INDUSTRY 4.0 PILOT LABORATORY

Károly SZÉLL
Alba Regia Technical Faculty, Óbuda University, Székesfehérvár, Hungary
szell.karoly@amk.uni-obuda.hu

Abstract: By introducing the concepts of the Internet of Things (IoT) and the Cyberphysical System (CPS), industrial automation is undergoing significant changes. These concepts are not entirely new, but in recent years they have become more and more penetrating into industrial automation, placing automation systems in a very different light. They support the latest trends, such as higher level interconnection of system components, cognitive automation, and information gathering and processing in cloud-based applications. The application of IoT's and CPS's ideas in industrial automation has led to the definition of Industry 4.0, where 4.0 refers to the fourth industrial revolution allowed by Internet technologies to create smart products, smart production and smart services. This paper introduces the industry 4.0 pilot laboratory at Obuda University, Alba Regia Technical Faculty.

Keywords: *Industry 4.0, IoT, digitization, smart manufacturing, OPC UA*

I. INTRODUCTION

Industry 4.0 as the fourth industrial revolution is an active field in modern automation [1]–[3]. The most important question in this topic: How do machines communicate? Based on the Reference Architectural Model Industrie 4.0 (RAMI4.0) we have chosen Open Platform Communications Unified Architecture (OPC UA) as standardized communication protocol [4].

II. EDUCATIONAL METHODOLOGY OF INDUSTRY 4.0

To demonstrate technologies, we needed a simulated industrial environment, which allows the presentation of the automation principles in classroom using the most modern HW and SW devices. With regard to HW devices, PLCs, pneumatic and electro-pneumatic equipment, and modern electric drive units were purchased. It was important when selecting software the device compatibility, long-term licensing, support, and price. When implementing the principles into practice, the system to be implemented has been broken down into its elements when designing it, where different students receive and solve the most typical tasks of their training. In the case of SW, the IT engineer, and in the case of HW, the electromechanical students have to solve more complex tasks. Of course, it is not a goal to draw a sharp line between the two professions in these educational developments. MSc students can be active throughout the process, thanks to mechatronic training. This means, they will be able to solve IT, electrical and mechanical tasks too.

The purpose of education is to understand the system's distinctive elements, applied in a system, where not only reliable operation is guaranteed, but industry's 4.0 principles also appear at all levels of the system. We have aimed at acquiring a technical approach where our engineers know the entire system from the outside and from the inside.

The implementation of the industry 4.0 pilot laboratory enables the cognition of the following processes and activities for our students:

- Introduction to electricity
- Basics of magnetism
- DC networks
- AC networks
- Signal analysis
- Basic physical principles of sensors
- Sensors technologies
- Digital electronics
- PLC technologies
- PLC programming
- Actuator technologies
- Introduction of practical pneumatics
- Compressed air technologies
- Air compression and distribution
- Air treatment
- Pneumatic actuators
- Directional control valves
- Pneumatic/elektro-pneumatic symbology

We need to build a flexible learning system where knowledge can be acquired dependant on the user's available time and requirements. Users have the option to take actual classes and additional Internet courses when this suits them best. To be able to develop different technology skills, the theoretical knowledge of our students must be acquired first.

Through a learning procedure, students can get connected and work through the different chapters and tests to complete these courses. Each chapter ends in a test, validating knowledge acquisition.

III. INTRODUCTION TO ELECTRICITY

The course runs through the production, transport, distribution and use of electrical energy, including the components and control circuits used. The student will become familiar with different types of circuits and

Manuscript received February 15, 2019; revised February 25, 2019

electrical applications and will be capable of understanding the laws and relationships between electrical parameters.

Chapters:

- Production of electricity
- Transmission and distribution
- Uses of electricity
- Atomic models
- Electrical circuit elements
- Electrical current (AC/DC)
- Voltage (AC/DC)
- Electrical power (AC/DC)
- Resistance and impedance
- Ohm's law, Watt's law, Kirchhoff's law
- Nonlinear circuits
- Time domain analysis
- Frequency domain analysis

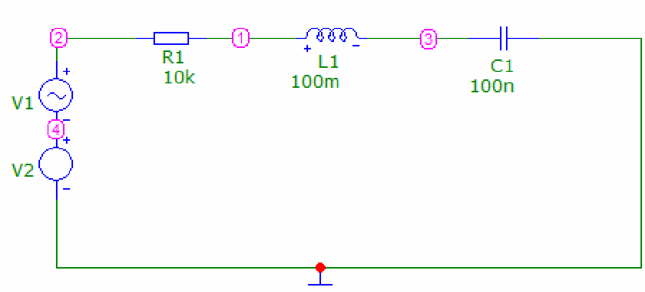

Figure 1. Simulation of RLC networks [5]

IV. INTRODUCTION TO INDUSTRIAL AUTOMATION

The Automation course introduces industrial automation, widening the students's knowledge on the importance, benefits and energy sources involved in these systems. It explores some specific assembly processes to understand generic automated systems.

Chapters:

- History of automation
- Automated process
- Automated system

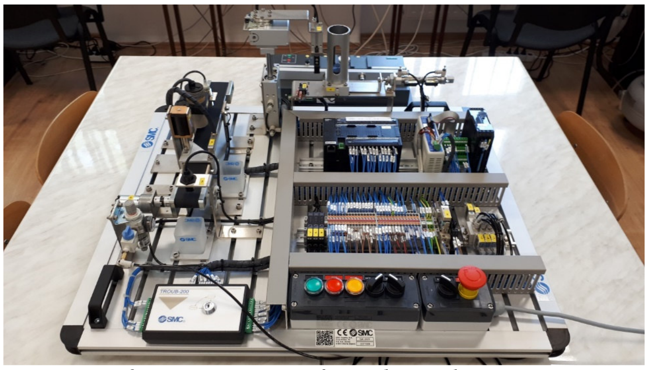

Figure 2. Training setup for industrial automation

V. PRINCIPLES OF PNEUMATICS

In this course students learn the basic principles, laws and components used in pneumatic/electropneumatic systems. The course focuses on up-to-date products, tools, solutions and methods widely used in automated industry. The motto is "knowing the real and present technologies to form the real systems for the future!" It covers the types, operating principles and symbols for the different components used in industrial applications [6].

Figure 3. Training setup for electropneumatics

Chapters:

- Objectives of cost effective automation
- History of pneumatics
- Basic principles of compressed air supply, production, preparation and distribution
- Structure and function of pneumatic devices and valves
- Power section devices (Linear and rotary actuators)
- Use of valves, and sensors
- Symbolic representation of devices and standards
- Reading pneumatic circuit diagrams
- Design of circuit diagrams
- Operating modes in pneumatic control systems
- Typical industrial circuit solutions
- Error detection and troubelshooting

VI. SENSORS TECHNOLOGY

This course allows users to become familiar with the fascinating world of sensors and transducers used in industry. Starting with general applications, features and parameters of sensors, it runs through the different types of sensors, their application and symbols. As manufacturing becomes more and more automated, the understanding of sensors is essential. Sensors are used for a wide range of solutions in automated production lines, such as temperature, pressure, force and distance measuring, detect the presence or position of tools, componenets and workpieces even the completion of process steps. This course gives our students an overview of sensor technology including the microscopic and marcoscopic design of sensors, function of the different types, and the applications and limitations in use.

Chapters:

- Introduction to sensors technology
- Features and properties of sensors
- Proximity sensor
- Position, speed and acceleration sensor
- Industrial process sensors
- Advanced sensors
- Sensor technology symbols
- Control theory [7]

Figure 4. Training setup for sensor technology

VII. PROGRAMMABLE CONTROLLERS

This course runs through the different types of industrial Controllers, focussing on a study of Programmable Logic Controllers (PLC). It introduces digital electronics to be able to understand how a Programmable device works. It also studies its general structure of the PLC, general concepts of programming methodology and applications for these devices [8].

Chapters:

- Introduction and PLC history
- Introduction to digital electronics
- Types and functions of PLCs
- General structure of PLC hardware
- Physical system integration of PLCs
- Basic concepts of PLC programming
- Common PLC programming in LD, FBD, IL.

