Attachment no 1 to ZW 16/2020

# PROGRAM OF STUDIES

**FACULTY:** Electrical Engineering

**MAIN FIELD OF STUDY:** Electrical Engineering

**DISCIPLINES:** D1 - automation, electronics, electrical engineering and space technologies (major discipline)

**EDUCATION LEVEL:** 2nd level

**FORM OF STUDIES:** full-time

**PROFILE:** general academic

**LANGUAGE OF STUDY:**
Polish - specialties: *Electrical Power Engineering, Industrial Electrical Engineering, Renewable Energy Sources*
English - specialties: *Control in Electrical Power Engineering, Renewable Energy Systems*

Content:
1. Assumed learning outcomes – attachment no.1 to Programme of Studies
2. Program of studies decription – attachment no. 2 to Programme of Studies
3. Plan of studies – attachment no. 3 to Programme of Studies

Resolution no. … of the Senate of Wroclaw University of Science and Technology

**In effect since** **2022/2023**

Attachment no. 3 to ZW 16/2020
Attachment no. 1 to programme of studies

# ASSUMED LEARNING OUTCOMES

**FACULTY:** **Electrical Engineering**
**MAIN FIELD OF STUDY:** **Electrical Engineering**
**EDUCATION LEVEL:** **second-level studies**
**PROFILE:** **general academic**

Location of the main-field-of study:

Branch of science: Engineering and technology

Discipline / disciplines (for several disciplines, please indicate the major discipline)

Automation, electronics, electrical engineering and space technologies

Explanation of the markings:

P7U – universal first degree characteristics corresponding to education at the second-level studies - 7 PRK level *
P7S – second degree characteristics corresponding to education at the second-level studies - 7 PRK level *

W - category "knowledge"
U - category "skills"
K - category "social competences"
K2ETK_W1, K2ETK_W2, K2ETK_W3,, ... - main-field-of study learning outcomes related to the category "knowledge"
K2ETK_U1, K2ETK_U2, K2ETK_U3,, ... - main-field-of study learning outcomes related to the category "skills"
K2ETK_K1, K2ETK_K2, K2ETK_K3,, ... - main-field-of study learning outcomes related to the category "social competences competences"

… _inż. – learning outcomes related to the engineer competences

* delete as applicable

| **Main field of study learning outcomes** | **Description of learning outcomes for the main-field-of study**<br>**Electrical Engineering**<br>After completion of studies, the graduate: | Reference to PRK characteristics | | |
|---|---|---|---|---|
| | | Universal first degree characteristics (U) | Second degree characteristics typical for qualifications obtained in higher education (S) | |
| | | | Characteristics for qualifications on 7 levels of PRK | Characteristics for qualifications on 7 levels of PRK, enabling acquiring engineering competences |
| **KNOWLEDGE (W)** | | | | |
| K2ETK_W1 | *has advanced knowledge about application of mathematical methods to description, synthesis and analysis of linear and nonlinear circuits and systems taking into account both continuous and discrete types* | **P7U_W** | **P7S_WG** | |
| K2ETK_W2 | *has knowledge about application of numerical and optimization methods to solution of engineering problem* | **P7U_W** | **P7S_WG** | **P7S_WG_inż** |
| K2ETK_W3 | *has knowledge on computational and analysis methods of power system faults* | **P7U_W** | **P7S_WG** | **P7S_WG_inż** |
| K2ETK_W4 | *has knowledge about description, analysis and modelling of electrical drive systems of different types of control, using different kinds of electrical motors* | **P7U_W** | **P7S_WG** | **P7S_WG_inż** |
| K2ETK_W5 | *student has extended knowledge of how to measure physical quantities using electrical methods*<br>*he/she knows how sensors, converters and other measuring instruments work and knows their construction*<br>*student knows the methods and measuring systems used to measure selected physical quantities* | **P7U_W** | **P7S_WG** | |
| K2ETK_W6 | *has knowledge about management, including quality management and business running* | | **P7S_WK** | **P7S_WK_inż** |
| K2ETK_W7 | *he understands the legal and standardisation framework of engineering and the need to act accordingly to it in everyday practice*<br>*has the knowledge about technical standardisation basics, responsibility for the quality and safety of manufactured goods,* | | **P7S_WK** | |

| | | | | |
|---|---|---|---|---|
| | *assessment of compatibility, making patent descriptions and patent database* | | | |
| K2ETK_W8 | *he knows the principles of operation of the power system in various operating states, technologies of generation, transmission, distribution and use of electrical energy.*<br>*Has the knowledge of technical, economic, environmental and legal aspects related to the operation of the power sector and its components* | **P7U_W** | **P7S_WG** | **P7S_WG_inż** |
| K2ETK_W9 | *has in-depth knowledge of issues related to various aspects of construction and operation of modern systems and devices used in widely understood electrical engineering.* | **P7U_W** | **P7S_WG** | **P7S_WG_inż** |
| K2ETK_W10 | *has knowledge in the field of operation and modeling of complex objects and power systems and electromechanical energy conversion.* | **P7U_W** | **P7S_WG** | **P7S_WG_inż** |
| K2ETK_W11 | *has an organized knowledge of various threats and problems related to the functioning of electrical systems, networks and devices.* | **P7U_W** | **P7S_WG** | **P7S_WG_inż** |
| K2ETK_W12 | *has knowledge in the field of reliability, continuity and certainty of electricity supply in the power system as well as applied solutions and technologies.*<br>*He knows the issues of electricity quality and the rules for the selection of devices, systems and systems improving the quality of energy.* | **P7U_W** | **P7S_WG** | **P7S_WG_inż** |
| K2ETK_W13 | *has knowledge in the field of physics, useful for understanding the phenomena, processes, operation of various systems and devices used in power installations,*<br>*knows the materials and technologies used in electrical engineering.* | **P7U_W** | **P7S_WG** | **P7S_WG_inż** |

| | | | | |
|---|---|---|---|---|
| K2ETK_W14 | *he knows the principles of operation and solutions of power electronic systems, has an organized knowledge of automation and control of various installations, systems and power facilities.* | **P7U_W** | **P7S_WG** | **P7S_WG_inż** |
| K2ETK_W15 | *has an organized knowledge of energy efficiency and rationalization of energy consumption.*<br>*Has extended knowledge of various electricity generation technologies, including renewable energy sources.* | ***P7U_W*** | ***P7S_WG***<br>***P7S_WK*** | |
| K2ETK_W16 | *has knowledge of the collection and processing of information as well as control and communication techniques used in the broadly understood electrical engineering.* | | | |
| K2ETK_W17 | *has detailed knowledge of the planning, design and operation of electrical systems, facilities and devices.* | **P7U_W** | **P7S_WG** | **P7S_WG_inż** |
| K2ETK_W18 | *has knowledge of the structures, methods and algorithms of automation and control as well as the construction of control systems used in electrical engineering.* | **P7U_W** | **P7S_WG** | **P7S_WG_inż** |
| K2ETK_W19 | *has an ordered and theoretically founded knowledge of selected branches of electrical engineering; knows and understands selected issues constituting detailed knowledge, appropriate for the education program within the selected specialization.* | **P7U_W** | **P7S_WG** | **P7S_WG_inż** |
| | | **SKILLS (U)** | | |
| K2ETK_U1 | *can properly apply the mathematical methods to description, synthesis and analysis of electrical linear and nonlinear circuits and systems, taking into account both continuous and discrete types* | **P7U_U** | **P7S_UW** | **P7S_UW_inż** |
| K2ETK_U2 | *can properly apply the numerical and optimization algorithms to solve engineering problems*<br>*is able to correctly define the problem, design an algorithm and interpret the results* | **P7U_U** | **P7S_UW** | **P7S_UW_inż** |

| | | | | |
|---|---|---|---|---|
| K2ETK_U3 | *can properly describe, conduct analysis and form models of electrical drive systems of different types of control using different kinds of motors* | **P7U_U** | **P7S_UW** | **P7S_UW_inż** |
| K2ETK_U4 | *student can measure selected physical quantities using suitable measuring instruments, sensors and converters relying on known methods and measuring systems*<br>*he/she can analyse the results of his/her measuring activities* | **P7U_U** | **P7S_UW** | **P7S_UW_inż** |
| K2ETK_U5 | *depending on the choice of level of studied language, student:*<br>*has knowledge, abilities and competence compatible with requirements specified for additional B2+ ESOKJ level characteristic for scientific and technical language connected with the studied discipline and related fields*<br>*or*<br>*has knowledge, abilities and competence compatible with requirements specified for additional C1+ ESOKJ level; makes use of specialist texts on his/her own, uses scientific and technical language in both oral and written forms, analyses given texts and presents them in various specialist debates* | **P7U_U** | **P7S_UK**<br>**P7S_UU** | |
| K2ETK_U6 | *depending on the choice of level of studied language, student:*<br>*has knowledge, abilities and competence compatible with requirements specified for A1 ESOKJ level,*<br>*has basic knowledge of studied language, knows daily life and fundamental intercultural behaviour basic vocabulary and grammatical structures*<br>*or*<br>*has knowledge, abilities and competence compatible with requirements specified for A2 ESOKJ level,*<br>*uses vocabulary and grammatical structures related to the studied field and accordingly with the socio-cultural knowledge, can participate in discussions on common subjects and to a certain extent talk about studies and professional work* | **P7U_U** | **P7S_UK**<br>**P7S_UU** | |

| | | | | |
|---|---|---|---|---|
| K2ETK_U7 | *is able to formulate and justify opinions, present problems related to studied field, related to working environment, also participate in scientific and professional discussions* | **P7U_U** | **P7S_UW**<br>**P7S_UK** | |
| K2ETK_U8 | *can design various systems, installations and devices used in electrical engineering in accordance with the requirements and with the use of modern design aids.* | **P7U_U** | **P7S_UW** | **P7S_UW_inż** |
| K2ETK_U9 | *he is able to carry out a multi-criteria analysis of selected phenomena, processes, systems, objects and electrotechnical devices.* | **P7U_U** | **P7S_UW** | **P7S_UW_inż** |
| K2ETK_U10 | *can model, using appropriate software, digital models of power grid elements and perform simulation analysis of dynamic phenomena in complex three-phase power grids.* | **P7U_U** | **P7S_UW** | **P7S_UW_inż** |
| K2ETK_U11 | *is able to carry out measurements and tests of various devices, systems and electrotechnical systems, as well as to correctly interpret and evaluate the obtained results.* | **P7U_U** | **P7S_UW** | **P7S_UW_inż** |
| K2ETK_U12 | *is able to use in a practical way knowledge in the field of selected electrotechnical departments, appropriate for the education program within the selected specialization.* | **P7U_U** | **P7S_UW** | **P7S_UW_inż** |
| K2ETK_U13 | *can solve problems in the field of collecting and processing information in the control process.*<br>*He is able to implement an installation project using solutions of broadly understood automation, select the right controller and its peripheral systems in accordance with the project requirements, program the controller in the selected programming language and carry out commissioning and testing works.* | **P7U_U** | **P7S_UW** | **P7S_UW_inż** |
| K2ETK_U14 | *is able to prepare and present a presentation containing the results of the master's thesis, as well as justify in a discussion the manner of implementation and the results achieved, knows the rules of creative discussion.* | **P7U_U** | **P7S_UW**<br>**P7S_UK** | **P7S_UW_inż** |

| | | | | |
|---|---|---|---|---|
| K2ETK_U15 | *is able to prepare a master's thesis in the area of specialization, including:*<br>*- is able to obtain information from literature, databases and other sources, integrate it, interpret and critically evaluate it,*<br>*- can plan and carry out experiments, including measurements and computer simulations, interpret the obtained results and draw conclusions,*<br>*- can use analytical, simulation and experimental methods to formulate and solve problems*<br>*- can formulate and test hypotheses related to research problems,*<br>*- is able to integrate knowledge from various fields and disciplines and apply a systemic approach, also taking into account non-technical aspects,*<br>*- can assess the usefulness and the possibility of using new achievements (techniques and technologies) in the represented discipline*<br>*- is able to propose improvements / improvements to the existing technical solutions,*<br>*- is able to interpret the obtained research results, draw appropriate conclusions and formulate recommendations,*<br>*- is able to edit a master's thesis in accordance with formal requirements* | **P7U_U** | **P7S_UW**<br>**P7S_UK**<br>**P7S_UO** | **P7S_UW_inż** |
| **SOCIAL COMPETENCES (K)** | | | | |
| K2ETK_K1 | *understands the need for live long learning and rising qualifications* | | **P7S_KK** | |
| K2ETK_K2 | *is able for a teamwork on a complex engineering task, according to his role in the team and the working time schedule* | **P7U_K** | | |
| K2ETK_K3 | *is aware about the importance and non-technical aspects of engineering activities, i.e. influence on environment, therefore takes responsible actions* | | **P7S_KO**<br>**P7S_KR** | |
| K2ETK_K4 | *correctly identifies and solves dilemmas related to profession* | **P7U_K** | **P7S_KK**<br>**P7S_KR** | |

| | | | | |
|---|---|---|---|---|
| K2ETK_K5 | *has the awareness of the social role of an technical university alumnus*<br>*understands the need of formulating and publishing, i.e. via mass media, information and opinions related to technical achievements in engineering and to other activities of an engineer*<br>*is able to publish it in a comprehensive manner, justifying different opinions* | **P7U_K** | **P7S_KO** | |
| K2ETK_K6 | *he can think critically and support his own view, so he can select priorities properly and choose appropriate measures to achieve the tasks defined by himself or other people taking into account the issues of social responsibility* | **P7U_K** | **P7S_KO** | |
| K2ETK_K7 | *knows the team work rules knows how to lead a small team and how to take responsibilities for the results* | **P7U_K** | **P7S_KR** | |

# DESCRIPTION OF THE PROGRAM OF STUDIES

**Main field of study - Electrical Engineering** **Profile - general academic**

**Level of studies - 2nd level** **Form of studies - full-time**

## 1. Description

| | |
|---|---|
| *1.1 Number of semesters*<br>*Specializations in polish: 3*<br>*Specializations in english: 4* | *1.2 Total number of ECTS points necessary to complete studies at a given level:*<br>*Specializations in polish: 90*<br>*Specializations in english: 120* |
| *1.3 Total number of hours:*<br>*Specializations in polish: 1080*<br>*Specializations in english: 1440* | *1.4 Prerequisites (particularly for second-level studies):*<br>*Completed undergraduate or graduate degree in the field, in which contents of Electrical Engineering related to Circuit Theory and Theory of Electromagnetic Field are contained as well as knowledge gained from at least one of the courses: Electrical Drives, Electrical Devices, Fundamentals of Control Theory, High Voltage Engineering.* |

| | |
|---|---|
| *1.5 Upon completion of studies graduate obtains professional degree of:*<br>*master of science, engineer* | *1.6 Graduate profile, employability:*<br>*A graduate of the second degree studies in the field of Industrial Electrical Engineering has advanced and well-established knowledge in the field of electrical engineering applications in production processes along with their automation. In this area, he has the ability to use IT tools for design and modeling.*<br>*A graduate of the second degree studies, specializing in Electrical Power Engineering, has advanced and well-established knowledge in the field of power system operation, automation as well as protection and control techniques in the power industry. Has the ability to use IT tools for design and modeling.*<br>*A graduate of the second degree studies specializing in Renewable Energy Sources has advanced and well-established knowledge in the field of these energy sources, including energy generation technologies, automation and control, as well as market mechanisms and investment processes in the energy sector with a dispersed structure. Has the ability to use IT tools to analyze phenomena in power systems with renewable energy sources.*<br>*A graduate of English-language study of the second degree specializing in Control in Electrical Power Engineering has advanced and well-established knowledge in the field of techniques of control and protection of power systems. Has the ability to use IT tools to analyze phenomena in power networks and design control systems.*<br>*A graduate of English-language study of the second degree specializing in Renewable Energy Systems has advanced and well-established knowledge of these energy sources, including energy generation technologies, automation and control, as well as market mechanisms and investment processes in energy with a distributed structure. Has the ability to use IT tools to analyze phenomena in power systems with renewable energy sources.*<br>*A graduate of the second degree studies in the field of Electrical Engineering is capable of creative work as well as decision-making and managing employee teams. He is prepared to continue his education at the Doctoral School.* |
| *1.7 Possibility of continuing studies:*<br>*Eligibility to apply for admission to a doctoral school, non-degree postgraduate programmes.* | *1.8 Indicate connection with University's mission and its development strategy:*<br>*The study program for Electrical Engineering is consistent with the mission and growth strategy of the University in the field of transferring knowledge and skills to students while maintaining high quality of education, it enables the formation of creative, critical and tolerant personalities of students open to new challenges.* |

**2. Detailed description:**

**2.1 Total number of learning outcomes in the program of study:**

**W (knowledge) = 19**

**U (skills) = 15**

**K (competences) = 7**

**W + U + K = 41**

**2.2 For the main field of study assigned to more than one discipline - the number of learning outcomes assigned to the discipline:**

**D1 (major):**

**2.3 For the field of study assigned to more than one discipline - percentage share of the number of ECTS points for each discipline:**

**D1 100 % ECTS points**

**2.4a. For the general academic profile field of study – the number of ECTS points assigned to the classes related to the University's academic activity in the discipline or disciplines to which the faculty is assigned:**

| | | |
|---|---|---|
| **Specializations conducted in Polish: Industrial Electrical Engineering, Electrical Power Engineering, Renewable Energy Sources** | 82 | ECTS |
| **Specializations conducted in English: Control in Electrical Power Engineering, Renewable Energy Systems** | 112 | ECTS |

**2.4b. For the practical profile of the main field of study - the number of ECTS points assigned to the classes shaping practical skills:**

ECTS

**2.5. Concise analysis of compliance of the assumed learning outcomes with the needs of the labor market:**

*Learning outcomes refer not only to the large sense of electrical engineering, in particular to automation and control in power systems, but - due to the demands of modern techniques and technologies currently used in power generation and industry – but also to the electronics, power electronics and microprocessor technology, computer science and management techniques and marketing. Obtaining the intended learning outcomes will enable graduates to find attractive and interesting work in the energy sector of the national economy, particularly in units where are designed and manufactured systems and control systems for the power industry. It is also ready to start a business in the electrical industry. Work on learning outcomes were refereed and discussed at the meetings of the Convention of the Faculty of Electrical Engineering (now the Social Council of the Faculty of Electrical Engineering), which includes, among others, representatives of industrial enterprises of the Polish territory, with particular consideration to Lower Silesia and the neighbouring provinces. The Convention also includes foreign members. At these meetings were presented and explained the needs of the labour market.*

**2.6. The total number of ECTS points that a student must obtain in classes requiring direct participation of academic teachers or other persons conducting classes and students (enter the sum of ECTS points for courses / groups of courses marked with the BU[1] code)**

| | | |
|---|---|---|
| Specializations conducted in Polish: Industrial Electrical Engineering, Electrical Power Engineering, Renewable Energy Sources | 63 | ECTS |
| Specializations conducted in English: Control in Electrical Power Engineering, Renewable Energy Systems | 84 | ECTS |

**2.7. Total number of ECTS points, which student has to obtain from basic sciences classes**

**Specializations conducted in Polish: Industrial Electrical Engineering, Electrical Power Engineering, Renewable Energy Sources**

| | |
|---|---|
| Number of ECTS points for obligatory subjects | 5 |
| Number of ECTS points for optional subjects | 0 |
| Total number of ECTS points | 5 |

**Specializations conducted in English: Control in Electrical Power Engineering, Renewable Energy Systems**

| | |
|---|---|
| Number of ECTS points for obligatory subjects | 7 |
| Number of ECTS points for optional subjects | 0 |
| Total number of ECTS points | 7 |

**2.8. Total number of ECTS points, which student has to obtain from practical classes, including laboratory classes**

**Specializations conducted in Polish: Industrial Electrical Engineering**

| | |
|---|---|
| Number of ECTS points for obligatory subjects | 19 |
| Number of ECTS points for optional subjects | 27 |
| Total number of ECTS points | 46 |

**Specializations conducted in Polish: Electrical Power Engineering**

| | |
|---|---|
| Number of ECTS points for obligatory subjects | 21 |
| Number of ECTS points for optional subjects | 28 |
| Total number of ECTS points | 49 |

**Specializations conducted in Polish: Renewable Energy Sources**

| | |
|---|---|
| Number of ECTS points for obligatory subjects | 19 |
| Number of ECTS points for optional subjects | 28 |
| Total number of ECTS points | 47 |

**Specializations conducted in English: Control in Electrical Power Engineering**

| | |
|---|---|
| Number of ECTS points for obligatory subjects | 26 |
| Number of ECTS points for optional subjects | 40 |
| Total number of ECTS points | 66 |

**Specializations conducted in English: Renewable Energy Systems**

| | |
|---|---|
| Number of ECTS points for obligatory subjects | 27 |
| Number of ECTS points for optional subjects | 40 |
| Total number of ECTS points | 67 |

**2.9. Minimum number of ECTS points, which student has to obtain doing education blocks offered as part of university-wide classes or other main field of study**

8 ECTS points

**2.10. Total number of ECTS points, which student may obtain doing optional blocks (min. 30% of total number of ECTS points)**

| | | |
|---|---|---|
| **Specializations conducted in Polish: Industrial Electrical Engineering, Electrical Power Engineering, Renewable Energy Sources** | 36 | ECTS |
| **Specializations conducted in English: Control in Electrical Power Engineering, Renewable Energy Systems** | 48 | ECTS |

**3. Description of the process leading to learning outcomes acquisition:**

*The process leading to the planned learning outcomes in the field of Electrical Engineering is multi-stage and compliant with the Education Quality Assurance System in force at the Faculty of Electrical Engineering. In the recruitment process, the aim is to accept candidates for second-cycle studies with the highest possible recruitment rates. During the first meetings, academic teachers conducting classes familiarize students with the prerequisites for a given subject, the assumed learning outcomes and the program of classes. The lecturers should also indicate the need for students' own systematic work and motivate them to think independently and draw conclusions. Achieving learning outcomes at the second degree of studies enables the acquisition of advanced knowledge in specialist subjects, characteristic of the chosen field of study and specialization. Academic teachers are available to students outside of scheduled classes during designated consultation hours. In order to gain access to the literature recommended by the teachers, students can use the resources of the Faculty Library and the Main Library of Wrocław University of Science and Technology. The classrooms in which the classes are held are equipped with modern audiovisual systems and appropriate measuring and research devices that enable students to acquire knowledge and acquire specialist skills. Second-cycle studies end with a diploma examination, which can be taken by a student who has completed the study program and obtained a positive grade in the diploma dissertation.*

**Specialization: Renewable Energy Systems**

# 4. List of education blocks:
## 4.1. List of obligatory blocks
### 4.1.1. List of general education blocks
#### 4.1.1.1. Liberal-managerial subjects block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | **University-wide** | **Concerning scientific activities** | **Practical** | **Type** |

#### 4.1.1.2. Foreign languages block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | **University-wide** | **Concerning scientific activities** | **Practical** | **Type** |

#### 4.1.1.3. Sporting classes block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | **University-wide** | **Concerning scientific activities** | **Practical** | **Type** |

#### 4.1.1.4. Information technologies block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | **University-wide** | **Concerning scientific activities** | **Practical** | **Type** |

