UNIVERSITY OF ZIELONA GÓRA

FACULTY OF ELECTRICAL ENGINEERING,
COMPUTER SCIENCE AND TELECOMMUNICATIONS

ERASMUS PROGRAMME

GENERAL DESCRIPTION AND ECTS SCORING FOR FIELDS OF STUDY:

CONTROL ENGINEERING AND ROBOTICS

POSTGRADUATE PROGRAMME

Collected and prepared for printing by

MACIEJ PATAN

OPTIMIZATION METHODS

Course code: 11.9-WE-AIR-MO-PK1_S2S

Type of course: Compulsory

Entry requirements: Mathematical analysis
Algebra
Numerical methods

Language of instruction: English

Director of studies: Professor Andrzej Obuchowicz

Name of lecturer: Professor Andrzej Obuchowicz, Professor Józef Korbicz

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					6
Lecture	20	2	I	Exam	
Class					
Laboratory	30	2		Grade	
Seminar					
Workshop					
Project					
Part-time studies					
Lecture	18	2	I	Exam	
Class					
Laboratory	18	2		Grade	
Seminar					
Workshop					
Project					

COURSE CONTENTS:

Linear programming. Standard form. Base solutions review method. Simplex method. Optimal choice of production stock. Mixtures problem. Optimal choice of a technological process. Transport and assignment problems. Linear-fractional programming.

Non-linear programming – optimization conditions. Convex sets and functions. Necessary and sufficient conditions for extremum existence of a problem without constrains. Method of Lagrange multipliers. Equality and inequality constrains. Karush-Kuhn-Tucker conditions. Regularity of constrains. Quadratic programming.

Non-linear programming – computation techniques. One-dimensional searching: gold ratio, Fibonacci, Kiefer, Powell and Davidon methods. Non-gradient methods: Hooke-Jeeves and Nelder-Mead algorithms. Continuous and discrete gradient method. Newton, Gauss-Newton and Levenberg-Marquardt methods. Basic methods of searching of direction of improvement: Fletcher-Reeves and Davidon-Fletcher-Powell methods. Optimization problems with constrains: penalty functions, complex method, gradient projection and permissible direction methods.

Basic methods of discrete and mixed optimization. Integer programming. Branch and bound method. Net programming. CPM and PERT methods. The shortest path and maximum flow problems. Elements of dynamic programming.

Global optimization. Stochastic optimization. Adaptive random search. Simulated annealing. Monte Carlo methods and Markov chains. Evolutionary algorithms.

Practical problems. Constrains simplification and elimination. Discontinuity elimination. Numerical estimation of gradient. Making use of numerical optimization libraries. Review of the most popular optimization libraries.

LEARNING OUTCOMES:

Skills and competencies needed to: optimization algorithms implementation to constrained and unconstrained problems in continuous and discrete domain; design and implementation of evolutionary algorithms; making use of popular optimization procedures and libraries.

ASSESSMENT CRITERIA:

Lecture – the main condition to get a pass is a positive evaluation of written or oral exam in the end of the semester.

Laboratory – the main condition to get a pass is a sufficient number of positive assessments of tests of theoretical preparing to each lab exercise and written reports of these exercises. The set of exercises is defined by the lecturer.

RECOMMENDED READING:

1. Bertsekas D.: *Nonlinear programming*, Athena Scientific, 2004
2. Bertsekas D.: *Convex Analysis and Optimization*, Athena Scientific, 2003
3. Spall J.: *Intoduction to Stochastic Search and Optimization: Estimation, Simulation and Contro*l, Wiley InterScience, 2003.

OPTIONAL READING:

1. Kukuła K.(Ed.): *Operation research in examples and problems*, PWN, Warszawa, 2006 (in Polish)
2. Kusiak J., Danielewska-Tułecka A., Oprocha P.: *Optimization. Chosen methods with sample applications,* PWN, Warszawa, 2009 (in Polish)

SYSTEM MODELING AND IDENTIFICATION

Course code: 11.9-WE-AIR-MII-PK2_S2S
Type of course: compulsory
Entry requirements: Calculus
Signals and systems
Control theory
Artificial intelligence methods
Language of instruction: Polish
Director of studies: Prof. Andrzej Janczak
Name of lecturer: Prof. Andrzej Janczak

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					6
Lecture	30	2	I	Exam	
Class					
Laboratory	30	2		Grade	
Seminar					
Workshop					
Project					
Part-time studies					
Lecture	18	2	I	Exam	
Class					
Laboratory	18	2		Grade	
Seminar					
Workshop					
Project					

COURSE CONTENTS:

Introduction. Plants and their models. Model using. System identification and mathematical modelling. Equivalence of models and equivalence criteria. Parameter estimation. Identifications error definitions. Building system models based on structure knowledge and measurements. Identification algorithm scheme.

Nonparametric identification methods. Transient states analysis. Frequency identification methods. Correlation methods. Power spectrum analysis.

Least squares method. Linear static models. Least squares problem. Normal equations**.** Analysis of least squares estimator. Best linear unbiased estimator. Confidence intervals of parameter estimates. Model complexity. Finding the least squares solution with orthogonal-triangular decomposition. Recursive least squares algorithm.

Models of dynamic systems. Model classification. General structure of linear model. AR, AR, MA, ARMA, FIR, ARX, ARMAX, OE, and Box-Jenkins models. Multi-input multi-output models. Nonlinear models. Wiener and Hammerstein models. Volterra and Kolmogorov-Gabor models. State-space models. Model structure selection.

Input signals. Deterministic signals. Stochastic signals. Input signals used In system identification. Persistent excitation condition.

Prediction error method. Simulation and prediction. Optimal predictors. Least-squares estimation of ARX model parameters. Parameter consistency problem. Instrumental variables method. Choice of instrumental variables.

Recursive identification. Properties of recursive identification algorithms. Recursive least squares method. Exponential forgetting. Recursive instrumental variables method. Recursive prediction error method. Parameter adaptation of self-tuning controller.

Closed-loop identification. Identificability of closed-loop systems. Direct identification methods. Indirect identification methods. Influence of feedback loop on estimation accuracy.

