Retraining of Fossil Fuel Mining Area Workforce for Modern Industry REMARKER

Project Results

Output 2: Re-training Course for Automation

Contents

Description

Today's industrial technology moves towards the direction, which allows the manufacturing of large amounts of different goods and selling them at higher profits. The evolution is supported by industrial automation. The programmable logic controllers (PLC) play an essential role in industrial automation. They are the elements of the control systems in the automated production system, which generates the controlling signals for various technological processes and machines based on written control programs and incoming data signals.

The most crucial component of an automated control system is the PLC and its control program (user program). Today Programmable Logic Controllers (PLCs) form an essential part of every automation process. Every system or machine has a controller. Depending on the type of technology used, controllers can be divided into pneumatic, hydraulic, electrical, and electronic controllers. Often a combination of different technologies is used. Furthermore, differentiation is made between hard-wired programmable (e.g., wiring of electromechanical or electronic components) and programmable logic controllers. The first is used primarily in cases where any reprogramming by the user is out of the question, and the job size warrants the development of a unique controller. However, if the job size does not require the development of a unique controller or if the user needs to make independent or straightforward program changes, then the preferred option is using a universal controller, where the program is written to an electronic memory.

The main aim of Output 2 is to develop the structure and specification of retraining module supporting pieces of training in the field of automation and PLC. The course is aimed at different target groups: employees of manufacturing plants, mainly operators of advanced machines, such as robots, automats, cells/machines for automated assembly, teachers / trainers / consultants in the field of automation and robotics, technicians, and also students.

1 Analysis of the curriculum in the field of Automation

In this section curriculum in the field of Automation at partner universities is presented. Both bachelor and master courses are taken into account. Aims, outcomes, and descriptions are collected and structured. Content of the lectures is provided for further analysis. Moreover, the dedicated literature and references is presented.

1.1 Tallinn University of technology (TalTech)

1.1.1 Bachelor studies

Course code	ATR0040
Course title in Estonian	Tootmise automatiseerimine
Course title in English	Industry Automation
ECTS credits	6.0
Assessment form	Examination
Teaching semester	Autumn
Lecturer	Tarmo Korõtko
Course aims	General account on the development, current state and perspectives of industry automation; introduction to the main terms used in the field of industry automation; exemplification of the automation yardstick; introduction to manufacturing automation systems in an enterprise; understanding of the development and description of automated control systems for different manufacturing processes; experience on programming of industrial controllers; introduction to integration of enterprise business and manufacturing systems.
Learning outcomes in the course	A student shall acquire: - clear comprehension of the contents and trends of modern industry automation; - clear understanding about meaning of main terms used in the field of industry automation; - knowledge of the human attributes being replaced by an automated manufacturing machine; - initial knowledge of different automated manufacturing systems of an enterprise; - clear understanding of the technological process concept and knowledge of the main methods used for the development and description of automated control systems of technological processes; - practical experience on programming of industrial controllers; - comprehension about methods and means used for integration of enterprise business and manufacturing systems.
Brief description of the course	Survey of manufacturing systems. Manufacturing technologies and plant models. Management and control of industrial processes. Improvement of products and their life cycle. Scope of automation. Definition phase, analysis and development. Using Visio tool for diagrams. Modelling and simulation. Simulation tools. Design phase. Project management. Project documentation and specifications. CAD and CAE tools. Implementation phase. SCADA tools and MMI interfaces. Visualization of automated industrial processes. Programming of PLCs. Installation phase. Mechanical tools. Final inspection, testing and documenting of system. Operation of automation system. Data communication in automated processes.

	ISO-OSI reference model for factory info systems. Local area networks and cabling systems in a factory.
Study literature	1) Pettai, E. Tootmise automatiseerimine. _ Tallinn: Elektriajamite ja jõuelektroonika instituut, 2005. _ 336 lk. 2) Degramo, E. P.; Back, J.T.; Kohscer, R. A. Materials and processes in manufacturing. John Wiley & Sons, 2003, 1154 p.
Daytime study: weekly hours	 4.0
lectures	2.0
Practices	2.0
exercises	0.0
Session-based study workload (in a semester):	 64.0
lectures	32.0
practices	32.0
exercises	0.0
Course description	http://ois2.ttu.ee/uusois/subject/ATR0040
Content of lectures	1) Introduction. Development of production automation 2) System description. Technological system. Concept of system life cycle. 3) System model. A model of a technological system. Modeling of technological systems and modeling tools. 4) The nature of system analysis. Techniques of technological system analysis. 5) Technological system requirements. Techniques for creating requirements for a technological system. 6) Design principles. Project types. Design tools (CAD, CAE, etc.). Software design and documentation. 7) Automated manufacturing systems, their types, terminology and classification. 8) Flexible manufacturing. 9) Production planning, forecasting and management methods. Principles of production organization. Organization of automated production. 10) Manufacturing process. Process planning tools. Product assembly and production equipment layout. Maintenance of production equipment and ergonomics of the working environment. 11) Industrial data communication networks 12) Industry 4.0. 13) Future trends.

1.1.2 Master studies

In TalTech advanced studies in the field of industrial automation is combined with electrical drives.