**Altogether for general education blocks**

| **Total number of hours** | | | | | **Total number of ZZU hours** | **Total number of CNPS hours** | **Total number of ECTS points** | **Number of ECTS points for DN classes** | **Number of ECTS points for BU classes** |
|---|---|---|---|---|---|---|---|---|---|
| **lec** | **cl** | **lab** | **pr** | **sem** | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### 4.1.2. List of basic sciences blocks
### 4.1.2.1. Mathematics block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM1330W | Numerical and Optimization Methods | 1 | | | | | K2ETK_W2 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | PD |
| 2 | W05ETK-SM1330L | Numerical and Optimization Methods | | | 1 | | | K2ETK_U2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | PD |
| | | Total | 1 | 0 | 1 | 0 | 0 | | 30 | 90 | 3 | 3 | 2,1 | | | | | | |

### 4.1.2.2. Physics block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM3312W | Measurement methods and techniques | 2 | | | | | K2ETK_W5 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | PD |
| 2 | W05ETK-SM3312L | Measurement methods and techniques | | | 2 | | | K2ETK_U4 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | PD |
| | | Total | 2 | 0 | 2 | 0 | 0 | | 60 | 120 | 4 | 4 | 2,8 | | | | | | |

### 4.1.2.3. Chemistry block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

**Altogether for basic sciences blocks**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 3 | 0 | 3 | 0 | 0 | 90 | 210 | 7 | 7 | 4,9 |

### 4.1.3. List of main-field-of-study blocks
### 4.1.3.1. Obligatory main-field-of-study block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM1332W | Circuits and Systems | 2 | | | | | K2ETK_W1 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | K |
| 2 | W05ETK-SM1332C | Circuits and Systems | | 1 | | | | K2ETK_U1 K2ETK_K1 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | K |
| 3 | W05ETK-SM2131W | Power Systems Faults | 2 | | | | | K2ETK_W3 K2ETK_K1 | 30 | 120 | 4 | 4 | 2,8 | T-Z | E | | DN | | K |
| 4 | W05ETK-SM3225W | Dynamics and Control of AC and DC Drives | 2 | | | | | K2ETK_W4 | 30 | 120 | 4 | 4 | 2,8 | T-Z | E | | DN | | K |
| 5 | W05ETK-SM3225L | Dynamics and Control of AC and DC Drives | | | 1 | | | K2ETK_U3 K2ETK_K2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | K |
| 6 | W05ETK-SM3225P | Dynamics and Control of AC and DC Drives | | | | 1 | | K2ETK_U3 K2ETK_K2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | K |
| | | Total | 6 | 1 | 1 | 1 | 0 | | 135 | 420 | 14 | 14 | 9,8 | | | | | | |

**Altogether for main-field-of-study blocks**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 6 | 1 | 1 | 1 | 0 | 135 | 420 | 14 | 14 | 9,8 |

### 4.1.4. List of specialization blocks
### 4.1.4.1. Obligatory specialization subjects block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM1331W | Power Quality Assessment | 2 | | | | | K2ETK_W12 K2ETK_K1 K2ETK_K2 | 30 | 90 | 3 | 3 | 2,1 | T-Z | Z | | DN | | S |
| 2 | W05ETK-SM1331L | Power Quality Assessment | | | 1 | | | K2ETK_U11 K2ETK_K1 K2ETK_K2 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 3 | W05ETK-SM1337W | Photovoltaic Cells | 2 | | | | | K2ETK_W13 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T-Z | E | | DN | | S |
| 4 | W05ETK-SM1337L | Photovoltaic Cells | | | 1 | | | K2ETK_U8 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 5 | W05ETK-SM1338W | Industrial ecology - selected problems | 1 | | | | | K2ETK_W11 K2ETK_K3 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | | S |
| 6 | W05ETK-SM1338S | Industrial ecology - selected problems | | | | | 1 | K2ETK_U9 K2ETK_K3 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 7 | W05ETK-SM2133W | Simulation and Analysis of Power System Transients | 1 | | | | | K2ETK_W10 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | | S |
| 8 | W05ETK-SM2133L | Simulation and Analysis of Power System Transients | | | 2 | | | K2ETK_U10 K2ETK_K6 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 9 | W05ETK-SM2135W | Artificial Intelligence Techniques | 2 | | | | | K2ETK_W9 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 10 | W05ETK-SM2135P | Artificial Intelligence Techniques | | | | 1 | | K2ETK_U8 K2ETK_K2 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 11 | W05ETK-SM2137W | Protection and Control of Distributed Energy Sources 1 | 1 | | | | | K2ETK_W9 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 12 | W05ETK-SM2137L | Protection and Control of Distributed Energy Sources 1 | | | 1 | | | K2ETK_U9 K2ETK_K1 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 13 | W05ETK-SM2139P | Fault Calculations | | | | 2 | | K2ETK_U9 K2ETK_K2 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 14 | W05ETK-SM2141S | Protection and Control of Distributed Energy Sources 2 | | | | | 1 | K2ETK_U13 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 15 | W05ETK-SM2331W | Renewable Energy Sources | 2 | | | | | K2ETK_W8 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T-Z | E | | DN | | S |
| 16 | W05ETK-SM2331S | Renewable Energy Sources | | | | | 1 | K2ETK_U9 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 17 | W05ETK-SM2332W | Water Power Plants 1 | 2 | | | | | K2ETK_W8 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 18 | W05ETK-SM2334W | Energy Storage Systems | 1 | | | | | K2ETK_W12 | 15 | 60 | 2 | 2 | 1,4 | T-Z | E | | DN | | S |
| 19 | W05ETK-SM2334P | Energy Storage Systems | | | | 1 | | K2ETK_U8 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 20 | W05ETK-SM2336S | Water Power Plants 2 | | | | | 1 | K2ETK_U9 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 21 | W05ETK-SM2536W | Integration of Distributed Resources in Power Systems | 2 | | | | | K2ETK_W10 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T-Z | E | | DN | | S |
| 22 | W05ETK-SM2536L | Integration of Distributed Resources in Power Systems | | | 1 | | | K2ETK_U9 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 23 | W05ETK-SM2537W | Legal Regulations and Investments in Power Systems with Distributed Energy Sources | 2 | | | | | K2ETK_W17 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 24 | W05ETK-SM2537S | Legal Regulations and Investments in Power Systems with Distributed Energy Sources | | | | | 1 | K2ETK_U9 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | W05ETK-SM3110W | Modelling of Electrical Machines | 1 | | | | | K2ETK_W9 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | | S |
| 26 | W05ETK-SM3110P | Modelling of Electrical Machines | | | | 2 | | K2ETK_U11 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 27 | W05ETK-SM3228W | Power Electronics | 2 | | | | | K2ETK_W14 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 28 | W05ETK-SM3228L | Power Electronics | | | 1 | | | K2ETK_U8 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 29 | W05ETK-SM3229W | Electromechanical Systems in Renewable Energy | 1 | | | | | K2ETK_W14 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | | S |
| 30 | W05ETK-SM3229S | Electromechanical Systems in Renewable Energy | | | | | 1 | K2ETK_U9 K2ETK_K1 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 31 | W05ETK-SM3311W | Electromagnetic Compatibility | 2 | | | | | K2ETK_W11 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 32 | W05ETK-SM3311L | Electromagnetic Compatibility | | | 1 | | | K2ETK_U11 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 33 | W09ETK-SM1501W | Advanced Technology in Electrical Power Generation | 2 | | | | | K2ETK_W19 | 30 | 90 | 3 | 3 | 2,1 | T-Z | Z | | DN | | S |
| 34 | W09ETK-SM1501C | Advanced Technology in Electrical Power Generation | | 1 | | | | K2ETK_U9 K2ETK_K3 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| | | Total | 26 | 1 | 8 | 6 | 6 | | 705 | 1530 | 51 | 51 | 35,7 | | | | | | |

**Altogether for specialization blocks**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 26 | 1 | 8 | 6 | 6 | 705 | 1530 | 51 | 51 | 35,7 |

## 4.2. List of optional blocks
### 4.2.1. List of general education blocks
#### 4.2.1.1. Liberal-managerial subjects block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W08ETK-SM1721S | Ethics in bussiness | | | | | 1 | K2ETK_U7 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | P | KO |
| 2 | W08ETK-SM3721S | The art of public speaking | | | | | 1 | K2ETK_U7 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | P | KO |
| 3 | W08ETK-SM3821S | Social communication | | | | | 1 | K2ETK_U7 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | P | KO |
| 4 | W05ETK-SM1231W | Intellectual property rights in the world | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 5 | W05ETK-SM1232W | Inventions and patents | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 6 | W05ETK-SM1233W | Industrial property and copyright for engineers | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 7 | W05ETK-SM1007W | Protection of Intellectual Property | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 8 | W05ETK-SM1008W | International Law | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 9 | W05ETK-SM2538W | Market Mechanisms in Power Systems with Distributed Energy Sources | 1 | | | | | K2ETK_W6 K2ETK_K3 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | | KO |
| 10 | W05ETK-SM1499W | Fundamentals of Management | 1 | | | | | K2ETK_W6 K2ETK_K3 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | | KO |
| | | Total | 2 | 0 | 0 | 0 | 1 | | 45 | 125 | 5 | 0 | 3,5 | | | | | | |

## 4.2.1.2. Foreign languages block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | SJO000-SM00 | Foreign language B2+ or C1+ | | 1 | | | | K2ETK_U5 K2ETK_K1 | 15 | 30 | 1 | | 0,7 | T | Z | O | - | P | KO |
| 2 | SJO000-SM00 | Foreign language A1 or A2 | | 3 | | | | K2ETK_U6 K2ETK_K1 | 45 | 60 | 2 | | 1,4 | T | Z | O | - | P | KO |
| | | Total | 0 | 4 | 0 | 0 | 0 | | 60 | 90 | 3 | 0 | 2,1 | | | | | | |

## 4.2.1.3. Sporting classes block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

## 4.2.1.4. Information technologies block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

**Altogether for general education blocks**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 2 | 4 | 0 | 0 | 1 | 105 | 215 | 8 | 0 | 5,6 |

## 4.2.2. List of basic sciences blocks

### 4.2.2.1. Mathematics block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | **University-wide** | **Concerning scientific activities** | **Practical** | **Type** |

### 4.2.2.2. Physics block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | **University-wide** | **Concerning scientific activities** | **Practical** | **Type** |

### 4.2.2.3. Chemistry block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | **University-wide** | **Concerning scientific activities** | **Practical** | **Type** |

**Altogether for basic sciences blocks**

| **Total number of hours** | | | | | **Total number of ZZU hours** | **Total number of CNPS hours** | **Total number of ECTS points** | **Number of ECTS points for DN classes** | **Number of ECTS points for BU classes** |
|---|---|---|---|---|---|---|---|---|---|
| **lec** | **cl** | **lab** | **pr** | **sem** | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## 4.2.3. List of main-field-of-study blocks

### 4.2.3.1. Optional main-field-of-study subjects block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | **University-wide** | **Concerning scientific activities** | **Practical** | **Type** |

**Altogether for main-field-of-study blocks**

| **Total number of hours** | | | | | **Total number of ZZU hours** | **Total number of CNPS hours** | **Total number of ECTS points** | **Number of ECTS points for DN classes** | **Number of ECTS points for BU classes** |
|---|---|---|---|---|---|---|---|---|---|
| **lec** | **cl** | **lab** | **pr** | **sem** | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## 4.2.4. List of specialization blocks
### 4.2.4.1. Specialization subjects block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM1230W | Visual Engineering Environments and Graphical Languages | 1 | | | | | K2ETK_W16 | 15 | 30 | 1 | 1 | 0,7 | T-Z | E | | DN | | S |
| 2 | W05ETK-SM1230L | Visual Engineering Environments and Graphical Languages | | | 2 | | | K2ETK_U13 K2ETK_K2 | 30 | 90 | 3 | 3 | 2,1 | T | Z | | DN | P | S |
| 3 | W05ETK-SM1334W | Signal and Systems | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 4 | W05ETK-SM1334C | Signal and Systems | | 1 | | | | K2ETK_U13 K2ETK_K1 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 5 | W05ETK-SM1335W | Advanced Signal Processing Methods | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 6 | W05ETK-SM1335C | Advanced Signal Processing Methods | | 1 | | | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 7 | W05ETK-SM2136W | Design of logic circuits | 1 | | | | | K2ETK_W14 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 8 | W05ETK-SM2136L | Design of logic circuits | | | 1 | | | K2ETK_U13 K2ETK_K1 K2ETK_K2 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 9 | W05ETK-SM2138W | Electrical Power Engineering – excursionary activities | 1 | | | | | K2ETK_W14 K2ETK_K6 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 10 | W05ETK-SM2138S | Electrical Power Engineering – excursionary activities | | | | | 1 | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 11 | W05ETK-SM2234W | PLC and Wireless Communications for Monitoring and Metering | 2 | | | | | K2ETK_W16 K2ETK_K6 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 12 | W05ETK-SM2234S | PLC and Wireless Communications for Monitoring and Metering | | | | | 1 | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 13 | W05ETK-SM2335W | Advanced Substations and Electrical Equipment | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 14 | W05ETK-SM2335P | Advanced Substations and Electrical Equipment | | | | 1 | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 15 | W05ETK-SM2534W | Power System Modelling | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 16 | W05ETK-SM2534P | Power System Modelling | | | | 1 | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 17 | W05ETK-SM2535W | Computer Control of  Power System | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 18 | W05ETK-SM2535S | Computer Control of  Power System | | | | | 1 | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 19 | W05ETK-SM3226W | Fuzzy Logic Control | 1 | | | | | K2ETK_W14 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 20 | W05ETK-SM3226L | Fuzzy Logic Control | | | 1 | | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 21 | W05ETK-SM3227W | Control of Power Electronic Converters | 1 | | | | | K2ETK_W14 K2ETK_K6 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 22 | W05ETK-SM3227L | Control of Power Electronic Converters | | | 1 | | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| | | Total | 3 | 1 | 1 | 0 | 0 | | 75 | 210 | 7 | 7 | 4,9 | | | | | | |

### 4.2.4.2. Training block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM5105Q | Diploma placement 4 weeks | | | | 40 | | K2ETK_U12 K2ETK_K6 | 160 | 120 | 4 | 4 | 2,8 | T | Z | | DN | P | S |
| | | Total | 0 | 0 | 0 | 40 | 0 | | 160 | 120 | 4 | 4 | 2,8 | | | | | | |

### 4.2.4.3. Diploma dissertation block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course | Way of crediting | Course | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | university-wide | zw. z dział. nauk. | practical | kind |
| 1 | W05ETK-SM5108S | Diploma seminar | | | | | 2 | K2ETK_U14 K2ETK_K6 | 30 | 90 | 3 | 3 | 2,1 | T-Z | Z | | DN | P | S |
| 2 | W05ETK-SM5117P | Diploma Project | | | | 8 | | K2ETK_U15 K2ETK_K6 | 120 | 240 | 8 | 8 | 5,6 | T | Z | | DN | P | S |
| 3 | W05ETK-SM5119D | Master's thesis | | | | 12 | | K2ETK_U15 K2ETK_K4 K2ETK_K6 | 180 | 540 | 18 | 18 | 12,6 | T | Z | | DN | P | S |
| 4 | W05ETK-SM5127P | Diploma Project | | | | 8 | | K2ETK_U15 K2ETK_K6 | 120 | 240 | 8 | 8 | 5,6 | T | Z | | DN | P | S |
| 5 | W05ETK-SM5129D | Master's thesis | | | | 12 | | K2ETK_U15 K2ETK_K4 K2ETK_K6 | 180 | 540 | 18 | 18 | 12,6 | T | Z | | DN | P | S |
| 6 | W05ETK-SM5137P | Diploma Project | | | | 8 | | K2ETK_U15 K2ETK_K6 | 120 | 240 | 8 | 8 | 5,6 | T | Z | | DN | P | S |
| 7 | W05ETK-SM5139D | Master's thesis | | | | 12 | | K2ETK_U15 K2ETK_K4 K2ETK_K6 | 180 | 540 | 18 | 18 | 12,6 | T | Z | | DN | P | S |
| | | Total | 0 | 0 | 0 | 20 | 2 | | 330 | 870 | 29 | 29 | 20,3 | | | | | | |

**Altogether for specialization blocks**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| **lec** | **cl** | **lab** | **pr** | **sem** | | | | | |
| 3 | 1 | 1 | 60 | 2 | 565 | 1200 | 40 | 40 | 28 |

## 4.3 Training block - concerning principles of training crediting – attachment no. 2

| Name of training: | Diploma placement 4 weeks | | |
|---|---|---|---|
| **Number of ECTS points** | **Number of ECTS points for BU classes** | **Training crediting mode** | **Code** |
| 4 | 2,8 | report from training | W05ETK-SM5105Q |
| **Training duration** | **Training objective** | | |
| 4 weeks | "The primary objective is to confront the theoretical knowledge acquired in the course included in the learning schedule, with the real demands of the employers. During practice the student gains industrial experience, take note of the basic technical equipment and technology of the companies, learns the specificity of work of the higher technical inspection facility, in particular:<br>• extends the knowledge gained during studies and develops the skills to use it,<br>• familiarize themselves with the specific of professional environment,<br>• shapes specific professional skills directly related to the place of practice,<br>• shapes the skills of effective communication in an organization,<br>• learns the functioning in an organizational structure, the principles of the organization of work and the division of powers, procedures, work planning, control,<br>• improves the ability of self organization, teamwork, effective time management, diligence, responsibility for assigned tasks,<br>• improves the ability to use a foreign language in professional contexts.<br>By free choice of the place of practice, ie by their own choice of the ""Company"" or the choice of units and facilities fromthe faculty list, students can pursue their professional interests. There is a possibility of some connection with the subject of the future practice of Master thesis. The practice allows you to focus the student's preferences with regard to the future work." | | |

## 4.4. Diploma dissertation block

| Type of diploma dissertation: | magister | |
|---|---|---|
| **Number of diploma dissertation semesters** | **Number of ECTS points** | **Code** |
| 1 | 29 | W05ETK-SM5108S<br>W05ETK-SM5117P<br>W05ETK-SM5127P<br>W05ETK-SM5137P<br>W05ETK-SM5119D<br>W05ETK-SM5129D<br>W05ETK-SM5139D |
| **Character of diploma dissertation** | | |
| Master's thesis has a computational, theoretical caracter, or may contain a description and analysis of the performed experimental studies. In each case it contains a section in which the author alone interpret and draw conclusions from their research. Intellectual contributions of private study should be clearly visible. | | |

| | |
|---|---|
| **Number of BU ECTS points:** | 20,3 |
| **Number of DN ECTS points:** | 29 |

## 5. Ways of verifying assumed learning outcomes

| Type of classes | Ways of verifying assumed learning outcomes |
|---|---|
| **lecture** | examination, progress/final test |
| **class** | progress/final test |
| **laboratory** | pretest, report from laboratory |
| **project** | project defence |
| **seminar** | participation in discussion, topic presentation, essay |
| **training** | report from training |
| **diploma dissertation** | prepared diploma dissertation |

## 6. Range of diploma dissertation

The diploma examination consists of the presentation of the diploma thesis and answers to randomly selected questions. The scope of the diploma examination includes questions on the following issues, according to the chosen specialization.

Renewable Energy Systems:

1. Numerical and optimisation methods
2. Power system faults
3. Dynamics and control of AC/DC drives
4. Circuits and systems
5. Measurement methods and techniques
6. Power quality assessment
7. Power electronics
8. Advanced technology in electrical power generation
9. Protection and control of distributed energy sources
10. Water power plants
11. Renewable energy sources
12. Integration of distributed resources in power systems
13. Electromechanical systems in renewable energy
14. Simulation and analysis of power system transients
15. Photovoltaic cells
16. Electromagnetic compatibility
17. Energy storage systems
18. Artificial intelligence techniques

## 7. Requirements concerning deadlines for crediting courses/groups of courses for all courses in particular blocks

| No. | Course code | Name of course | Crediting by deadline of... (number of semester) |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

## 8. Plan of studies (attachment no. ...)

Approved by faculty student government legislative body:

.................... ........................................................................................................................................

Date Name and surname, signature of student representative

.................... ........................................................................................................................................

