control systems in a simulation environment .

Teaching methods

A) Lectures: multimedia presentation with slides, additionally supported by examples provided and analyzed on a blackboard.
B) Laboratory classes: programing and simulation tasks performed in teams of 2-4 students in the topic 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. Dodds, 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	125	5,00
Classes requiring direct contact with the teacher	42	1,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	83	3,50