Course code	EEV5040
Course title in Estonian	Tööstusautomaatika ja elektriajamid
Course title in English	Industrial Automation and Drives
ECTS credits	6.0
Assessment form	Examination
Teaching semester	autumn
Lecturer	Anton Rassõlkin; Tarmo Korõtko

Course aims	1. To introduce industrial and building automation technologies, automation, devices programming languages and data communication interfaces and protocols. 2. To introduce the development, contemporary problems and motor control principles of today's industry. 3. To develop necessary analysis abilities to plan industrial automation, as well as development and implementation skills of industrial automation solutions. 4. To introduce ac machine dynamics modelling and vector models and practical realization of vector control application in industry.
Learning outcomes in the course	The student: - is acquainted with production technologies and industrial technical systems of different industries, including hardware and software resources of industrial automation (pneumatic systems, drives, controllers, SCADA, servers), industrial data communication and standards; - is acquainted with standardized programming languages (IEC 61311-3, IEC 61499, DIN 66312) for industrial controllers and robots; - is acquainted with contemporary problems of electrical drives and dynamics of ac electrical drives, principles of vector control and direct torque control; - knows how to program industrial automation devices, data communication and condition monitoring systems, including implementation of controllers for the control of production processes; - has experience in motor dynamics modelling, including vector control of ac electrical machines and transformation of vector coordinates.
Brief description of the course	Overview of production technologies. Industrial controllers, SCADA systems, data communication systems. Programming languages IEC 61311-3, IEC 61499, DIN 66312. P, PI, PID controllers, Principles of ac electrical machines vector control. Modelling of ac electrical machine dynamics, vector models. Realization of vector control. Transformation of vector coordinates and devices used for that.
Study literature	1. Lecture conspectus 2. Study literature(for distance learning): 3. F. Lamb, Industrial automation: hands-on, New York: bMcGraw-Hill Education, 2013. 4. V. Vodovozov, Electrical Drive: Performance, Design and Control, LAP Lambert Academic Publishing, 2014.
Daytime study: weekly hours	4.0
lectures	2.0
Practices	2.0
exercises	0.0
Session-based study workload (in a semester):	64.0
lectures	32.0
practices	32.0
exercises	0.0
Course description	http://ois2.ttu.ee/uusois/subject/EEV5040
Content of lectures	1) Introduction to automation.

	2) Introduction to sensor devices; Different types of sensors; Sensing elements; Sensor signals; Signal stability and conditioning. 3) Introduction to actuator devices; Different types of actuators; Actuating elements; Control signals. 4) Introduction to PLC-s; Classification of PLC-s; PLC components; PLC programming languages and standards. 5) PLC programming concepts; PLC regulators; PLC special functionalities. 6) Classification of HMI's; HMI components; HMI design. 7) Advanced SCADA systems; Industrial communication networks and protocols; Building automation networks and protocols. 8) Current and future trends in automation systems; Best practices for automation project management. 9) Introduction to electrical drives. 10) Modern concepts of electrical drives. 11) Vector models of AC electrical machines. Transforming vector variables. 12) AC motor parameters estimation. 13) Vector control principles of AC induction and synchronous motors. 14) Sensorless control of electrical drives. Model predictive control of electrical drives. 15) Advanced control strategies of electrical drives (incl. fuzzy logic control, synthetic load). 16) Trends and future development of electrical drive.

1.2 Silesian University of Technology (SUT)

1.2.1 Bachelor studies

In SUT basic automation bachelor studies consists of two courses: a lecture course and a laboratory course.

Lecture course

Course code	Es1-23-V
Course title in English	Automatics and Automatic Control
ECTS credits	2.0
Assessment form	Examination, test
Teaching semester	Autumn
Lecturer	dr Henryk Urzędniczok
Course aims	Student obtain basic competences in dynamic properties of technical devices, knows principles of operation of control and regulation systems, methods of analysis of regulation systems, simplified control systems design, selection of regulator
Learning outcomes in the course	Student is able to: - characterize basic input and output mathematical models expressing the static and dynamic properties of continuous and discrete objects and regulation systems as well is able to use their time and frequency characteristics in practice; - create mathematical models of dynamics for simple technical devices and use them to analyze problems of automatic control;

	- know principles of creating and transforming structural schemes; Knows the structure, operating principles, properties and the usage of control systems with basic structures; - calculate analytically the time and frequency characteristics of the control systems and values of selected indicators characterizing the quality of the systems, can analyze the stability of the control system; - choose types of regulators and their parameters, including PID regulator and can design algorithms of discrete regulators.
Study literature	1) Gessing R.: Control Fundamentals, Wyd. Pol. Śl. 2004
Daytime study: weekly hours	 3.0
lectures	2.0
Practices	0.0
exercises	1.0
Session-based study workload (in a semester):	 45.0
lectures	30.0
practices	0.0
exercises	15.0
Content of lectures	1) Basic questions and concepts of automation: object and control system, control and automatic regulation. 2) Mathematical modeling of static and dynamic objects: description in time domain; Laplace transform and its application to description of objects. 3) Step and pulse response, transient state and steady state. 4) Description in the frequency domain, frequency characteristics (Bode and Nyquist). 5) Z-transform and its application to discrete system description. 6) Basic dynamic models of real objects. 7) Structural analysis of control systems - structural schemes, simplification of complex systems. 8) Classification and basic structure of control systems. Design of regulator. 9) Analysis of control system properties - stability (Hurwitz, Nyquist method); Assessment of quality. 10) PID as a universal controller - structure, basic mathematical model, examples of implementation. Methods of optimal parameters settings.

Laboratory course

Course code	Es1-23-VI
Course title in English	Automatics and Automatic Control
ECTS credits	2.0
Assessment form	Examination, evaluation of laboratory exercises
Teaching semester	Autumn
Lecturer	dr Henryk Urzędniczok
Course aims	The aim of the course is to consolidate appropriate competences in the following areas: principles of control and control systems, typical practical solutions in this field, systems analysis methods, including the use of computer simulation methods, simplified design and commissioning and testing of control systems, documentation of tests results.

Learning outcomes in the course	Student is able to: - perform measurements and elaborate results to determine the basic dynamic models in the time and frequency domain for different devices and control systems; - know the structure and principles of operation of selected control systems, can explain phenomena and interpret results obtained during practical tests of selected systems; - use computer programs for simulation of dynamic properties of objects and control systems; - perform experiments and calculation of parameters the PID controller according to selected engineering methods; - elaborate, present in the form of diagrams, tables and graphs and discuss the results of calculations and studies of objects and regulation systems.
Study literature	1) Urzędniczok H.: A set of instructions for the laboratory "Basics of Automatics". Didactic materials available on laboratory stands and in “Magazyn Plików / Automatics and Automatic Control” on Faculty WebSite (http://www.elektr.polsl.pl/index.php/student/magazyn-plikow/category/42-automatics-and-automatic-control). 2) Proficy Machine Edition. GETTING STARTED. Ver s i on 6 . 0 0. June 2009 (GFK-1868M)
Daytime study: weekly hours	 2.0
lectures	0.0
Practices	2.0
exercises	0.0
Session-based study workload (in a semester):	 30.0
lectures	0.0
practices	30.0
exercises	0.0
Content of laboratories	1) Programming of PLC. 2) Simulation experiments - determination of time and frequency characteristics for continuous and discrete objects of different types, study of properties of selected control systems, including analysis of system stability. 3) Structural and parametric identification of objects based on a measurement experiment. 4) Examination of the properties of different control systems (on-off, follow-up, compensating feedback, PID controler), including the analysis of the influence of parameters of objects and regulators on the course of regulation processes, influence of disturbances, quality evaluation of processes.

1.3 University of West Bohemia (UWB)

1.3.1 Bachelor studies

In UWB basics of automation consist of two courses “Basic Course of Automation for Electrical Engineering” and “Automation in Power System and Power Engineering”.

Basic Course of Automation for Electrical Engineering

Course code	KEV/ZAE
Course title in English	Basic Course of Automation for Electrical Engineering
ECTS credits	4.0
Assessment form	Examination
Teaching semester	Autumn
Guarantor	Ing. Vojtěch Blahník, Ph.D.
Lecturer	Ing. Vojtěch Blahník, Ph.D., Ing. Martin Janda, Ph.D., Doc. Ing. Martin Pittermann, Ph.D., Doc. Ing. Václav Šmídl, Ph.D.
Tutorial lecturer	Ing. Vojtěch Blahník, Ph.D., Ing. Jiří Fořt, Ph.D., Doc. Ing. Tomáš Glasberger, Ph.D., Ing. Martin Janda, Ph.D., Doc. Ing. Martin Pittermann, Ph.D., Ing. Miloš Straka, Ing. Jakub Ševčík, Ing. Josef Štengl
Course aims	Teach students knowledge of the theory of linear continuous control and basic issues of continuous non-linear control and discrete control. Provide information about basic issues of control with semiconductor converters and microprocessor controllers. Introduce Hysteresis control, Logic control and give examples of control systems at electrical engineering field
Learning outcomes in the course	Knowledge – knowledge resulting from the course: - explain the control loop function; - distinguish the basic types of controllers; - recognize basic control algorithms; - explain behaviors at the control loop. Skills – skills resulting from the course: - evaluate the functionality of the proposed control algorithm and controller setting; - design a basic control loop with parameters; - design gains for a common PI controller; - design of common control algorithms.
Study literature	1) Tůma, František. Automatické řízení 1 : lineární spojité dynamické systémy. Plzeň : Západočeskáuniverzita, 2003. ISBN 80-7082-953-2. 2) Zeman, K. Studijní texty na počídačové síti.
Daytime study: weekly hours	 4.0
lectures	2.0
Practices	2.0
exercises	0.0
Session-based study workload (in a semester):	 52.0
lectures	26.0
practices	26.0
exercises	0.0

Content of lectures	1) Introduction of automation in electrical engineering. 2) Introduction of linear systems. 3) Mathematical description of linear systems. 4) Basic types of linear controllers a using for feedback control. 5) Stability and simplified Nyquist criterion of stability. 6) Block control circuits, transfer function and behavior. 7) Engineering methods for design of control circuits. 8) Basic issues of digital (discrete) control circuits, microprocessor controllers. 9) Control circuits for semiconductor converters. 10) State-space representation of linear systems. 11) Control systems based on State-space representation. 12) Proportional resonant controller compared with conventional PI controller. 13) Introduction to advanced control methods.

Automation in Power System and Power Engineering

Course code	KEV/AVSE
Course title in English	Automation in Power System and Power Engineering
ECTS credits	5.0
Assessment form	Examination
Teaching semester	Spring
Guarantor	Ing. Jan Michalík, Ph.D.
Lecturer	Ing. Bedřich Bednář, Ph.D., Ing. Milan Bělík, Ph.D., Ing. Jan Michalík, Ph.D., Ing.Martin Sirový, Ph.D., Mgr. Eduard Ščerba, Ph.D., Ing. et Ing. Martin Vinš
Tutorial lecturer	Ing. Bedřich Bednář, Ph.D., Ing. Milan Bělík, Ph.D., Ing. Štěpán Janouš, Ph.D., Ing.Patrik Kalaj, Ing. Tomáš Košan, Ph.D., Ing. Jan Michalík, Ph.D., Ing. Jiří Očenášek, Ing. Martin Sirový, Ph.D., Mgr. Eduard Ščerba, Ph.D., Ing. Jan Štěpánek, Ph.D., Ing. et Ing. Martin Vinš
Course aims	- to acquaint students with the issues of automated control and communication systems used in intelligent building systems and power systems; - to present selected key components used in these systems such as microprocessors, programmable logic PLC communication buses and protocols, and systems where these components are used as part of a whole, i.e. system installations, lighting systems or autonomous power sources; - to show in a broader context how these sub-components and sub-assemblies fit into the overall concept of energy-efficient and intelligent buildings.
Learning outcomes in the course	Knowledge - knowledge resulting from the course: - to have general overview of intelligent buildings in terms of both the whole and the individual components; - to describe the basic functions and structure of the microcontoler and the possibilities of its use; - to describe the selected peripherals of the microprocessor, to explain their function and application; - to explain the taught communication buses and protocols; - to describe the general structure and function of the PLC;

