POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Digital controllers and PLC [S1AiR1E>SPiRC]

Course

Field of study
Automatic Control and Robotics

Year/Semester
3/6

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
English

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
45

Laboratory classes
30

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

6,00

Coordinators

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Lecturers

Prerequisites

A student starting this course should have basic knowledge of computer science, digital logic, control theory, electronics and microprocessor systems. He/She should have the ability to obtain information from the indicated sources. In addition, in terms of social competence, the student must present such qualities as teamwork, honesty, cognitive curiosity and creativity.

Course objective

Course objective: 1. to provide students with basic knowledge of programming and application of programmable controllers in control processes, in the creation and analysis of control algorithms for subsystems and systems, the use of programming tools for the implementation of control tasks. 2. to master the knowledge and skills of the application of programmable controllers for the implementation of control of industrial processes, to acquire the ability to use selected PLC programming languages, to acquire the ability to operate equipment for the implementation of digital control and tools used for the programming of industrial systems. 3 Master the knowledge of discrete implementation of selected controllers, the principles of selection, application and testing of PID class controllers and discrete implementation of selected dynamic blocks. Mastering the ability to select regulator settings under industrial conditions. 4 To develop in students the ability to creatively solve problems in the configuration, programming and use of industrial control systems. The lecture program covers the following topics: W1. Introduction to programmable logic controllers, history and area of application, classifications of programmable logic controllers. PLC programming languages according to IEC 61131. Fundamentals of ladder logic language, contacts, coils, flip-flops. Principles of program development in LD. W2. Timers, counters, comparators and mathematical operations in PLC, implementation of simple control algorithms. Types of variables, addressing principles, absolute and symbolic addresses. W3. Concept and operation of the operating system of a programmable logic controller, duty cycle. Program memory, data memory, mapping of input and output states. Structural organization of the program, organization blocks, functions and function blocks. W4. Structured text language - basic ST (SCL) constructs, operators, built-in functions, type conversion. Design and writing of complex functions and function blocks, data blocks, formal, temporary and static variables. W5. Drum control, examples of dedicated blocks, description in the form of finite automata, implementation in LD and ST languages. W6. Complexity of description in the form of an automaton, justification for the introduction of the SFC sequence graph language. Description and basic structures of SFC, implementation of selected control tasks in SFC. W7. Discrete realization of selected automation blocks. Evaluation of the accuracy of implementation, notation in PLC languages. W8. Construction of PLC, power supply and operating conditions, discrete DC and AC inputs, analog inputs, mechanical, inductive, capacitive, ultrasonic, optical sensors, digital outputs: DC, AC, relay, connecting relays and contactors, overvoltage protection of outputs. W9. Concepts of control, compensation, regulation, structure of PID controller - theoretical and practical, 2DOF structure, structures according to ISA -I, II, III. Operation and experimental identification of P, I, D blocks, concept of doubling time, advance. W10. Selection of regulator settings - identification of step response parameters, fast-test, other forcing. Identification of KLT object parameters. Selection of settings by Z-N, Aastrom methods, modulus and symmetry criteria, others. W11. Custom implementation of the PID algorithm, wind-up phenomenon, prevention - AWU structures. W12. Implementation of PID algorithm in PLC - functional blocks, structures and limitations, autotuning. W13. The issue of temperature measurement and control, temperature sensors - resistive, thermocouples, other, dedicated temperature modules, structure of temperature control system (hysteresis controllers, hysteresis with correction, quasi-continuous) W14. Operator panels, PLC as part of a complex automation system. W15. Good practices in PLC programming The program of laboratory exercises includes learning PLC programming in LD and ST languages (Exercises 1 to 5), followed by the design and implementation of control systems for selected laboratory facilities (Exercises 6 to 10), and selected advanced issues in the application of controllers in control systems (Exercises 11 to 14).

Course-related learning outcomes

Knowledge:
Knows and understands to an advanced degree the theory and methods in the architecture and programming of microprocessor systems, knows and understands selected high- and low-level microprocessor programming languages; knows and understands the principle of operation of basic peripheral modules and communication interfaces used in microprocessor systems [K1_W13 (P6S_WG)].
Has a comprehensive knowledge of the structures and operating principles of analogue and discrete control systems (open-loop and feedback) and linear and simple non-linear analogue and digital controllers [K1_W16 (P6S_WG)].
Knows and understands to an advanced degree the structure and principles of operation of programmable industrial controllers, as well as their analog and digital peripheral systems; knows and understands the principle of operation of basic communication interfaces used in industrial control systems [K1_W19 (P6S_WG)].
Knows the methods, techniques, tools and materials used in solving simple engineering tasks in the field of automation and robotics [K1_W23 (P6S_WG)].
Skills:

Can interpret with understanding the design technical documentation and simple technological diagrams of automation and robotics systems [K1_U2 (P6S_UW)].
Is able to select parameters and settings of a basic industrial controller and configure and program an industrial programmable controller [K1_U18 (P6S_UW)].
Is able to evaluate the suitability of routine methods and tools for designing automation and robotics systems, and select and apply the appropriate method and tools [K1_U24 (P6S_UW)].
Is able to construct an algorithm to solve a simple measurement and control task and implement, test and run it in a selected programming environment on a microprocessor platform [K1_U27 (P6S_UW)].
Social competences:
Is aware of the necessity of a professional approach to technical issues, meticulous familiarization with the documentation and environmental conditions in which the devices and their components may function; is ready to observe the principles of professional ethics and require this from others, respecting the diversity of views and cultures [K1_K5 (P6S_KR)].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The knowledge acquired in the lecture is verified by a written exam. The exam consists of 20 - 30 questions (test and open), variously scored. The threshold for passing: 50% of the points. Credit issues, on the basis of which questions are developed, are made available to students using the university system of electronic courses.
Skills acquired in laboratory classes are verified on the basis of ongoing evaluation of students' work and three 15-minute tests or a 45-minute credit colloquium, consisting of 5-7 questions/tasks variously scored depending on their difficulty. Passing threshold: 50% of the points.

Programme content

The lecture syllabus covers the following topics:

1. Hardware issues: construction of the PLC, connecting external input (sensors) and output devices (actuators), operator panels, preliminary concepts of fieldbus.

2. Controller software organisation: operating system, operation cycle, memory, organisational blocks, functions and function blocks, interrupts and exception handling.

3. Programming issues: a systematic course in programming languages: ladder logic LD, structured text ST and action sequences SFC. Different programming paradigms for controllers: procedural programming, drum control, finite automata, object-oriented programming.

4 Theoretical and implementation issues in industrial control systems for continuous quantities - discrete controllers, analysis and implementation of a PID controller, parameter selection and self-tuning, practical implementation in a PLC.

The programme of laboratory exercises includes learning PLC programming in LD and ST languages , followed by design and implementation of control systems for selected laboratory objects.

Course topics

The lecture syllabus covers the following topics:

L1. Introduction to programmable logic controllers, history and area of application, classifications of programmable logic controllers. IEC 61131 compliant PLC programming languages. Ladder logic language basics, contacts, coils, flip-flops.
Ladder logic, contacts, coils, flip-flops. Principles of program development in LD.

L2. Timers, counters, comparators and mathematical operations in PLC, implementation of simple control algorithms. Types of variables, addressing principles, absolute and symbolic addresses.

L3. Concept and operation of the operating system of a programmable controller, duty cycle. Program memory, data memory, representation of input and output states. Internal representation of data types. Structural organisation of the program, organisational blocks, functions and function blocks.

L4. Structured text language - basic ST constructs (SCL), operators, built-in functions, type conversion. Procedural programming: program structure design, design, creation, placement of data blocks, global and local data blocks, design and invocation of functions, function blocks, formal, temporary and static variables.

L5. Drum control, examples of dedicated blocks, description of control task in finite automaton form, implementation in LD and ST languages.

L6. Complexity of description in the form of an automaton, motivation for the introduction of the SFC sequence graph language. Description and basic structures of SFC, implementation of selected control tasks in SFC.

L7. Discrete realisation of selected automation blocks. Accuracy assessment of realisation, implementation in PLC languages.

L8. Construction of PLC, power supply and operating conditions, discrete DC and AC inputs, analogue inputs, mechanical, inductive, capacitive, ultrasonic, optical sensors, digital outputs: DC, AC, relay, connecting relays and contactors, overvoltage protection of outputs

L9. Concepts of control, compensation, regulation, PID controller structure - theoretical and practical, 2DOF structure, structures according to ISA -I, II, III. Operation and experimental identification of P, I, D blocks, concept of doubling time, advance time. Two and three position controllers, software implementation of hysteresis.

L10. Selection of controller settings - identification of step response parameters, fast-test, other forcing. Identification of KLT object parameters. Selection of settings using Z-N, Aastrom methods, modulus and symmetry criteria, others.

L11. Custom implementation of PID algorithm, wind-up phenomenon, prevention of wind-up phenomenon of AWU structure.

L12. Implementation of PID algorithm in PLC - functional blocks, structures and limitations, autotuning

L13. Temperature measurement and control, temperature sensors - resistive, thermocouples, other, dedicated temperature modules, structure of temperature control system (hysteresis controllers, hysteresis controllers with correction, quasi-continuous)

L14. Operator panels, PLC as a part of complex automation system

L15. Good practices in PLC programming

The programme of laboratory exercises includes learning PLC programming in LD and ST languages (exercises 1 to 4), followed by the design and implementation of control systems for selected laboratory objects (exercises 5 to 9) and selected advanced issues in the application of controllers in control systems (exercises 10 to 14).

Teaching methods

1. lecture: multimedia presentation, presentation illustrated by examples given on the blackboard.
2. laboratory exercises: introduction to the task, programming the task and its verification, testing the results of the program.

Bibliography

1. Hugh Jack,: Automating Manufacturing Systems with PLCs, P.Eng. Michigan, USA, 2010 (available online)
2. Petruzella, Frank D. Programmable logic controllers — 4th ed., McGraw-Hill, New York, 2011
3. Tom Mejer Antonsen, PLC Control with Structured Text, Randers, Denmark 2020

4. Programming Guideline for S7-1200/S7-1500, Siemens

Breakdown of average student's workload

	Hours	ECTS
Total workload	150	6,00
Classes requiring direct contact with the teacher	75	3,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	75	3,00