Date Dean’s signature

BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
Traditional – enter T, remote – enter Z
Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
University-wide course /group of courses – enter O
DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

**Specialization: Control in Electrical Power Engineering**

## 4. List of education blocks:

### 4.1. List of obligatory blocks

### 4.1.1. List of general education blocks

#### 4.1.1.1. Liberal-managerial subjects block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

#### 4.1.1.2. Foreign languages block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

#### 4.1.1.3. Sporting classes block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

#### 4.1.1.4. Information technologies block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

**Altogether for general education blocks**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## 4.1.2. List of basic sciences blocks

### 4.1.2.1. Mathematics block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM1330W | Numerical and Optimization Methods | 1 | | | | | K2ETK_W2 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | PD |
| 2 | W05ETK-SM1330L | Numerical and Optimization Methods | | | 1 | | | K2ETK_U2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | PD |
| | | Total | 1 | 0 | 1 | 0 | 0 | | 30 | 90 | 3 | 3 | 2,1 | | | | | | |

### 4.1.2.2. Physics block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM3312W | Measurement methods and techniques | 2 | | | | | K2ETK_W5 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | PD |
| 2 | W05ETK-SM3312L | Measurement methods and techniques | | | 2 | | | K2ETK_U4 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | PD |
| | | Total | 2 | 0 | 2 | 0 | 0 | | 60 | 120 | 4 | 4 | 2,8 | | | | | | |

### 4.1.2.3. Chemistry block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

**Altogether for basic sciences blocks**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 3 | 0 | 3 | 0 | 0 | 90 | 210 | 7 | 7 | 4,9 |

## 4.1.3. List of main-field-of-study blocks

### 4.1.3.1. Obligatory main-field-of-study block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM1332W | Circuits and Systems | 2 | | | | | K2ETK_W1 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | K |
| 2 | W05ETK-SM1332C | Circuits and Systems | | 1 | | | | K2ETK_U1 K2ETK_K1 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | K |
| 3 | W05ETK-SM2131W | Power System Faults | 2 | | | | | K2ETK_W3 K2ETK_K1 | 30 | 120 | 4 | 4 | 2,8 | T-Z | E | | DN | | K |
| 4 | W05ETK-SM3225W | Dynamics and Control of AC and DC Drives | 2 | | | | | K2ETK_W4 | 30 | 120 | 4 | 4 | 2,8 | T-Z | E | | DN | | K |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | W05ETK-SM3225L | Dynamics and Control of AC and DC Drives | | | 1 | | | K2ETK_U3 K2ETK_K2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | K |
| 6 | W05ETK-SM3225P | Dynamics and Control of AC and DC Drives | | | | 1 | | K2ETK_U3 K2ETK_K2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | K |
| | | Total | 6 | 1 | 1 | 1 | 0 | | 135 | 420 | 14 | 14 | 9,8 | | | | | | |

**Altogether for main-field-of-study blocks**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 6 | 1 | 1 | 1 | 0 | 135 | 420 | 14 | 14 | 9,8 |

### 4.1.4. List of specialization blocks

### 4.1.4.1. Obligatory specialization subjects block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM1120W | Advanced High Voltage Technology | 2 | | | | | K2ETK_W11 K2ETK_K7 | 30 | 90 | 3 | 3 | 2,1 | T-Z | Z | | DN | | S |
| 2 | W05ETK-SM1120L | Advanced High Voltage Technology | | | 2 | | | K2ETK_U11 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 3 | W05ETK-SM1331W | Power Quality Assessment | 2 | | | | | K2ETK_W12 K2ETK_K1 K2ETK_K2 | 30 | 90 | 3 | 3 | 2,1 | T-Z | Z | | DN | | S |
| 4 | W05ETK-SM1331L | Power Quality Assessment | | | 1 | | | K2ETK_U11 K2ETK_K1 K2ETK_K2 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 5 | W05ETK-SM2132W | Digital Control Techniques | 2 | | | | | K2ETK_W14 K2ETK_K2 K2ETK_K6 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 6 | W05ETK-SM2132L | Digital Control Techniques | | | 1 | | | K2ETK_U12 K2ETK_K2 K2ETK_K6 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 7 | W05ETK-SM2133W | Simulation and Analysis of Power System Transients | 1 | | | | | K2ETK_W10 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | | S |
| 8 | W05ETK-SM2133L | Simulation and Analysis of Power System Transients | | | 2 | | | K2ETK_U10 K2ETK_K6 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 9 | W05ETK-SM2134W | Digital Signal Processing for Protection and Control | 2 | | | | | K2ETK_W9 | 30 | 60 | 2 | 2 | 1,4 | T-Z | E | | DN | | S |
| 10 | W05ETK-SM2134P | Digital Signal Processing for Protection and Control | | | | 2 | | K2ETK_U12 K2ETK_K2 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 11 | W05ETK-SM2135W | Artificial Intelligence Techniques | 2 | | | | | K2ETK_W9 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 12 | W05ETK-SM2135P | Artificial Intelligence Techniques | | | | 1 | | K2ETK_U8 K2ETK_K2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 13 | W05ETK-SM2134P | Fault Calculations | | | | 2 | | K2ETK_U9 K2ETK_K2 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 14 | W05ETK-SM2140W | Fiber Optics Communications and Sensors | 2 | | | | | K2ETK_W13 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 15 | W05ETK-SM2140L | Fiber Optics Communications and Sensors | | | 2 | | | K2ETK_U12 K2ETK_K6 | 30 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 16 | W05ETK-SM2231W | Power System Protection | 2 | | | | | K2ETK_W9 K2ETK_K6 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 17 | W05ETK-SM2231L | Power System Protection | | | 2 | | | K2ETK_U12 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 18 | W05ETK-SM2233W | Power System Automation and Security | 2 | | | | | K2ETK_W16 K2ETK_K6 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 19 | W05ETK-SM2233S | Power System Automation and Security | | | | | 1 | K2ETK_U12 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 20 | W05ETK-SM2331W | Renewable Energy Sources | 2 | | | | | K2ETK_W8 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T-Z | E | | DN | | S |
| 21 | W05ETK-SM2331S | Renewable Energy Sources | | | | | 1 | K2ETK_U9 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 22 | W05ETK-SM2531W | Electric Power System Operation and Control | 2 | | | | | K2ETK_W8 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 | W05ETK-SM2531S | Electric Power System Operation and Control | | | | | 1 | K2ETK_U13 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 24 | W05ETK-SM2532W | Electrical Power Systems Management | 1 | | | | | K2ETK_W17 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | | S |
| 25 | W05ETK-SM2532S | Electrical Power Systems Management | | | | | 1 | K2ETK_U13 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 26 | W05ETK-SM3311W | Electromagnetic Compatibility | 2 | | | | | K2ETK_W11 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 27 | W05ETK-SM3311L | Electromagnetic Compatibility | | | 1 | | | K2ETK_U11 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 28 | W09ETK-SM1501W | Advanced Technology in Electrical Power Generation | 2 | | | | | K2ETK_W15 | 30 | 90 | 3 | 3 | 2,1 | T-Z | Z | | DN | | S |
| 29 | W09ETK-SM1501C | Advanced Technology in Electrical Power Generation | | 1 | | | | K2ETK_U9 K2ETK_K3 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| | | Total | 26 | 1 | 11 | 5 | 4 | | 705 | 1530 | 51 | 51 | 35,7 | | | | | | |

**Altogether for specialization blocks**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 26 | 1 | 11 | 5 | 4 | 705 | 1530 | 51 | 51 | 35,7 |

## 4.2. List of optional blocks

### 4.2.1. List of general education blocks

#### 4.2.1.1. Liberal-managerial subjects block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W08ETK-SM1721S | Ethics in bussiness | | | | | 1 | K2ETK_U7 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | P | KO |
| 2 | W08ETK-SM3721S | The art of public speaking | | | | | 1 | K2ETK_U7 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | P | KO |
| 3 | W08ETK-SM3821S | Social communication | | | | | 1 | K2ETK_U7 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | P | KO |
| 4 | W05ETK-SM1231W | Intellectual property rights in the world | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 5 | W05ETK-SM1232W | Inventions and patents | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 6 | W05ETK-SM1233W | Industrial property and copyright for engineers | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 7 | W05ETK-SM1007W | Protection of Intellectual Property | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 8 | W05ETK-SM1008W | International Law | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 9 | W05ETK-SM2538W | Market Mechanisms in Power Systems with Distributed Energy Sources | 1 | | | | | K2ETK_W6 K2ETK_K3 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | | KO |
| 10 | W05ETK-SM1499W | Fundamentals of Management | 1 | | | | | K2ETK_W6 K2ETK_K3 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | | KO |
| | | Total | 2 | 0 | 0 | 0 | 1 | | 45 | 125 | 5 | 0 | 3,5 | | | | | | |

### 4.2.1.2. Foreign languages block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | SJO000-SM00 | Foreign language B2+ or C1+ | | 1 | | | | K2ETK_U5 K2ETK_K1 | 15 | 30 | 1 | | 0,7 | T | Z | O | - | P | KO |
| 2 | SJO000-SM00 | Foreign language A1 or A2 | | 3 | | | | K2ETK_U6 K2ETK_K1 | 45 | 60 | 2 | | 1,4 | T | Z | O | - | P | KO |
| | | Total | 0 | 4 | 0 | 0 | 0 | | 60 | 90 | 3 | 0 | 2,1 | | | | | | |

### 4.2.1.3. Sporting classes block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

### 4.2.1.4. Information technologies block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

**Altogether for general education blocks**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 2 | 4 | 0 | 0 | 1 | 105 | 215 | 8 | 0 | 5,6 |

### 4.2.2. List of basic sciences blocks
### 4.2.2.1. Mathematics block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

### 4.2.2.2. Physics block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

## 4.2.2.3. Chemistry block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

**Altogether for basic sciences blocks**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## 4.2.3. List of main-field-of-study blocks

## 4.2.3.1. Optional main-field-of-study subjects block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |

**Altogether for main-field-of-study blocks**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## 4.2.4. List of specialization blocks

## 4.2.4.1. Specialization subjects block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM1230W | Visual Engineering Environments and Graphical Languages | 1 | | | | | K2ETK_W16 | 15 | 30 | 1 | 1 | 0,7 | T-Z | E | | DN | | S |
| 2 | W05ETK-SM1230L | Visual Engineering Environments and Graphical Languages | | | 2 | | | K2ETK_U13 K2ETK_K2 | 30 | 90 | 3 | 3 | 2,1 | T | Z | | DN | P | S |
| 3 | W05ETK-SM1334W | Signal and Systems | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 4 | W05ETK-SM1334C | Signal and Systems | | 1 | | | | K2ETK_U13 K2ETK_K1 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 5 | W05ETK-SM1335W | Advanced Signal Processing Methods | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 6 | W05ETK-SM1335C | Advanced Signal Processing Methods | | 1 | | | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 7 | W05ETK-SM2136W | Design of logic circuits | 1 | | | | | K2ETK_W18 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 8 | W05ETK-SM2136L | Design of logic circuits | | | 1 | | | K2ETK_U12 K2ETK_K1 K2ETK_K2 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 9 | W05ETK-SM2138W | Electrical Power Engineering – excursionary activities | 1 | | | | | K2ETK_W18 K2ETK_K6 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 10 | W05ETK-SM2138S | Electrical Power Engineering – excursionary activities | | | | | 1 | K2ETK_U12 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 11 | W05ETK-SM2234W | PLC and Wireless Communications for Monitoring and Metering | 2 | | | | | K2ETK_W16 K2ETK_K6 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 12 | W05ETK-SM2234S | PLC and Wireless Communications for Monitoring and Metering | | | | | 1 | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 13 | W05ETK-SM2335W | Advanced Substations and Electrical Equipment | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 14 | W05ETK-SM2335P | Advanced Substations and Electrical Equipment | | | | 1 | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 15 | W05ETK-SM2534W | Power System Modelling | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 16 | W05ETK-SM2534P | Power System Modelling | | | | 1 | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 17 | W05ETK-SM2535W | Computer Control of Power System | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 18 | W05ETK-SM2535S | Computer Control of Power System | | | | | 1 | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 19 | W05ETK-SM3226W | Fuzzy Logic Control | 1 | | | | | K2ETK_W18 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 20 | W05ETK-SM3226L | Fuzzy Logic Control | | | 1 | | | K2ETK_U12 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 21 | W05ETK-SM3227W | Control of Power Electronic Converters | 1 | | | | | K2ETK_W18 K2ETK_K6 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 22 | W05ETK-SM3227L | Control of Power Electronic Converters | | | 1 | | | K2ETK_U12 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| | | Total | 3 | 1 | 1 | 0 | 0 | | 75 | 210 | 7 | 7 | 4,9 | | | | | | |

### 4.2.4.2. Training block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM5105Q | Diploma placement 4 weeks | | | | 40 | | K2ETK_U12 K2ETK_K6 | 160 | 120 | 4 | 4 | 2,8 | T | Z | | DN | P | S |
| | | Total | 0 | 0 | 0 | 40 | 0 | | 160 | 120 | 4 | 4 | 2,8 | | | | | | |

### 4.2.4.3. Diploma dissertation block

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM5108S | Diploma seminar | | | | | 2 | K2ETK_U14 K2ETK_K6 | 30 | 90 | 3 | 3 | 2,1 | T | Z | | DN | P | S |
| 2 | W05ETK-SM5117P | Diploma Project | | | | 8 | | K2ETK_U15 K2ETK_K6 | 120 | 240 | 8 | 8 | 5,6 | T | Z | | DN | P | S |
| 3 | W05ETK-SM5119D | Master's thesis | | | | 12 | | K2ETK_U15 K2ETK_K4 K2ETK_K6 | 180 | 540 | 18 | 18 | 12,6 | T | Z | | DN | P | S |
| 4 | W05ETK-SM5127P | Diploma Project | | | | 8 | | K2ETK_U15 K2ETK_K6 | 120 | 240 | 8 | 8 | 5,6 | T | Z | | DN | P | S |
| 5 | W05ETK-SM5129D | Master's thesis | | | | 12 | | K2ETK_U15 K2ETK_K4 K2ETK_K6 | 180 | 540 | 18 | 18 | 12,6 | T | Z | | DN | P | S |
| 6 | W05ETK-SM5137P | Diploma Project | | | | 8 | | K2ETK_U15 K2ETK_K6 | 120 | 240 | 8 | 8 | 5,6 | T | Z | | DN | P | S |
| 7 | W05ETK-SM5139D | Master's thesis | | | | 12 | | K2ETK_U15 K2ETK_K4 K2ETK_K6 | 180 | 540 | 18 | 18 | 12,6 | T | Z | | DN | P | S |
| | | Total | 0 | 0 | 0 | 20 | 2 | | 330 | 870 | 29 | 26 | 20,3 | | | | | | |

**Altogether for specialization blocks**

| **Total number of hours** | | | | | **Total number of ZZU hours** | **Total number of CNPS hours** | **Total number of ECTS points** | **Number of ECTS points for DN classes** | **Number of ECTS points for BU classes** |
|---|---|---|---|---|---|---|---|---|---|
| **lec** | **cl** | **lab** | **pr** | **sem** | | | | | |
| 3 | 1 | 1 | 60 | 2 | 565 | 1200 | 40 | 40 | 28 |

## 4.3 Training block - concerning principles of training crediting – attachment no. 2

| Name of training: | Diploma placement 4 weeks | | |
|---|---|---|---|
| **Number of ECTS points** | **Number of ECTS points for BU classes** | **Training crediting mode** | **Code** |
| **4** | **2,8** | **report from training** | **W05ETK-SM5105Q** |
| **Training duration** | **Training objective** | | |
| **4 weeks** | "The primary objective is to confront the theoretical knowledge acquired in the course included in the learning schedule, with the real demands of the employers. During practice the student gains industrial experience, take note of the basic technical equipment and technology of the companies, learns the specificity of work of the higher technical inspection facility, in particular:<br>• extends the knowledge gained during studies and develops the skills to use it,<br>• familiarize themselves with the specific of professional environment,<br>• shapes  specific professional skills directly related to the place of practice,<br>• shapes the skills of effective communication in an organization,<br>• learns the functioning in an organizational structure, the principles of the organization of work and the division of powers, procedures, work planning, control,<br>• improves the ability of self organization, teamwork, effective time management, diligence, responsibility for assigned tasks,<br>• improves the ability to use a foreign language in professional contexts.<br>By free choice of the place of practice, ie by their own choice of the ""Company"" or the choice of units and facilities fromthe faculty list, students can pursue their professional interests. There is a possibility of some connection with the subject of the future practice of Master thesis. The practice allows you to focus the student's preferences with regard to the future work." | | |

## 4.4. Diploma dissertation block

| Type of diploma dissertation: | magister | |
|---|---|---|
| **Number of diploma dissertation semesters** | **Number of ECTS points** | **Code** |
| **1** | **29** | **W05ETK-SM5108S**<br>**W05ETK-SM5117P**<br>**W05ETK-SM5127P**<br>**W05ETK-SM5137P**<br>**W05ETK-SM5119D**<br>**W05ETK-SM5129D**<br>**W05ETK-SM5139D** |
| **Character of diploma dissertation** | | |
| Master's thesis has a computational, theoretical caracter, or may contain a description and analysis of the performed experimental studies. In each case it contains a section in which the author alone interpret and draw conclusions from their research. Intellectual contributions of private study should be clearly visible. | | |

| | |
|---|---|
| **Number of BU ECTS points:** | 20,3 |
| **Number of DN ECTS points:** | 26 |

## 5. Ways of verifying assumed learning outcomes

| Type of classes | Ways of verifying assumed learning outcomes |
|---|---|
| **lecture** | examination, progress/final test |
| **class** | progress/final test |
| **laboratory** | pretest, report from laboratory |
| **project** | project defence |
| **seminar** | participation in discussion, topic presentation, essa |
| **training** | report from training |
| **diploma dissertation** | prepared diploma dissertation |

## 6. Range of diploma dissertation

The diploma examination consists of the presentation of the diploma thesis and answers to randomly selected questions. The scope of the diploma examination includes questions on the following issues, according to the chosen specialization.

Control in Electrical Power Engineering:

1. Numerical and optimisation methods
2. Power system faults
3. Dynamics and control of AC/DC drives
4. Circuits and systems
5. Measurement methods and techniques
6. Power quality assessment
7. Advanced technology in electrical power generation
8. Electrical power system operation and control
9. Power system protection
10. Simulation and analysis of power system transients
11. Digital signal processing for protection and control
12. Fiber optics communication and sensors
13. Renewable energy sources
14. Electrical power systems management
15. Power system automation and security
16. Electromagnetic compatibility
17. Artificial intelligence techniques
18. Advanced high voltage technology

## 7. Requirements concerning deadlines for crediting courses/groups of courses for all courses in particular blocks

| No. | Course code | Name of course | Crediting by deadline of... (number of semester) |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

## 8. Plan of studies (attachment no. ...)

Approved by faculty student government legislative body:

....................
Date

.......................................................................................................................................
Name and surname, signature of student representative

....................
Date

.......................................................................................................................................
Dean's signature

BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
Traditional – enter T, remote – enter Z
Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
University-wide course /group of courses – enter O
DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

# PLAN OF STUDIES

| | |
|---|---|
| **FACULTY:** | Electrical Engineering |
| **MAIN FIELD OF STUDY:** | Electrical Engineering |
| **EDUCATION LEVEL:** | 2nd level |
| **FORM OF STUDIES:** | full-time |
| **PROFILE:** | general academic |
| **SPECIALIZATION:** | Renewable Energy Systems |
| **LANGUAGE OF STUDY:** | english |
| **IN EFFECT SINCE:** | 2022/2023 |

**Plan of studies structure (optionally)**

1) in ECTS point layout

2) in hourly layout

### 1. Set of obligatory and optional courses and groups of courses in semestral arrangement

### Semester 1

**Obligatory courses / groups of courses** **number of ECTS points: 27**

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM1330W | Numerical and Optimization Methods | 1 | | | | | K2ETK_W2 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | PD |
| 2 | W05ETK-SM1330L | Numerical and Optimization Methods | | | 1 | | | K2ETK_U2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | PD |
| 3 | W05ETK-SM1331W | Power Quality Assessment | 2 | | | | | K2ETK_W12 K2ETK_K1 K2ETK_K2 | 30 | 90 | 3 | 3 | 2,1 | T-Z | Z | | DN | | S |
| 4 | W05ETK-SM1331L | Power Quality Assessment | | | 1 | | | K2ETK_U11 K2ETK_K1 K2ETK_K2 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 5 | W05ETK-SM1332W | Circuits and Systems | 2 | | | | | K2ETK_W1 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | K |
| 6 | W05ETK-SM1332C | Circuits and Systems | | 1 | | | | K2ETK_U1 K2ETK_K1 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | K |
| 7 | W05ETK-SM2131W | Power Systems Faults | 2 | | | | | K2ETK_W3 K2ETK_K1 | 30 | 120 | 4 | 4 | 2,8 | T-Z | E | | DN | | K |
| 8 | W05ETK-SM2139P | Fault Calculations | | | | 2 | | K2ETK_U9 K2ETK_K2 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 9 | W05ETK-SM3225W | Dynamics and Control of AC and DC Drives | 2 | | | | | K2ETK_W4 | 30 | 120 | 4 | 4 | 2,8 | T-Z | E | | DN | | K |
| 10 | W05ETK-SM3225L | Dynamics and Control of AC and DC Drives | | | 1 | | | K2ETK_U3 K2ETK_K2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | K |
| 11 | W05ETK-SM3225P | Dynamics and Control of AC and DC Drives | | | | 1 | | K2ETK_U3 K2ETK_K2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | K |
| 12 | W09ETK-SM1501W | Advanced Technology in Electrical Power Generation | 2 | | | | | K2ETK_W19 | 30 | 90 | 3 | 3 | 2,1 | T-Z | Z | | DN | | S |
| 13 | W09ETK-SM1501C | Advanced Technology in Electrical Power Generation | | 1 | | | | K2ETK_U9 K2ETK_K3 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| | | Total | 11 | 2 | 3 | 3 | 0 | | 285 | 810 | 27 | 27 | 18,9 | | | | | | |

**Optional courses / groups of courses** **minimum** | **60** | **hours in semester,** | **3** | **ECTS points**

| No. | Course code | Name of course | Weekly number of hours | | | | | Field-of-study educational effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| **Optional courses block: Foreign Language** | | | | | | | | | | **ECTS** | | | **hours** | | | | | | |
| 1 | SJO000-SM00 | Foreign language B2+ or C1+ | | 1 | | | | K2ETK_U5 K2ETK_K1 | 15 | 30 | 1 | | 0,7 | T | Z | O | - | P | KO |
| 2 | SJO000-SM00 | Foreign language A1 or A2 | | 3 | | | | K2ETK_U6 K2ETK_K1 | 45 | 60 | 2 | | 1,4 | T | Z | O | - | P | KO |

**Altogether in semester**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN | Number of ECTS points for BU |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 11 | 6 | 3 | 3 | 0 | 345 | 900 | 30 | 27 | 21 |

## Semester 2

**Obligatory courses / groups of courses** **number of ECTS points: 25**

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM2133W | Simulation and Analysis of Power System Transients | 1 | | | | | K2ETK_W10 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | | S |
| 2 | W05ETK-SM2133L | Simulation and Analysis of Power System Transients | | | 2 | | | K2ETK_U10 K2ETK_K6 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 3 | W05ETK-SM2137W | Protection and Control of Distributed Energy Sources 1 | 1 | | | | | K2ETK_W9 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 4 | W05ETK-SM2137L | Protection and Control of Distributed Energy Sources 1 | | | 1 | | | K2ETK_U9 K2ETK_K1 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 5 | W05ETK-SM2331W | Renewable Energy Sources | 2 | | | | | K2ETK_W8 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T-Z | E | | DN | | S |
| 6 | W05ETK-SM2331S | Renewable Energy Sources | | | | | 1 | K2ETK_U9 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 7 | W05ETK-SM2332W | Water Power Plants 1 | 2 | | | | | K2ETK_W8 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 8 | W05ETK-SM2334W | Energy Storage Systems | 1 | | | | | K2ETK_W12 | 15 | 60 | 2 | 2 | 1,4 | T-Z | E | | DN | | S |
| 9 | W05ETK-SM2334P | Energy Storage Systems | | | | 1 | | K2ETK_U8 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 10 | W05ETK-SM2536W | Integration of Distributed Resources in Power Systems | 2 | | | | | K2ETK_W10 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T-Z | E | | DN | | S |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | W05ETK-SM2536L | Integration of Distributed Resources in Power Systems | | | 1 | | | K2ETK_U9 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 12 | W05ETK-SM3110W | Modelling of Electrical Machines | 1 | | | | | K2ETK_W9 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | | S |
| 13 | W05ETK-SM3110P | Modelling of Electrical Machines | | | | 2 | | K2ETK_U11 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 14 | W05ETK-SM3228W | Power Electronics | 2 | | | | | K2ETK_W14 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 15 | W05ETK-SM3228L | Power Electronics | | | 1 | | | K2ETK_U8 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 16 | W05ETK-SM3229W | Electromechanical Systems in Renewable Energy | 1 | | | | | K2ETK_W14 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | | S |
| 17 | W05ETK-SM3229S | Electromechanical Systems in Renewable Energy | | | | | 1 | K2ETK_U9 K2ETK_K1 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| | | Total | 13 | 0 | 5 | 3 | 2 | | 345 | 750 | 25 | 25 | 17,5 | | | | | | |

**Optional courses / groups of courses** **minimum** **175** **hours in semester,** **6** **ECTS points**

| No. | Course code | Name of course | Weekly number of hours | | | | | Field-of-study educational effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM5105Q | Diploma placement 4 weeks | | | | 40 | | K2ETK_U12 K2ETK_K6 | 160 | 120 | 4 | 4 | 2,8 | T | Z | | DN | P | S |
| **Optional courses block: Management** | | | | | | | | | | **ECTS** | | **2** | **hours** | | **1** | | | | |
| 1 | W05ETK-SM2538W | Market Mechanisms in Power Systems with Distributed Energy Sources | 1 | | | | | K2ETK_W6 K2ETK_K3 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | | KO |
| 2 | W05ETK-SM1499W | Fundamentals of Management | 1 | | | | | K2ETK_W6 K2ETK_K3 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | | KO |

**Altogether in semester**

| | Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN | Number of ECTS points for BU |
|---|---|---|---|---|---|---|---|---|---|---|
| | lec | cl | lab | pr | sem | | | | | |
| | 14 | 0 | 5 | 3 | 2 | 360 | 800 | 27 | 25 | 18,9 |
| practice | 0 | 0 | 0 | 40 | 0 | 160 | 120 | 4 | 4 | 2,8 |