	- to have general overview of KNX system, to explain its principles and possibilities of use; - to have general overview of systems and automation possibilities for residential and commercial purposes; - to have general overview of autonomous energy sources for residential and commercial purposes. Skills - skills resulting from the course: - to program a simple program in C code on the microprocessor; - to program a simple PLC program.
Study literature	1) Willi Meyer. KNX/EIB Engineering Tool Software. 2013. ISBN 9783810103550; 2) Senthil Kumar, Saravanan, Jeevanathan. Microprocessors and Microcontrollers. Oxford UniversityPress, 2016. ISBN 9780199466597; 3) Pinker Jiří. Mikroprocesory a mikropočítače. 2004. ISBN 80-7300-110-1; 3) Martinásková Marie, Šmejkal Ladislav. PLC a automatizace 1 základní pojmy, úvod doprogramování. 2002. ISBN 80-86056-58-9; 4) Šmejkal Ladislav. PLC a automatizace 2 Sekvenční logické systémy a základy fuzzy logiky. 2005.ISBN 80-7300-087-3.
Daytime study: weekly hours	 5.0
lectures	3.0
Practices	2.0
exercises	0.0
Session-based study workload (in a semester):	 65.0
lectures	39.0
practices	26.0
exercises	0.0
Content of lectures	1) Introduction to Automation Techniques - introduction, importance of small automation devices. Contact Logic - Circuits withSwitches, Logic Functions, Time Relays, Line Diagram. 2) PLC - Introduction, typical applications, HW concept, I/O interface, HMI, programming methods. 3) Microcontrollers - Introduction to microcontrollers, use, processor structure, register principle, program and data memory,processor configuration. Repeat of basics C language, basic program structure, program compilation procedure. 4) Microcontrollers - Types of microprocessor peripherals and their use (ADC, DAC, I/O, timer, communication peripherals - SCI,SPI, CAN). Real-time applications, interruptions. 5) Communications - Modbus RTU, Modbus TCP/IP, CANbus, EherCAT, SCI, SPI. 6) Basics of Industrial Automation - Architecture and Topology of DCS for Industrial Applications, DCS, HSI. 7) Introduction to intelligent buildings for residential and commercial purposes. The concept of an energy-efficient building. 8) Automation, measurement and control options - system installations, lighting control systems. Collection of measured values

	(water flow meter, calorimeter and electricity meter), DEMO example of intelligent construction. 9) Introduction to intelligent buildings for living and commercial purposes - energy balance, calculation of energy balance,measurement of thermal leakage of buildings, thermovision, thermal energy accumulation. 10) Photovoltaic systems and RES as autonomous power sources for intelligent wiring - possibilities of integrating PVP into thebuilding's control system with regard to maximum use of electricity, utilization of energy storage and island operation of thebuilding, cooperation of hybrid PVPs and electric vehicle charging stations. 11) Heat pumps and RES as autonomous heat sources for intelligent buildings - the possibilities of integrating sources into thebuilding's control system with a view to maximizing heat utilization. 12) Connectivity options for individual systems. 13) Concept of energy-saving building - possibility of using automation in buildings.

1.4 University of Applied Science Mittelhessen (THM)

1.4.1 Bachelor studies

In THM basics of automation consist of two courses “Fundamentals of Automation” and “Process Control”.

Fundamentals of Automation

Course title in English	Fundamentals of Automation
ECTS credits	Evaluation according to the General Regulations (5)
Assessment form	Examination
Teaching semester	Autumn
Lecturer	Prof. Dr. Swen Graubner
Learning outcomes in the course	Professional Skills: The students can… - know the basics of hydraulic and pneumatic systems; - calculate the essential parameters of hydraulic and fluid power systems; - put simple hydraulic and pneumatic circuits into practice; - recognize examples of applications of hydraulics and pneumatics; - identify areas of application for programmable logic controllers; - solve basic automation tasks with the help of PLC. Methodical Skills: The students can… - train their ability to solve problems systematically; - develop skills to distinguish the areas of application of different automation methods. Social Skills: The students can… - learn to work on engineering tasks in small groups in a problem-oriented manner; - work on exercise tasks in groups and thereby train their teamwork and communication skills.

	Self-competence: The students can… - recognize knowledge gaps in the context of laboratory and project work and independently develop the knowledge required to solve problems; - can apply existing knowledge to new and specific problems; - independently organize the preparation and follow-up of the course material; - work on complex technical problems under time constraints; - recognize deficits in their professional understanding in collaboration with other students and improve their self-awareness; - strengthen their stamina when working on difficult tasks.
Brief description of the course	Hydraulics, pneumatics, PLC, infrastructure, basics and applications of control techniques. Hydraulics, pneumatics, plc, infrastructure, basics and applications of control techniques.
Study literature	Appropriate recommendations will be made as part of the course.
Daytime study: weekly hours	 4.0
lectures	2.0
practices	0.0
exercises	2.0
Session-based study workload (in a semester):	 150.0
lectures	30.0
practices	30.0
exercises	15.0
self-learning	90.0
Content of lectures	1) Automation, hydraulic and pneumatic symbols, physical principles of hydraulics and pneumatics, generation, cooling, storage and distribution of compressed air, pneumatic elements. 2) Hydraulic elements, oil circuits, preparation of oil, control systems based on hydraulics and pneumatics. 3) Fields of application of PLCs, basics of PLC programming, introduction to the construction of PLC circuits.

