



## COURSE DESCRIPTION CARD - SYLLABUS

Course name

Networks and distributed control systems [S1AiR1E>PO3-SiRSS]

### 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

elective

### Number of hours

Lecture

30

Laboratory classes

30

Other

0

Tutorials

0

Projects/seminars

0

### Number of credit points

5,00

### Coordinators

dr inż. Dominik Łuczak

dominik.luczak@put.poznan.pl

### Lecturers

### Prerequisites

Knowledge: A student starting this subject should have basic knowledge of electronics and basic programming. Skills: The student should have the ability to solve basic problems in the field of digital signal processing and the ability to obtain information from specified sources. He should also understand the need to expand his competences and be ready to cooperate in a team. Social competences: In addition, in the area of social competences, the student must exhibit such qualities as honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture, respect for other people.

### Course objective

The aim of the course is to learn the theoretical foundations, principles of operation and possible applications of devices communicating with other objects of a distributed control system without human intervention (Machine to Machine, M2M), both wired and wirelessly via the global Internet network or local network. After completing the education, the student should be able to: 1) develop a simple application for an edge device allowing remote management of a selected item connected to the global network, 2) develop a device enabling communication with other objects on the Internet or local network, 3) prepare a user interface for remote management of one or several objects.

### Course-related learning outcomes

#### Knowledge:

Has a basic knowledge of the handling and use of IT tools for the design, rapid prototyping, simulation and visualisation of automation and robotics systems and for recording the design of mechanical constructions [K1\_W10 (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 determine and use models of simple electromechanical systems and selected industrial processes, and use them for analysis and design of automation and robotics systems [K1\_U11 (P6S\_UW)].

Be able to use selected rapid prototyping tools for automation and robotics systems [K1\_U13 (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)].

Be able to design and implement a local ICT network (including an industrial network) by selecting and configuring communication elements and devices (wired and wireless) [K1\_U28 (P6S\_UW)].

#### Social competences:

Is aware of the responsibility for his/her own work and is ready to follow the rules of teamwork and take responsibility for jointly implemented tasks; is able to lead a small team, set goals and determine priorities leading to the realisation of the task; is ready to play a responsible professional role. [K1\_K3 (P6S\_KR)].

Is ready to prioritise in order to complete a task defined by himself or others [K1\_K4 (P6S\_KO)].

The graduate is aware of the need for a professional approach to technical issues, meticulous familiarization with the documentation and environmental conditions in which the equipment and its components can operate. The graduate is ready to observe the rules of professional ethics and to demand it from others, to respect the diversity of opinions and cultures [K1\_K5 (P6S\_KR)].

### Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

#### Formative assessment:

a) in terms of lectures:

based on answers to questions about the material covered in previous lectures,

b) within the scope of the laboratory:

based on the assessment of knowledge and understanding of current issues presented in the course.

c) In both forms of classes, it is possible to use Problem-Based Learning (PBL) tasks that support the current research and technical needs of the course coordinator and are supervised by the instructor, taking into account the iterative and cyclical nature of task implementation, provided that they are consistent with the course content.

#### Summary rating:

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

i. assessment of knowledge and skills demonstrated on a multiple-choice test.

ii. discussion of the results,

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

i. development of an IoT control and measurement system in its basic version.

ii. development of an IoT control and measurement system in an extended version.

c) The summative assessment may include the results of Problem-Based Learning (PBL) assignments developed for the research and technical needs of the course coordinator and supervised by the instructor, provided they are consistent with the course curriculum.

d) Obtaining additional points for activity during classes, in particular for:

i. independent construction of the electronic module of the control and measurement system and preparation of documentation

ii. effectiveness of applying acquired knowledge when solving a given problem

iii. comments related to the improvement of teaching materials.

## Programme content

The subject covers a wide range of issues related to the Internet of Things (IoT), from basic elements and application tasks, to system construction, development modules, programming environments and data exchange formats. Students also learn web applications with a RESTful interface, configuration of Linux operating systems with selected hardware elements, e.g. GPIO, SPI, UART, I2C, creating a server application for devices with limited resources, structure and interaction of web interfaces (e.g. HTML, jQuery, CSS, Bootstrap), selected network protocols (e.g. Ethernet, IP, TCP, UDP, DHCP, ARP, HTTP, MQTT) and security issues.

