# POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

## COURSE DESCRIPTION CARD - SYLLABUS

Course name
Programming of PLCs and industrial controllers [S1AiR2>PLC]

### Course

Field of study
Automatic Control and Robotics

Year/Semester
2/4

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

### Number of hours

Lecture
30

Laboratory classes
30

Other
0

Tutorials
0

Projects/seminars
0

### Number of credit points

5,00

### Coordinators

dr hab. inż. Stefan Brock prof. PP
stefan.brock@put.poznan.pl

dr inż. Jarosław Majchrzak
jaroslaw.majchrzak@put.poznan.pl

### 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

The objectives of the course are: 1 To provide students with basic knowledge of programming and application of programmable logic controllers in control processes, in terms of creating and analysing control algorithms for subsystems and systems, using programming tools to implement control tasks. 2. To master the knowledge and skills for 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 programming industrial systems. 3 To master the knowledge of discrete realisation of selected controllers, principles of selection, use and testing of PID class controllers and discrete realisation of selected dynamic blocks. To master the skills of selection of controller settings in industrial conditions. 4 To develop in students the ability to creatively solve problems in the configuration, programming and use of industrial control systems.

## Course-related learning outcomes

Knowledge:
1. has basic knowledge of architectures and programming of microprocessor systems, knows selected high and low level microprocessor programming languages, knows and understands how to work;
2. has a structured knowledge of structures and principles of operation of analog and discrete control systems (open and feedback) and linear and simple non-linear controllers;
3. has a clear understanding of the structure and principles of operation of programmable industrial controllers and their analog and digital peripheral systems; knows and understands the principle of operation of basic communication interfaces;
4. is familiar with the basic methods, techniques, tools and materials used to solve simple engineering tasks in the field of automation and robotics;

Skills:
1. is able to select parameters and settings of the basic industrial controller and configure and program the industrial programmable controller;
2. is able to assess the suitability of routine methods and tools for the design of automation and robotics systems, and to select and apply an appropriate method and tools;
3. is able to construct an algorithm for solving a simple measurement and calculation-control task and to implement, test and run it in a selected programming environment on the platform;

Social competences:
1. is aware of the need for a professional approach to technical issues, scrupulous familiarization with the documentation and environmental conditions in which the equipment and its components can;

## 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. Topics, 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 current assessment of students' work and optional three 15-minute tests or a 45-minute credit colloquium, consisting of 5-7 questions/tasks variously scored depending on their degree of 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 with examples given on the board.
2. Laboratory exercises: introduction to the task, programming the task and its verification, testing the results of the programme.

## Bibliography


Basic:
1. Lecture materials successively shared by the lecturer in electronic form..
2. Kwaśniewski J. Sterowniki SIMATIC S7-1200 w praktyce inżynierskiej. Wydawnictwo BTC, Legionowo 2013
3. Kwaśniewski J. Język tekstu strukturalnego w sterownikach SIMATIC S7-1200 i S7-1500. Wydawnictwo BTC, Legionowo 2014
4. Brock S., Muszyński R., Urbański K., Zawirski K. : „Sterowniki programowalne” - Wydawnictwo Politechniki Poznańskiej
5. Sałat R., Korpysz K., Obstawski P.: Wstęp do programowania sterowników PLC, Wydawnictwa Komunikacji i Łączności WKŁ 2009.
6.Kasprzyk J.: Programowanie sterowników przemysłowych, WNT Warszawa, 2014
7. Kwaśniewski J. Sterowniki SIMATIC S7-1200 i S7-1500 w zaawansowanych systemach sterowania, BTC 2018
8. Simatic S7 Programowalny sterownik S7-1200. Podręcznik systemu, Siemens

Additional:
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 2014


## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 125 | 5,00 |
| Classes requiring direct contact with the teacher | 63 | 2,50 |
| Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation) | 62 | 2,50 |