Modeling of static and dynamic nonlinear systems using neural networks and fuzzy models. Neural network models of static and dynamic nonlinear systems. Learning algorithms. Generalization. Neural network model testing and validation. Optima architecture selection. Fuzzy logic. Fuzzy models. Mamdani, Takagi-Sugeno-Kang and Tsukamoto inference methods. Neuro-fuzzy models. Parameter optimization. Rule base optimization. Operator optimization. Examples of neural network and fuzzy modeling.

LEARNING OUTCOMES:

Skills and competencies needed to perform linear and nonlinear system modeling and identification tasks. Skills and competencies of model structure selection of control systems and solving parameter estimation tasks.

ASSESSMENT CRITERIA:

Lecture – the main condition to get a pass is a sufficient number of positive evaluations of written or oral tests conducted at least once per semester.

Laboratory – the main condition to get a pass is a positive assessment of the laboratory tasks assigned by the lecturer.

RECOMMENDED READING:

4. L. Ljung, *System identification. Theory for the User*. Prentice Hall, Upper Saddle River, 1999
5. O. Nelles, *Nonlinear System Identification*. *From Classical Approaches to Neural Networks and Fuzzy models*. Springer, New York, Berlin, Heidelberg, 2001
6. T. Söderström, P. Stoica, *System Identification*. Prentice Hall, Upper Saddle River, 1994

OPTIONAL READING:

3. M. Nørgaard, O. Ravn, N.K. Poulsen, L.K. Hansen, *Neural Networks for Modelling and Control of Dynamic Systems.* Springer, London, 2000

CONTROL THEORY

Course code: 06.0-WE-AIR-TS-PK3_S2S

Type of course: compulsory

Entry requirements: Mathematical analysis, Linear algebra, Control Engineering, Continuous Process Control

Language of instruction: English

Director of studies: Dr. Wojciech Paszke

Name of lecturer: Dr. Wojciech Paszke

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					6
Lecture	30	2	I	Exam	
Class					
Laboratory	30	2		Grade	
Seminar					
Workshop					
Project					
Part-time studies					
Lecture	18	2	I	Exam	
Class					
Laboratory	18	2		Grade	
Seminar					
Workshop					
Project					

COURSE CONTENTS:

Introduction to nonlinear systems. The most common nonlinear systems. The state space representation. An equilibrium point. Typical behaviour of nonlinear systems. Limit cycles.

Analysis of dynamic properties of nonlinear systems with the phase plane method. The second order nonlinear systems; graphical representation with phase portraits. Singular points. Graphical and numerical methods for generating of a phase portrait. Stability analysis of nonlinear systems by using the phase plane method.

Stability analysis. Different definitions to a nonlinear system stability. Lyapunov's linearization method. Lyapunov's second (direct) method. Global asymptotic stability analysis. La Salle's theorem. Stability of time-varying nonlinear systems. Instability theorems. Absolute stability criterions. A sector nonlinearity. Popov and circle criterion. Controller synthesis based on Lyapunov's method.

The describing function method. Definitions of a limit cycle and characteristics. The existence theorem. Definition of the describing function. Describing function for systems with input saturation, output deadzone and hysteresis respectively. Using the describing function method for limit cycle analysis. Stability analysis of a limit cycle.

Feedback linearization. Mathematical basics of feedback linearization. Lie's algebra. Input-output linearization. Linearization conditions. Controllability conditions. Algorithm for an input-state linearization. Normal forms. Diffeomorphism. Algorithm for an input-output linearization. Internal dynamics. Asymptotic properties of nonlinear minimum phase systems.

Introduction to multivariable control. Transfer functions for MIMO systems. Multivariable frequency response analysis. Condition number and RGA. General control problem formulation. Internal stability of feedback systems. Stabilizing controllers. H2 and H∞ system norms. Control system design.

Limitations on performance in SISO and MIMO systems. Perfect control and plant inversion. Constraints on sensitivity functions .Limitations imposed by RHP zeros and poles. Phase lag and uncertainty.

Introduction to robustness. Representing uncertainty in the frequency domain. Robust stability and performance. Parametric uncertainty and complex unstructured uncertainty. Mu-synthesis and DK-iteration.

LEARNING OUTCOMES:

Skills and competencies needed to model, analyze and design of nonlinear and/or multivariable dynamical systems with wide range of methods. Applications of such methods to nonlinear circuits and control systems are the main scope of this course.

ASSESSMENT CRITERIA:

Lecture – obtaining a positive grade in written or oral exam.

Laboratory – the main condition to get a pass is scoring sufficient marks for all laboratory exercises.

RECOMMENDED READING:

1. D. Atherton, An introduction to Nonlinearity in Control systems, Ventus Publishing, 2011.
2. H. K. Khalil, Nonlinear Systems, 3rd edition, Prentice Hall, 2002.
3. S. Skogestad, I. Postlethwaite: Multivariable feedback control. Analysis and design. John Wiley and Sons, 2nd edition, 2005.
4. P. Albertos, A. Sala : Multivariable control systems: An engineering approach, Springer, London, 2004.
5. K.J. Åström, R.M. Murray, *Feedback Systems: An Introduction for Scientists and Engineers*, Princeton University Press, Princeton, 2009

OPTIONAL READING:

REMARKS:

AUTOMATIC ACTUATOR SYSTEMS

Course code: 11.9-WE-AIR-UWA-PK4_S2S

Type of course: compulsory

Entry requirements: Basics of Electrical engineering and electronics
Programmable logic controller

Language of instruction: Polish

Director of studies: Professor Igor Korotyeyev

Name of lecturer: Professor Igor Korotyeyev

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					6
Lecture	30	2	I		
Class					
Laboratory	30	2		Grade	
Seminar					
Workshop					
Project					
Part-time studies					
Lecture	18	2	I	Exam	
Class					
Laboratory	18	2		Grade	
Seminar					
Workshop					
Project					

COURSE CONTENT:

Introduction. Engineering realization of actuator device in automatic systems. Energy sources used in actuator device. Examples of actuator device applications in automatics.

Pneumatic actuating devices. Physical behavior of gas's. Compressed air – production and distribution. Pneumatic elements of automatic devices. Construction and basic behavior of pneumatic drive. Interconnections of actuator devices. Computer design of actuator devices. Examples of using of pneumatic actuating devices in automatics.