Laboratory classes give students the opportunity to practically apply the acquired knowledge. They include familiarization with the equipment, occupational health and safety rules, design environment, JSON format, development of a RESTful interface, configuration of the Linux system, development of applications for Linux to support selected GPIO, SPI, UART, I2C interfaces, user interface design, development of web interfaces (e.g. HTML, jQuery, Bootstrap) with interactive elements, with the possibility of using signal processing algorithms, as well as development and testing of the control and measurement system.

The course program provides comprehensive preparation for working with Internet of Things applications. Students will gain theoretical knowledge and practical skills necessary to design, create and implement IoT edge devices in various fields.

## Course topics

The lecture program covers the following topics:

1. Elements and tasks of Internet of Things applications. Data exchange format between systems - JSON, REST interface (representational state transfer), HTTP client.
2. REST application in PHP. HTTP server on IoT and REST device.
3. Linux operating system configuration - GPIO, SPI, UART, I2C configuration.
4. Linux system - access rights, shell scripts, creating users, SSH remote access.
5. Structure of the web interface – HTML, jQuery. Web interface interaction - JS, jQuery
6. Presentation of the web interface - CSS, Bootstrap.
7. Selected communication protocols (e.g. Ethernet, IP, TCP, UDP, TLS, DHCP, ARP, HTTP, MQTT).

The laboratory curriculum covers the following topics:

1. Organizational classes - familiarization with health and safety equipment and footnotes, introduction to the design environment. JSON data exchange format.
2. Parsing JSON data.
3. REST application in PHP. HTTP server on the IoT edge device.
4. HTTP client.
5. CLI (Command Line Interface) for LED arrays. REST interface for LED arrays.
6. Command line interface for sensors. REST interface for sensors.
7. I2C interface. REST interface for a sensor with an I2C interface.
8. Web user interface - dynamic generation of the interface structure for sensors (jQuery and HTML).
9. Web user interface - dynamic generation of the interface structure for LED arrays (jQuery and HTML).
10. Web user interface - presentation layer (CSS and Bootstrap).
11. Final application including a basic application with the possibility of extension with additional modules, e.g. MQTT, WS, HTTPS, CRON, a single-board computer via SPI or UART manages the NUCLEO-ST32F7 board implementing automatic regulation applications.

## Teaching methods

1. Lecture: multimedia presentation illustrated with computer simulations and a real system
2. Laboratory classes: the use of single-board development modules with a set of sensors, programming environments for Internet applications
3. Both forms of instruction offer the opportunity to incorporate elements of Problem-Based Learning (PBL), in which students work on problems and projects defined for the research and technical needs of the course coordinator and supervised by the instructor. This approach places particular emphasis on the iterative nature of work, encompassing problem analysis, solution design, practical verification, and systematic refinement.

## Bibliography

### Basic

1. Ilya Grigorik, Wydajne aplikacje internetowe. Przewodnik, Helion, 2014 / Ilya Grigorik, High Performance Browser Networking, 2013
2. Justin Hutchens, Skanowanie sieci z Kali Linux : receptury : bezpieczeństwo sieci w Twoich rękach!, Helion, 2015 / Justin Hutchens, Kali Linux Network Scanning Cookbook, 2014
3. Adam Gerber, Clifton Craig, Android Studio : wygodne i efektywne tworzenie aplikacji, Helion, 2016 / Adam Gerber, Clifton Craig, Learn Android Studio Build Android Apps Quickly and Effectively, 2015
4. Adrian McEwen, Hakim Cassimally, Designing the Internet of Things, Wiley, 2013.

### Additional

1. Łuczak, D. Machine Fault Diagnosis through Vibration Analysis: Continuous Wavelet Transform with Complex Morlet Wavelet and Time–Frequency RGB Image Recognition via Convolutional Neural Network. *Electronics* 2024, 13, 452, doi:10.3390/electronics13020452.
2. Łuczak, D.; Brock, S.; Siembab, K. Cloud Based Fault Diagnosis by Convolutional Neural Network as Time–Frequency RGB Image Recognition of Industrial Machine Vibration with Internet of Things Connectivity. *Sensors* 2023, 23, 3755, doi:10.3390/s23073755.
3. Łuczak D., Remote laboratory with WEB interface, *Computer Applications in Electrical Engineering*, Vol. 9, str. 257-268, Poznań, 2011, ISSN 1508-4248.
4. Karol Rogowski, Świat poza jQuery : biblioteki : AngularJS, KnockoutJS i BackbonesJS, Wydawnictwo Naukowe PWN, 2014.

## Breakdown of average student's workload

	Hours	ECTS
Total workload	120	5,00
Classes requiring direct contact with the teacher	60	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	60	2,50