COURSE DESCRIPTION

1. Course title: IMPLEMENTATION OF CONTROL ALGORITHMS

2. Course code


4. Level of studies: MA,MSc programme

5. Mode of studies: intramural

6. Field of study: AUTOMATICS AND ROBOTICS (FACULTY SYMBOL) RAU

7. Profile of studies: general

8. Programme: Automatic Control

9. Semester: 2

10. Faculty teaching the course: AEI

11. Course instructor: Dr hab. inż. Jacek Czeczot, Prof. Nzw. w Pol. Śl.

12. Course classification: programme courses

13. Course status: elective

14. Language of instruction: Polish, partially English (15h of Lectures)

15. Pre-requisite qualifications: Numerical methods, Process dynamics, Control fundamentals. Advanced control. Process identification. It is assumed that students have basic skills in dynamical and input-output modelling, they know the modelling in the form of linear and nonlinear state equations for simple dynamical processes, they have ability of linearizing nonlinear dynamical models and deriving the transfer function models with the dynamical parameters depending on the physical parameters of processes. The ability of the practical identification of the static and dynamic characteristics of the industrial processes is assumed, with the application of the basic approximation and interpolation methods. It is also assumed that students have basic skills in synthesis of simple control systems, they know the structure, operating conditions and simple tuning methods for the PID controller as well as the simple methods of quantifying the control performance.

16. Course objectives: The course is dedicated to the application of the advanced control structures and of the advanced control algorithms that are the most frequently used in the industrial practice. The considered aspects are the most important implementation issues with the application of different additional techniques that ensure reliable practical control. The problem of tuning on the basis of the measurement data is discussed. Apart from conventional control algorithms (such as PID controller, On-Off controller, etc.), the more advanced control strategies are also presented. More advanced functionalities of the function blocks that allow for implementation of the control strategies in the PLC devices are also discussed.

17. Description of learning outcomes:

<table>
<thead>
<tr>
<th>Nr</th>
<th>Learning outcomes description</th>
<th>Method of assessment</th>
<th>Teaching methods</th>
<th>Learning outcomes reference code</th>
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<tbody>
<tr>
<td>1.</td>
<td>Meaning of the parts of the practical control system together with their influence on the control performance are known</td>
<td>SP, OS</td>
<td>WT, L</td>
<td>K,W2/1; W6/2; W20/1 W21/1</td>
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<tr>
<td>2.</td>
<td>Identification methods for determining the values of the parameters of the simplified static an dynamic models from the measurement data are known, the possibilities of the application of these models for improving control performance are also known</td>
<td>SP, CL, OS</td>
<td>WT, L</td>
<td>K,W10/2; W11/1; W13/2</td>
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<tr>
<td>3.</td>
<td>Methods of improving the control performance by the application of the advanced structures of the control system and of the advanced model-based controllers are known.</td>
<td>SP, CL, OS</td>
<td>WT, L</td>
<td>K,W3/2; W10/3; W14/3; W17/2</td>
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</table>
4. Additional functionalities of the industrial controllers that allow for practical implementation as well as for safe control in the case of fault are known. | CL, OS | WT, L | K_W22/2

5. One is able to define the conditions for designing the practical identification experiment and to determine the static and dynamic properties of the real process. | SP, CL, OS | WT, L | K_U1/2; U2/2; U3/2; U14/1

6. One is able to choose the proper control structure together with the proper control strategy and its tunings. | SP, CL, OS | WT, L | K_U23/2

7. One is able to quantify the control performance of the practical control system, to detect the possible problems and to suggest the suitable improvements. | CL, OS | WT, L | K_U7/2; U23/2; U25/2

8. One is able to implement both the conventional and the advanced control strategies in the PLC devices. | CL | WT, L | K_U7/2; U9/1

9. One is able to take the independent decisions on the best possible solutions for effective practical implementation of the control systems. | CL, OS | WT, L | K_K1/1; K2/1; K4/2; K6/1

