Course name: **Programming and digital transmission in PLC controllersc**

Course

Field of study	Year/Semester
Computer Science	1/1
Area of study (specialization)	Profile of study
Internet of Things	general academic
Level of study	Course offered in
Second-cycle studies	polish
Form of study	Requirements
full-time	obligatory

Number of hours

Lecture	Laboratory classes
15	30

Number of credit points

6

Lecturers

Responsible for the course/lecturer
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Responsible for the course/lecturer
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Prerequisites

A student starting this course should have:
1. Basic knowledge of electrical engineering, electronics, automatics, digital technology, mathematical logic, measuring systems and actuators.
2. The ability to solve basic problems of systemic and programmatic creation of specific logical-functional structures, delineated ways of presenting their operation and creating algorithms for handling systems with conditional operation.
3. Ability to obtain information from the indicated sources.

In addition, in terms of social quality, the student must be honest, responsible, persistent in solving the problems of the subject, cognitive curiosity, creativity and personal culture.

Course objective

1. Provide students with basic knowledge about the construction, operation, programming and application of programmable controllers and their selection for monitoring and control of the technological process of the embedded system.

2. Acquiring the principles of the correct creation of a control system with the use of a PLC including: declaration of system variables, algorithm of its operation, program development and its verification.
3. Acquainting students with the structure, configuration and programming of selected serial ports PLC controllers, RS standards of transmission and communication with open systems and with security transmitted data.

Subiect learning outcomes

Knowledge

1. The student has an ordered, theoretically founded general knowledge in the field of properties and possibilities of using PLC controllers for selected technological processes, methods of their programming and testing the application program.
2. The student has theoretically founded detailed knowledge related to selected issues in the field of PLC programming.
3. The student has the knowledge necessary to:
   - designing an automation system using a PLC controller,
   - developing an algorithm for processing and generating signals in the PLC controller,
   - ensuring communication between PLC devices,
   - implement the processing algorithm in the PLC controller.

Skills

As a result of the conducted classes, the student is able to:

- obtain information from the literature on the subject and other sources, integrate it and make it interpretation,
- use to formulate and solve engineering tasks and simple research problems analytical, simulation and experimental methods used during laboratory exercises,
- propose improvements (rationalization) of existing technical solutions,
- design and implement a simple automation system based on a PLC controller,
- define and describe a system solution for a specific task,
- design the adopted solution on the selected PLC platform,
- run and verify the correct operation of the adopted systemic solution.

Social competence

Pass of the course means that the student:

- understands that in the field of PLC controllers and their programming there is constant modernization, requiring constant improvement of the ability to use them,
- knows examples and understands the reasons that can lead to malfunctioning systems with PLC controller,
- can properly define the priorities for the implementation of a specific task in the field of programming PLC controllers.

Methods verifivation of learning outcomes and assessment criteria

The learning outcomes presented above are verified as follows:

Formative assessment:

a) in the field of lectures:
   ● on the basis of answers to questions about the material discussed in previous lectures,
b) in the field of laboratories:
   ● on the basis of an assessment of the current progress in the implementation of tasks.

Summative assessment:

a) in the field of lectures, verification of the assumed learning outcomes is carried out by:

- assessment of knowledge demonstrated on a written test of a problem nature: 10÷15 questions open-ended lectures without the right to use lecture notes; score (given) depending on the degree of difficulty of the question on a scale of 1 ÷ 3 points; satisfactory from 51% of the maximum number of points,
- discussion of the test results,

b) in the field of laboratories, verification of the assumed learning outcomes is carried out by:

- assessment of skills related to the implementation of laboratory exercises, this assessment also includes the skillwork in a team.
- continuous assessment, during each class (oral answers) - rewarding skill development use of learned principles and methods,
- assessment of the report prepared in the event of failure to complete a given exercise during classeslaboratory; (this also results in the need to complete the exercise outside of class) and assessment reports on a problem task assigned for own solution.

Obtaining additional points for activity during laboratory classes, especially for:

- discuss additional aspects of the issue,
- effectiveness of applying the acquired knowledge while solving a given problem,
- comments related to the improvement of teaching materials,
- identifying students' perceptual difficulties enabling ongoing improvement of the process didactic.

Program content

The program of 8 lectures covers the following topics:

1. Overview: subject matter, literature and conditions for passing. Introduction: definition of the driver PLC; freely programmable controller. Overview of PLC products from different companies. Drivers compact and modular: characteristics, configuration, set completion. Extension modules driver. Operator terminal. PLC programming languages. Programmable relays – characteristics and possibilities on the example of drivers: LOGO (Siemens), Alpha XL (Mitsubishi Electric), Need (Relpol) and Easy (Moeller). I / O circuits. AlphaXL controller: the place of the controller in the hierarchy of PLC controllers, structure and expansion possibilities, input and output signals, operator terminal functions. Inputting signals analog. Communication with the environment. AL-VLS utility software and its functions: blocks functional. Programming the Alpha XL controller: creating logical functions, signal processing binary, memory, counting, arithmetic, time and communication blocks and circuits and special.
2. Binary channel, basic definitions: transmit coding, modulation, modulation and transmission rate. Structure of the data transmission terminal UKTD. Interfaces: RS232, RS422, RS485 and USB for communication with the PLC: parameters, signals, data transfer control. Alpha XL communication with the environment: additional RS232 communication port: configuration communication: with a higher-level controller by means means of a modem or a radio modem in the GSM network.
3. FX compact controller: hardware characteristics of the FX family; entry and exit binary, analog and transmission signals to/from the controller. Possibilities and Limitations modular expansion of the controller. Types of external devices cooperating with controllers FX. Internal devices - operands of logical and advanced instructions; sequence of actions in program loop and loop cycle time. Driver instruction characteristics: program elements ladder; basic instructions of the controller: creating simple and block logic functions, differentiation of the state of a binary variable, state memory of a binary point of a logical network, relays counters and timers. System binary status and initialization variables and numeric variables status and diagnostic. Support for external and time interrupts. Fast counters.
4. FX Compact Controller: characteristics of advanced instructions and their notation for operations 16 and 32 bitwise; instructions to change the order of program execution; instructions for comparing, sending, decoding and encoding; arithmetic of driver processing: ranges of numerical variables, arithmetic and logic instructions on the driver word; quad notation for notation of operands binary; index addressing; floating