## Semester 3

**Obligatory courses / groups of courses** **number of ECTS points: 20**

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM1337W | Photovoltaic Cells | 2 | | | | | K2ETK_W13 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T-Z | E | | DN | | S |
| 2 | W05ETK-SM1337L | Photovoltaic Cells | | | 1 | | | K2ETK_U8 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 3 | W05ETK-SM1338W | Industrial ecology - selected problems | 1 | | | | | K2ETK_W11 K2ETK_K3 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | | S |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | W05ETK-SM1338S | Industrial ecology - selected problems | | | | | 1 | K2ETK_U9 K2ETK_K3 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 5 | W05ETK-SM2135W | Artificial Intelligence Techniques | 2 | | | | | K2ETK_W9 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 6 | W05ETK-SM2135P | Artificial Intelligence Techniques | | | | 1 | | K2ETK_U8 K2ETK_K2 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 7 | W05ETK-SM2141S | Protection and Control of Distributed Energy Sources 2 | | | | | 1 | K2ETK_U13 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 8 | W05ETK-SM2336S | Water Power Plants 2 | | | | | 1 | K2ETK_U9 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 9 | W05ETK-SM2537W | Legal Regulations and Investments in Power Systems with Distributed Energy Sources | 2 | | | | | K2ETK_W17 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 10 | W05ETK-SM2537S | Legal Regulations and Investments in Power Systems with Distributed Energy Sources | | | | | 1 | K2ETK_U9 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 11 | W05ETK-SM3311W | Electromagnetic Compatibility | 2 | | | | | K2ETK_W11 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 12 | W05ETK-SM3311L | Electromagnetic Compatibility | | | 1 | | | K2ETK_U11 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 13 | W05ETK-SM3312W | Measurement methods and techniques | 2 | | | | | K2ETK_W5 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | PD |
| 14 | W05ETK-SM3312L | Measurement methods and techniques | | | 2 | | | K2ETK_U4 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | PD |
| | | Total | 11 | 0 | 4 | 1 | 4 | | 300 | 600 | 20 | 20 | 14 | | | | | | |

**Optional courses / groups of courses** minimum **135** **hours in semester,** **9** **ECTS points**

| No. | Course code | Name of course | Weekly number of hours | | | | | Field-of-study educational effect symbol | Number of hours | | Number of ECTS points | | | Form of course/ group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM5117P | Diploma Project | | | | 8 | | K2ETK_U15 K2ETK_K6 | 120 | 240 | 8 | 8 | 5,6 | T | Z | | DN | P | S |
| 2 | W05ETK-SM5127P | Diploma Project | | | | 8 | | K2ETK_U15 K2ETK_K6 | 120 | 240 | 8 | 8 | 5,6 | T | Z | | DN | P | S |
| 3 | W05ETK-SM5137P | Diploma Project | | | | 8 | | K2ETK_U15 K2ETK_K6 | 120 | 240 | 8 | 8 | 5,6 | T | Z | | DN | P | S |
| **Optional courses block: Law** | | | | | | | | | | **ECTS** | | 1 | | **hours** | 1 | | | | |
| 1 | W05ETK-SM1231W | Intellectual property rights in the world | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 2 | W05ETK-SM1232W | Inventions and patents | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 3 | W05ETK-SM1233W | Industrial property and copyright for engineers | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 4 | W05ETK-SM1007W | Protection of Intellectual Property | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 5 | W05ETK-SM1008W | International Law | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |

**Altogether in semester**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN | Number of ECTS points for BU |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 12 | 0 | 4 | 9 | 4 | 435 | 865 | 29 | 28 | 20,3 |

## Semester 4

**Optional courses / groups of courses** **minimum** 300 **hours in semester,** 30 **ECTS points**

| No. | Course code | Name of course | Weekly number of hours: lec | cl | lab | pr | sem | Field-of-study educational effect symbol | Number of hours: ZZU | CNPS | Number of ECTS points: total | DN classes | BU classes | Form of course/ group of courses | Way of crediting | Course/group of courses: University-wide | Concerning scientific activities | Practical | Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | W05ETK-SM5108S | Diploma seminar | | | | | 2 | K2ETK_U14 K2ETK_K6 | 30 | 90 | 3 | 3 | 2,1 | T-Z | Z | | DN | P | S |
| 2 | W05ETK-SM5119D | Master's thesis | | | | 12 | | K2ETK_U15 K2ETK_K4 K2ETK_K6 | 180 | 540 | 18 | 18 | 12,6 | T | Z | | DN | P | S |
| 3 | W05ETK-SM5129D | Master's thesis | | | | 12 | | K2ETK_U15 K2ETK_K4 K2ETK_K6 | 180 | 540 | 18 | 18 | 12,6 | T | Z | | DN | P | S |
| 4 | W05ETK-SM5139D | Master's thesis | | | | 12 | | K2ETK_U15 K2ETK_K4 K2ETK_K6 | 180 | 540 | 18 | 18 | 12,6 | T | Z | | DN | P | S |
| **Optional courses block: Social Sciences and Ethics** | | | | | | | | | | **ECTS** | | **2** | **hours** | | **1** | | | | |
| 1 | W08ETK-SM1721S | Ethics in bussiness | | | | | 1 | K2ETK_U7 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | P | KO |
| 2 | W08ETK-SM3721S | The art of public speaking | | | | | 1 | K2ETK_U7 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | P | KO |
| 3 | W08ETK-SM3821S | Social communication | | | | | 1 | K2ETK_U7 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | P | KO |
| **Optional courses block: A** | | | | | | | | | | **ECTS** | | **4** | **hours** | | **3** | | | | |
| 1 | W05ETK-SM1230W | Visual Engineering Environments and Graphical Languages | 1 | | | | | K2ETK_W16 | 15 | 30 | 1 | 1 | 0,7 | T-Z | E | | DN | | S |
| 2 | W05ETK-SM1230L | Visual Engineering Environments and Graphical Languages | | | 2 | | | K2ETK_U13 K2ETK_K2 | 30 | 90 | 3 | 3 | 2,1 | T | Z | | DN | P | S |
| 3 | W05ETK-SM1334W | Signal and Systems | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 4 | W05ETK-SM1334C | Signal and Systems | | 1 | | | | K2ETK_U13 K2ETK_K1 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 5 | W05ETK-SM1335W | Advanced Signal Processing Methods | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 6 | W05ETK-SM1335C | Advanced Signal Processing Methods | | 1 | | | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 7 | W05ETK-SM2234W | PLC and Wireless Communications for Monitoring and Metering | 2 | | | | | K2ETK_W16 K2ETK_K6 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 8 | W05ETK-SM2234S | PLC and Wireless Communications for Monitoring and Metering | | | | | 1 | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 9 | W05ETK-SM2335W | Advanced Substations and Electrical Equipment | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 10 | W05ETK-SM2335P | Advanced Substations and Electrical Equipment | | | | 1 | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 11 | W05ETK-SM2534W | Power System Modelling | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 12 | W05ETK-SM2534P | Power System Modelling | | | | 1 | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 13 | W05ETK-SM2535W | Computer Control of Power System | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 14 | W05ETK-SM2535S | Computer Control of Power System | | | | | 1 | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |

| Optional courses block: B | | | | | | | | | | ECTS | | 3 | hours | | 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | W05ETK-SM2136W | Design of logic circuits | 1 | | | | | K2ETK_W14 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 2 | W05ETK-SM2136L | Design of logic circuits | | | 1 | | | K2ETK_U13 K2ETK_K1 K2ETK_K2 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 3 | W05ETK-SM2138W | Electrical Power Engineering – excursionary activities | 1 | | | | | K2ETK_W14 K2ETK_K6 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 4 | W05ETK-SM2138S | Electrical Power Engineering – excursionary activities | | | | | 1 | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 5 | W05ETK-SM3226W | Fuzzy Logic Control | 1 | | | | | K2ETK_W14 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 6 | W05ETK-SM3226L | Fuzzy Logic Control | | | 1 | | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 7 | W05ETK-SM3227W | Control of Power Electronic Converters | 1 | | | | | K2ETK_W14 K2ETK_K6 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 8 | W05ETK-SM3227L | Control of Power Electronic Converters | | | 1 | | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |

**Altogether in semester**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN | Number of ECTS points for BU |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 3 | 1 | 1 | 12 | 3 | 300 | 890 | 30 | 28 | 21 |

## 2. Set of examinations in semestral arrangement

| Course code | Names of courses ending with examination | Semester |
|---|---|---|
| W05ETK-SM1332W | Circuits and Systems | 1 |
| W05ETK-SM2131W | Power Systems Faults | 1 |
| W05ETK-SM3225W | Dynamics and Control of AC and DC Drives | 1 |
| W05ETK-SM2331W | Renewable Energy Sources | 2 |
| W05ETK-SM2334W | Energy Storage Systems | 2 |
| W05ETK-SM2536W | Integration of Distributed Resources in Power Systems | 2 |
| W05ETK-SM1337W | Photovoltaic Cells | 3 |
| one exam from optional courses block A | | 4 |

## 3. Numbers of allowable deficit of ECTS points after particular semesters

| Semester | Allowable deficit of ECTS points after semester |
|---|---|
| 1 | 5 |
| 2 | 5 |
| 3 | 5 |
| 4 | 0 |

Opinion of student government legislative body

.....................
Date

..............................................................................................................................
Name and surname, signature of student representative

.....................
Date

..............................................................................................................................
Dean’s signature

BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
Traditional – enter T, remote – enter Z
Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
University-wide course /group of courses – enter O
DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

# PLAN OF STUDIES

| | |
|---|---|
| **FACULTY:** | Electrical Engineering |
| **MAIN FIELD OF STUDY:** | Electrical Engineering |
| **EDUCATION LEVEL:** | 2nd level |
| **FORM OF STUDIES:** | full-time |
| **PROFILE:** | general academic |
| **SPECIALIZATION:** | Control in Electrical Power Engineering |
| **LANGUAGE OF STUDY:** | english |
| **IN EFFECT SINCE:** | 2022/2023 |

**Plan of studies structure (optionally)**

1) in ECTS point layout

2) in hourly layout

### 1. Set of obligatory and optional courses and groups of courses in semestral arrangement

## Semester 1

**Obligatory courses / groups of courses** **number of ECTS points: 27**

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | **University-wide** | **Concerning scientific activities** | **Practical** | **Type** |
| 1 | W05ETK-SM1330W | Numerical and Optimization Methods | 1 | | | | | K2ETK_W2 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | PD |
| 2 | W05ETK-SM1330L | Numerical and Optimization Methods | | | 1 | | | K2ETK_U2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | PD |
| 3 | W05ETK-SM1331W | Power Quality Assessment | 2 | | | | | K2ETK_W12 K2ETK_K1 K2ETK_K2 | 30 | 90 | 3 | 3 | 2,1 | T-Z | Z | | DN | | S |
| 4 | W05ETK-SM1331L | Power Quality Assessment | | | 1 | | | K2ETK_U11 K2ETK_K1 K2ETK_K2 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 5 | W05ETK-SM1332W | Circuits and Systems | 2 | | | | | K2ETK_W1 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | K |
| 6 | W05ETK-SM1332C | Circuits and Systems | | 1 | | | | K2ETK_U1 K2ETK_K1 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | K |
| 7 | W05ETK-SM2131W | Power System Faults | 2 | | | | | K2ETK_W3 K2ETK_K1 | 30 | 120 | 4 | 4 | 2,8 | T-Z | E | | DN | | K |
| 8 | W05ETK-SM2139P | Fault Calculations | | | | 2 | | K2ETK_U9 K2ETK_K2 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 9 | W05ETK-SM3225W | Dynamics and Control of AC and DC Drives | 2 | | | | | K2ETK_W4 | 30 | 120 | 4 | 4 | 2,8 | T-Z | E | | DN | | K |
| 10 | W05ETK-SM3225L | Dynamics and Control of AC and DC Drives | | | 1 | | | K2ETK_U3 K2ETK_K2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | K |
| 11 | W05ETK-SM3225P | Dynamics and Control of AC and DC Drives | | | | 1 | | K2ETK_U3 K2ETK_K2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | K |
| 12 | W09ETK-SM1501W | Advanced Technology in Electrical Power Generation | 2 | | | | | K2ETK_W15 | 30 | 90 | 3 | 3 | 2,1 | T-Z | Z | | DN | | S |
| 13 | W09ETK-SM1501C | Advanced Technology in Electrical Power Generation | | 1 | | | | K2ETK_U9 K2ETK_K3 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| | | Total | 11 | 2 | 3 | 3 | 0 | | 285 | 810 | 27 | 27 | 18,9 | | | | | | |

**Optional courses / groups of courses** minimum **60** hours in semester, **3** ECTS points

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| **Optional courses block: Foreign Language** | | | | | | | | | | **ECTS** | **3** | | **hours** | | **4** | | | | |
| 1 | SJO000-SM00 | Foreign language B2+ or C1+ | | 1 | | | | K2ETK_U5 K2ETK_K1 | 15 | 30 | 1 | | 0,7 | T | Z | O | - | P | KO |
| 2 | SJO000-SM00 | Foreign language A1 or A2 | | 3 | | | | K2ETK_U6 K2ETK_K1 | 45 | 60 | 2 | | 1,4 | T | Z | O | - | P | KO |

**Altogether in semester**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 11 | 6 | 3 | 3 | 0 | 345 | 900 | 30 | 27 | 21 |

## Semester 2

**Obligatory courses / groups of courses** **number of ECTS points: 24**

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM2132W | Digital Control Techniques | 2 | | | | | K2ETK_W14 K2ETK_K2 K2ETK_K6 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 2 | W05ETK-SM2132L | Digital Control Techniques | | | 1 | | | K2ETK_U12 K2ETK_K2 K2ETK_K6 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 3 | W05ETK-SM2133W | Simulation and Analysis of Power System Transients | 1 | | | | | K2ETK_W10 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | | S |
| 4 | W05ETK-SM2133L | Simulation and Analysis of Power System Transients | | | 2 | | | K2ETK_U10 K2ETK_K6 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 5 | W05ETK-SM2134W | Digital Signal Processing for Protection and Control | 2 | | | | | K2ETK_W9 | 30 | 60 | 2 | 2 | 1,4 | T-Z | E | | DN | | S |
| 6 | W05ETK-SM2134P | Digital Signal Processing for Protection and Control | | | | 2 | | K2ETK_U12 K2ETK_K2 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 7 | W05ETK-SM2140W | Fiber Optics Communications and Sensors | 2 | | | | | K2ETK_W13 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 8 | W05ETK-SM2140L | Fiber Optics Communications and Sensors | | | 2 | | | K2ETK_U12 K2ETK_K6 | 30 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 9 | W05ETK-SM2231W | Power System Protection | 2 | | | | | K2ETK_W9 K2ETK_K6 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 10 | W05ETK-SM2231L | Power System Protection | | | 2 | | | K2ETK_U12 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 11 | W05ETK-SM2331W | Renewable Energy Sources | 2 | | | | | K2ETK_W8 K2ETK_K6 | 30 | 60 | 2 | 2 | 1,4 | T-Z | E | | DN | | S |
| 12 | W05ETK-SM2331S | Renewable Energy Sources | | | | | 1 | K2ETK_U9 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 13 | W05ETK-SM2531W | Electric Power System Operation and Control | 2 | | | | | K2ETK_W8 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 14 | W05ETK-SM2531S | Electric Power System Operation and Control | | | | | 1 | K2ETK_U13 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| | | Total | 13 | 0 | 7 | 2 | 2 | | 360 | 720 | 24 | 24 | 16,8 | | | | | | |

**Optional courses / groups of courses** minimum **175** hours in semester, **6** ECTS points

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM5105Q | Diploma placement 4 weeks | | | | 40 | | K2ETK_U12 K2ETK_K6 | 160 | 120 | 4 | 4 | 2,8 | T | Z | | DN | P | S |
| **Optional courses block: Management** | | | | | | | | | | **ECTS** | | **2** | **hours** | | **1** | | | | |
| 1 | W05ETK-SM2538W | Market Mechanisms in Power Systems with Distributed Energy Sources | 1 | | | | | K2ETK_W6 K2ETK_K3 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | | KO |
| 2 | W05ETK-SM1499W | Fundamentals of Management | 1 | | | | | K2ETK_W6 K2ETK_K3 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | | KO |

**Altogether in semester**

| | Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|---|
| | lec | cl | lab | pr | sem | | | | | |
| | 14 | 0 | 7 | 2 | 2 | 375 | 770 | 26 | 24 | 18,2 |
| practice | 0 | 0 | 0 | 40 | 0 | 160 | 120 | 4 | 4 | 2,8 |

## Semester 3

**Obligatory courses / groups of courses** **number of ECTS points: 21**

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM1120W | Advanced High Voltage Technology | 2 | | | | | K2ETK_W11 K2ETK_K7 | 30 | 90 | 3 | 3 | 2,1 | T-Z | Z | | DN | | S |
| 2 | W05ETK-SM1120L | Advanced High Voltage Technology | | | 2 | | | K2ETK_U11 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | S |
| 3 | W05ETK-SM2135W | Artificial Intelligence Techniques | 2 | | | | | K2ETK_W9 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 4 | W05ETK-SM2135P | Artificial Intelligence Techniques | | | | 1 | | K2ETK_U8 K2ETK_K2 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 5 | W05ETK-SM2233W | Power System Automation and Security | 2 | | | | | K2ETK_W16 K2ETK_K6 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 6 | W05ETK-SM2233S | Power System Automation and Security | | | | | 1 | K2ETK_U12 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 7 | W05ETK-SM2532W | Electrical Power Systems Management | 1 | | | | | K2ETK_W17 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | | S |
| 8 | W05ETK-SM2532S | Electrical Power Systems Management | | | | | 1 | K2ETK_U13 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 9 | W05ETK-SM3311W | Electromagnetic Compatibility | 2 | | | | | K2ETK_W11 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 10 | W05ETK-SM3311L | Electromagnetic Compatibility | | | 1 | | | K2ETK_U11 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 11 | W05ETK-SM3312W | Measurement methods and techniques | 2 | | | | | K2ETK_W5 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | PD |
| 12 | W05ETK-SM3312L | Measurement methods and techniques | | | 2 | | | K2ETK_U4 K2ETK_K7 | 30 | 60 | 2 | 2 | 1,4 | T | Z | | DN | P | PD |
| | | Total | 11 | 0 | 5 | 1 | 2 | | 285 | 630 | 21 | 21 | 14,7 | | | | | | |

**Optional courses / groups of courses** **minimum** **135** **hours in semester,** **9** **ECTS points**

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM5117P | Diploma Project | | | | 8 | | K2ETK_U15 K2ETK_K6 | 120 | 240 | 8 | 8 | 5,6 | T | Z | | DN | P | S |
| 2 | W05ETK-SM5127P | Diploma Project | | | | 8 | | K2ETK_U15 K2ETK_K6 | 120 | 240 | 8 | 8 | 5,6 | T | Z | | DN | P | S |
| 3 | W05ETK-SM5137P | Diploma Project | | | | 8 | | K2ETK_U15 K2ETK_K6 | 120 | 240 | 8 | 8 | 5,6 | T | Z | | DN | P | S |
| **Optional courses block: Law** | | | | | | | | | | | **ECTS** | **1** | **hours** | | **1** | | | | |
| 1 | W05ETK-SM1231W | Intellectual property rights in the world | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 2 | W05ETK-SM1232W | Inventions and patents | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 3 | W05ETK-SM1233W | Industrial property and copyright for engineers | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 4 | W05ETK-SM1007W | Protection of Intellectual Property | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |
| 5 | W05ETK-SM1008W | International Law | 1 | | | | | K2ETK_W7 K2ETK_K3 K2ETK_K5 | 15 | 25 | 1 | | 0,7 | T-Z | Z | O | - | | KO |

**Altogether in semester**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 12 | 0 | 5 | 9 | 2 | 420 | 895 | 30 | 29 | 21 |

## Semester 4

**Optional courses / groups of courses** **minimum** **300** **hours in semester,** **30** **ECTS points**

| No. | Course code | Name of course | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form of course/group of courses | Way of crediting | Course/group of courses | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | total | DN classes | BU classes | | | University-wide | Concerning scientific activities | Practical | Type |
| 1 | W05ETK-SM5108S | Diploma seminar | | | | | 2 | K2ETK_U14 K2ETK_K6 | 30 | 90 | 3 | 3 | 2,1 | T | Z | | DN | P | S |
| 2 | W05ETK-SM5119D | Master's thesis | | | | 12 | | K2ETK_U15 K2ETK_K4 K2ETK_K6 | 180 | 540 | 18 | 18 | 12,6 | T | Z | | DN | P | S |
| 3 | W05ETK-SM5129D | Master's thesis | | | | 12 | | K2ETK_U15 K2ETK_K4 K2ETK_K6 | 180 | 540 | 18 | 18 | 12,6 | T | Z | | DN | P | S |
| 4 | W05ETK-SM5139D | Master's thesis | | | | 12 | | K2ETK_U15 K2ETK_K4 K2ETK_K6 | 180 | 540 | 18 | 18 | 12,6 | T | Z | | DN | P | S |
| **Optional courses block: Social Sciences and Ethics** | | | | | | | | | | | **ECTS** | **2** | **hours** | | **1** | | | | |
| 1 | W08ETK-SM1721S | Ethics in bussiness | | | | | 1 | K2ETK_U7 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | P | KO |
| 2 | W08ETK-SM3721S | The art of public speaking | | | | | 1 | K2ETK_U7 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | P | KO |
| 3 | W08ETK-SM3821S | Social communication | | | | | 1 | K2ETK_U7 K2ETK_K6 | 15 | 50 | 2 | | 1,4 | T-Z | Z | O | - | P | KO |
| **Optional courses block: A** | | | | | | | | | | | **ECTS** | **4** | **hours** | | **3** | | | | |
| 1 | W05ETK-SM1230W | Visual Engineering Environments and Graphical Languages | 1 | | | | | K2ETK_W16 | 15 | 30 | 1 | 1 | 0,7 | T-Z | E | | DN | | S |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | W05ETK-SM1230L | Visual Engineering Environments and Graphical Languages | | | 2 | | | K2ETK_U13 K2ETK_K2 | 30 | 90 | 3 | 3 | 2,1 | T | Z | | DN | P | S |
| 3 | W05ETK-SM1334W | Signal and Systems | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 4 | W05ETK-SM1334C | Signal and Systems | | 1 | | | | K2ETK_U13 K2ETK_K1 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 5 | W05ETK-SM1335W | Advanced Signal Processing Methods | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 6 | W05ETK-SM1335C | Advanced Signal Processing Methods | | 1 | | | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 7 | W05ETK-SM2234W | PLC and Wireless Communications for Monitoring and Metering | 2 | | | | | K2ETK_W16 K2ETK_K6 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 8 | W05ETK-SM2234S | PLC and Wireless Communications for Monitoring and Metering | | | | | 1 | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 9 | W05ETK-SM2335W | Advanced Substations and Electrical Equipment | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 10 | W05ETK-SM2335P | Advanced Substations and Electrical Equipment | | | | 1 | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 11 | W05ETK-SM2534W | Power System Modelling | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 12 | W05ETK-SM2534P | Power System Modelling | | | | 1 | | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 13 | W05ETK-SM2535W | Computer Control of Power System | 2 | | | | | K2ETK_W16 | 30 | 90 | 3 | 3 | 2,1 | T-Z | E | | DN | | S |
| 14 | W05ETK-SM2535S | Computer Control of Power System | | | | | 1 | K2ETK_U13 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| **Optional courses block: B** | | | | | | | | | | **ECTS** | | **3** | | **hours** | **2** | | | | |
| 1 | W05ETK-SM2136W | Design of logic circuits | 1 | | | | | K2ETK_W18 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 2 | W05ETK-SM2136L | Design of logic circuits | | | 1 | | | K2ETK_U12 K2ETK_K1 K2ETK_K2 K2ETK_K7 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 3 | W05ETK-SM2138W | Electrical Power Engineering – excursionary activities | 1 | | | | | K2ETK_W18 K2ETK_K6 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 4 | W05ETK-SM2138S | Electrical Power Engineering – excursionary activities | | | | | 1 | K2ETK_U12 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T-Z | Z | | DN | P | S |
| 5 | W05ETK-SM3226W | Fuzzy Logic Control | 1 | | | | | K2ETK_W18 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 6 | W05ETK-SM3226L | Fuzzy Logic Control | | | 1 | | | K2ETK_U12 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |
| 7 | W05ETK-SM3227W | Control of Power Electronic Converters | 1 | | | | | K2ETK_W18 K2ETK_K6 | 15 | 60 | 2 | 2 | 1,4 | T-Z | Z | | DN | | S |
| 8 | W05ETK-SM3227L | Control of Power Electronic Converters | | | 1 | | | K2ETK_U12 K2ETK_K6 | 15 | 30 | 1 | 1 | 0,7 | T | Z | | DN | P | S |