Hydraulic actuating device. Construction, basis of operation and main behavior of hydraulic actuating devices. Mathematical formulation of behavior of functional systems and hydraulic devices. Power supply, control and execute parts of hydraulic devices. Graphical symbols of main functional systems of hydraulic devices. Examples of using of hydraulic actuating devices in automatics.

Electrical actuating device. Electrical machines used in automatics as actuating devices. Power supply of actuating motors. Position, speed and torque controls of electric drives. DC and AC motors, brushless and stepper motor drivers in automatics. Actuating devices in electrothermics. Examples of using of electrical and electropneumatic actuating devices in automatics.

Using of actuating devices in automatics. Controllers in automatic devices. Examples of using automatic devices with pneumatic, hydraulic, electrical and electropneumatic actuating devices.

LEARNING OUTCOMES:

Skills and competencies in sphere of knowledge of work bases as well as availability of automatic actuating devices.

ASSESSMENT CRITERIA:

Lecture – the main condition to get a pass is a sufficient number of positive evaluations of written or oral tests conducted at least once per semester.

Laboratory – the main condition to get a pass is a positive assessments of the all laboratory exercises specified by the laboratory program.

RECOMMENDED READING:

1. Z. Zajda, L. Żebrowski, Devices and automatic systems, Wrocław Politechnics publishing house, Wrocław, 1993, “in Polish”
2. J. Bednarczyk, Electrical elements of automatics*,* AGH, Kraków, 1988, “in Polish”
3. J. Honczarenko, Industrial robots. Construction and using. WNT, Warszawa, 2004, “in Polish”
4. A. Pizoń, Analog and digital electrohydraulic automatic devices. WNT, Warszawa, 1995, „in Polish”
5. M. Hering, Bases of electrothermics*. Parts I and II*, Warszawa, WNT, 1992, 1998, „in Polish”

OPTIONAL READING:

1. B. Chorowski, M. Werszko, Mechanical devices of automatics, Warszawa, WNT, „in Polish”
2. P. Osiecka, Hydrostatic machine drive, Warszawa, WNT, 2004, „in Polish”
3. T. Legierski, J. Kasprzyk, J. Wyrwał, J. Hajda, PLC controller programming, Computer d Publishing House of Jacek Skalmierski, Gliwice, 1998, „in Polish”

SENSORICS AND INDUSTRIAL MEASUREMENTS

Kod przedmiotu: 06.0-WE-AIR-SIPP-PK5_S2S

Type of course: compulsory

Entry requirements: Fundamentals of electrical engineering

Fundamentals of metrology

Language of instruction: Polish

Director of studies: Prof. Ryszard Rybski

Name of lecturer: Prof. Ryszard Rybski

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					6
Lecture	30	2	I	Grade	
Class					
Laboratory	30	2		Grade	
Seminar					
Workshop					
Project					
Part-time studies					
Lecture	18	2	I	Grade	
Class					
Laboratory	18	2		Grade	
Seminar					
Workshop					
Project					

COURSE CONTENTS:

Introduction. Measurement sensors properties in metrology. Sensors typology. Sensors manufacturing technologies.

Sensors and converters in measurement systems. Analogue, digital-analogue and analogue-digital converters. Sensors output signal transmission. Sensors and measurement converters interfaces. Intelligent sensors. Wireless sensory networks.
Temperature measurements. Resistance based thermometers. Thermoelectric thermometers. Semiconductor based temperature sensors. Pyrometers. Noise thermometers. Fiber optic thermometers.

Pressure measurements. Piezoresistive sensors. Piezoresistive sensor error compensation. Strain gages. Capacitive sensors.

Level measurements. Float, hydrostatic and capacitive level meters. Ultrasounds in level measurements.

Liquid velocity and flow measurements. Liquid velocity measurements with anemometric method. Doppler velocimeters. Orifice plate meters. Rotameters. Turbine flow meters. Coriolis flow meters. Ultrasonic flow meters. Electromagnetic flow meters. Fluid density meters.

Measurements of movement. Inductive and capacitive movement sensors. Proximity sensors. Fiber optic movement sensors. Ultrasonic converters in movement measurements.

Motion parameters measurement. Rotational speed measurements. Vibrations and quakes measurements. Piezoelectric accelerometers. Capacitive accelerometers.

Force and mass measurements. Strain gages. Strain gages measurement systems. Piezoelectric force sensors.

Humidity measurements. Humidity measurements: psychrometric hygrometer, dew point hygrometer, impedance based humidity sensors. Humidity of solids measurements: impedance method, spectrometric methods.

LEARNING OUTCOMES:

Knowledge and competence in carying out analyses for basic non-electric values sensors and converters as far as their metrological properties, and in solving typical metrological tasks in the industrial measurements domain.

ASSESSMENT CRITERIA:

Lecture – the main condition to get a pass is acquiring a positive evaluation ftom the written test.

Laboratory – the main condition to get a pass is acquiring positive assessments from theoretical background evaluation tests perceding practical exercises, and from exercise reports as selected by the lecturer.

RECOMMENDED READING:

1. D.M. Scott, *Industrial process sensors*, CRC Press, 2007
2. J. Vetelino, A. Reghu, *Introduction to sensors*. CRC Press, 2010
3. J. Fraden, *Handbook of modern sensors*. Springer, 2010
4. R. Pallas-Areny, J.G. Webster, *Sensors and signal conditioning*. John Willey& Sons, Inc., Chichester, 2001
5. S. Tumanski, *Principles of electrical measurement*. Taylor & Francis, 2006

OPTIONAL READING

INTELLIGENT CONTROL METHODS

Course code:	11.9-WE-AIR-ISS-PS6_S2S
Type of course:	compulsory
Entry requirements:	Automatic control, Modelling and simulation, Programming with essentials of algorithmics
Language of instruction:	English
Director of studies:	Prof. Marcin Witczak
Name of lecturer:	Prof. Marcin Witczak

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					6
Lecture	30	2	II	Grade	
Class					
Laboratory	30	2		Grade	
Seminar					
Workshop					
Project					
Part-time studies					
Lecture	18	2	II	Grade	
Class					
Laboratory	18	2		Grade	
Seminar					
Workshop					
Project					

COURSE CONTENTS:

Introduction to artificial neural networks: Properties of neural networks, basic structures, training methods, application areas in automatic control and robotics.