Process Control

Course title in English	Process Control/ Programmable Logic Controllers
ECTS credits	Evaluation according to the General Regulations (5)
Assessment form	Examination
Teaching semester	Autumn
Lecturer	Prof. Dr. Thomas Glotzbach
Learning outcomes in the course	Professional Skills: The students can… - list the most important components of automation technology and classify the terms continuous control, (continuous) control and discrete control in these; - reflect the basic control options; - distinguish combinatorial and sequential controls and reproduce the main methods of handling them;

	- name types of programmable logic controllers and the five programming languages defined by the European standard EN 61131; - name important topics from the field of Industry 4.0 and assess their influence on control technology. Methodical Skills: The students can… - evaluate the general development of automation technology and discover general patterns that can provide information about future developments; - break down the differences between the terms control and regulation and demonstrate high-level classification; - give examples of different ways of realizing controls. Social Skills: The students can… - explain exercises to each other and solve complex mathematical problems in a group; - present and discuss exercises and own results on the blackboard; - work together on real tasks in the accompanying practical course. Self-competence: The students can… - independently follow up and deepen the contents of the script worked out in the lecture; - improve their understanding of mathematical description using illustrative tasks; - apply theoretical knowledge to real-world tasks in the internship.
Brief description of the course	Control engineering: From the mathematical basics of combinatorial and sequential controls to PLC programming. Process control: from the mathematical foundations of logic and sequential control forward to programming of Programmable Logic Controllers
Study literature	1) Schmid, D. et al.: Automatisierungstechnik, Verlag Europa-Lehrmittel. 2) Schmid, D. et al.: Steuern und Regeln, Verlag Europa-Lehrmittel. 3) Weck, M., Brecher, Ch.: Machine Tools 4, Springer-Vieweg Verlag. 4) Karaali, C.: Fundamentals of Control Engineering, Vieweg+Teubner Verlag. 5) Wellenreuther, G., Zastrow, D.: Automatisieren mit SPS - Theorie und Praxis, Springer Vieweg. 6) John, K.-H.; Tiegelkamp, M.: SPS-Programmierung mit IEC 1131-3, Springer-Verlag. 7) Lunze, J.: Automation Technology, De Gruyter Oldenburg Verlag.
Daytime study: weekly hours	 6.0
lectures	3.0
practices	1.0
exercises	2.0
Session-based study workload (in a semester): 	 210.0
lectures	45.0

practices	30.0
exercises	15.0
self-learning	120.0
Content of lectures	1) Introduction to automation technology. 2) The difference between taxes and rules. 3) Basic control options. 4) Design and modeling of combinatorial controls. 5) Design and modeling of sequential controls. 6) Use of programmable logic controllers (PLC). 7) Topics from the area of Industry 4.0 and automation safety.

1.4.2 Master studies

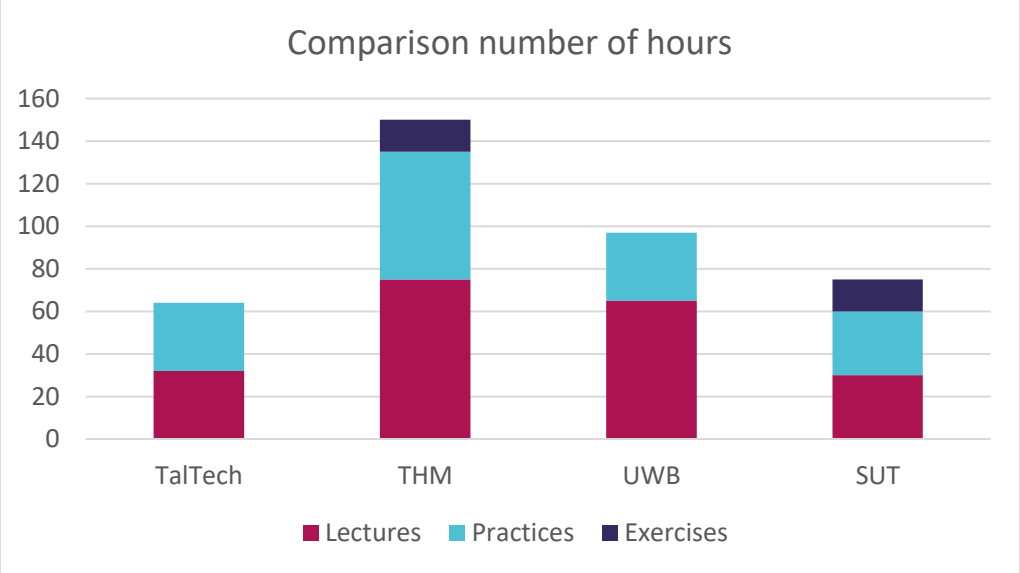
Course title in English	Automation technical seminar
ECTS credits	5.0
Assessment form	Exam with practical part
Teaching semester	autumn
Lecturer	Invited lecturers
Learning outcomes in the course	Knowledge: - students become familiar with various current topics in automation technology and understand their interrelationships and terminology. Skills: - students learn to apply methods of professional research as well as presentation and lecture techniques. Competencies: - students will be able to work in teams of 2 or 3 to structure a complex of topics, delve into detailed issues, and situate the chosen issues in a larger context, understandably and to represent them in a well-founded manner.
Study literature	Current publications can be used as supplements in the course of the event be made available.
Daytime study: weekly hours	 2.0
lectures	0.0
practices	2.0
exercises	0.0
Session-based study workload (in a semester): 	 150.0
lectures	0.0
practices	32.0
exercises	0.0
self-learning	118.0
Content of lectures	The students work in small teams on a previously defined set of topics under guidance (topics and lecturer alternate if possible) and prepare this in a joint team presentation. The selected topics are related to current trends in automation technology (Industry 4.0, Smart Factory, Smart Home, etc.). If possible, the content will be supplemented by an excursion and/or an expert technical lecture.

