Control engineering - course description

General information

Course name	Control engineering
Course ID	06.9-WE-AutP-ContrEng-Er
Faculty	Faculty of Computer Science, Electrical Engineering and Automatics
Field of study	Automatic Control and Robotics
Education profile	academic
Level of studies	First-cycle Erasmus programme
Beginning semester	winter term 2022/2023

Course information

Semester	4
ECTS credits to win	6
Course type	obligatory
Teaching language	english
Author of syllabus	• dr hab. inż. Wojciech Paszke, prof. UZ

Classes forms

The class form	Hours per semester (full-time)	Hours per week (full-time)	Hours per semester (part-time)	Hours per week (part-time)	Form of assignment
Lecture	30	2	-	-	Exam
Laboratory	30	2	-	-	Credit with grade

Aim of the course

Skills and competencies needed to model, analyze and design of linear dynamical systems with time and frequency domain methods.

Prerequisites

Mathematical analysis, Mathematical foundations of engineering, Modeling and simulation. Signals and dynamic systems.

Scope

Control of continuous systems: Feedback control: performance indexes, disturbance Rejection and sensitivity, steady-state error, response of closed-loop system.

Introduction to modeling of simple electrical and mechanical systems in time frequency domains. State-space representation. Converting a Transfer Function to State Space and vice versa.

Block Diagrams of feedback systems. Signal-flow graphs. Mason's rule. Signal-flow graphs of state equations.

Time response. Poles, zeros, and system response. Analysis of first order systems. Basic performance indexes. The second order system. System response with additional poles. System response with zeros. Time domain solution of state equations.

Root locus method: Root locus of basic feedback systems. Guidelines for sketching a root locus, controller parameters selection based on a root locus. Controller synthesis with dynamic compensation method (lead and lag compensation), parameters selection for lead and lag compensators. Application of the root locus method for nonlinear systems and systems with delays.

Frequency response method: Frequency response: mathematical foundations, determination of bandwidth. Bode plot techniques: drawing plots for systems with real and complex poles, non-minimal phase systems. Steady-state error. The Nyquist stability criterion: Nyquist plots, applications of the Nyquist stability criterion for controller design, stability margins (phase and gain margins). Relation between closed-loop transient and closed-loop frequency responses. Relation between closed- and open-loop frequency responses. Relation between closed-loop transient and open-loop frequency responses. Steady-state error characteristics from frequency response.

Designing Lead and Lag Compensators. Transient Response via Gain Adjustment. Lag and Lead Compensators. Lead-lag compensator design using either root locus or frequency response

Classical Three-term (PID) controller: Basic features, PID controller tuning with analytical and Ziegler-Nichols methods. Robustness analysis: disturbances and uncertainty. Digital implementation of continuous controllers.

Teaching methods

lecture: classical lecture,

laboratory: laboratory exercises, projects carried out in two-person group.

Learning outcomes and methods of theirs verification

Outcome description	Outcome symbols	Methods of verification	The class form
He can check the stability of linear systems using the Routh and Nyquist criteria		• a quiz • an ongoing monitoring during classes	• Laboratory

Outcome description	Outcome symbols	Methods of verification	The class form
Has knowledge on the basic types and structures of control systems		• an exam - oral, descriptive, test and other	• Lecture
Ability to design linear controllers by serial connecting lead-lag compensators.		• an exam - oral, descriptive, test and other • an ongoing monitoring during classes	• Lecture • Laboratory
Ability to tune the PID controller parameters by various methods		• a quiz • an ongoing monitoring during classes	• Laboratory
Is able to analyze a linear dynamic system in the time and frequency domains		• an exam - oral, descriptive, test and other	• Lecture

Assignment conditions

Lecture – obtaining a positive grade in written or oral exam.

Laboratory – the main condition to get a pass is scoring sufficient marks for all laboratory exercises.

Recommended reading

1. Nise N.S.: *Control Systems Engineering*, 6th Edition International Student Version, John Wiley & Sons, Inc. , 2011.
2. Golnaraghi F., Kuo B.: *Automatic Control Systems*, 9th Edition, John Wiley & Sons, Inc., 2010.
3. Franklin G.E, Powell J.D. Emami-Naeini A.: *Feedback Control of Dynamics Systems.* Addison-Wesley, Upper Saddle River, New Jersey, 2002
4. Dorf, J.C., Bishop R.: *Modern Control Systems*, Prentice-Hall, 2002

Further reading

1. K.J. Åström, R.M. Murray, *Feedback Systems: An Introduction for Scientists and Engineers*, Princeton University Press, Princeton, 2009.

Notes

Modified by dr hab. inż. Wojciech Paszke, prof. UZ (last modification: 11-04-2022 09:05)