**Altogether in semester**

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Number of ECTS points for DN classes | Number of ECTS points for BU classes |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| 3 | 1 | 1 | 12 | 3 | 300 | 890 | 30 | 28 | 21 |

## 2. Set of examinations in semestral arrangement

| Course code | Names of courses ending with examination | Semester |
|---|---|---|
| W05ETK-SM1332W | Circuits and Systems | 1 |
| W05ETK-SM2131W | Power System Faults | 1 |
| W05ETK-SM3225W | Dynamics and Control of AC and DC Drives | 1 |
| W05ETK-SM2134W | Digital Signal Processing for Protection and Control | 2 |
| W05ETK-SM2231W | Power System Protection | 2 |
| W05ETK-SM2331W | Renewable Energy Sources | 2 |
| W05ETK-SM2233W | Power System Automation and Security | 3 |
| one exam from optional courses block A | | 4 |

## 3. Numbers of allowable deficit of ECTS points after particular semesters

| Semester | Allowable deficit of ECTS points after semester |
|---|---|
| 1 | 5 |
| 2 | 5 |
| 3 | 5 |
| 4 | 0 |

Opinion of student government legislative body

.....................
Date

..............................................................................................................................
Name and surname, signature of student representative

.....................
Date

..............................................................................................................................
Dean’s signature

BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes

Traditional – enter T, remote – enter Z

Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)

University-wide course /group of courses – enter O

DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned

Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Zaawansowana technika wysokich napięć** |
| Name of subject in English: | **Advanced High Voltage Technology** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM1120 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 30 | | |
| Number of hours of total student workload (CNPS): | 90 | | 60 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | | 2 | | |
| including number of ECTS points for practical (P) classes : | | | 2 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | | 1.40 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basics of physics and electrostatics
2. Fundamentals of materials engineering

## SUBJECT OBJECTIVES

C1. Getting to know the behavior of dielectric materials under the influence of a strong electric field
C2. Acquiring practical skills necessary for the proper assambly of testing and measuring devices, and proper implementation and development of measurement results.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Can describe and explain phenomena and processes responsible for the behavior of insulating materials under the influence of a strong electric field

PEU_W02 Is able to describe high-voltage insulation systems

*relating to skills:*

PEU_U01 Knows how to properly perform measurements in high-voltage systems and then develop and interpret results.

PEU_U02 Can use the knowledge gained earlier to describe the mechanism of phenomena.

*relating to social competences:*

PEU_K01 Awareness of teamwork and responsibility of all members of the team for the execution of the task

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Electrostatic fundamentals | 2 |
| Lec 2 | Electrification of solid and liquid materials. Electrostatic hazards. Electrostatic charge elimination techniques | 2 |
| Lec 3 | Electrostatic precipitation | 2 |
| Lec 4 | Electrostatic atomization and spraying | 2 |
| Lec 5 | Electrostatic printing technology and electrophotography | 2 |
| Lec 6 | Application of electrostatic separation | 2 |
| Lec 7 | Nonthermal plasma – fundamentals and applications | 2 |
| Lec 8 | High voltage generation | 2 |
| Lec 9 | Electric field. Air dielectric strength. | 2 |
| Lec 10 | The strength of insulating liquids. | 2 |
| Lec 11 | The strength of solid dielectrics | 2 |
| Lec 12 | High voltage cables | 2 |
| Lec 13 | Overvoltages and its reduction | 2 |
| Lec 14 | Non-destructive diagnostic methods. Overhead high voltage insulation. | 2 |
| Lec 15 | Test | 2 |
| | Total hours: | **30** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Introduction, safety work regulations, subject area of the laboratory | 3 |
| Lab 2 | Measurements of AC high voltage. | 3 |
| Lab 3 | Test system of DC high voltage. | 3 |
| Lab 4 | Surface electric strength of the post and bushing insulators under AC 50 Hz high voltage | 3 |
| Lab 5 | Measurement of dielectric loss factor and partial discharges in the high voltage insulation systems | 3 |
| Lab 6 | Voltage distribution on the string of disc insulators | 3 |
| Lab 7 | Wave phenomena in the model long power line | 3 |
| Lab 8 | Electric strength of insulation systems in the air at the AC high voltage | 3 |
| Lab 9 | Generation and measurement of impulse high voltage | 3 |
| Lab 10 | Last term, course acceptance | 3 |
| | Total hours: | **30** |

| TEACHING TOOLS USED |
|---|
| N1. traditional lecture<br>N2. Laboratory conducted in the traditional manner |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_K01 | Test |
| P(W) | P=F1 | |
| F1(L) | PEU_U02<br>PEU_K01 | evaluation of preparation for laboratory classes |
| F2(L) | PEU_U01<br>PEU_U02<br>PEU_K01 | Evaluation reports |
| P(L) | P=0.7*F1+0.3*F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Kuffel E., Zaengl W.S., Kuffel J., High Voltage Engineering Fundamentals. Newnes, Oxford, 2000
[2] Holtzhausen J.P., Vosloo W.L., High Voltage Engineering, Practice and Theory. Stellenbosch University 2008
[3] R. Arora, W. Mosch; High Voltage Insulation Engineering; New Age International (P) Limited Publischers 2008


**SECONDARY LITERATURE:**


[1] Ryan M.H., High Voltage Engineering and Testing. Institution of Electrical Engineers, London 2001
[2] IEEE standard 4-1995, IEEE Standard Techniques for High-Voltage Testing
[3] A. Haddad, D. Warne; Advances in High Voltage Engineering, The Institution of Engineering and Technology 2009


## SUBJECT SUPERVISOR


Maciej Jaroszewski, maciej.jaroszewski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Graficzne środowiska inżynierskie i języki programowania wizualnego** |
| Name of subject in English: | **Visual Engineering Environments and Graphical Languages** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM1230 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | 30 | | |
| Number of hours of total student workload (CNPS): | 30 | | 90 | | |
| Form of crediting: | examination | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | 3 | | |
| including number of ECTS points for practical (P) classes : | | | 3 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | 2.10 | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has the basic knowledge related to programming languages including data types and structures, operators, functions and procedures as well as objects.
2. Is computer-literate and has the high comfort level with using MS Windows operating system.
3. Is able to speak English and is familiar with English technical terminology at intermediate level required to comprehend and understand information and matters given during lectures and laboratory tutorials as well as well to communicate effectively and to discuss technical issues with lecturer as well as with other students.

### SUBJECT OBJECTIVES

C1. To make a student acquainted with methodology and rules of graphical object-oriented programming language using selected development environment.

C2. To let a student acquire practical knowledge and skills required for writing computer applications using graphical programming language.

C3. Promotion of teamwork and team programming.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Being able to explain and describe the concept of object-oriented graphical programming.

PEU_W02 Being able to characterize basic and advanced objects and graphical functional blocks offered by a selected visual object-oriented programming language.

*relating to skills:*

PEU_U01 Being able to develop an algorithm to solve computational and remote-control-related problem taking into account specific requirements of visual object-oriented programming language.

PEU_U02 Being able to implement the develop algorithm in the form of a program prepared, run, tested and optimized in the selected visual object-oriented programming language.

*relating to social competences:*

PEU_K01 Is open to team work idea and is determined to co-operate in a team.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introductory information: basic requirements, rules and forms of credition. Review on the “visual” software packages: high-level languages, process visualization tools, integrated programming and development environments, graphical languages. Concept of object-oriented graphical programming. Objects and their mutual connections as the syntax of graphical programming. Rules of data flow, sequencing, multithreading. | 2 |
| Lec 2 | Local and global variables, registers, containers, input and output terminals. Data types and structures. Data conversion and promotion/demotion rules. Functions and user objects, user objects nesting and dependency. | 2 |
| Lec 3 | Basic objects and functional blocks: their classification, inputs and outputs, functionality and hints on their use. | 2 |
| Lec 4 | Advanced mathematical, statistical and signal processing objects and functions. Text and binary file processing objects. | 2 |
| Lec 5 | Data exchange and control of external programs: ActiveX automation, .NET compliancy, Matlab engine control, network solutions. Communication and control of external devices, control of digital communication interfaces. | 2 |
| Lec 6 | Communication and device control using SCPI, VISA, ModBus. IVI device standards. Virtual instrument idea, instrument drivers. Graphical user interface and data visualization. | 2 |
| Lec 7 | Principles, tips and tricks helpful in designing data processing and control programs. Efficiency and speed optimization issues. Special solutions for improving execution speed and numerical processing power, „embedded” and „real-time” applications. | 2 |
| Lec 8 | Overview of selected practical applications and realizations (related e.g. to data manipulation, image processing and computer-controlled measurement and automation). | 1 |
| | Total hours: | **15** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Basic operations within visual engineering environment package. Program editing (loading, linking and deleting objects, creation of new user objects and user functions), edition of terminals and definition of data types. Running a program, searching for and correction of errors, preview of container content and data flow. | 2 |
| Lab 2 | Practical presentation of application and operation of basic objects and functional blocks offered by the visual programming environment – students are requested to fulfill mini-programming tasks (including puzzle game, reaction speed tester, primes generator, visualize computing results, create files documenting measurements, processing of data read from a file). | 16 |
| Lab 3 | Presentation of the test tasks and their allocation for student groups. Preparation of test task application: elaboration of algorithms, implementation in the visual object-oriented programming environment. | 10 |
| Lab 4 | Group presentation of the application implementing the allocated test tasks. An overview and discussion of the developed algorithms and programming solutions. | 2 |
| | Total hours: | **30** |

**TEACHING TOOLS USED**

N1. Lectures given using traditional as well as modern audiovisual techniques (including multimedia presentations).
N2. Demonstration of device functionality and operation, demonstration of software package functionality, configuration and options.
N3. Hands-on computing experience with software package during laboratory tutorials supervised by the lecturer.
N4. Consultation (with the lecturer).
N5. Team work and working on one’s own using demo version of the visual software package made available to students.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F(W) | PEU_W01<br>PEU_W02 | Oral examination. |
| P(W) | P=F1 | |
| F1(L) | PEU_U01<br>PEU_U02 | Assessment of the completed algorithm, its implementation in a selected graphical programming language and operation of the completed program. |
| F2(L) | PEU_K01 | Assessment of the incurred workload into achievements of the student group. |
| P(L) | P=0,7F1+0,3F2 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] R. Helsel, Graphical programming-a tutorial for HP Vee, Prentice Hall PTR, London, 1995.
[2] W. Tłaczała, Środowisko LabView w eksperymencie wspomaganym komputerowo, WNT, Warszawa 2002.
[3] R. H. Bishop, LabView Student edition 6i, Upper Sadle River, Prentice-Hall 2001.

**SECONDARY LITERATURE:**

[1] W. Winiecki, Organizacja komputerowych systemów pomiarowych. WPW, Warszawa 1997.
[2] L. U. Wells, LabView for everyone: graphical programming made even easier, Upper Saddle River, Prentice Hall 1997.
[3] related information and services provided by Agilent (Keysight) and National Instruments companies available at their websites.


## SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)


Paweł Żyłka, pawel.zylka@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Metody numeryczne i metody optymalizacji** |
| Name of subject in English: | **Numerical and Optimization Methods** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM1330 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge about the properties of multivariable functions
2. Basic knowledge in the field of calculus
3. Basic knowledge in the field of matrix algebra

## SUBJECT OBJECTIVES

C1. Transfer of the basic knowledge and skills needed for correct formulation of optimization problems
C2. Ordered presentation of various optimization methods
C3. Training the skills in practical use of software packages for solving optimization problems

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 knows the rules of mathematical formulation of optimization problems
PEU_W02 knows basic methods and algorithms used to solve an optimization problem

*relating to skills:*

PEU_U01 is able to formulate an optimization problem in mathematical terms
PEU_U02 is able to solve an optimization problem correctly selecting the solving algorithm

*relating to social competences:*

PEU_K01 creativity in searching for the solution of a given problem

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Basic terms. Goal function, constrains, problem parameters. Formulation and classification of optimization tasks. Examples of problems | 2 |
| Lec 2 | Elements of calculus and matrix algebra related to optimization problems. Convex sets and convex functions | 2 |
| Lec 3 | Nonlinear optimization without constrains. Sufficient and necessary conditions for optimization of unconstrained problems | 2 |
| Lec 4 | Algorithms for unconstrained problems used for minimum search. Steepest descent algorithm. Conjugate gradient algorithm. Newton algorithm and quasi Newton method | 2 |
| Lec 5 | Minimum search of a one variable function. Golden section search algorithm | 2 |
| Lec 6 | Nonlinear optimization with constrains. Kuhn-Tucker conditions. Lagrange function. Duality formulation | 2 |
| Lec 7 | Penalty function methods. Linear optimization. Integer numbers optimization | 2 |
| Lec 8 | Final test | 1 |
| | Total hours: | **15** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | H&S regulations. Laboratory working rules. Rules for working in a group. Rules for final crediting. Preliminary conditions. Presentation of subsequent labs contents | 1 |
| Lab 2 | Constructing a mathematical model of an optimization problem. Analytical determination of the extremum of a function | 4 |
| Lab 3 | Research on the effectiveness of numerical algorithms dedicated for problems without constrains | 4 |
| Lab 4 | Solving problems with constrains | 2 |
| Lab 5 | Applying the Optimization Toolbox of Matlab | 4 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lecture with multimedia presentations |
| N2. Computer laboratory suitable for group working |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01 PEU_W02 | Written final test |
| P(W) | P=F1 | |
| F1(L) | PEU_U01 PEU_U02 PEU_K01 | Grading the corectness of optimization problem solutions |
| P(L) | P=F1 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] .K.P. Chong, S.H. Żak: An Introduction to Optimization, 2nd edition, New York, John Wiley, 2001
[2] J.F. Bonnans: Numerical optimization: theoretical and practical aspects, Springer-Verlag, 2003
[3] M. Asghar Bhatti: Practical Optimization Methods, Berlin, Springer-Verlag 2000

**SECONDARY LITERATURE:**

[1] J. Nocedal, S. J. Wright, Numerical Optimization, Springer-Verlag, 2003

**SUBJECT SUPERVISOR**

Przemysław Janik, przemyslaw.janik@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Ocena jakości energii** |
| Name of subject in English: | **Power Quality Assessment** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM1331 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 15 | | |
| Number of hours of total student workload (CNPS): | 90 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | | 0.70 | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knows basic lows of electrical engineering and electrical quantity.
2. Is able to implement fundamental mathematical formulation in software environment as Matlab etc.
3. Understands the need and possibility of lifelong learning, achieving new skills professional as well as personal and social.

### SUBJECT OBJECTIVES

C1. Getting the knowledge about different power quality disturbances, origin and impact of power quality disturbances
C2. Getting the knowledge about power quality indices as well as standards and regulations dedicated to limits and methods of power quality assessment
C3. Acquire practical skills of application of fundamental algorithms used in identification of power quality parameters as well as method of assessment and reporting

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Have general knowledge about power quality issues including relations to electromagnetic compatibility
PEU_W02 Know legislative formulation and regulation concerning limits in power quality
PEU_W03 Know the structure and range of power quality report

*relating to skills:*

PEU_U01 Decide and select limits of power quality disturbances for particular electrical equipments
PEU_U02 Implement fundamental algorithms used in calculation of parameters of the power quality disturbances
PEU_U03 Is able to join the origin of power quality disturbances with its potential influence on condition of work of electrical equipment

*relating to social competences:*

PEU_K01 Is responsible for entrusted task, exhibits creative attitude and cooperation in team

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Crucial issues and definitions of power quality, legislative documents, standards and regulations, review and classification of power quality disturbances, power quality disturbances linked to electromagnetic compatibility, | 2 |
| Lec 2 | Power quality disturbances in relations to electromagnetic compatibility. Review and classification of power quality disturbances. | 2 |
| Lec 3 | Methods of measurement and algorithms for disturbances of main frequency. Origin of power quality disturbances and potential impact on the operation of electrical power systems elements. | 2 |
| Lec 4 | Methods of measurement and algorithms for disturbances of voltage. Origin of power quality disturbances and potential impact on the operation of electrical power systems elements. Example of emission and immunity test of the electrical equipments. | 2 |
| Lec 5 | Methods of measurement and algorithms for disturbances of voltage and current waveform. Origin of power quality disturbances and potential impact on the operation of electrical power systems elements. Example of emission and immunity test of the electrical equipments. | 2 |
| Lec 6 | Methods of measurement and algorithms for disturbances of symmetry and power balance. Origin of power quality disturbances and potential impact on the operation of electrical power systems elements. | 2 |
| Lec 7 | Methods of measuring and assessment of the quality of electricity supply in low voltage and medium voltage power systems, the limits for the power quality disturbances, meaning of quality of the supply for distribution system operator. | 2 |
| Lec 8 | Methods of measuring and assessment of the quality of electricity supply in high voltage power systems, the limits for the power quality disturbances, meaning of quality of the supply for transmission system operator. | 2 |
| Lec 9 | Review of power quality recorders. Scope of the report of power quality, distribution of real measurements for the power quality report. | 2 |
| Lec 10 | Discussion of exemplary power quality report. Examples of power quality disturbances finder. | 2 |
| Lec 11 | Power quality monitoring systems, distributed measurement systems, time synchronization, on-line access. | 2 |
| Lec 12 | Power quality monitoring systems, data based tools in the evaluation of the multipoint measurement data. | 2 |
| Lec 13 | Selected methods of reducing or elimination of voltage disturbances. | 2 |
| Lec 14 | Selected methods of reducing or elimination of voltage and current waveform disturbances. | 2 |
| Lec 15 | Oral test, defence of power quality report | 2 |
| | Total hours: | **30** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Information about the regulation of work in the laboratory, requirements for passing the course, distribution of the instructions and additional materials | 1 |
| Lab 2 | Algorithms for voltage dips assessment. Part 1. | 2 |
| Lab 3 | Algorithms for voltage dips assessment. Part 2. | 2 |
| Lab 4 | Algorithms for harmonics assessment. Part 1. | 2 |
| Lab 5 | Algorithms for harmonics assessment. Part 2. | 2 |
| Lab 6 | Configuration of power quality recorder and assessment of the selected power quality parameters on the basis of real measurement at the laboratory setup. Part 1. | 2 |
| Lab 7 | Configuration of power quality recorder and assessment of the selected power quality parameters on the basis of real measurement at the laboratory setup. Part 2. | 2 |
| Lab 8 | Discussion the reports on particular laboratories, final marks, additional term of the laboratory. | 2 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lectures with multimedia presentation |
| N2. Organization of the laboratory work in subgroup |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Oral test, assessment of power quality report |
| P(W) | P=F1 | |
| F1(L) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Evaluation of preparing for laboratories |
| F2(L) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Evaluation of reports on particular laboratories |
| P(L) | P=0,2*F1+0,8*F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Arrillaga J. Watson N. R.: Power System Quality Assessment, John Wiley & Sons, New York, 2000.
[2] Bollen M. H. J.: Understanding Power Quality Problems Voltage Sags and Interruptions, IEEE Press, New York, USA, 2000.
[3] Dugan R. C., McGranaghan M. F., Beaty H. W.: Electrical Power Systems Quality, McGraw-Hill, New York, USA, 1986.


**SECONDARY LITERATURE:**


[1] Electrical Power Quality and Utilization - Journal
[2] Leonardo Energy – Power Quality Guide


## SUBJECT SUPERVISOR


Tomasz Sikorski, tomasz.sikorski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Obwody i układy** |
| Name of subject in English: | **Circuits and Systems** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM1332 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | 15 | | | |
| Number of hours of total student workload (CNPS): | 90 | 30 | | | |
| Form of crediting: | examination | crediting with grade | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | 1 | | | |
| including number of ECTS points for practical (P) classes : | | 1 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | 0.70 | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knows basic lows of electrical engineering and recognize electrical quantity.
2. Knows differential and integral calculus of one variable function, linear algebra and mathematic calculation in complex domain.
3. Can implement basic differential calculation, linear algebra and calculation on complex number.
4. Can recognize fundamental electrical problems and tools for its solution.