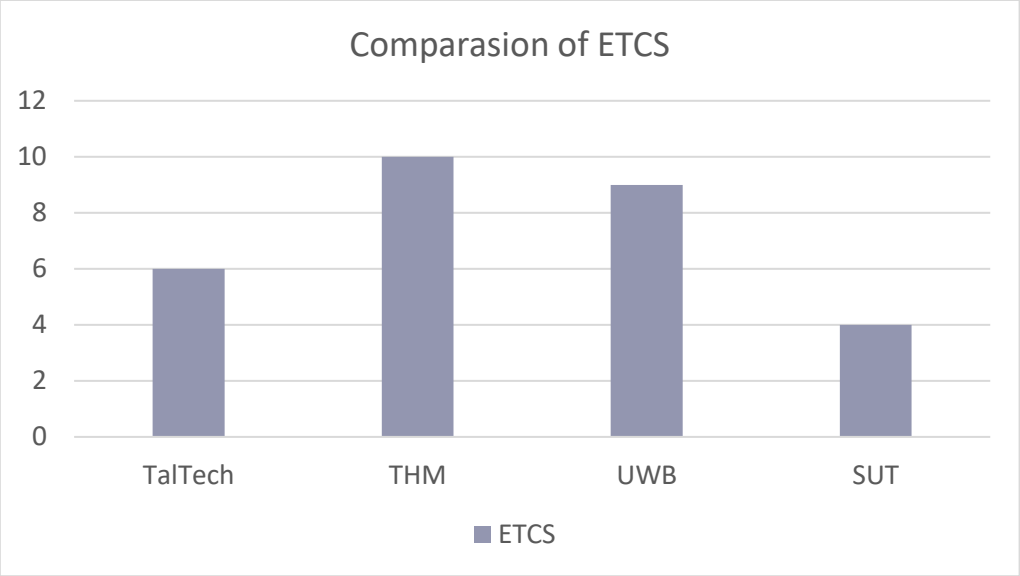
2 Comparison of automation cirricula

2.1 Bachelor studies

Comparison of the courses consists of two parts: the first part shows the difference between the workload of the courses (in the hours in a semester); the second part presents similar topics in automation courses between universities and topics are special in each program.

	TalTech	THM	UWB	SUT
Number of hours in semester	64	150	117	75
lectures	32	75	65	30
practices	32	60	52	30
exercises	0	15	0	15
ETCS credits	6	10	9	4



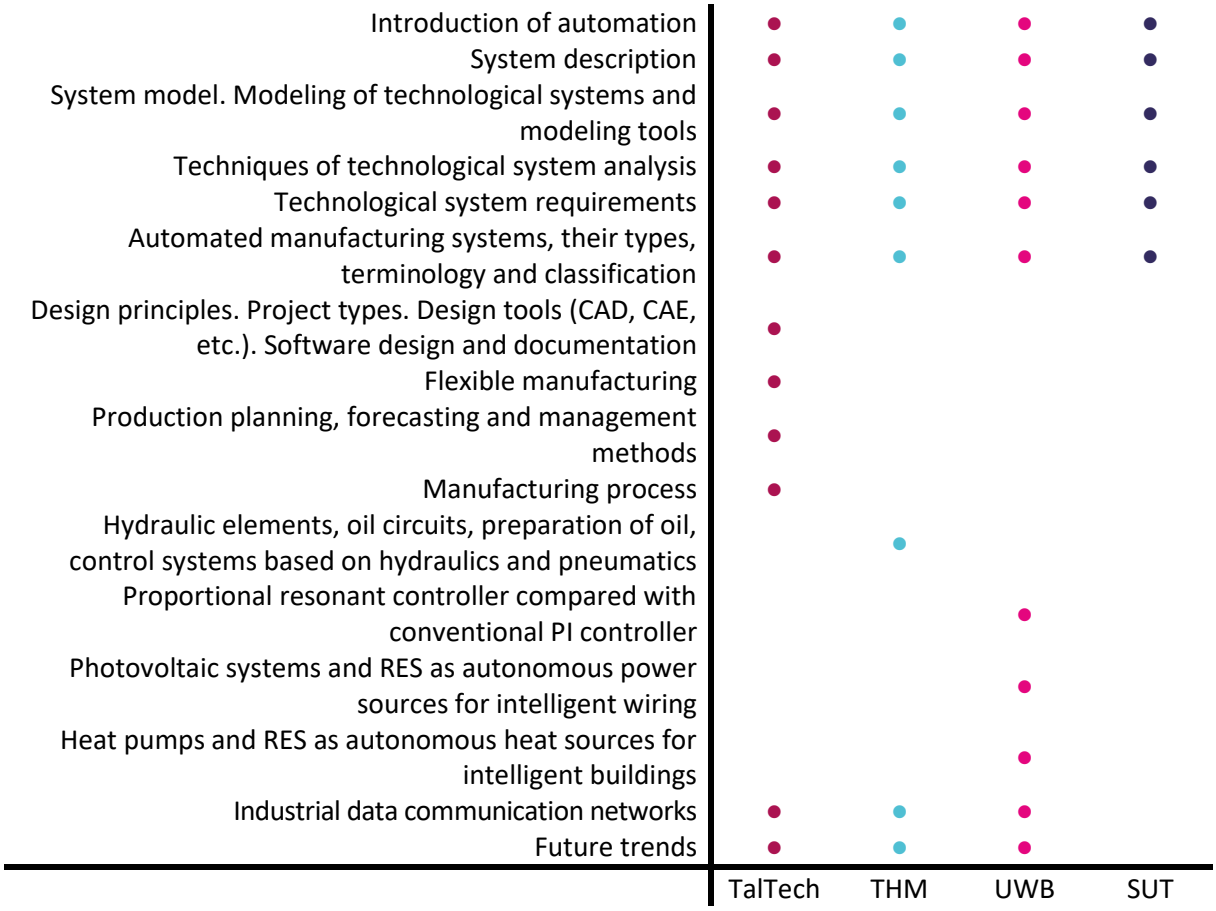


As seen from the graphs the bigger value of the study hours in the THM and UWB, the smaller the TAlTech. Only THM and SUT have study hours for exercises. The number of lecture hours in TalTech

and SUT is similar, however, THM and UWB is bigger two times. Study hours for practices are similar between TalTech and SUT universities. This depends on THM and UWB having two courses for automation for bachelor's studies.

The ETCS is similar by pair between TalTech-SUT and THM-UWB, the average value is 7,25.

Topics



Based on the comparison of topics between universities, possibly to make the next conclusion:

1. The common topics between universities are introduction of automation; system description; system model. Modeling of technological systems and modeling tools; techniques of technological; system analysis; technological system requirements; automated manufacturing systems, their types, terminology and classification.

2. In TalTech additional teach design principles. Project types. Design tools (CAD, CAE, etc.). Software design and documentation; flexible manufacturing; production planning, forecasting and management methods; manufacturing process.

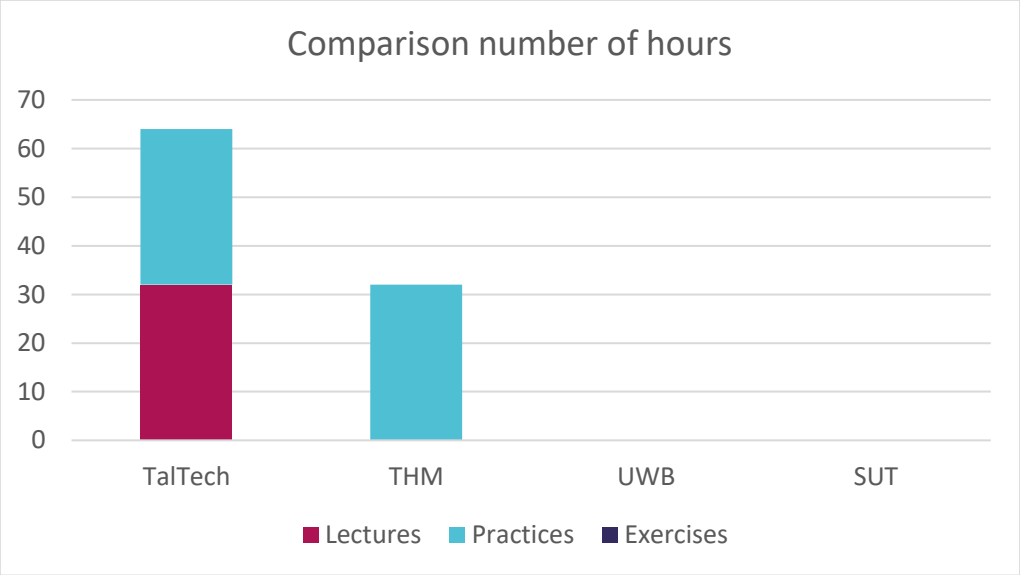
3. In THM additional teach hydraulic elements, oil circuits, preparation of oil, control systems based on hydraulics and pneumatics.

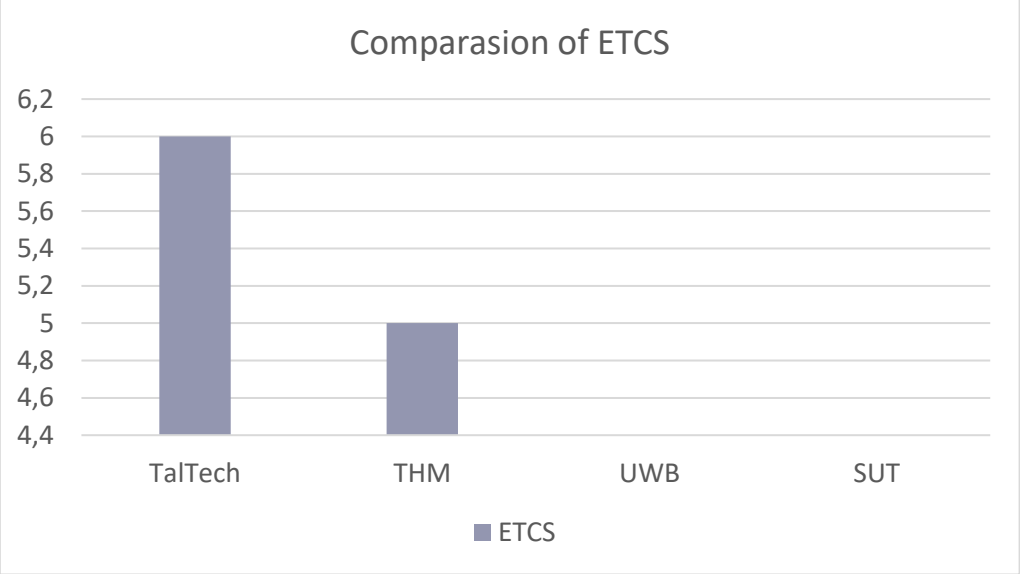
4. In UWB additional teach proportional resonant controller compared with conventional PI controller; photovoltaic systems and RES as autonomous power sources for intelligent wiring; heat pumps and RES as autonomous heat sources for intelligent buildings.

5. The common topic in TalTech, THM and UWB are industrial data communication networks and future trends.

2.2 Master studies

	TalTech	THM	UWB	SUT
Workload:	64	32	—	—
lectures	32	0		
practices	32	32		
exercises	0	0		
ETCS credits	6	5		





As seen from the graphs UWB and SUT haven't courses for master studies for automation. A comparison TalTech and THM shows only in TalTech has lectures for master studies for automation. Master course for automation in THM based on practices, technical lectures, or excursions.

The ETCS bigger in TalTech, the average value is 5,5.

3 Curricula for re-training course for automation

Based on the comparison of the course programs of the universities participating in the project, the following course program of power electronics is proposed:

Course title in English	Re-training course for automation
ECTS credits	1.25
Assessment form	Examination
Teaching semester	autumn - spring
Course aims	1. To introduce industrial and building automation technologies, automation, devices programming languages and data communication interfaces and protocols. 2. To introduce the development, contemporary problems and motor control principles of today's industry. 3. To develop necessary analysis abilities to plan industrial automation, as well as development and implementation skills of industrial automation solutions. 4. To introduce ac machine dynamics modelling and vector models and practical realization of vector control application in industry.
Learning outcomes in the course	A student shall acquire: - with production technologies and industrial technical systems of different industries, including hardware and software resources of industrial automation (pneumatic systems, drives, controllers, SCADA, servers), industrial data communication and standards; - with standardized programming languages (IEC 61311-3, IEC 61499, DIN 66312) for industrial controllers and robots; - with standardized programming languages (IEC 61311-3, IEC 61499, DIN 66312) for industrial controllers and robots; - with contemporary problems of electrical drives and dynamics of ac electrical drives, principles of vector control and direct torque control;
Brief description of the course	Survey of manufacturing systems. Manufacturing technologies and plant models. Management and control of industrial processes. Improvement of products and their life cycle. Scope of automation. Definition phase, analysis and development. Using Visio tool for diagrams. Modelling and simulation. Simulation tools. Design phase. Project management. Project documentation and specifications. CAD and CAE tools. Implementation phase. SCADA tools and MMI interfaces. Visualization of automated industrial processes. Programming of PLCs. Installation phase. Mechanical tools. Final inspection, testing and documenting of system. Operation of automation system. Data communication in automated processes. ISO-OSI reference model for factory info systems. Local area networks and cabling systems in a factory.
Session-based study workload (in a semester):	32.0
lectures	32.0
practices	0.0
exercises	0.0

Content of lectures	1) Introduction of automation. 2) System description. 3) System model. Modeling of technological systems and modeling tools. 4) Techniques of technological system analysis. 5) Technological system requirements. 6) Automated manufacturing systems, their types, terminology and classification. 7) Design principles. Project types. Design tools (CAD, CAE, etc.). 8) Software design and documentation. 9) Industrial data communication networks. 10) Future trends.

4 Conclusion

In conclusion, a comprehensive analysis of the provided outputs highlights the presence of shared focal points within the realm of automation across various universities. These common threads encompass a range of subjects such as automation introduction, system depiction, modeling techniques, tools for modeling, scrutiny of technological systems, stipulated requirements, and the expansive domain of automated manufacturing systems.

However, it is noteworthy that each university infuses its curriculum with a distinctive array of subjects that embellish the overarching theme of automation. At TalTech, the accentuation lies on the inculcation of design principles, diverse project typologies, adeptness with design tools, adeptness with flexible manufacturing paradigms, and the finesse of production planning. THM, on the other hand, extends specialized instruction on hydraulic intricacies, oil circuitry nuances, and the intricate realm of control systems based on hydraulics and pneumatics. UWB's curriculum delves into the realms of proportional resonant controllers, photovoltaic systems, and the complexities of heat pumps.

Moreover, a nexus of shared interest manifests in the arenas of industrial data communication networks and prognostications about future trends, unifying the educational agendas of TalTech, THM, and UWB.

The allocation of study hours, a pivotal determinant of academic engagement, exhibits discernible variance amongst these universities. THM and UWB exhibit a more pronounced dedication of hours to studies, both in lecture delivery and practical exercises, thereby surpassing the commitments of TalTech. While the parity between TalTech and SUT's lecture hours is palpable, the pedagogical institutions of THM and UWB eclipse this benchmark significantly. Parallels can be drawn in the allocation of practical study hours between TalTech and SUT. In the realm of credits, the European Credit Transfer and Accumulation System (ECTS) values harmonize within pairs of universities, fostering a comparative framework. The calculated average ECTS value spanning these institutions stands at 7.25, underlining a shared commitment to the standardization of educational recognition.

In summation, while the underpinning common topics foster a foundational understanding across these universities, each establishment crafts an educational voyage that is distinctly its own. Discrepancies in the distribution of study hours and ECTS values substantiate the diversification of educational encounters that these institutions offer. This synthesis of shared essence and individualistic enrichment contributes to a tapestry of automation education that is both unified and richly diverse across these academic enclaves.