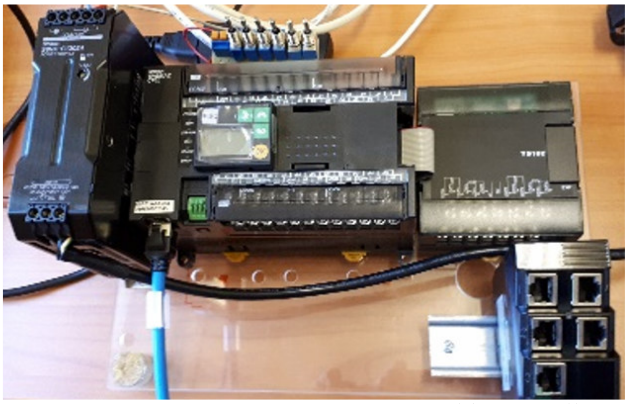

Figure 5. Training setup for programmable controllers

VIII. OPC-UA

The word is an acronym for Open Platform Communications. The whole OPC is about interoperability and standardization. While the traditional OPC solved the interoperability problem of the device at the control level, the same level of standardization required the Enterprise layer. The classic OPC is based on Microsoft DCOM, which may be vulnerable to these layers. The urgency of simplicity, maximum interoperability, and security has led the OPC Foundation to create a unified data communication method for parts of DA, HDA, A & E, and existing OPC specification security. OPC is a standard issued by the OPC Foundation. In another words OPC means OLE for process control. The basic objective of the OPC standard is to enable hardware manufacturers to create software drivers (OPCs) and software vendors to create applications (so-called OPC Clients) that use standard data exchange. This makes it possible to use the software and hardware of different vendors together. The most widely used version of OPC is version 2. This replaces the earlier version 1 standard. Allows suppliers of industrial-controlled hardware for the production of drivers (so-called OPC ervers) and visualization software vendors such as SCADA (so-called OPC Clients) methodology for data exchange [9].

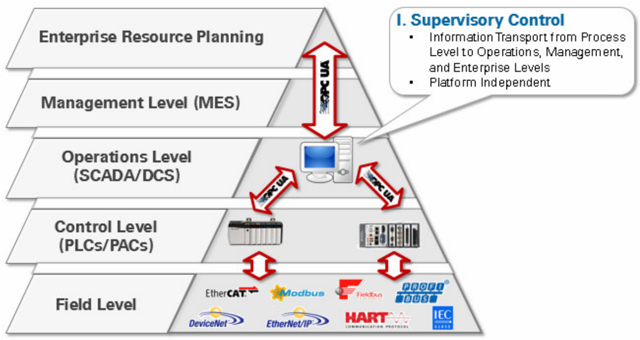

Figure 6. OPC Unified Architecture [10]

OPC Unified Architecture is an extension of the highly successful OPC communication protocol. It enables data collection and information modelling as well as reliable and reliable communication between the site and the company [11].

The most important features and benefits of OPC-UA:

- Platform is neutral, executable on all operating systems
- Future-ready and legacy-friendly

- Easy to configure and maintain
- Provides Service-based technology
- Gives Increased visibility
- Allows Greater connectivity
- Ensure Higher performance

IX. CONCLUSION

The implementation of the industry 4.0 pilot laboratory enables the cognition of the following processes and activities for our students:

- Smart manufacturing
- Internet of things
- Cyber-physical systems
- Big data
- Quality management
- Robust industrial solutions

ACKNOWLEDGMENT

The authors wish to thank the support to the Arconic Foundation.

REFERENCES

[1] F. Zezulka, P. Marcon, I. Vesely, and O. Sajdl, "Industry 4.0 – An Introduction in the phenomenon," IFAC-PapersOnLine, vol. 49, no. 25, pp. 8–12, Jan. 2016.
[2] Y. Lu, "Industry 4.0: A survey on technologies, applications and open research issues," Journal of Industrial Information Integration, vol. 6, pp. 1–10, Jun. 2017.
[3] E. Hofmann and M. Rüsch, "Industry 4.0 and the current status as well as future prospects on logistics," Computers in Industry, vol. 89, pp. 23–34, Aug. 2017.
[4] "Plattform Industrie 4.0." [Online]. Available: https://www.plattform-i40.de/I40/Navigation/EN/InPractice/Online-Library/online-library.html. [Accessed: 09-Apr-2018].
[5] "Micro-Cap 12," 27-Aug-2018. [Online]. Available: http://www.spectrum-soft.com/demo.shtm. [Accessed: 27-Aug-2018].
[6] "Instructor portal," 27-Aug-2018. [Online]. Available: https://www.smctraining.com/newpage/indexnews/61. [Accessed: 27-Aug-2018].
[7] "Simulink Control Design," 27-Aug-2018. [Online]. Available: https://www.mathworks.com/products/simcontrol.html. [Accessed: 27-Aug-2018].
[8] "CX-Server OPC," 27-Aug-2018. [Online]. Available: https://industrial.omron.hu/hu/products/cx-server-opc. [Accessed: 27-Aug-2018].
[9] "Unified Architecture - OPC Foundation," 27-Aug-2018. [Online]. Available: https://opcfoundation.org/about/opc-technologies/opc-ua/. [Accessed: 27-Aug-2018].
[10]"Why OPC UA Matters - National Instruments." [Online]. Available: http://www.ni.com/white-paper/13843/en/. [Accessed: 09-Apr-2018].
[11]"OPU UA Client FBs," 27-Aug-2018. [Online]. Available: http://www.plcopen.org/pages/promotion/publications/downloads/press_releases/opcua_fbs_april2014.htm. [Accessed: 27-Aug-2018].