Multilayer perceptrons: Structure of the artificial neuron. Network topologies and information processing, the BackPropagation (BP) algorithm and its modifications, generalization properties, regulatization. Application of multilayer perceptrons to classification.

Dynamic networks: Multilayer perceptrons with tapped delay lines, recurrent networks (Williams-Zipser) and partially recurrent networks (Elman). Series-parallel and parallel identification models.

Introduction to fuzzy logic: Fuzzy sets, fuzzyfication and defuzzyfication, the fuzzy interference system, the rule base. Mamdani and Takagi-Sugeno models.

Inverse model control: Analysis of control system with inverse model, basic assumptions. Designing of the inverse model using neural networks. Collecting the training data. Synthesis of the control system with the neural inverse model. Implementing the neural based inverse control in the Simulink environment.

Feedforward control: Analysis of PID control system with additional feedforward control. Synthesis of feedforward control using neural inverse model. Implementing the neural based feedforward control in the Simulink environment.

Model predictive control: Analysis of model predictive control systems. Neural network based design of *i*-step ahead predictor. Defining the optimal control sequence selection as the optimization problem. Synthesis of neural based model predictive control. Implementing the neural based predictive control in the Simulink environment.

Fuzzy control: Fuzzy realization of the PID controller. Comparison of the fuzzy controller with the PID controller. Designing the rule base. Synthesis of the fuzzy controller. Implementing the fuzzy logic based control in the Simulink environment.

LEARNING OUTCOMES:

Skills and competencies needed to design neural neworks based control sytems, and knowledge of the main approaches and techniques to implement such control schemes. Skills and competencies required to construct fuzzy logic based controllers together with techniques to determine the rule base.

ASSESSMENT CRITERIA:

Lecture – the main condition to get a pass is a sufficient number of positive evaluations of written or oral tests conducted at least once per semester.

Laboratory exercices – the main condition to get a pass is a positive assessment of the both written tests and project reports assigned by the lecturer.

RECOMMENDED READING:

1. S. Haykin, *Neural networks. A comprehensive foundation, 2nd edition,* Prentice-Hall, New Jersey, 1999.
2. O. Nelles, *Nonlinear system identification. From classical approaches to neural networks and fuzzy models*, Springer-Verlag, Berlin, 2001.
3. L. Rutkowski, *New soft computing techniques for system modelling, pattern classification and image processing*, Springer-Verlag, London, 2004.
4. M. Noorgard, O. Ravn, N.M. Poulsen, L.K. Hansen, *Neural networks for Modelling and Control of Dynamic Systems*, Springer-Verlag, London, 2000.

OPTIONAL READING:

ROBOT LOCALIZATION AND NAVIGATION

Course code: 11.9-WE-AIR-LINR-PS8_S2S
Type of course: compulsory
Entry requirements: Fundamentals of robotics
Robot control
Language of instruction: English
Director of studies: Dr. Maciej Patan
Name of lecturer: Dr. Maciej Patan

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					6
Lecture	30	2	II	Exam	
Class					
Laboratory	30	2		Grade	
Seminar					
Workshop					
Project					
Part-time studies					
Lecture	18	2	II	Exam	
Class					
Laboratory	18	2		Grade	
Seminar					
Workshop					
Project					

COURSE CONTENTS:

Introduction. Typical mobile robot platforms. Legs and wheels as the movement mechanisms. Essential problems. Examples and applications.

Robot perception. Sensor classification. Characterization of sensor performance and uncertainty of measurements. Feature extraction. Perception algorithms. Vision algorithms. Models of workspace (raster, geometric, topological).

Kinematics of mobile robots. Kinematic models and constraints. Controllability of robot. Workspace and motion control. Kinematics of actuators (camera, laser rangefinders, manipulators, etc.).

Localization of mobile robot. Classification of methods. Challenges in localization. Odometry. Localization based on maps. Probabilistic methods. Kalman filtering In localization. Systems based on environmental marks and global positioning systems. Autonomous map building.

Navigation. Trajectory planning. Classification of motion planning methods. Fundamental techniques of motion planning (visibility graphs, workspace decomposition, Bayesian methods, potential methods etc.). Obstacles avoidance. Movement optimization.

Mobile robot networks. Models of robotnic networks. Centralized and multiagent systems. Methods of motion planning for swarms of robots. Coordination of tasks. Problems of connectivity, randez-vous and optimal robot deployment.

LEARNING OUTCOMES:

Skills and competencies in the framework of proper mathematical formulation for the tasks of localization and navigation. Skills in application of sensor-driven methods and algorithms for robot perception. Abilities of solving trajectory planning problems for swarms of mobile robots and creativity in using dedicated programs and available numerical libraries.

ASSESSMENT CRITERIA:

Lecture – the main condition to get a pass is a positive assessment of written or/and oral examination test

Laboratory – the main condition to get a pass is a sufficient number of positive evaluations of written or oral tests conducted at least three times per semester and positive evaluations of the laboratory tasks assigned by the lecturer.

RECOMMENDED READING:

1. Siegwart R., Nourbakhsh I.: *Introduction to autonomous mobile robots*, MIT Press, 2004
2. Murphy R.: *Introduction to AI Robotics*, MIT Press, 2000
3. V.J. Lumelsky.: Sensing, Intelligence, Motion., Wiley, 2006

OPTIONAL READING:

INDUSTRIAL AUTOMATION

Course code: 06.0-WE-AIR-APP-PS11_S2S

Type of course: compulsory

Entry requirements: Operating systems, concurrency programming, assembler programming

Language of instruction: Polish

Director of studies: Ass. Prof. Paweł Majdzik Ph. D.

Name of lecturer: Ass. Prof. Paweł Majdzik Ph. D.

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					3
Lecture	15	1	III	Grade	
Class					
Laboratory	30	2		Grade	
Seminar					
Workshop					
Project					
Part-time studies					
Lecture	9	1	III	Grade	
Class					
Laboratory	18	2		Grade	
Seminar					
Workshop					
Project					

COURSE CONTENTS:

Introduction. Basic terms of Industrial Automation, automation of technical products and technical plants components of an industrial automation system. The types of automation devices and structures, automation hierarchies, distributed automation systems, different types and application areas of field busses.

Devices of industrial production systems. Interfaces between the technical process and the automation computer system, sensors and actuators, representation of process data in automation computers, field bus systems. Flexible Manufacturing System, synchronizations metods and concepts, scheduling methods of industrial tasks.

Real-time systems. Real-time programming methods, the types of Real-time programs, the metods of design of Real-time systems, parts of a real-time operating system, organization tasks of a real-time operating system.

Programming languages. Programming languages applied in industrial automation systems and Real - time systems. Synchronization of tasks, communication between tasks, scheduling methods, programming Programmable Logic Controllers (PLC), universal programming languages for Industrial Automation, Real-time programming language.

LEARNING OUTCOMES:

Skills and competencies needed to design and to implementation simple industrial systems especially Flexible Manufacturing System. The knowlegde of the metods and techniques to implement real - time systems. Skills of programming Programmable Logic Controllers by using different techniques.

ASSESSMENT CRITERIA:

Lecture – the main condition to get a pass is a sufficient number of positive evaluations of written or oral tests conducted at least once per semester.

Laboratory – the main condition to get a pass is a positive assessment of the all laboratory exercises.

RECOMMENDED READING:

1. Mikulczyński, T.: *Automatization of industrial processes.* Wydawnictwa Naukowo-Techniczne WNT, Warszawa, 2009.
2. Burns A, Wellings A. Concurrent and Real-Time Programming in Ada, Cambridge University Press
3. Kowalewski, H.: Automatization of discreet production processes, WNT, Warszawa, 1984.

OPTIONAL READING:

1. Collins K.: *PLC Programming for Industrial Automation.* Exposure Publishing, 2006

DECENTRALISED SYSTEMS OF CONTROL ENGINEERING AND ROBOTICS

Course code: 11.9-WE-AIR-ZUAR-PS12_S2S

Type of course: compulsory

Entry requirements: Technique of automatic control
Control of continuous processes

Language of instruction: Polish

Director of studies: Prof. Marcin Witczak

Name of lecturer: Prof. Marcin Witczak, Dr. Paweł Majdzik

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					6
Lecture	30	2	III	Grade	
Class					
Laboratory	30	2		Grade	
Seminar					
Workshop					
Project					
Part-time studies					
Lecture	18	2	III	Grade, Exam	
Class					
Laboratory	9	1		Grade	
Seminar					
Workshop					
Project					

COURSE CONTENTS:

Introduction. Functional computer structures for control engineering. Hardware structures – classification. Features of systems: DCS, hybrid, SCADA.

System structures. Review of DCS structures, network structures, redundancy.

Process stations. Review of process stations: functions, hardware structures, redundancy, software.

Development directions. New functions of DCS, advanced control systems and diagnostics in DCS.

Introduction to Proficy Process Systems. Demonstration of exemplary solutions.

Design of DCS. Review of Architectures of *Proficy Process Systems. Engineer stations. Alarm maintenance. Process data processing. Operator consoles. Acquisition and processing of historical data.*

LEARNING OUTCOMES:

Skills and competencies regarding various DCS solutions as well as the ability of designing DCS for control and monitoring of industrial processes.

ASSESSMENT CRITERIA:

Lecture – the main condition to get a pass is a sufficient number of positive evaluations of written or oral tests conducted at least once per semester. In the case of part-time studies, the main condition is to pass an exam.

Laboratory – the main condition to get a pass is a sufficient number of positive evaluations of written or oral tests conducted after each lab.

RECOMMENDED READING:

1. A. G. Aghdam, J. Lavaei: *Decentralized control of interconnected systems*, VDM Verlag, Berlin, 2008
2. Bailey D. i E. Wright: Practical SCADA for Industry, Elsevier, London, 2003
3. P. Tatjewski: *Zaawansowane sterowanie obiektów przemysłowych, struktury i algorytmy*, EXIT, Warszawa 2002.
4. GE Fanuc: Proficy Process Systems – dokumentacja, www.astor.com.pl
5. Stanisław H. Żak, *Systems and Control*, Oxford University Press, New York, 2003

OPTIONAL READING:

1. –

ADVANCED DECISION SYSTEMS

Course code: 11.9-WE-AIR-ZSD-PS13_S2S
Type of course: compulsory
Entry requirements: Mathematical logic, artificial intelligence methods, expert systems
Language of instruction: English
Director of studies: Prof. Andrzej Pieczyński
Name of lecturer: Prof. Andrzej Pieczyński

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					3
Lecture	15	1	III	Grade	
Class					
Laboratory	15	1		Grade	
Seminar					
Workshop					
Project					
Part-time studies					
Lecture	9	1	III	Exam	
Class					
Laboratory	9	1		Grade	
Seminar					
Workshop					
Project					

COURSE CONTENTS:

The incomplete, uncertain and inaccurate information in a decision making task. Parametric and nonparametric decision problems. Application of rough and expanded expert systems. Capabilities theory. Rough and fuzzy sets application in knowledge bases. Decision tree optimization.

Knowledge discovery in data bases, data exploration. Preliminary data preparation. Soft computing in data mining.

Application of neural networks in decision making. Neural networks in data grouping and classification tasks. Knowledge extraction from data bases with application of neural networks.

Fuzzy decision systems. Application of neuro-fuzzy and evolution-fuzzy systems in the knowledge base creation. Fuzzy classifiers. Various types of neuro-fuzzy decision systems.

Application of rough sets as support of decision making. Domination based rough sets. Patterns classification induction resulting in principles formulation for decision making.

Decision supporting systems design. Hybrid decision systems.

LEARNING OUTCOMES:

Skills and competence in knowledge exploration from data bases. Advanced decision systems design. Intelligent computation usage in decision making systems.

ASSESSMENT CRITERIA:

Lectures: the main condition to get a pass is acquiring sufficient marks from two written tests (full time studies) or a written exam (part time studies)

Laboratory: the main condition to get a pass is acquiring sufficient marks from all laboratory exercises (a test covering theoretical knowledge related to exercised tasks and exercises documentation).

RECOMMENDED READING:

1. Dettmer H.W.: *The Logical Thinking Process: A Systems Approach to Complex Problem Solving,* ASQ Quality Press, 2007
2. Matsatsinīs N.F., Siskos Y.: *Intelligent support systems for marketing decisions,* Springer, 2003
3. Marakas G.M.: *Decision support systems in the 21st century,* Prentice Hall, 2003
4. Rakus-Andersson E.; Yager, R.R.; Ichalkaranje, N.: *Recent Advances in Decision Making,* Springer, 2009
5. Turban E., Sharda R., Dursun D.: *Decision support systems and business intelligence systems,* Prentice Hall, 2010

OPTIONAL READING:

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MULTI-AGENT SYSTEMS

Course code: 11.9-WE-AIR-SW-PSW_A9_S2S
Type of course: optional
Entry requirements: Programming with essentials of algorithmics
Artificial intelligence methods
Distributed systems
Language of instruction: Polish
Director of studies: Prof. Dariusz Uciński
Name of lecturer: Dr. Mariusz Jacyno

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					2
Lecture	30	2	II	Grade	
Class					
Laboratory					
Seminar					
Workshop					
Project	15	1		Grade	
Part-time studies					
Lecture	18	2	II	Grade	
Class					
Laboratory					
Seminar					
Workshop					
Project	9	1		Grade	

COURSE CONTENTS:

Introduction. Agents and objects. Agents and expert systems. Agents and distributed systems. Typical behaviours of agent systems.

Intelligent agents. Abstract architectures for intelligent agents. Design of intelligent agents. Deductive reasoning agents. Agents as reactive systems. Hybrid agents.

Multiagent systems. Social aspects of agency theory. Coordination techniques. Distributed problem solving. Collaboration: cooperative distributed problem solving (CDPS), partial global planning, consistency and coordination.

Distributed and dencetralised systems engineering. Multi-agent systems as complex systems. Engineering autonomic systems using agent-based techniques. Applying multi-agent systems to model distributed, multi-robot systems in cooperative scenarios. Decentralised control techniques based on bio-inspired coordination algorithms.

LEARNING OUTCOMES:

Skills and competencies needed to design intelligent autonomous agents, and knowledge of the main approaches and techniques to implement such agents. Skills and competencies of designing multi-agent systems together with techniques to enable communication and cooperation in such systems.

ASSESSMENT CRITERIA:

Lecture – the main condition to get a pass is a sufficient number of positive evaluations of written or oral tests conducted at least once per semester.

Project – the main condition to get a pass is a positive assessment of the project task assigned by the lecturer.

RECOMMENDED READING:

1. M. Wooldridge. *Multi-agent systems (second edition)*, MIT Press, 2013
2. Y. Shoham and K. Leyton-Brown *Multiagent Systems: Algorithmic, Gamer-Theoretic, and Logical Foundations,* Cambridge University Press, Cambridge, 2008

OPTIONAL READING:

1. M. Wooldridge, *An Introduction to MutliAgent Systems*, Wiley, Chichester, 2009

MACHINE VISION AT ROBOTICS AND AUTOMATIZATION

Course code: 11.9-WE-AIR-WMWRIA-PSW_A9_S2S

Type of course: optional

Entry requirements: Digital signal processing
Vision systems
Decision support systems

Language of instruction: Polish

Director of studies: Dr. Bartłomiej Sulikowski

Name of lecturer: Dr. Bartłomiej Sulikowski

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					2
Lecture	30	2	II	Grade	
Class					
Laboratory					
Seminar					
Workshop					
Project	15	1		Grade	
Part-time studies					
Lecture	18	2	II	Grade	
Class					
Laboratory					
Seminar					
Workshop					
Project	9	1		Grade	

COURSE CONTENTS:

Digital Image Acquisition. Optics. Discretization. Shannon Theorem. CCD and CMOS sensors, Images transfer effective methods

Integration of the vision systems with executive devices (robots, automatic control systems) and protection systems.

Global and local transformations. Fourier transformation. Fast Fourier transformation. Hadamard transformation. Linear and nonlinear operators.

Segmentation methods. Thresholding. Gradient methods.

Feature selection and extraction. Statistical methods. Principal Component Analisys (PCA). Entropy minimization method (ME).

Classification. NN methods, Artificial intelligence methods in pattern recognition.

Stereovision.

Image oriented robot control. Orientation. Movement detection.

LEARNING OUTCOMES:

The knowledge enhancement about vision systems. Skills and competencies required for the usage of vision at robot control tasks. Ability needed to integrate the vision systems with the automatic control systems.

ASSESSMENT CRITERIA:

Lecture – the main condition to get a pass is a sufficient number of positive evaluations of written or oral tests conducted at least once per semester.

Project – the main condition to get a pass is a positive assessment of the project task assigned by the lecturer.

RECOMMENDED READING:

1. Horn B. K. P., *Robot Vision*, MIT Press, McGraw--Hill, 1986
2. Nieniewski M., *Digital Images segmentation. Watershed segmentation method,* EXIT, Warsaw, 2005 (in Polish)
3. Davies E.R., *Machine Vision. Theory, algorithms, practicalities,* Elsevier, 2005
4. Hornberg A. (ed)., *Handbook of machine vision*, Willey-VCH Verlag, 2006

OPTIONAL READING:

1. Skarbek W., *Digital images representation methods*, PLJ, Warsaw, 1993, (in Polish).
2. Pavlidis T., *Graphics and image processing*, WNT, Warsaw, 1987, (in Polish).
3. Tadeusiewicz R., Korohoda P., *Computer-based analisys and processing of images*, FPT, Cracow, 1997, (in Polish).
4. Ballard D. H., Brown C. M., *Computer Vision*, Prentice--Hall, New York, 1982.

METHODS OF PROGRAMMING OF LOGIC CONTROLLERS

Course code: 11.9-WE-AIR-MPSL-PSW_B10_S2S
Type of course: optional
Entry requirements: -
Language of instruction: Polish/English
Director of studies: prof. dr hab. inż. Marian Adamski, dr inż. Małgorzata Kołopieńczyk
Name of lecturer: prof. dr hab. inż. Marian Adamski, dr inż. Małgorzata Kołopieńczyk

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					2
Lecture	30	2	II	Grade	
Laboratory	15	1		Grade	
Part-time studies					
Lecture	18	2	II	Grade	
Laboratory	9	1		Grade	

COURSE CONTENTS:

Introduction to formal specification and verification of programs for logical control. Reactive systems.
Petri nets and SFC control diagrams.
Design of program in Ladder Diagram language with use of decision tables.
New generation PLC controllers: S7 series. Network configuration, system structure. Programming with new engineering tools.
PLC programming according to IEC-61131-3 standard. Process visualisation. Human Machine Interface in control system.
Implementation of control algorithms. Program concurrency. Diagnostics of control algorithm.
Algorithm specification in Function Block Diagram and Ladder Diagram. Modular and linear program structure.
Program testing and verification.

LEARNING OUTCOMES:

Competences in basic PLC systems design and programming.

ASSESSMENT CRITERIA:

Lecture: written test

Laboratory: written test

RECOMMENDED READING:

1. F. Bonifatti, P. Monari, U. Samperi, IEC 1131-1 Programming Methodology. Software engineering methods for industrial automated systems, CJ International, 1997.
2. L. A. Bryan, E. A. Bryan: Programmable controllers. Theory and Implementation., Amer Technical Pub, 2003.
3. K. Collins: PLC Programming for Industrial Automation, Exposure Publishing, 2006.

REMARKS:

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AUTOMATION OF SYSTEMS USING RENEWABLE ENERGY SOURCES

Course code: 06.0-WE-AIR-ASZOZE-PSW_C14_S2S

Type of course: optional

Entry requirements: Programmable Logical Controllers, visualization and monitoring of industrial processes, sensors and industrial measurement, automatic management systems

Language of instruction: Polish

Director of studies: Professor Grzegorz Benysek

Name of lecturer: Doctor Marcin Jarnut

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					2
Lecture	15	1	III	Grade	
Class					
Laboratory	15	1		Grade	
Seminar					
Workshop					
Project					
Part-time studies					
Lecture	9	1	III	Grade	
Class					
Laboratory	9	1		Grade	
Seminar					
Workshop					
Project					

COURSE CONTENTS:

Introduction. Energy resources and energy needs.

Renewable energy sources. Wind energy. Wind transformation systems. Solar energy. Types and construction of solar collectors. Examples of industrial installations using photo-voltaic cells. Geothermic energy. Basic functioning and construction of heat pumps. Biogas, biomass and waste heat. Fermentation as a means of obtaining biogas. Exploitation of straw, brush wood. Exploitation of electrolysis and hydrogen.

Renewable energy source control systems. Control in systems using photo-voltaic cells. Automation of wind generators. Automatic control of heat pumps. Control systems for solar collectors. Controlling systems using biomass and biogas.

Energy systems using renewable energy sources. Automation of systems using combined renewable electrical energy sources. Systems using photo-voltaic cells and solar collectors. Heating systems using heat pumps, solar collectors and boilers fueled by biomass or biogas.

Renewable energy sources in intelligent buildings. Intelligent buildings. Control systems in intelligent buildings. Exploitation of renewable energy sources in intelligent buildings. Management of electrical energy. Heating systems. Automation of different systems in intelligent buildings. Application of PLC controllers in intelligent buildings using renewable energy sources.

LEARNING OUTCOMES:

Ability and competence in the areas: design and application of automated systems and automatic regulation in systems using renewable energy sources.

ASSESSMENT CRITERIA:

Lecture – the main condition to get a pass is a sufficient number of positive evaluations of written or oral tests conducted at least once per semester.

Laboratory – course accreditation is conditional upon obtaining positive grades from all laboratory exercises anticipated in the realization the laboratory programme framework.

RECOMMENDED READING:

1. Heier S., Waddington R.: Grid integration of wind energy conversion systems, John Wiley & Sons, 2006.
2. Luque A.: Handbook of photovoltaic science and engineering, John Wiley & Sons, 2003.
3. R. O'Hayre, *Fuel Cell Fundamentals,* John Wiley & Sons, 2006

OPTIONAL READING:

4. E. Klugmann, E. Klugmann-Radziemska, *Alternatywne źródła energii. Energetyka fotowoltaiczna*, Wydawnictwo Ekonomia i Środowisko, Białystok, 1999
5. W. Lewandowski, *Proekologiczne źródła energii odnawialnej*, WNT, Warszawa, 2001
6. J. Marecki, *Podstawy przemian energii*, WNT, Warszawa, 1995
7. T. Legierski, J. Kasprzyk, J. Wyrwał, J. Hajda, *Programowanie sterowników PLC*, Wydawnictwo Pracowni Komputerowej Jacka Skalmierskiego, Gliwice 1998

INDUSTRIAL DRIVES AND ELECTRIC VEHICLES

Course code: 06.0-WE-AIR-NUPIPM-PSW_C14_S2S

Type of course: optional

Entry requirements: Control engineering
Precision drives and industrial robots
Actuators

Language of instruction: Polish

Director of studies: Prof. Adam Kempski

Name of lecturer: Dr. Robert Smoleński

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					2
Lecture	15	1	III	Grade	
Class					
Laboratory	15	1		Grade	
Seminar					
Workshop					
Project					
Part-time studies					
Lecture	9	1	III	Grade	
Class					
Laboratory	9	1		Grade	
Seminar					
Workshop					
Project					

COURSE CONTENTS:

Structures and control algorithms of the drives applied in industrial devices and electrical vehicles. DC drives: commutator with electromagnetic excitation, commutator with permanent magnet excitation, brushless DC. Three-phase AC drives: asynchronous induction squirrel-cage, permanent magnet synchronous motor, synchronous reluctance.

Pneumatic and hydraulic drives. Structure and principles of operation of basic pneumatic elements. Examples of the typical pneumatic drives. Introduction to hydraulic drives. Hydraulic servo drives.

Specificity of industrial devices drives. Mechanical characteristics of the load and drives selection for: machine tool, crane, winder, cam, etc. Monitoring-control systems for drives.

Electromechanical systems of vehicles. Electric drives for vehicles. Hybrid drive systems. Structure of torque transfer arrangement. Electrical steering system. Electrohydraulic and electromechanical brakes. Fuel cells. Properties of accumulator types (mechanical, electrochemical, hydro accumulators, ultra capacitors). Conceptions of electrical cars charging.

LEARNING OUTCOMES:

Abilities and competences in the area of analyses concerning drive requirements for industrial devices and vehicles as well as proper selection of drive systems, power supply, and control strategies.

ASSESSMENT CRITERIA:

Lecture – the main condition to get a pass is a sufficient number of positive evaluations of written or oral tests conducted at least once per semester.

Laboratory – in order to get a credit it is necessary to earn positive grades for all laboratory works defined by tutor

RECOMMENDED READING:

1. I. Boldea, S.A. Nasar, Electric Drives, CRC Press, 1999
2. T. Orłowska-Kowalska, Bezczujnikowe układy napędowe z silnikami indukcyjnymi, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław, 2003
3. M. P. Kaźmierkowski, F. Blaabjerg, R. Krishnan, Control in Power Electronics, Selected Problems, Elsevier, 2002
4. T. R. Crompton, Battery Reference Book, Newnes, Oxford, 2003

OPTIONAL READING:

1. H. Tunia, M. P. Kaźmierkowski, Automatyka napędu przekształtnikowego, PWN, 1987, (in Polish)
2. Z. Grunwald, Napęd elektryczny, WNT, 1987 (in Polish)
3. W. Szejnach, Napęd i sterowanie pneumatyczne, WNT, 2005 (in Polish)

CONTROL IN THE STRUCTURE OF WIDE-AREA NETWORKS

Course code:	06.5-WE-AIR-SWSSR-PSW_D15_S2S
Type of course:	optional
Entry requirements:	Programming with essentials of algorithmic, Computer networks
Language of instruction:	Polish
Director of studies:	Assoc. Professor Wiesław Miczulski
Name of lecturer:	Dr. Robert Szulim

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					2
Lecture	15	1	III	Grade	
Laboratory	15	1		Grade	
Part-time studies					
Lecture	9	1	III	Grade	
Laboratory	9	1		Grade	

COURSE CONTENTS:

Introduction. Selected elements of the network technologies used in the structure of the wide area network. Protocols: TCPIP, HTTP, FTP and SMTP.

Overview of the capabilities of modern operating systems used in embedded devices and servers to communicate with external devices using TCPIP protocol. Dedicated software solutions for the data exchange in heterogeneous network environments. TCP and UDP streams of the network data exchange.

Selected elements of building concurrent applications. Use them to build applications that use Internet technologies and automation equipment. Processes, threads, sharing resources and deadlock avoiding.

The Web Servers. The construction of servers, administration and implementation in the wide area network structure. Launching the web server on Windows and Linux operating systems. Designing Web portals to cooperate with control devices.

The use of Java and. NET control in the structure of a wide area network. The use of selected elements of the technology to transmit data over the network environments and present them in the form of applets on Web pages.

Integration of database systems with the automation devices. Selected elements of building applications for embedded systems to collect data in databases and make them available for further processing.

LEARNING OUTCOMES:

Skills and competence in the use and design of equipment and information systems using Internet technologies in the control structure of the wide area network.

ASSESSMENT CRITERIA:

Lecture – pass condition is to obtain a positive evaluation of the test in writing.

Laboratory - pass condition is to obtain positive evaluations of the tests of the theoretical background to the exercise and completion of all laboratory exercises.

RECOMMENDED READING:

1. W.R. Stevens, *Programming web applications in Unix*, Scientific and Technical Publishers, Warsaw 1995
2. Carver R., Tai K.: *Modern multithreading*, Wiley Publications, 2006
3. Wei L., Matthews C., Parziale L., Rosselot N., Davis C., Forrester J., Britt D., *TCP/IP Tutorial and Technical Overview*, An IBM Redbooks publication, 2006

OPTIONAL READING:

1. Boese E., *An Introduction to Programming with Java Applets*, Jones and Bartlett publishers, 2009
2. Hart C., Kaufmann J., Sussman D., Ulmann C., *Beginning ASP.NET 2.0*, Wiley Publishing, 2006
3. Stephens R., *Start Here! Fundamentals of Microsoft® .NET Programming*, Microsoft, 2011
4. Ullman Jeffrey D., Widom Jennifer , *A First Course in Database Systems,* Pearson Prentice Hall, 2008

COMMUNICATION SYSTEMS

Course code: 06.5-WE-AiR-ASzOŹE-PSWD15_S2S
Type of course: optional
Entry requirements: Computer networks
Language of instruction: Polish
Director of studies: Dr. Emil Michta
Name of lecturer: Dr. Emil Michta

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					2
Lecture	15	1	III	Grade	
Laboratory	15	1		Grade	
Part-time studies					
Lecture	9	1	III	Grade	
Laboratory	9	1		Grade	

COURSE CONTENTS:

Evolution of the communication systems. ISO/OSI and ISA models. Classification of the communication systems. Communication model of the automation networked system. Analysis of the communication parameters. Static and dynamic tasks models. Analysis of the time constrains in automation systems - RM, DM and EDF methods.

Local communication systems. Fieldbus networks and local area networks in the automation systems. Communication standards of the local communication systems. Analysis and synthesis of the automation systems based on networks: Profibus, CAN, LonWorks and Interbus-S. Analysis and synthesis of the automation systems based on IEEE 802.11 and IEEE 802.15 networks. Industrial Ethernet in local communication systems. Wide area communication systems. Standard and dedicated wide area communication systems in automation. Use of the cable, fiber and wireless telecommunication networks. Internet technologies in distributed automation systems. Time constrains in TCP/IP networks. Protocol tunneling in local systems. Security of the data transfers. Solutions of the communication systems in industrial process and object automation. Integration of the communication systems.

LEARNING OUTCOMES:

Knowledge of the communication systems features. Skills and competencies needed to analysis and synthesis communication systems used to object , industrial proces and envinronment automation.

ASSESSMENT CRITERIA:

Lecture – the main condition to get a pass is a sufficient number of positive evaluations of written tests conducted at least once per semester.

Laboratory – the main condition to get a pass is a positive assessment of the theoretical prepare to laboratory tasks and positive assesment of the laboatory tasks.

RECOMMENDED READING:

1. Kowalik R., Pawlicki C.: *Fundamentals of Communication* (in polish). Publishing House of the Warsaw University of Technology. Warszawa, 2006.
2. Michta E.: *Communication models of the networked measurement and control systems* (in polish). Publishing House of the Technical University of Zielona Góra. Zielona Góra, 2000.
3. Thompson L.M.: *Industrial Data Communication*. ISA, 2007.

OPTIONAL READING:

1. Mahalik N.P.: *Fieldbus Technology*. Springer, 2003
2. Neuman P.: *Communication systems in automation*. COSIW, Warszawa, 2003