10. One is able to present and to motivate the suggested solution of the control system. | OS, CL | L | K_K2/1; K7/2

18. Teaching modes and hours
Lecture / BA / MA Seminar / Class / Project / Laboratory
Lecture 30, Laboratory 30

19. Syllabus description:
Semester : 2

Lecture
Lectures consists of the following topics:
1. Introduction to the subject, basic aspects of the practical implementation of the control algorithms.
2. Classification of the control systems, criteria for determining manipulated variable.
3. Adaptation, selftuning, advanced control structures: cascade control, ratio control, split range control, feedforward control, multivariable control.
4. Limitation from the control system resulting from statical and dynamical properties of the process.
5. Conventional control algorithms: On+Off control, PWM control, continuous PID control.
6. Practical aspect of the implementation of conventional controllers (On+Off, PID, etc.), different structures of the PID controller, practical methods of tuning PID controllers.
7. Discrete form of the PID controller, limitation of the controller output, anti windup action, bumpless switching.
8. Designing the experiments for identification of the dynamic properties of the process, influence of the measurement noise, uncertainty resulting from measurement data, influence of the dynamics of the actuating system.
9. Approximation and interpolation of the static and dynamic characteristics of the process on the basis of the measurement data collected during the identification experiment.
10. Practical implementation of the gain-scheduling technique on the basis of the static and dynamic properties of the process.
11. Design of the linear and nonlinear feedforward correctors, feedforward control on the basis of the model of the process.
12. General overview of the functionalities accessible in the hardware PID blocks available in the most popular programmable controllers (SIPART DR24, SIMATIC S7, itp.)
13. Introduction to the metodology of reducing the order of the physical model of the process, affine form of the model, nonstationary form as a method of simplification of the form of the model.
15. Introduction to predictive control – synthesis of the simple predictive controllers, reference trajectory, prediction horizon, repetition rule.
16. Practical aspects of the implementation of the simple model-based controllers: PMBC (Process Model-Based Control), linearizing control, PFC (Predictive Functional Control). Advantages and disadvantages of each control strategy.
17. Adaptation and integral action as two methods for compensating modelling inaccuracies in the model-based controllers: GMC (Generic Model Control) and B-BAC (Balance-Based Adaptive Control).
18. Perspectives for the advanced control strategies, limitations for their practical implementation.
Laboratory

The laboratory classes are strictly correlated with the topics discussed during lectures and the students have the possibility of implementing simple and advanced control structures and strategies. Laboratories are divided into 4 blocks and each block is dedicated to one laboratory installation and consists of 3 laboratory classes. Consequently, every group of students has to pass 12 meetings. For each laboratory block, the appropriate introduction is given, which includes the specific issues dealing with the particular process. On the basis of the lectures, students are obliged to prepare the problems that are required for doing the laboratory exercises. Additionally, the specific description is available for each block.

The list of processes with short description is presented below and it corresponds to the particular laboratory blocks:

1. Block 1: Control of pH process (identification of the static and dynamic characteristic of the process, implementation of the PID controller in the form of the PLC-based function block, gain-scheduling technique, implementation of the GMController)
2. Block 2: Control of the heating processes, part 1. (identification of the static and dynamic characteristic of the process, implementation of the single-loop control system, tuning of the P, PI controllers, operating point value, nonlinear feedforward correction, B-BAController)
3. Block 3: Control of the hydraulic process. (identification of the static and dynamic characteristic of the process, implementation of the nonlinear control system, tuning of the control system with the integral process, gain-scheduling technique, valve control).
4. Block 4: Control of the heating processes, part 2. (implementation and tuning of the predictive controller PFC, feedforward correction)

Each block consists of the following stages:

a) Introduction to the particular laboratory pilot plant.
b) Identification experiments for the particular systems, collecting the appropriate measurement data.
c) Implementation of the chosen control algorithms.
d) Experimental validation of the control performance.
d) Discussion on the results.
d) Preparation of the report.

20. Examination: not

19. Primary sources:

22. Secondary sources:

23. Total workload required to achieve learning outcomes

<table>
<thead>
<tr>
<th>Lp.</th>
<th>Teaching mode :</th>
<th>Contact hours / Student workload hours</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Lecture</td>
<td>30/0</td>
</tr>
<tr>
<td>2</td>
<td>Classes</td>
<td>0/0</td>
</tr>
<tr>
<td>3</td>
<td>Laboratory</td>
<td>30/30</td>
</tr>
<tr>
<td>4</td>
<td>Project</td>
<td>0/0</td>
</tr>
<tr>
<td>5</td>
<td>BA/ MA Seminar</td>
<td>0/0</td>
</tr>
<tr>
<td>6</td>
<td>Other</td>
<td>0/0</td>
</tr>
<tr>
<td></td>
<td>Total number of hours</td>
<td>60/30</td>
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</tbody>
</table>

24. Total hours: 90

25. Number of ECTS credits: 3

26. Number of ECTS credits allocated for contact hours: 1

27. Number of ECTS credits allocated for in-practice hours (laboratory classes, projects): 2

26. Comments: