Syllabus for the Course "Technologies of Automated Process Control and Automated Regulation"

Duration: 10 academic weeks + exam period

Class load: 30 academic hours (15 lectures + 15 practical sessions)

Independent study: 42 hours

Form of interim assessment: pass/fail exam and graded course project defence

Course format: System Engineering + AI-Assisted Industrial Control Design

1. General Characteristics of the Discipline

The discipline **«Technologies of Automated Process Control and Automated Regulation»** belongs to the professional module of the Master's programme **AI-Augmented Digital Systems Engineering** and is delivered in the 4th semester as the final course of the track **«Intelligent Cyber-Physical Systems»**.

The course volume is 2 ECTS credits.

The course provides a holistic understanding of designing control systems for technological processes and industrial cyber-physical systems, combining automatic control methods, industrial automation architectures, and modern digital technologies.

The discipline completes the engineering logic of the track:

IIoT → Cyber-Physical Systems → Integrated Robotic Systems → Technologies of Automated Process Control and Automated Regulation

Within the course, students move from system architecture design to managing the dynamics of technological processes.

The course develops an understanding that any industrial system is a controllable physical process requiring:

- parameter measurement;
- data processing;
- control decision-making;
- implementation of automatic control algorithms.

Special attention is given to the integration of automation systems with digital platforms, including:

- Industrial Internet of Things (IIoT);
- Digital Twins;
- intelligent data analysis methods;
- use of LLM as a tool for engineering analysis and design.

2. Place of the Discipline in the Programme Structure

The discipline serves as:

- the final systems engineering course of the **Intelligent Cyber-Physical Systems** track;
- an integration module between the architecture of cyber-physical systems and process control;
- a practical course in designing industrial automation systems.

The course builds on the learning outcomes of the following disciplines:

- **Industrial Internet of Things (IIoT)**;
- **Cyber-Physical Systems Technologies**;
- **Integrated Robotic Complexes and Information Systems**.

The discipline completes students' systemic understanding of:

- industrial automation architecture;
- methods of process control;
- integration of robotics, IIoT, and information systems.

3. Learning Objectives

The objectives of the discipline are:

- developing a systemic understanding of automated process control principles;
- mastering methods for analysing the dynamics of technological systems;
- developing skills in designing automatic control systems;
- forming competencies in developing process control system (PCS) architecture;
- mastering modern approaches to integrating control systems with digital platforms;
- developing skills in systems design of intelligent production systems;

- fostering a culture of using LLM as a tool for engineering analysis and control system design.

4. Course Tasks

Within the discipline, the following tasks are addressed:

- studying the architecture of automated process control systems;
- analysing dynamics and modelling technological processes;
- mastering automatic control methods;
- studying principles of control system design based on PLC and DCS;
- developing algorithms for process control;
- studying supervisory control systems (SCADA);
- mastering methods of integrating control systems with IIoT and digital platforms;
- studying intelligent data analysis methods for process control;
- developing skills in systems design of intelligent production systems;
- developing skills in using LLM for engineering analysis, design, and documentation.

5. Expected Learning Outcomes

Upon completing the discipline, students should:

Know:

- architecture of automated process control systems;
- principles of designing automatic control loops;
- methods for modelling technological processes;
- operation principles of industrial controllers (PLC, DCS);
- architecture of supervisory control systems (SCADA);
- methods of integrating control systems with industrial digital platforms;
- modern approaches to intelligent process control.

Be able to:

- analyse the dynamics of technological processes;
- develop mathematical models of processes;
- design automatic control systems;
- design PCS architecture;
- design monitoring and supervisory control systems;
- analyse and design integration of control systems with IIoT;
- apply LLM for engineering analysis and control system design.

Possess skills in:

- systems analysis of technological processes;
- tools for designing control loops;
- designing automation system architecture;
- designing operator interfaces;
- integrating control systems into digital production environments;
- using LLM in engineering activities.

6. Main Content of the Discipline

The discipline includes the following thematic sections:

Architecture of automated process control systems.
Dynamics and modelling of technological processes.
Fundamentals of automatic control.
PID control of technological processes.
Modern methods of process control.
Industrial controllers and real-time systems.
Supervisory control and visualisation systems.
Integration of PCS with IIoT and digital platforms.
Intelligent methods of process control.
Integrated control systems for intelligent production.

7. Course Project

The course project aims to develop a concept for a process control system or production system.

Within the project, students must:

- analyse a technological process;
- develop a process dynamics model;
- design an automatic control algorithm;
- develop PCS architecture;
- design a monitoring and supervisory control system;
- propose elements of integration with IIoT and digital platforms.

The project is completed in stages throughout the semester and defended via a presentation of the developed solution.

8. Use of LLM in the Educational Process

Within the discipline, Large Language Models (LLM) are used as a tool for engineering analysis and project support.

LLM are applied for:

- analysing control system architecture;
- developing automation system concepts;
- formulating mathematical process models;
- analysing control algorithms;
- preparing project documentation.

Use of LLM is accompanied by critical evaluation of results and engineering reflection.

CALENDAR-THEMATIC SCHEDULE

«Technologies of Automated Process Control and Automated Regulation»

IW - Independent Study / Independent Work

Week	Content	Lect. (h)	Sem. (h)	IW (h)
1	Lecture: Industrial Automation Architecture and Cyber-Physical Production Systems (ISA-95 levels). Classroom activity: Seminar — analysis of smart factory architecture. Discussion — structure of a digital enterprise. Independent study: Regular assignment — analysing the architecture of an automated process control system (APCS) for a selected industrial facility. Course project — selecting a course project topic and describing the technological process. Learning outcome: Students understand the structure of modern industrial automation and the role of process control. LLM use: LLM is used to analyse production system architecture and generate CPS architecture variants.	2	2	4

2	Lecture: Process Dynamics and Modelling. Classroom activity: Digital lab — modelling process dynamics (temperature, level, speed). Independent study: Regular assignment — building a simple mathematical model of a technological process. Course project — formalising the process model for the project. Learning outcome: Understanding the dynamic behaviour of technological processes. LLM use: LLM helps formulate mathematical models and verify the correctness of process variables.	2	2	4
3	Lecture: Fundamentals of Automatic Control (Feedback Control Systems). System stability. Classroom activity: Seminar — analysing control loops in a technological process. Independent study: Regular assignment — solving tasks on transient process analysis. Course project — designing the control loop structure for the project. Learning outcome: Understanding feedback principles and system stability. LLM use: LLM serves as an interactive consultant for control system analysis.	2	2	4
4	Lecture: PID Control. Methods of controller tuning. Classroom activity: Digital lab — tuning a PID controller for a model process. Independent study: Regular assignment — calculating PID parameters for a given process. Course project — developing a control algorithm within the project. Learning outcome: Students can design basic control algorithms. LLM use:	2	2	4

	LLM helps explain the impact of PID parameters and generate tuning options.			
5	Lecture: Advanced Process Control: cascade, adaptive, predictive control. Classroom activity: Seminar — comparing control strategies. Independent study: Regular assignment — analysing the efficiency of different control algorithms. Course project — selecting a control strategy for the course project. Learning outcome: Understanding the advantages of various process control methods. LLM use: LLM is used to analyse control scenarios and compare algorithms.	2	2	4
6	Lecture: Industrial Controllers and Real-Time Systems (PLC, DCS, Real-Time Control Systems). Classroom activity: Digital lab — developing control logic for a PLC. Independent study: Regular assignment — studying the IEC 61131-3 standard. Course project — designing the controller architecture for the project. Learning outcome: Understanding industrial control architecture. LLM use: LLM assists in developing control algorithms.	2	2	4
7	Lecture: SCADA and Supervisory Control Systems (SCADA, HMI). Classroom activity: Seminar — designing an operator interface. Independent study: Regular assignment — analysing SCADA system functions. Course project — designing a monitoring	1	1	4

	system for the project. Learning outcome: Developing an understanding of human-machine interaction. LLM use: LLM generates operator interface scenarios.			
8	Lecture: Integration of APCS and the Industrial Internet of Things (IIoT, Digital Twins). Classroom activity: Digital lab — developing a digital twin concept. Independent study: Regular assignment — analysing digital twin architecture. Course project — developing a digital process model for the project. Learning outcome: Understanding integration of control and digital technologies. LLM use: LLM analyses data flows and digital twin architecture.	1	1	4
9	Lecture: AI-Driven Process Control. Classroom activity: Discussion — applying AI in industry. Independent study: Regular assignment — reviewing modern intelligent control technologies. Course project — adding intelligent control elements to the project. Learning outcome: Recognising AI capabilities in process control. LLM use: LLM develops AI support control scenarios.	1	1	5
10	Lecture: Integrated Control Systems for Intelligent Production (Autonomous Manufacturing Systems). Classroom activity: Presentations and discussion of course projects. Independent study: Regular assignment — preparing the final project report. Course project — completing the course project.	0	—	—

	Learning outcome: Integrating all course knowledge into a unified control system. LLM use: LLM prepares project documentation and analyses solutions.			

1. Course Project Objective

The course project aims to develop students' practical skills in designing automated process control systems using modern automatic control methods, industrial automation architectures, and digital technologies.

Within the project, students must develop a concept for a process or production control system, including:

- a process model;
- control system structure;
- automatic control algorithms;
- industrial automation architecture;
- monitoring and supervisory control system;
- digital integration elements (IIoT, digital twin);
- intelligent control support capabilities.

2. General Course Project Task

Students are tasked with developing a concept for an automated process or production control system.

Possible of the following control object types may be selected:

- robotic production cell;
- automated production line;
- technological process (thermal, chemical, energy, etc.);
- intelligent warehouse system;
- transport process control system;
- process equipment control system.

The project must include:

- process analysis;

- process model development;
- automatic control system design;
- APCS architecture development;
- SCADA monitoring system integration;
- digital integration and intelligent control elements.

3. Step-by-Step Course Project Development Procedure

The project is developed in stages throughout the semester.

Stage 1. Selecting a Control Object

- describing the technological process;
- defining control objectives;
- identifying key process parameters.
  Outcome: control object description and control task formulation.

Stage 2. Process Analysis

- identifying controlled variables;
- defining control inputs;
- analysing disturbances;
- specifying system constraints.
  Outcome: process flow diagram.

Stage 3. Developing a Mathematical Process Model

- creating a mathematical process model;
- developing a dynamic system model;
- designing a control structure diagram.
  Permitted models: aperiodic link, oscillatory system, nonlinear models.
  Outcome: technological process dynamics model.

Stage 4. Designing an Automatic Control System

- selecting control system structure;
- developing control loops;
- choosing regulator type (PID, cascade, adaptive, Model Predictive Control).
  Outcome: process control algorithm.

Stage 5. Developing APCS Architecture

- defining sensors and measurement systems;
- selecting actuators;
- specifying PLCs;
- designing SCADA systems.
  Outcome: hierarchical control system architecture.

Stage 6. Designing a Monitoring and Control System

- defining monitoring parameters;
- structuring HMI;
- designing alarm systems.
  Outcome: monitoring system concept.

Stage 7. Digital Technology Integration

- implementing IIoT;
- developing digital twins;
- integrating data analysis systems;
- adding intelligent decision support.

Stage 8. Developing an Integrated Control System

- designing overall system architecture;
- ensuring component interaction;
- mapping information flows.
  Outcome: integrated process control system.

4. LLM Use in Project Development

LLM may be used for:

- control system architecture analysis;
- mathematical model formulation;
- control algorithm development;
- control scenario analysis;
- project documentation preparation.

LLM output must be critically evaluated.

5. Course Project Report Structure

- Introduction.

- Process description.
- Control object analysis.
- Mathematical process model.
- Control algorithm development.
- APCS architecture.
- Monitoring and supervisory control system.
- Digital technology integration.
- Final control system architecture.
- Conclusion.

6. Project Defence Procedure

Defence is a public presentation and discussion of the solution. Students must present:

- task formulation;
- process analysis;
- developed model;
- control algorithm;
- system architecture;
- digital integration elements.

Presentation must include:

- control system diagrams;
- automation architecture;
- simulation results.

7. Project Assessment Criteria

- task formulation correctness;
- process analysis quality;
- control method justification;
- APCS architecture completeness;
- engineering solution depth;
- presentation and defence quality.