point operations. Communication with the blocks intelligent processing of AC and CA: transfer instructions, configuring blocks. Introducing and outputting analog signals to / from the controller. Embedded protocol, communication with an operator terminal.
5. Compact controller FX: state sequence programming SFC: cyclic and multi-state processes: process state graph and state network: state decomposition and determination of transition conditions; building state sequence networks in the utility software: state markers, start states, descent / descent of alternate and parallel process states, instructions to change the order of execution state functions and output from SFC section; the order of creating a PLC program with an SFC section. Examples of using PLC programming: processing of impulse information: time measurement the duration or period of the pulse signal. Characteristics of the methods of synthesis of multi-state systems in the PLC. SFC: generating waveforms of signals given by graphs, graphs time schedule or event table.
6. Redundant protection of serial data. Linear codes in matrix notation; properties linear codes. Control and generating matrix; Hamming distance, weight distribution, ability code detection and correction.
7. Linear codes in polynomial notation. Polynomial serial encoding "on the go". Advanced redundant coding instructions in the FX controller. Coding and decoding polynomials in the FX controller.
8. FX compact controller: Programming serial ports for external communication: configuration hardware; operating instructions for the built-in serial ports of the controller. Intelligent modules external communication: RS and network. Internet communication modules.

Laboratory exercises are performed in groups of 2 during 15 2-hour lessons.

Each of the 8 training stations is equipped with a PC computer with software a tool for programming controllers and a Mitsubishi Electric Alpha type PLC XL and FX. Each computer contains the content of the exercise tasks as well as the manufacturer's literature concerning PLC controllers in Polish and English. The practice tasks consist of writing program, its launch and testing until it works correctly. Within one exercise, depending on the subject of the exercise, the group performs from one to several tasks. Each the student may receive didactic software tools for a given type of controller, designed to write and test programs written by yourself.

Exercise topics:

1. Introduction to Alpha (AL) controller programming: communication with the controller; simulation and program monitoring; programming elements of memory circuits - flip-flops and their synthesis.
2. AL: Programming a 3-bit serial counter with a state decoder. Visualization of the counter status and decoder on the operator panel and software counter. Conditions for the concurrency of the two counters.
3. AL: Number multiplexer; bit-to-number and number-to-bit converter.
4. AL: Asynchronous frame transmitter and receiver.
5. AL: Pumping station simulator: programming of pump control systems and water level transducer in the tank.
6. Introduction to programming FX controllers: GX-Developer utility: communication with controller; program simulation and monitoring; basic instructions; flip-flops; programming logic functions; impulse control system with memory.
7. FX: Programming time relays (timers) and counters: types of timers and counters; filtration impulse disturbance; presentation of system clock markers; time measurement of events. Programming the equivalent of the DELAY function block from the AL driver; system presentation clock markers; creating software generators; generation of complex waveforms temporal.
8. FX. Transfer and indexing instructions; entering numbers into the table from the telephone impulse dial.
9. FX. SFC programming: Direct reading of the level transmitter from the pumping station simulator.
10. AL: Serial encoder by g (x).
11. FX: Polynomial encoder (16.8).
12. FX: Polynomial encoder (40,24).
13. FX: Serial port support. Serial transfer via RS485 link between two controllers. Data block transfer with redundant protection and its verification.
14. Network communication between FX controllers via the embedded network.
15. FX: Synthesis of the acoustic alarm signaling system on the basis of the system state graph. Doing up arrears.

Teaching methods

Lecture:

A multimedia presentation or a presentation of the controller programming using the utility program.

Laboratory exercises:

Discussion on the topic of the exercise, task programming and verification, performing experiments team.

Literature

Primary:

1. R. Mielcarek: Programowanie zagadnień transmisyjnych w sterownikach PLC. WPP, Poznań 2019.
2. R. Mielcarek: Programowanie sterowników PLC. WPP, Poznań 2012.
3. Legierski, J. Wyrwał, J. Kasprzyk, J. Hajda: Programowanie sterowników PLC. Wydawnictwo Pracowni Komputerowej Jacka Skalmierskiego, Gliwice 1998.
4. J. Kwaśniewski: Programowalne sterowniki przemysłowe w systemach sterowania. Wydawnictwo: Katedra Automatyzacji Procesów AGH, Kraków 1999.
5. W. Mielczarek: Szeregowe interfejsy cyfrowe. Helion, 1993.
6. S.Flaga: Programowanie sterowników PLC w języku drabinkowym. BTC 2010.

Complementary:

1. www.mitsubishi-automation.pl**:** Mitsubishi Electric PLC controllers: manuals: programming, communication and industrial networks of Alpha and FX controllers.
2. www.simens.com: Siemens PLC controllers: manuals programming and communication controllers Logo and Simatic.
3. www.relpol.pl: Need controller - application and programming.
4. www.moeller.pl: Easy controller - properties, programming, application.

Breakdown of average student's workload

	Hours	ECTS
Total workload	90	3
Classes requiring direct contact with the teacher	40	1,5
Student's own work (literature studies, preparation for laboratory classes, preparation of reports, preparation for a final test)	40	1,5