## SUBJECT OBJECTIVES

C1. Getting the knowledge techniques used in synthesis of electrical circuits.
C2. Acquire skills of nonlinear circuit analysis.
C3. Getting the knowledge about state variable matrix application.
C4. Getting the knowledge about application of continuous representation of signals, transfer function in operator and frequency form.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Have knowledge about circuit synthesis
PEU_W02 nows elements of nonlinear circuits analysis including stability issues
PEU_W03 Formulate general theory of system description using state variable matrix. Formulate genera theory of system description using transfer function in operator and frequency form

*relating to skills:*

PEU_U01 Decide and select method of circuit synthesis on the basis of immittance function
PEU_U02 Knows elements of nonlinear circuits analysis including stability issues
PEU_U03 Formulate general theory of system description using state variable matrix. Formulate genera theory of system description using transfer function in operator and frequency form

*relating to social competences:*

PEU_K01 Is responsible for entrusted task, exhibits creative attitude in selection of calculation techniques

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction to circuits and electrical systems. Properties of circuits General problems description of the circuits according to the circuit components and operating state. General issues concerning signal transfer through the system. | 2 |
| Lec 2 | Selected issues of circuits synthesis. positive rational functions, immittance function of driving point impedance. | 2 |
| Lec 3 | Selected issues of circuits synthesis. Techniques for synthesis of passive RC, RL, LC circuits, Foster and Cauer synthesis. Part 1. | 2 |
| Lec 4 | Selected issues of circuits synthesis. Techniques for synthesis of passive RC, RL, LC circuits, Foster and Cauer synthesis. Part 2. | 2 |
| Lec 5 | Selected issues of nonlinear circuits analysis. Characteristics of driving point nonlinear elements. | 2 |
| Lec 6 | Selected issues of nonlinear circuits analysis. Selected methods of nonlinear circuits analysis. | 2 |
| Lec 7 | Selected issues of nonlinear circuits analysis. Stability of nonlinear circuits, phase plane. | 2 |
| Lec 8 | Selected issues of nonlinear circuits analysis. Stability of nonlinear circuits, stability in Lapunov theory. | 2 |
| Lec 9 | Selected issues of time series and matrix functions. differential and integral operation of matrix functions. | 2 |
| Lec 10 | Selected issues of time series and matrix functions. State variable, transfer matrix, excitation matrix, output matrix. | 2 |
| Lec 11 | Selected issues of time series and matrix functions. Application of engine values. | 2 |
| Lec 12 | Selected issues of continuous representation of deterministic signals. Two-side Laplace transform, convergence area, inverse transformation. | 2 |
| Lec 13 | Selected issues of continuous representation of deterministic signals. Fourier transform, relation of two-sides Laplace and Fourier transforms, signal parameters in time and frequency domain. | 2 |
| Lec 14 | Selected issues of continuous representation of deterministic signals. Transfer function of LTI circuits, elements of filter synthesis. Hilbert compound. | 2 |
| Lec 15 | Selected issues of continuous representation of deterministic signals. Elements of filter synthesis. | 2 |
| | Total hours: | **30** |

| **Classes** | | **Number of hours:** |
|---|---|---|
| Cl 1 | Information about the regulation of time schedule and requirements for passing the course. Application of synthesis of linear circuit - introduction | 2 |
| Cl 2 | Application of synthesis of linear circuit | 2 |
| Cl 3 | Application of methods of nonlinear circuits analysis. Part 1 | 2 |
| Cl 4 | Application of methods of nonlinear circuits analysis. Part 2 | 2 |
| Cl 5 | Application of state variable matrix in analysis of the circuits analysis. Part 1 | 2 |
| Cl 6 | Application of state variable matrix in analysis of the circuits analysis. Part 2 | 2 |
| Cl 7 | Application of transfer function of LTI circuits | 2 |
| Cl 8 | Crediting test | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lectures with multimedia presentation |
| N2. Classes work in subgroup |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Examination |
| P(W) | P=F1 | |
| F1(C) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Crediting test |
| P(C) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] A. Papoulis – Obwody i układy, WKiŁ, 1998 (PL) / A. Papoulis – Circuits and Systems: A modern approach, The Oxford Series in Electrical and Computer Engineering (EN)
[2] S. Haykin, B. Van Veen – Signals and systems, John Wiley & Sons, Inc., 1999.
[3] S T.H. Glisson – Introduction to system analysis, McGraw-Hill, Inc, 1985.
[4] G. E. Carlson – Signal and linear system analysis, John Wiley & Sons, Inc., 1998.
[5] Ch.T. Chen – System and signal analysis, Oxford University Press, 1994.

**SECONDARY LITERATURE:**

[1] A. D. Poularikas - The handbook of formulas and tables for signal processing, CRC Press, 2000
[2] Additional educational supplies http://eportal.eny.pwr.wroc.pl/

## SUBJECT SUPERVISOR

Tomasz Sikorski, tomasz.sikorski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Sygnały i Systemy** |
| Name of subject in English: | **Signal and Systems** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM1334 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | 15 | | | |
| Number of hours of total student workload (CNPS): | 90 | 30 | | | |
| Form of crediting: | examination | crediting with grade | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | 1 | | | |
| including number of ECTS points for practical (P) classes : | | 1 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | 0.70 | | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knows basic lows of electrical engineering and recognize electrical quantity.
2. Knows differential and integral calculus of one variable function, linear algebra and mathematic calculation in complex domain.
3. Can implement basic differential calculation, linear algebra and calculation on complex number.
4. Can recognize fundamental electrical problems and tools for its solution. Competence
5. Understands the need and possibility of lifelong learning, achieving new skills professional as well as personal and social.

### SUBJECT OBJECTIVES

C1. Getting the knowledge about using of delta Dirac function and step function in description of system
C2. Learn possible application of state variable matrix, system matrix and engine values.
C3. Getting the knowledge about graphical representation of circuit's equations.
C4. Getting the knowledge about of stability formulation.
C5. Acquire skills of digital circuit description.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Have a knowledge in using of delta Dirac function and step function in description of system. Knows methods of system descriptions using state variable matrix.

PEU_W02 Knows methods of graphical representations of system equations Knows the methods of define system stability criterions

PEU_W03 Knows the techniques of digital systems description

*relating to skills:*

PEU_U01 Apply delta Dirac function and step function in description of system. Use the method of system description based on state variable matrix.

PEU_U02 Select the method of graphical system representation using graph and block scheme techniques. Is able to select stability criteria and conclude about the stability

*relating to social competences:*

PEU_K01 Is responsible for entrusted task, exhibits creative attitude in selection of calculation techniques

| PROGRAMME CONTENT | | |
|---|---|---|
| Lecture | | Number of hours: |
| Lec 1 | Selected issues of system description. The basic properties of systems. The basic signals used in the system analysis. Elements of the theory of distribution. Step and Dirac impulse. Differentiation in terms of distribution theory. | 2 |
| Lec 2 | Selected issues system description. Impulse and step response of linear time-invariant systems. Duhamel integral and convolution. Calculation of convolution of positive-time side signals. | 2 |
| Lec 3 | Selected issues of description. Determination of impulse response, step response, and response for given excitation. | 2 |
| Lec 4 | Selected issues of time series and matrix functions. Differential and integral operation of matrix functions. | 2 |
| Lec 5 | Selected issues of time series and matrix functions. State variable, transfer matrix, excitation matrix, output matrix. | 2 |
| Lec 6 | Selected issues of time series and matrix functions. Application of engine values. | 2 |
| Lec 7 | Selected issues of graphical representation of circuit equations. flow graphs, block schemes, reduction of scheme blocks. Part 1. | 2 |
| Lec 8 | Selected issues of graphical representation of circuit equations. flow graphs, block schemes, reduction of scheme blocks. Part 2. | 2 |
| Lec 9 | Selected issues of graphical representation of circuit equations. flow graphs, block schemes, reduction of scheme blocks. Part 3. | 2 |
| Lec 10 | Selected issues of system stability. Definition of stability of transmission element, stability conditions, Hurwitz polynomial. | 2 |
| Lec 11 | Selected issues of system stability. Algebraic criteria, frequency criteria of linear stationary systems. Part 1. | 2 |
| Lec 12 | Selected issues of system stability. Algebraic criteria, frequency criteria of linear stationary systems.Part 2. | 2 |
| Lec 13 | Selected issues of digital system description. Impulse signal and his meaning in digitalization process, two-side ‘Z” transform, relation of ‘Z” transform with Laplace and Fourier technique. | 2 |
| Lec 14 | Selected issues of digital system description. sampling theory, spectrum of digital signals, stationarity, causality, stability of digital systems. | 2 |
| Lec 15 | Selected issues of digital system description. Frequency characteristic of digital systems. | 2 |
| | Total hours: | **30** |

| Classes | | Number of hours: |
|---|---|---|
| Cl 1 | Information about the regulation of time schedule and requirements for passing the course. Determination of impulse and step response of the systems. | 2 |
| Cl 2 | Application of theory of distribution in determination of step, impulse response and response for given excitations. | 2 |
| Cl 3 | Application of state variable matrix in determination of step and impulse response | 2 |
| Cl 4 | Application of state variable matrix in determination of system response for given excitations. Application of engine values for stability criterion. | 2 |
| Cl 5 | Application of graphical system representation using flow graphs | 2 |
| Cl 6 | Application of graphical system representation using block schemes | 2 |
| Cl 7 | Application of stability criterions | 2 |
| Cl 8 | Credititng test | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lectures with multimedia presentation |
| N2. Classes work in subgroup |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Examination |
| P(W) | P=F1 | |
| F1(C) | PEU_U01<br>PEU_U02<br>PEU_K01 | Crediting test |
| P(C) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] S. Haykin, B. Van Veen – Signals and systems, John Wiley & Sons, Inc., 1999.
[2] S T.H. Glisson – Introduction to system analysis, McGraw-Hill, Inc, 1985.
[3] G. E. Carlson – Signal and linear system analysis, John Wiley & Sons, Inc., 1998.
[4] Ch.T. Chen – System and signal analysis, Oxford University Press, 1994.

**SECONDARY LITERATURE:**

[1] A. D. Poularikas - The .handbook of formulas and tables for signal processing, CRC Press, 2000.
[2] Additional educational supplies http://eportal.eny.pwr.wroc.pl/

## SUBJECT SUPERVISOR

Tomasz Sikorski, tomasz.sikorski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Zaawansowane metody przetwarzania sygnałów** |
| Name of subject in English: | **Advanced Signal Processing Methods** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM1335 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | 15 | | | |
| Number of hours of total student workload (CNPS): | 90 | 30 | | | |
| Form of crediting: | examination | crediting with grade | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | 1 | | | |
| including number of ECTS points for practical (P) classes : | | 1 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | 0.70 | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge in the fields of calculus and linear algebra
2. Basic knowledge of the C language
3. Ability of systematic work and individual problem solving

## SUBJECT OBJECTIVES

C1. Understanding and proper application of digital signal processing methods
C2. Presentation of tools for description and analysis of digital systems in time and frequency domain
C3. Ability to design and implement simple digital systems

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 knows mathematical methods for description and analysis of digital systems in time and frequency domain
PEU_W02 knows algorithms for digital filter design

*relating to skills:*

PEU_U01 is able to provide a spectral analysis of a signal
PEU_U02 is able to design a simple digital filter

*relating to social competences:*

PEU_K01 creativity in searching for the solution of a given problem

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Discrete signal and systems – examples, mathematical notation, sampling, aliasing. Part I. | 2 |
| Lec 2 | Discrete signal and systems – examples, mathematical notation, sampling, aliasing. Part II. | 2 |
| Lec 3 | Description and analysis of digital systems in time domain: difference equation, convolution, impulse response, block schemes, state space variables, system classification. Part I. | 2 |
| Lec 4 | Description and analysis of digital systems in time domain: difference equation, convolution, impulse response, block schemes, state space variables, system classification. Part II. | 2 |
| Lec 5 | Z transform: definition of Z transform, the correlation of Z transform to Laplace transform, basic properties of Z transform , inverse Z transform (methods and computational examples), the area of convergence and its meaning, computations. Part I. | 2 |
| Lec 6 | Z transform: definition of Z transform, the correlation of Z transform to Laplace transform, basic properties of Z transform , inverse Z transform (methods and computational examples), the area of convergence and its meaning, computations. Part II. | 2 |
| Lec 7 | Applications of the Z transform: solving of difference equations, the transfer function, casuality and stability of systems. Part I. | 2 |
| Lec 8 | Applications of the Z transform: solving of difference equations, the transfer function, casuality and stability of systems. Part II. | 2 |
| Lec 9 | Discrete Fourier transform: Definition of DFT (introduction, examples, properties), correlation of DFT to Z transform, inverse DFT, elimination of leakage with the window method, resolution of FFT. Part I. | 2 |
| Lec 10 | Discrete Fourier transform: Definition of DFT (introduction, examples, properties), correlation of DFT to Z transform, inverse DFT, elimination of leakage with the window method, resolution of FFT. Part II. | 2 |
| Lec 11 | Digital filters: introduction, methods of description, examples, classification. Finite impulse response filters -FIR. Design of FIR, window method. Part I. | 2 |
| Lec 12 | Digital filters: introduction, methods of description, examples, classification. Finite impulse response filters -FIR. Design of FIR, window method. Part II. | 2 |
| Lec 13 | Fast Fourier transform FFT. Correlation between FFT and DFT. Part I. | 2 |
| Lec 14 | Fast Fourier transform FFT. Correlation between FFT and DFT. PartII. | 2 |
| Lec 15 | Algorithm for FFT: computational scheme, implementation example, butterfly structures for FFT. | 2 |
| | Total hours: | **30** |

| **Classes** | | **Number of hours:** |
|---|---|---|
| Cl 1 | Mathematical description, generation and sampling for discrete signals. Part I. | 2 |
| Cl 2 | Mathematical description, generation and sampling for discrete signals. Part II. | 2 |
| Cl 3 | Z transform, Inverse Z transform. Part I. | 2 |
| Cl 4 | Z transform, Inverse Z transform. Część II. | 2 |
| Cl 5 | Transfer function, impulse response, difference equation, block scheme. Part I. | 2 |
| Cl 6 | Transfer function, impulse response, difference equation, block scheme. Part II. | 2 |
| Cl 7 | Fourier Transform - implementation. Part I. | 2 |
| Cl 8 | Fourier Transform - implementation. Part II. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lecture with multimedia presentations |
| N2. Classes with problems for individual solving |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | exam |
| P(W) | P=F1 | |
| F1(C) | PEU_U01<br>PEU_U02<br>PEU_K01 | final test |
| P(C) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] S. Haykin, B. Van Veen – Signals and Systems, John Wiley & Sons, Inc., 1999
[2] D. F. Elliot – Handbook of Digital Signal Processing, Academic Press, Inc., 1987
[3] S. M. Kay – Modern Spectral Estimation, Prentice Hall, Signal Processing Series, Englewood Cliffs, 1988

**SECONDARY LITERATURE:**

[1] M. Vetterli, J. Kovacevic - Wavelets and Subband Coding, Englewood Cliffs, Prentice Hall, 1994

## SUBJECT SUPERVISOR

Przemysław Janik, przemyslaw.janik@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Zwarcia w systemie elektroenergetycznym** |
| Name of subject in English: | **Power System Faults** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2131 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | | |
| Number of hours of total student workload (CNPS): | 120 | | | | |
| Form of crediting: | examination | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 4 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.80 | | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has basic knowledge on a power system operation.
2. Knowledge of complex number calculations.

## SUBJECT OBJECTIVES

C1. Gaining knowledge on faults occurring in power systems.
C2. Familiarization with methods for analysis of fault waveforms and for fault identification.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has knowledge on faults occurring in high voltage networks.
PEU_W02 Has knowledge on faults occurring in medium voltage networks.
PEU_W03 Has knowledge on analysis of fault waveforms and on fault identification.

*relating to skills:*

*relating to social competences:*

PEU_K01 Is able to independent thinking and to performing analysis of technical information.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Establishing conditions for passing and marking the lecture. Causes and consequences of faults, classifications of faults, aims of fault calculations. | 2 |
| Lec 2 | Fault identification - digital algorithms for fault detection. | 2 |
| Lec 3 | Fault identification - digital algorithms for fault direction discrimination and fault classification. | 2 |
| Lec 4 | Fault calculations - application of per units, method of symmetrical components, calculations in phase co-ordinates. | 2 |
| Lec 5 | Models of generators and power transformers in fault calculations. | 2 |
| Lec 6 | Equivalent circuit diagrams of overhead and cable lines for symmetrical components. Modal transformation, calculations in phase co-ordinates. | 2 |
| Lec 7 | Analysis of three-phase symmetrical faults. Analysis of single phase faults. | 2 |
| Lec 8 | Analysis of phase-to-phase faults. Analysis of phase-to-phase-to-earth faults. | 2 |
| Lec 9 | Analysis of broken conductor failure and broken conductor failure combined with phase-to-earth fault. | 2 |
| Lec 10 | Requirements of international standards for fault calculations. | 2 |
| Lec 11 | Earth faults in networks with isolated neutral point. | 2 |
| Lec 12 | Earth faults in networks with neutral point earthed through compensating reactor and through resistor. | 2 |
| Lec 13 | Microprocessor-based fault recorders and fault locators – application basics. | 2 |
| Lec 14 | Fault location on power lines with use of local and two-end measurements. | 2 |
| Lec 15 | Transformation of fault voltages and currents by instrument protective transformers. | 2 |
| | Total hours: | **30** |

**TEACHING TOOLS USED**

N1. Informative lecture.
N2. Student's own work.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01 PEU_W02 PEU_W03 | Presence at the lectures |
| F2(W) | PEU_W01 PEU_W02 PEU_W03 PEU_K01 | Written or oral examination |
| P(W) | P=0,1F1+0,9F2 | |

**PRIMARY AND SECONDARY LITERATURE**


**PRIMARY LITERATURE:**

[1] Iżykowski J., Power system faults. PRINTPAP, 2011, p. 190.

**SECONDARY LITERATURE:**

[1] Glover J. D., Sarma M., Power system analysis and design. PWS Publishing Company Boston, second edition, 1994.
[2] Michalik M., Rosołowski E., Simulation and analysis of power system transients. PRINTPAP, 2011.
[3] Saha M.M., Iżykowski J., Rosołowski E., Fault location on power networks. Springer-Verlag London, Series: Power Systems, 2010, 425 p.


**SUBJECT SUPERVISOR**


Jan Iżykowski, jan.izykowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Cyfrowe Techniki Sterowania** |
| Name of subject in English: | **Digital Control Techniques** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2132 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of basics of continuous control systems.
2. Knowledge of basics synthesis and analysis of digital systems.
3. Basic knowledge of MATLAB / Simulink software.
4. Practical skills of using MATLAB: writing programs.
5. Is capable of implementing digital algorithms based on difference equations.

### SUBJECT OBJECTIVES

C1. Acquaintance of knowledge related to: function of analogue filtering in the context of proper operation of digital systems, digital signal processing, representation methods of discrete-time systems, appropriate sampling time selection, effect of pole location on system response.

C2. Practical skills to analyze and design of both finite and infinite impulse response filters.

C3. Practical skills to: PID digital controller tuning, design of digital controller dedicated to particular object, design of state variable feedback controller and state observer.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Possesses knowledge related to processing of continuous signals, their discretization and processing of digital signals.

PEU_W02 Has a basic knowledge of structure of digital control systems and their design methods.

PEU_W03 Possesses knowledge related to design of digital filters and various types of digital regulators.

*relating to skills:*

PEU_U01 Is able to select appropriate sampling time, represent continuous control system with use of transfer function and state space model, retrieve difference equation of digital model of continuous plant and implement this equation.

PEU_U02 Is able to design and perform analysis of digital filters.

PEU_U03 Is able to tune as well as design digital controller of a given output transient performance indices.

*relating to social competences:*

PEU_K01 Is able to carry out a complex engineering project in a competent way, unaided as well as to cooperate with a team if required

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Setting rules of course crediting. Tasks, structures and interface circuits of digital control system. | 2 |
| Lec 2 | Classification of plants in digital control, basic notions used in analysis and design of real time control systems. | 2 |
| Lec 3 | Classification of plants in digital control, basic notions used in analysis and design of real time control systems. | 2 |
| Lec 4 | Digital models of continuous plants. | 2 |
| Lec 5 | Processing of the plant output signals by interface circuits. | 2 |
| Lec 6 | Processing of input digital signals – digital filtration, design of recursive digital filters based on analog lowpass filters transformation. | 2 |
| Lec 7 | Processing of input digital signals – digital filtration, design of recursive digital filters based on analog lowpass filters transformation. | 2 |
| Lec 8 | Processing of input digital signals – digital filtration, design of nonrecursive digital filters. | 2 |
| Lec 9 | Design of nonrecursive digital filters using the Fourier transformation. | 2 |
| Lec 10 | Digital PID regulators. | 2 |
| Lec 11 | Design of the dedicated digital regulator for the determined plant and for predetermined transfer function of the closed-loop system K(z). | 2 |
| Lec 12 | Robust digital regulators. | 2 |
| Lec 13 | Design methods of state variable feedback controller. | 2 |
| Lec 14 | Digital controller with a state observer. | 2 |
| Lec 15 | Pass test. | 2 |
| | Total hours: | **30** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Introduction. Setting rules of course crediting. Acquaintance with lab stands, safety rules and available software. | 2 |
| Lab 2 | Design and analysis of recursive digital filters based on analog lowpass filters transformation. | 2 |
| Lab 3 | Design and analysis of recursive digital filters based on analog lowpass filters transformation. | 1 |
| Lab 4 | Design of nonrecursive digital filters using the inverse DFT. | 2 |
| Lab 5 | Tuning of the digital PID regulator. | 2 |
| Lab 6 | Design of dedicated and robust digital regulators. | 2 |
| Lab 7 | Design of state variable feedback controller. | 2 |
| Lab 8 | State variable feedback controller with a state observer. | 2 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Project presentation.
N2. Informative lecture.
N3. Presentation of the reports.
N4. Matlab program.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Participation in the course |
| F2(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Pass test |
| P(W) | P = 0,1F1+ 0,9F2 | |
| F1(L) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Activity during the classes |
| F2(L) | PEU_U01<br>PEU_U02<br>PEU_U03 | Presentation of the reports done |
| P(L) | P = 0.7F1+ 0.3F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] Digital Control Systems – the lecture outline, provided by subject supervisor.

**SECONDARY LITERATURE:**


[1] Kuo B.C.: Digital Control Systems, Hold. Reinhard and Winston Inc. 1981.
[2] Bozic S. M.: Digital and Kalman Filtering, Edward Arnold Publishers, London 1984.
[3] Astrom K.J., Wittenmark B.: Computer Controlled Systems, Printice Hall, London 1989.
[4] Iserman R.: Digital Control Systems, Springers-Verlag, Berlin 1988.
[5] Vaccaro R.J.:Digital Control, A State Space Approach, McGrew-Hill, New York 1995.


## SUBJECT SUPERVISOR


Daniel Bejmert, daniel.bejmert@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Komputerowa analiza elektromagnetycznych stanów przejściowych** |
| Name of subject in English: | **Simulation and Analysis of Power System Transients** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2133 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | 30 | | |
| Number of hours of total student workload (CNPS): | 30 | | 60 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | 2 | | |
| including number of ECTS points for practical (P) classes : | | | 2 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | 1.40 | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Student should have the basic knowledge of fundamentals of circuit theory and basics of differential calculus
2. Student should know how to formulate digital models of electrical circuits and to conduct analyses regarding accuracy, stability and frequency characteristics.
3. Student should know how to calculate the parameters of basic elements of the line

### SUBJECT OBJECTIVES

C1. To provide knowledge of methods for solving differential equations describing electrical circuits.
C2. Learning how to formulate digital models of electrical circuits and to conduct analyses regarding accuracy, stability and frequency characteristics.
C3. To provide knowledge of modelling a power line with distributed parameters.
C4. Familiarization with methods of modelling and simulation of renewable energy sources.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Student gets the knowledge on description of models for linear electrical circuits with use of differential equations and their numerical solution applying different numerical procedures of integration.

PEU_W02 Student gets the knowledge regarding evaluation of accuracy and stability of the solution of a differential equation in a numerical way.

*relating to skills:*

PEU_U01 Student is able to model linear elements and branches and also a power transmission line with distributed parameters, in particular, applying a graphical editor of this program, forms a structure of a simulative model, sets simulation parameters, conducts a simulation and analyses waveforms of signals from a modelled system.

PEU_U02 Student is able to apply results of computer simulation to analyse of dynamic electric circuits.

*relating to social competences:*

PEU_K01 Student can act independently and cooperate within a group working on a complex engineering project.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction, syllabus of the course, basic definitions. Computer programs for electromagnetic transients simulations - general description. | 2 |
| Lec 2 | Digital models of linear elements (R, L, C) of an electric network | 2 |
| Lec 3 | Basic concept of numerical solution of a dynamic network equations | 2 |
| Lec 4 | Line model with distributed parameters. | 2 |
| Lec 5 | Numerical oscillation and limitations of using the computer tools to simulation of electromagnetic transients. | 2 |
| Lec 6 | Modelling of relays, measuring algorithms and instrument transformers | 2 |
| Lec 7 | Modelling of power electronic converters | 2 |
| Lec 8 | Qualified test | 1 |
| | Total hours: | **15** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Presentation of health and safety rules, and general regulations of the laboratory. Establishing conditions for passing and marking the project course. General familiarization with the ATPEMTP program. | 2 |
| Lab 2 | Simulation of a 3-phase network with line, load and a fault. | 2 |
| Lab 3 | Simulation of 3-phase transformer with magnetizing characteristic. Test of the transformer energising. | 2 |
| Lab 4 | Simulation of the instrument transformers with the relay input chain. | 2 |
| Lab 5 | Modelling of faults in 3-phase network with transformer and instrument transformers. | 2 |
| Lab 6 | Modelling of digital measuring algorithms applied in relay protection units. | 2 |
| Lab 7 | Simulation of the induction motors. Test of start and load changing. | 2 |
| Lab 8 | Testing of the synchronous generation with excitation control scheme. | 2 |
| Lab 9 | Simulation of generation station with control scheme; fault analysis | 2 |
| Lab 10 | Modelling of a power electronic converters | 2 |
| Lab 11 | Modelling of DFIG generator and power control system. | 2 |
| Lab 12 | Simulation of ride-through faults on the line connected wind generator. | 2 |
| Lab 13 | Modelling of the photovoltaic source. | 2 |
| Lab 14 | Simulation of the interconnection between the photovoltaic source with the utility network. | 2 |
| Lab 15 | Additional term. | 2 |
| | Total hours: | **30** |

**TEACHING TOOLS USED**

N1. Informative lecture.
N2. ATP-EMTP simulation program.
N3. Lab reports.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01 PEU_W02 | Attendance on lectures |
| F2(W) | PEU_W01 PEU_W02 | Qualified test |
| P(W) | P=0,1*F1+0,9*F2 | |
| F1(L) | PEU_U01 PEU_U02 | aktywność na zajęciach |
| F2(L) | PEU_U01 PEU_U02 PEU_K01 | Project reports |
| P(L) | P=0,3*F1+0,7*F2 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] ROSOŁOWSKI E., Komputerowe metody analizy elektromagnetycznych stanów przejściowych. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2009.
[2] http://zas.ie.pwr.wroc.pl/ER/przyklady_D1/index.html - przykłady niektórych modeli wraz z plikami źródłowymi do programu ATP-EMTP.
[3] N. Watson, J. Arrillaga: Power systems electromagnetic transients simulation. The Institution of Electrical Engineers, London 2003.
[4] H.W. Dommel: Electromagnetic Transients Program. Reference Manual. BPA, Portland, 1986.

**SECONDARY LITERATURE:**

[1] Alternative Transients Program. Rule Book. K.U. Leuven, EMTP Center, 1987.
[2] P. Kacejko P., J. Machowski: Faults in power systems, WNT Warszawa 2002 (in polish).
[3] Materiały dostępne na stronie: http://www.rose.pwr.wroc.pl/


## SUBJECT SUPERVISOR


Eugeniusz Rosołowski, eugeniusz.rosolowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Cyfrowe przetwarzanie sygnałów w układach automatyki elektroenergetycznej** |
| Name of subject in English: | **Digital Signal Processing for Protection and Control** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2134 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | 30 | |
| Number of hours of total student workload (CNPS): | 60 | | | 60 | |
| Form of crediting: | examination | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | 2 | |
| including number of ECTS points for practical (P) classes : | | | | 2 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | 1.40 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of basics of power system control, digital signal processing and numerical methods.
2. Practical skills of using MATLAB and ATP-EMTP software.

## SUBJECT OBJECTIVES

C1. Acquaintance of knowledge related to digital power system protection and control systems including: digital filtration, measurement of criteria values and decision making.

C2. Practical skills to analyze and design of both hardware structure and software of digital control and protection for power systems, with special consideration to algorithms of digital filtration, measurement of criteria values and decision making.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Possesses knowledge related to structure of digital power system control and protection systems as well as knowledge related to processing of continuous signals, their discretization and processing of digital signals.

PEU_W02 Possesses knowledge related to digital filtering, algorithms of criteria values measurement, their accuracy and dynamics as well as possibilities of measurement errors elimination.

PEU_W03 Possesses knowledge related to deterministic and probabilistic decision processes, fundamentals of adaptive systems and structure of multi-criteria devices.

*relating to skills:*

PEU_U01 Is able to model and evaluate operation of the measurement path and A/D conversion units as well as to perform analysis and synthesis of digital recursive and non-recursive filters.

PEU_U02 Is able to model and evaluate operation of digital algorithms for protection criteria measurement.

PEU_U03 Is able to model and evaluate operation of the basic decision making algorithms for decision making in power system protection and control.

*relating to social competences:*

PEU_K01 Is able to carry out a complex engineering project in a competent way.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Setting rules of course crediting. Historical perspective, development of analog and digital power system control systems, reasons for and benefits of digital control, advantages of digital implementation. | 2 |
| Lec 2 | Mathematical basis for control and protection algorithms: complex Fourier series, Fourier transform, Discrete Fourier transform, Z-transform, analog and discrete integration. | 2 |
| Lec 3 | Analog filters: standard low-pass approximations, frequency and time response of the filter, analog filter design, frequency band transformation. | 2 |
| Lec 4 | Analog to digital converters, multiplexer and analog memory, quantization time and errors, Shannon sampling theorem, practical sampling rates. Classification of digital filters. | 2 |
| Lec 5 | Design of recursive filters using impulse invariant techniques. Design of recursive filters using frequency prewarping and the bilinear transformation, problems of quantization and round-off errors. | 2 |
| Lec 6 | Design of non-recursive digital filters using a window function, commonly used FIR filter window functions and associated frequency responses. | 2 |
| Lec 7 | Signal orthogonalization algorithms: single & double delay methods, FIR orthogonal filters, correlation, least squares estimation technique. | 2 |
| Lec 8 | Signal magnitude estimation: digital integration methods, orthogonal components based methods, correlation, detailed algorithms. | 2 |
| Lec 9 | Measurement of other power system quantities: algorithms of estimation of active and reactive power, impedance components, signal phase, digital estimation of power system frequency and frequency deviation. | 2 |
| Lec 10 | Measurements in dynamic state of estimation, measurement error sources (signal distortion, harmonics, fundamental frequency deviation, ...). | 2 |
| Lec 11 | Influence of current transformers on the quality of criteria values calculation. Methods od CT saturation detection and correction of distorted secondary current. | 2 |
| Lec 12 | Special algorithms. Application of wavelet transform for detection of high impedance faults. | 2 |
| Lec 13 | Decision making process, decision regions and borders, deterministic and probabilistic decision making methods. | 2 |
| Lec 14 | Adaptive control and protection systems, multi-criteria systems, integrated measurement, control and protection systems. | 2 |
| Lec 15 | Wide area measurements for power system protection and control. | 2 |
| | Total hours: | **30** |

| **Project** | | **Number of hours:** |
|---|---|---|
| Proj 1 | Introduction. Setting rules of course crediting. Acquaintance with lab stands and available software. | 2 |
| Proj 2 | Design and evaluation of signal pre-processing and A/D conversion units. | 4 |
| Proj 3 | Synthesis and analysis of digital IIR and FIR filters. | 4 |
| Proj 4 | Quality evaluation of selected methods of digital estimation of signal magnitude. | 4 |
| Proj 5 | Assessment of digital algorithms for power and impedance components measurement. | 4 |
| Proj 6 | Evaluation of digital algorithms for frequency measurement. | 2 |
| Proj 7 | Analysis of digital algorithms for symmetrical components extraction. | 2 |
| Proj 8 | Design and evaluation of adaptive algorithms for measurement of selected protection criteria. | 4 |
| Proj 9 | Evaluation of selected methods and algorithms of decision making. | 2 |
| Proj 10 | Reserve date, accounting for the executed projects. | 2 |
| | Total hours: | **30** |

**TEACHING TOOLS USED**

N1. Informative lecture.
N2. Matlab and ATP-EMTP programmes.
N3. Project presentation.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Participation in the course. |
| F2(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Final examination. |
| P(W) | P = 0,1F1 + 0,9F2 | |
| F1(P) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Activity during the classes. |
| F2(P) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Presentation of the project done. |
| P(P) | P = 0,2F1 + 0,8F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] Rebizant W., Szafran J., Wiszniewski A., Digital signal processing in power system protection and control, Springer, London 2011.
[2] Rebizant W., Wiszniewski A., Digital signal processing for protection and control, Skrypt PWr, Wrocław 2011
[3] Ungrad H., Winkler W., Wiszniewski A., Protection techniques in electrical energy systems, Marcel Dekker Inc. New York, Basel, Hong Kong 1995
[4] Jackson L.B., Digital filters and signal processing, Kluwer Academic Publishers, Boston 2002.

**SECONDARY LITERATURE:**

[1] Szafran J., Wiszniewski A., „Algorytmy pomiarowe i decyzyjne cyfrowej automatyki elektroenergetycznej", WNT, Warszawa 2001
[2] Winkler W., Wiszniewski A, „Automatyka zabezpieczeniowa w systemach elektroenergetycznych", WNT, Warszawa 2004
[3] Wiszniewski A., „Algorytmy pomiarów cyfrowych w automatyce elektroenergetycznej", WNT, Warszawa 1990

## SUBJECT SUPERVISOR

Waldemar Rebizant, waldemar.rebizant@pwr.edu.pl

Zał. nr 5 do ZW 16/2020

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Techniki sztucznej inteligencji** |
| Name of subject in English: | **Artificial Intelligence Techniques** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2135 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | 15 | |
| Number of hours of total student workload (CNPS): | 60 | | | 30 | |
| Form of crediting: | crediting with grade | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | 1 | |
| including number of ECTS points for practical (P) classes : | | | | 1 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | 0.70 | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of basics of power system control, digital signal processing and numerical methods
2. Practical skills of using MATLAB and ATP-EMTP software

### SUBJECT OBJECTIVES

C1. Acquaintance of knowledge related artificial intelligence techniques application to digital power system protection and control systems

C2. Acquiring practical skills to design and analyze control and protection units for power systems, with application of artificial intelligence techniques

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Possesses knowledge related to expert systems: basic features, structure, inference methods, conflict resolution strategies, application fields.

PEU_W02 Possesses knowledge related to fuzzy logic systems: fuzzy signals, membership functions, fuzzy settings, fuzzyfication and defuzzyfication methods, realization of multi-criteria algorithms.

PEU_W03 Possesses knowledge related to artificial neural networks (features, neurone types, activation functions, neural network structures, learning methods, application fields) as well as genetic algorithms (evolutionary strategies, genetic modifications).

*relating to skills:*

PEU_U01 Is able to apply expert systems for power system control and protection purposes.

PEU_U02 Is able to apply fuzzy logic technique for power system control and protection purposes.

PEU_U03 Is able to apply artificial neural networks as well as genetic algorithms for power system control and protection purposes.

*relating to social competences:*

PEU_K01 Is able to carry out a complex engineering project in a competent way, unaided, undertaking multi-criterial analysis.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Setting rules of course crediting. Definition of artificial intelligence (AI), AI as a branch of science, AI techniques in power systems, statistics of AI application in power system protection and control. | 2 |
| Lec 2 | AI approach to protection and control tasks – problems of contemporary digital protection systems, protection relay as a classifying unit, protection tasks as pattern recognition tasks. | 2 |
| Lec 3 | Expert Systems (ES) – definitions, knowledge base, data base, inference mechanisms. | 2 |
| Lec 4 | ES – semantic rules and structures, acquisition of rules, inference methods, conflict resolving strategies. | 2 |
| Lec 5 | Expert Systems – application fields, examples. | 2 |
| Lec 6 | Fuzzy Logic (FL) – basics of fuzzy sets theory, operations on fuzzy sets, fuzzy arithmetic. Linguistic variables, operators of aggregation, fuzzy reasoning. | 2 |
| Lec 7 | Elements of FL in power system protection – fuzzy criteria signals, fuzzy settings, fuzzy comparison, amount of information, multi-criterial decision making. | 2 |
| Lec 8 | Examples of FL technique application in power system protection. | 2 |
| Lec 9 | Artificial Neural Networks (ANN) – neurone models, activation functions, multilayer perceptrons, feed-forward networks. | 2 |
| Lec 10 | ANN architectures: feed-forward networks, ANNs with feedback connections, Hopfield networks, Kohonen networks. | 2 |
| Lec 11 | ANN design problems – network structure selection, generation of training patterns, training algorithms with and without the teacher, learning process acceleration techniques, knowledge generalisation vs. overfitting. | 2 |
| Lec 12 | Examples of ANN application in power system control. | 2 |
| Lec 13 | Genetic algorithms – evolutionary strategies, genetic modification of individuals, genetic optimisation, application examples. | 2 |
| Lec 14 | Comparison of described AI techniques, hybrid structures, examples. | 2 |
| Lec 15 | Crediting test. | 2 |
| | Total hours: | **30** |

| **Project** | | **Number of hours:** |
|---|---|---|
| Proj 1 | Design and implementation of an expert system for chosen decision task. | 4 |
| Proj 2 | Design and evaluation of the fuzzy logic based measurement/decision unit. | 4 |
| Proj 3 | Design and evaluation of the neural network based measurement/decision unit. | 4 |
| Proj 4 | Implementation of genetic optimization procedures for selected measurement/decision task. | 2 |
| Proj 5 | Presentations of executed projects, crediting. | 1 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Informative lecture.
N2. Matlab and ATP-EMTP programmes.
N3. Project presentation.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01 PEU_W02 PEU_W03 | Participation in the course. |
| F2(W) | PEU_W01 PEU_W02 PEU_W03 | Final colloquium/test. |
| P(W) | P = 0,1F1 + 0,9F2 | |
| F1(P) | PEU_U01 PEU_U02 PEU_U03 PEU_K01 | Activity during the classes. |
| F2(P) | PEU_U01 PEU_U02 PEU_U03 PEU_K01 | Presentation of the projects done. |
| P(P) | P = 0,2F1 + 0,8F2 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] Rebizant W., Szafran J., Wiszniewski A., Digital signal processing in power system protection and control, Springer, London 2011
[2] Russel S.J., Norvig P., Artificial intelligence: a modern approach, Prentice Hall, Pearson, 2010
[3] James J. Buckley, Esfandiar Eslami, An introduction to fuzzy logic and fuzzy sets, Heidelberg Physica-Verlag, 2002
[4] Dillon T.S. and Niebur D. (edited by), Neural Network Applications in Power Systems, CRL Publishing Ltd., London 1996
[5] Liebowitz J., The Handbook of applied expert systems, Boca Raton, CRC Press, 1998

**SECONDARY LITERATURE:**

[1] Gottlob G. And Nejdl W. (ed. by), Expert Systems in Engineering: Principles and Applications, Proceedings of the International Workshop, Vienna, Austria, Sept. 1990
[2] Cichocki A., Unbehauen R., Neural Networks for Optimization and Signal Processing, John Wiley & Sons, 1993
[3] Yager R.R. and Filev D.P., Essentials of Fuzzy Modelling and Control, J. Wiley & Sons, Inc., New York, USA, 1994
[4] Ringland G.A. and Duce D.A. (ed. By), Approaches to Knowledge Representation: An Introduction, Research Studies Press Ltd., Wiley & Sons, Chichester, England, 1988
[5] Pao Y.A., Adaptive Pattern Recognition and Neural Networks, Addison-Wesley, Reading, MA, 1989


## SUBJECT SUPERVISOR


Waldemar Rebizant, waldemar.rebizant@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Projektowanie układów logicznych** |
| Name of subject in English: | **Design of logic circuits** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM2136 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. To be familiar with fundamentals of digital circuits.
2. To know how to practically interconnect simple digital circuits and verify their operation.
3. To be able to think and act in a creative way.
4. To be able to work in a team.

## SUBJECT OBJECTIVES

C1. Gaining theoretical and practical knowledge on combinatorial logic circuits: canonical form, Karnaugh maps method, phenomenon of hazards.
C2. Gaining theoretical and practical knowledge on sequential logic circuits: the method of consecutive switching tables, Moore and Mealy type automata, races phenomenon.
C3. Familiarization with methods concerning: presenting a logic circuit operation, selecting of design methods, practical analysis/synthesis methods and ways of implementing logic circuits.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has knowledge on operation, analysis and synthesis methods of combinatorial logic circuits.
PEU_W02 Has knowledge on operation, analysis and synthesis methods of sequential logic circuits.

*relating to skills:*

PEU_U01 Is able to conduct both analysis and synthesis, as well as to implement combinatorial logic circuits with use of the Karnaugh maps method, with eliminating a hazard phenomenon.
PEU_U02 Student is able to conduct both analysis and synthesis, as well as to implement asynchronous logic circuits with use of the method of consecutive switching tables, in particular Moore and Mealy types, with eliminating of races phenomenon.
PEU_U03 Student is able to conduct both analysis and synthesis, as well as to implement synchronous logic circuits.

*relating to social competences:*

PEU_K01 Student is able to act independently and cooperate within a group working on a complex engineering project.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Conditions for passing and marking the course. Basics of Boole algebra. Typical logic gates and circuits and their graphic symbols. | 2 |
| Lec 2 | Design of combinatorial logic circuits. | 2 |
| Lec 3 | Sequential automata – types, general characteristic, design principles. | 2 |
| Lec 4 | Design of sequential automata with the method of consecutive switching tables. | 2 |
| Lec 5 | Sequential automata – description of Moore and Mealy type automata. | 2 |
| Lec 6 | Sequential automata – design steps. | 2 |
| Lec 7 | Implementation of asynchronous sequential automata, elimination of races phenomenon and hazards. | 2 |
| Lec 8 | Pass test. | 1 |
| | Total hours: | **15** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Presentation of health and safety rules, and general regulations of the laboratory. Conditions for passing and marking the course. General familiarization with the laboratory stands and simulative software. | 2 |
| Lab 2 | Design of asynchronous sequential logic circuits with use of the transition tables and output maps. Implementation of circuits with use of logic gates - part 1. | 2 |
| Lab 3 | Design of asynchronous sequential logic circuits with use of the transition tables and output maps. Implementation of circuits with use of logic gates - part 2. | 2 |
| Lab 4 | Design of asynchronous sequential logic circuits with use of the transition tables and output maps. Implementation of circuits with use of flip-flops. | 2 |
| Lab 5 | Design of asynchronous sequential logic circuits with the method of consecutive switching tables. | 2 |
| Lab 6 | Multiplexers, de-multiplexers and code conversion circuits, adders, subtractors, comparators, counters and memory registers - investigation of selected circuit. | 2 |
| Lab 7 | Design of synchronous sequential logic circuits. | 2 |
| Lab 8 | Summary of laboratory excercises. | 1 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Informative lecture.
N2. Didactic models of digital circuits.
N3. Programmme for simulating digital circuits.
N4. Report on performed laboratory excercise.
N5. Student's own work.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester)* *P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | Presence at the lectures |
| F2(W) | PEU_W01<br>PEU_W02 | Crediting test |
| P(W) | P=0,1F1+0,9F2 | |
| F1(L) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Activity at the laboratory |
| F2(L) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Reports from the laboratory assigenements |
| P(L) | P=0,3F1+0,7F2 | |

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE:**<br>[1] Mano M. Morris, Digital design (second edition), Prentice-Hall Int., Inc., Englewood Cliffs, New Jersey, 1991.<br>[2] M. Morris Mano, C. R. Kime: Logic and computer design fundamentals, Pearson Prentice-hall Int., 2004, 3rd ed.<br>[3] Tocci R.J., Digital Systems. Principles and applications, Prentice-Hall Int., Inc., London, 1988.<br>**SECONDARY LITERATURE:**<br>[1] Układy logiczne. Ćwiczenia laboratoryjne. Skrypt Politechniki Wrocławskiej pod red. Mirosława Łukowicza. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław, 2002<br>[2] Wilkinson B., Układy cyfrowe. WKŁ, Warszawa, 2000<br>[3] Skorupski A., Podstawy techniki cyfrowej. WKŁ, Warszawa, 2001<br>[4] Kamionka-Mikuła H., Małysiak H., Pochopień B., Układy cyfrowe. Teoria i przykłady. Wydawnictwo Pracowni Komputerowej Jacka Skalmierskiego. Wydanie III poszerzone. Gliwice 2001. |

| SUBJECT SUPERVISOR |
|---|
| Justyna Herlender, justyna.herlender@pwr.edu.pl |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Elektroenergetyka-zajęcia terenowe** |
| Name of subject in English: | **Electrical Power Engineering – excursionary activities** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM2138 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | 15 |
| Number of hours of total student workload (CNPS): | 60 | | | | 30 |
| Form of crediting: | crediting with grade | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | | 0.70 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. The student has ordered theoretical knowledge necessary to develop a detailed topic in the broadly understood power system and control systems area.
2. Can properly apply the knowledge learned to prepare an article and a multimedia presentation.
3. Can cooperate in an international group.

## SUBJECT OBJECTIVES

C1. Extension and transplantation of knowledge in the field of electrical power engineering in the context of industrial practice.
C2. Expansion of skills to develop independently and present selected topics in power engineering.
C3. Acquisition of skills related to active participation in the discussion on presented of results.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 He knows about methods of control of RES systems, in particular those related to real industrial objects.

PEU_W02 He knows about algorithms of control of RES systems, in particular those related to real industrial objects.

*relating to skills:*

PEU_U01 He can independently characterize and evaluate the utility values of basic RES systems in relation to the problems of functioning in the electric power system.

PEU_U02 He can evaluate the importance of RES control systems for cooperation with the power network.

*relating to social competences:*

PEU_K01 He can translate general principles and values of academic community into practical attitudes and behaviours during the international educational trip.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Principles of work and credit. Papers characteristics. | 2 |
| Lec 2 | Characteristics of RES objects - in relation to visited industrial objects (field activities) part.1. | 2 |
| Lec 3 | Characteristics of RES objects - in relation to visited industrial objects (field activities) part.2. | 2 |
| Lec 4 | Methods of control of RES objects - in relation to visited industrial objects (field activities) part 1. | 2 |
| Lec 5 | Methods of control of RES objects - in relation to visited industrial objects (field activities) part 2. | 2 |
| Lec 6 | Practical restrictions on the control of RES objects - in relation to visited industrial objects (field activities) part.1. | 2 |
| Lec 7 | Practical restrictions on the control of RES objects - in relation to visited industrial objects (field activities) part.2. | 2 |
| Lec 8 | Summary. Discussion of the results of written assignments. | 1 |
| | Total hours: | **15** |

| **Seminar** | | **Number of hours:** |
|---|---|---|
| Sem 1 | Requirements, individual subjects, nature of work, division into groups, conditions of credit. | 2 |
| Sem 2 | Se2-8. Presentation of the performed analysis for a given problem in the field of power engineering. | 13 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Field courses in industry, power plants, etc. and a seminar using multimedia presentations.
N2. Substantive discussion on the presented issues.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01 PEU_W02 | Evaluation of the article / written report (distinguished works recommended to KNS) |
| P(W) | P=F1 | |
| F1(S) | PEU_U01 PEU_U02 PEU_K01 | Evaluation of multimedia presentation. |
| F2(S) | PEU_U01 PEU_U02 PEU_K01 | Active participation in the didactic trip related to power engineering. |
| P(S) | P=0.7*F1+0.3*F2 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] Ehrlich, Robert (1938- ). Renewable energy : a first course / Boca Raton [etc.] : CRC Press/Taylor & Francis Group, cop. 2013
[2] Goodstal, Gary. Electrical theory for renewable energy Clifton Park : Delmar Cengage Learning, cop. 2013
[3] Thomashow, Mitchell. The nine elements of a sustainable campus / Cambridge, Mass. London, The MIT Press, cop. 2014

**SECONDARY LITERATURE:**

[1] Literature related directly to the individual subject of student work.

**SUBJECT SUPERVISOR**

Przemysław Janik, przemyslaw.janik@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Obliczenia zwarciowe** |
| Name of subject in English: | **Fault Calculations** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2139 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 30 | |
| Number of hours of total student workload (CNPS): | | | | 60 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 2 | |
| including number of ECTS points for practical (P) classes : | | | | 2 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 1.40 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has basic knowledge on power system operation.
2. Has basic knowledge on programming in Matlab.
3. Is able to state and verify simple calculation algorithms.
4. Is able to think and act in a creative way.
5. Is able to work in a team.

## SUBJECT OBJECTIVES

C1. Gaining knowledge on power system faults.
C2. Familiarization with methods for analysis of fault signals and fault identification.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 Is able to analyse fault signals obtained from computer simulation.
PEU_U02 Is able to conduct fault identification and to determine its characteristic features.

*relating to social competences:*

PEU_K01 Is able to act independently and cooperate within a group working on a complex engineering project.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Project** | | **Number of hours:** |
| Proj 1 | Presentation of health and safety rules and general regulations of the laboratory. Establishing conditions for passing and marking the project course. Introduction - aim and contents of the projects to be performed. | 2 |
| Proj 2 | Familiarization with loading the simulation data from ATP-EMTP simulation into the Matlab programme and visualisation of the signals. | 2 |
| Proj 3 | Digital filtering of fault signals from ATP-EMTP simulation. | 2 |
| Proj 4 | Digital algorithms for fault detection. | 2 |
| Proj 5 | Digital algorithm for fault direction discrimination. | 2 |
| Proj 6 | Digital algorithm for fault classification - part 1. | 2 |
| Proj 7 | Digital algorithm for fault classification - part 2. | 2 |
| Proj 8 | Distance protection - digital measurement of fault-loop impedance and reflection of MHO decision characteristic - part 1. | 2 |
| Proj 9 | Distance protection - digital measurement of fault-loop impedance and reflection of MHO decision characteristic - part 2. | 2 |
| Proj 10 | One-end fault location - the sample solution applied in modern protection terminal for power line - part 1. | 2 |
| Proj 11 | One-end fault location - the sample solution applied in modern protection terminal for power line - part 2. | 2 |
| Proj 12 | Fault location on power line with use of measurements of voltage and current from both line ends - part 1. | 2 |
| Proj 13 | Fault location on power line with use of measurements of voltage and current from both line ends - part 2. | 2 |
| Proj 14 | Calculation of fault currents in a given faulted network. | 2 |
| Proj 15 | Summary and description of the performer projects. | 2 |
| | Total hours: | **30** |

| TEACHING TOOLS USED |
|---|
| N1. Matlab software.<br>N2. Report on performed project.<br>N3. Student's own work. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(P) | PEU_U01<br>PEU_U02<br>PEU_K01 | Activity at the project classes |
| F1(P) | PEU_U01<br>PEU_U02<br>PEU_K01 | Marks from reports on the completed projects |
| P(P) | P=0,3F1+0,7F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Iżykowski J., Power system faults. PRINTPAP, 2011, p. 190.


**SECONDARY LITERATURE:**


[1] Glover J. D., Sarma M., Power system analysis and design. PWS Publishing Company Boston, second edition, 1994.
[2] Michalik M., Rosołowski E., Simulation and analysis of power system transients. PRINTPAP, 2011.
[3] Saha M.M., Iżykowski J., Rosołowski E., Fault location on power networks. Springer-Verlag London, Series: Power Systems, 2010, 425 p.


## SUBJECT SUPERVISOR


Jan Iżykowski, jan.izykowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Czujniki i komunikacja światłowodowa** |
| Name of subject in English: | **Fiber Optics Communications and Sensors** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2140 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 30 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Student has structured and theoretically formed knowledge necessary to understand phenomena related to fiber optics and communications
2. Student has a basics knowledge on electromagnetic field theory
3. Is able to select properly, to connect as well as to coordinable performance of elements and fiber sensors in measuring transmission networks
4. Is able to perform properly and effectively basic research on operation parameters of both active and passive optoelectronic elements
5. Is able to conduct work in a team and understands the need for continuous education

### SUBJECT OBJECTIVES

C1. Acquaintance of student with basic knowledge necessary to understand physical phenomena related to optoelectronic transmission of signals

C2. Acquaintance of student with modern structures of optoelectronic elements as well as with ways of processing and data transmission in optical networks

C3. Creation of skills and ability to create modern technique methods and measuring tools to test and design fiber optics communication networks

C4. The acquisition of practical knowledge and skills to apply and to complete fiber optics circuits carrying out measurements and preparation of test protocols

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Knows structure and specifics of optical path work

PEU_W02 Has knowledge about optical phenomenon and optical elements dedicated for optical transmission

*relating to skills:*

PEU_U01 Is able to precise purpose and scope of research, project measurement circuit and select measurement equipment

PEU_U02 Is able to elaborate results and determine conclusions if about fiber guide condition

*relating to social competences:*

PEU_K01 Is conscious about responsibility for his own work and is willing to acknowledge teamwork rules

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Acquaintance with the subject, its program and the requirements of completion | 2 |
| Lec 2 | Principles of wave theory of light propagation | 2 |
| Lec 3 | Dielectric light guides, properties, basic parameters, fabrication | 2 |
| Lec 4 | Problems of effective propagation of the light wave in fiber guides | 2 |
| Lec 5 | Mechanisms of power losses in fiber guides: dispersion, refraction | 2 |
| Lec 6 | Properties, classifications and operational parameters of the fiber guides | 2 |
| Lec 7 | Light-emitting diodes (LED) as the light-wave source | 2 |
| Lec 8 | Laser diodes (LD) as the light-wave source | 2 |
| Lec 9 | Photodiodes, phototransistors and photoresistors in detection systems of the light-wave | 2 |
| Lec 10 | Splices and optical connectors | 2 |
| Lec 11 | Auxiliary, passive elements in fiber-optics networks and systems | 2 |
| Lec 12 | Expanding optical system capacity by multiplexing | 2 |
| Lec 13 | Digital and analog modulation of optical signals | 2 |
| Lec 14 | Optical phenomena employed in fiber sensors | 2 |
| Lec 15 | Completion quiz | 2 |
| | Total hours: | **30** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Introduction to the rules of safety (BHP) and to internal regulations applicable in the lab. Determination of completion criteria. General learning in the lab. Stands and acquaintance with physical models of optical and optoelectronics elements as well as with performance criteria | 2 |
| Lab 2 | Measurement of attentuation of a multisegment fiber optics transmission system | 2 |
| Lab 3 | Attenuation measurement of optical fiber guides | 2 |
| Lab 4 | Testing of optical polarizer | 2 |
| Lab 5 | Investigation of radiation angular characteristics of semiconductor lasers | 2 |
| Lab 6 | Investigation of output spectrum and light-current characteristics of optical light source | 2 |
| Lab 7 | Investigation of matching efficiency of optical connectors | 2 |
| Lab 8 | Communication in BPL smart meters model (TCP/IP) | 2 |
| Lab 9 | Communication in PLC smart meters model (PRIME) | 2 |
| Lab 10 | Communication between devices using the MODBUS protocol (RS485) | 2 |
| Lab 11 | Local Power Protection Operator - local point of the Control and Supervision System (SCADA) | 2 |
| Lab 12 | GOOSE communication - IEC61850 compliant communication - Part I | 2 |
| Lab 13 | MMS communication - introduction to IEC61850 compliant communication - part II | 2 |
| Lab 14 | Access Gateway - communication (using DNP3 protocol) with remote monitoring center | 2 |
| Lab 15 | Completion and arrears exercises | 2 |
| | Total hours: | **30** |

**TEACHING TOOLS USED**

N1. Lecture with the use audiovisual techniques multimedia presentations, transparencies

N2. Laboratory measurements on physical models of the fiber optic elements and using PSP devices, conducted in the traditional manual in the groups

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | Oral or written completion test |
| P(W) | P=F1 | |
| F1(L) | PEU_U01 | Checking and assessment of preparation for lab exercises |
| F2(L) | PEU_U02 | Evaluation of reports of performed exercises |
| P(L) | P=0,3F1+0,7F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


Chai Yeh, Hanbook of Fiber Optics – Theory and Applications, Academic Press. Inc, London 1990.
Hornet J.L., Optical Signal Processing, Academic Press, Inc. London 1990.
Winkler W., Wiszniewski A., Automatyka zabezpieczeniowa w systemach elektroenergetycznych, WNT, Warszawa 2004.
Handbook of Optics Volume I-V, Mc Graw Hill Companies Inc.,Third Edition, USA 2010


**SECONDARY LITERATURE:**


Gagliardi R.M., Karp S., Optical Communications, Willey-int.Pub.
CIGRE Working Group 35.04, optical Cable Selection fo Electricity Utilities, Febr. 2001


## SUBJECT SUPERVISOR


Grzegorz Wiśniewski, grzegorz.wisniewski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Elektroenergetyczna Automatyka Zabezpieczeniowa** |
| Name of subject in English: | **Power System Protection** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2231 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 30 | | |
| Number of hours of total student workload (CNPS): | 90 | | 60 | | |
| Form of crediting: | examination | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | | 2 | | |
| including number of ECTS points for practical (P) classes : | | | 2 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | | 1.40 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Student has structured and theoretically founded knowledge necessary to understand the purpose and tasks of modern power system protection
2. Student has a basic understanding of the criteria and methods of protection and automation solutions to the basic components of the power system
3. Is able to select setting as well as to connect and coordinate the work of one – and many inputs measuring relays in power protections
4. Is able to perform properly and effectively basic research as well as field tests of digital and analog measuring executive units of protection
5. Is able to conduct work in a team and understands the need for continuous education

## SUBJECT OBJECTIVES

C1. Acquaintance of a student with modern solutions of power system protections
C2. The acquisition of practical knowledge and skills for setting the criteria quantities to protect electric machines, devices and power networks
C3. Creation of skills and ability to use modern methods, techniques and measurement tools for testing relays and protection systems
C4. The acquisition of practical knowledge and skills related to completion of circuits of power system automation, carrying out measurements and preparation of test protocols

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 student has structured and theoretically founded knowledge necessary to understand the purpose and tasks of modern protection and restitution automation for low – and middle voltage power networks

PEU_W02 Has structured and theoretically founded knowledge necessary to selection of operation criteria of protection and restitution automation for low and middle voltage networks as well as to ways of solution for fundamental elements of electric power system (generators, transformers, motors, power lines)

*relating to skills:*

PEU_U01 Can handle the protections tester. Is able to link protection with current and voltage measuring circuits as well as with these for ground faults and control in MV-line models

PEU_U02 Can select and perform setting of triping values for MV and LV protection

PEU_U03 Is able to evaluate the characteristics of basic criteria for operation of protection of electric power objects

*relating to social competences:*

PEU_K01 He has a sense of responsibility for him own work and a willingness to comply with the principles of teamwork

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Acquaintance with the subject the requirements of completion, principles of power system protection and basic definitions | 2 |
| Lec 2 | Relays and relaying systems, new generation of digital relays, the trend in progress | 2 |
| Lec 3 | Converters of measuring quantities, measuring current and voltage transformers | 2 |
| Lec 4 | Filters of symmetrical components | 2 |
| Lec 5 | Fault detection criteria in machines and electrical equipment | 2 |
| Lec 6 | Methodology for setting of input parameters for simple one-input relay systems | 2 |
| Lec 7 | Fault detection criteria in electric power networks | 2 |
| Lec 8 | Ways of setting of multi-input relay systems (directional, differential and distance protection) | 2 |
| Lec 9 | Protection of synchronous and asynchronous generators | 2 |
| Lec 10 | Protection of MV and LV power transformers | 2 |
| Lec 11 | Protection of MV and LV electric motors of high power | 2 |
| Lec 12 | Disturbances in transmission and distribution el. power networks | 2 |
| Lec 13 | Distribution MV and LV power network protections | 2 |
| Lec 14 | Protection of HV and MV transmission power networks | 2 |
| Lec 15 | The objectives and operation principles of preventive and restitution automation | 2 |
| | Total hours: | **30** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Introduction to the rules of safety and to internal procedure applicable in the lab. Determination of completion criteria. Presentation of the lab stands and acquaintance with physical models of protections as well as with performance criteria | 3 |
| Lab 2 | Examinations of zero sequence current filters | 3 |
| Lab 3 | Investigation of protection of inverse (dependent) time characteristics | 3 |
| Lab 4 | Examination of AC motor protection | 3 |
| Lab 5 | Examination of distance protection | 3 |
| Lab 6 | Examination of automatic restoration system | 3 |
| Lab 7 | Examination of auto-reclosing unit | 3 |
| Lab 8 | Examination of differential protection of the power networks | 3 |
| Lab 9 | Examination of generator protection | 3 |
| Lab 10 | Completion and arrears exercises | 3 |
| | Total hours: | **30** |

| TEACHING TOOLS USED |
|---|
| N1. Lecture with the use of audiovisual techniques, multimedia presentations, transparencies |
| N2. Laboratory testing conducted in the traditional manner in students group |
| N3. A report of the measurements |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | Oral and written exam |
| P(W) | P=F1 | |
| F1(L) | PEU_U01<br>PEU_U02<br>PEU_U03 | Checking and assessment of preparation for lab exercises |
| F2(L) | PEU_U01<br>PEU_U02<br>PEU_U03 | Evaluation of reports performer exercises |
| P(L) | P=0,4F1+0,6F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

Horowitz S.H., Phadke A.G., Power System Relaying, RSP England, 1992.
Ungrad H., Winkler W., Wiszniewski A., Protection Techniques in Electrical Energy Systems, Marcel Dekker Inc., New York, 1995.
Winkler W., Wiszniewski A., Automatyka zabezpieczeniowa w systemach elektroenergetycznych, WNT, Warszawa 2004.
Synal B., Elektroenergetyczna automatyka zabezpieczeniowa : podstawy, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2003.
Praca zbiorowa por red. B. Synala, Automatyka Elektroenergetyczna, ćwiczenia laboratoryjne cz.I : Przetworniki sygnałów pomiarowych i przekaźniki automatyki zabezpieczeniowej, cz.II : Układy automatyki zabezpieczeniowej i regulacyjnej, Skrypt Politechniki Wrocławskiej, Wrocław 1991.

**SECONDARY LITERATURE:**

Wróblewski J., Zespoły elektroenergetycznej automatyki zabezpieczeniowej : zasady budowy, WNT, Warszawa 1993.
Wiszniewski A., Algorytmy pomiarów cyfrowych w automatyce elektroenergetycznej, WNT,Warszawa 1990

## SUBJECT SUPERVISOR

Grzegorz Wiśniewski, grzegorz.wisniewski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Automatyka i bezpieczeństwo systemu elektroenergetycznego** |
| Name of subject in English: | **Power System Automation and Security** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2233 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | | 15 |
| Number of hours of total student workload (CNPS): | 90 | | | | 30 |
| Form of crediting: | examination | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | | | | 0.70 |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. 1. Student has structured and theoretically founded knowledge necessary to understand phenomena associated with transient states under disturbances in networks and electrical machines
2. Has a basic knowledge on electric power protection
3. Is able to analyze properly selection joining and coordination of performance of elements and units of preventing and restitution automation
4. Is able to interpret the operation risk of electric power system and decide on selection of appropriate remedy
5. Is able to conduct work in a team and understands the need for continuous education

### SUBJECT OBJECTIVES

C1. Acquaintance of a student with basic knowledge needed to understand physical phenomena associated with transient states under disturbances in networks and electric machinery

C2. Acquaintance with modern solutions of preventive and restitution automation with use of advanced digital techniques of data processing and transformation

C3. Creation of skills and ability to recognition and ability to recognition and interpretation of risks arising from transient states under disturbances

C4. The acquisition of a knowledge related to modern trends in control and safe management of supply and distribution of electric energy

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has detailed knowledge on methods of solution of safe control of automated electric power systems

PEU_W02 Is able to decide on effective way to use elements of power restitution automation

*relating to skills:*

PEU_U01 Able to obtain information from the literature and database on selected problems in the field of reliability, safety and modern concept of solutions of power systems protection

PEU_U02 Able to formulate conclusion drawn from analysis of a selected power network concerning safe central and operation of automated electrical power systems

*relating to social competences:*

PEU_K01 He has a sense of responsibility for his work and a willingness to comply with the principles of teamwork

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Acquaintance with the subject its program | 2 |
| Lec 2 | Switching and auxiliary as contact as well as contactless units in automation, classification, parameters and category of utilizations, electrical and mechanical endurance | 2 |
| Lec 3 | Reed relays and sensors, structure principle of operation, switching properties and application considerations | 2 |
| Lec 4 | Advanced current converters for digital protections (Hall sensor, Rogowski coils etc) | 2 |
| Lec 5 | Security problems in MV network with no effective earthing under a single phase grounding | 2 |
| Lec 6 | Overvoltage protection in power system, external and internal threats, resonance phenomena | 2 |
| Lec 7 | Power line carrier system (PLC) for central, management and data distribution in electric power networks | 2 |
| Lec 8 | Coordinated central: automatic restoration, auto reclosing and load shedding in electric power system | 2 |
| Lec 9 | Wide Area Protection System – application fields, GPS synchronization of measurements | 2 |
| Lec 10 | Substation automation and integration – cooperation with SCADA system | 2 |
| Lec 11 | Modern trends in substation automation – application of intelligent electric devices, internet – based solutions | 2 |
| Lec 12 | Blackouts – reasons of wide area developing faults | 2 |
| Lec 13 | Voltage and angle stability monitoring – PMU | 2 |
| Lec 14 | Adaptive protection system | 2 |
| Lec 15 | Summary and discussion of the final examination | 2 |
| | Total hours: | **30** |

| **Seminar** | | **Number of hours:** |
|---|---|---|
| Sem 1 | Acquaintance with program, requirements and way of completion, selection of problems itself | 1 |
| Sem 2 | Individual tasks and projects for presentation of selected problems related to reliability, safe operation and modern solutions and concepts of automated electric power systems | 14 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Lecture with use of audiovisual techniques, multimedia presentation, transparences
N2. Seminar with use of audiovisual techniques, multimedia presentation, transparences
N3. Problem discussion, consultation

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01 PEU_W02 | Oral or written exam |
| P(W) | P=F1 | |
| F1(S) | PEU_U01 PEU_U02 | Assessment of individual presentation and students ability |
| F2(S) | PEU_U01 PEU_U02 | Assessment of student activities under seminar |
| P(S) | P = 0,7F1 + 0,3F2 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

KTV Grattan, Sensors technology, Systems and Applications, A.Hilger IOP Publishing Ltd.1991
Power System Protection Vol.4 : Digital Protection and Signaling, Short Run Press Ltd. Exeter 1997
Ungrad H., Winkler W., Wiszniewski A., Protection Techniques in Electrical Energy Systems, Marcel Dekker Inc., New York 19

**SECONDARY LITERATURE:**

Wybrane artykuły publikowane w renomowanych czasopismach światowych

**SUBJECT SUPERVISOR**

Grzegorz Wiśniewski, grzegorz.wisniewski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **PLC oraz bezprzewodowa komunikacja dla potrzeb monitoringu i pomiarów** |
| Name of subject in English: | **PLC and Wireless Communications for Monitoring and Metering** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM2234 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | | 15 |
| Number of hours of total student workload (CNPS): | 90 | | | | 30 |
| Form of crediting: | examination | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | | | | 0.70 |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Student has structured and theoretically founded knowledge necessary to understand phenomena related with as wire as well as wireless processing and transmission
2. Has a basic knowledge on electromagnetic field theory
3. Is able to apply properly knowledge of modern physics to analyze the efficiency of operation of communication systems employed in monitoring and metering
4. Is able to exploit properly common rules and laws of physics to the qualitative and quantitative analysis of an engineering issues
5. Able to conduct work in a team and understands the need for continuous education

### SUBJECT OBJECTIVES

C1. Acquaintance with basic knowledge necessary to understand phenomena accompanying both wire and wireless transmission of analog and digital signals
C2. Acquaintance with opportunities to use PLC technique and wire communication in monitoring and metering
C3. Creation of skills and ability to use PLC and wireless communication for monitoring and metering in automated electric power systems
C4. The acquisition of a knowledge related on current trends in signal transmission technology for industrial applications

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has knowledge on physical basis of operation, implementation and use of PLC technology

PEU_W02 Has knowledge on physical basis of operation, implementation and use of both wire and wireless telecommunication technology

*relating to skills:*

PEU_U01 Able to extract information from literature and database on selected problem in field of reliability of PLC technology and/or wireless telecommunication for selected monitoring and metering systems

PEU_U02 Has the ability of analyzing the results and formulating conclusions, as well as preparation and delivering presentation

*relating to social competences:*

PEU_K01 Has a sense of responsibility for his own work and willingness to comply with the principles of teamwork

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Acquaintance with the subject and requirements of completion | 2 |
| Lec 2 | PLC and wireless telecommunication tasks, basic functions | 2 |
| Lec 3 | Standardization of PLC technology – advantages and disadvantages | 2 |
| Lec 4 | Architecture of electric network, modeling of electric devices, layered architecture OSI | 2 |
| Lec 5 | Transmission channel functionality, synchronization, frame control, management, frame priorities | 2 |
| Lec 6 | Overview of network security issues | 2 |
| Lec 7 | Network mode functionality, master-slave, peer-to-peer, centralized | 2 |
| Lec 8 | Areas of application, voice, video, multimedia, equipment for different modems, PLC modems | 2 |
| Lec 9 | Coupling problems; transformers and metering devices | 2 |
| Lec 10 | Choice of transmission cabling | 2 |
| Lec 11 | Application problems of selected sensors | 2 |
| Lec 12 | Control of environment conditions and automated meter reading | 2 |
| Lec 13 | Architecture of LAN and WAN wireless networks, advantages and disadvantages | 2 |
| Lec 14 | Architecture of LAN and WAN wire networks, advantages and disadvantages | 2 |
| Lec 15 | Repetition and discussion of exam issues | 2 |
| | Total hours: | **30** |

| **Seminar** | | **Number of hours:** |
|---|---|---|
| Sem 1 | Acquaintance with program, requirements and way of completion | 1 |
| Sem 2 | Individual projects and presentations (with use of audiovisual techniques) on application of PLC and telecommunication networks | 14 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Lecture with use of audiovisual techniques, multimedia presentation, transparences.
N2. Seminar with use of audiovisual techniques, multimedia presentation, transparences
N3. Discussion on presented material

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_K01 | Written exam |
| P(W) | P=F1 | |
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Individual performance evaluation |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Assesment of student activities during seminar |
| P(S) | P=0,8F1+0,2F2 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] Xavier Carcelle, Power Line Communication in Practice, Artec House, Boston London 2006
[2] Yang Xiao, Yi Pan, Emerging Wireless LANs, Wireless PANs, Wireless MANs, Willey&Sons, Inc. Pub. 2009


**SECONDARY LITERATURE:**


[1] Selected papers published in recognized international journals and/or presented in internet


**SUBJECT SUPERVISOR**


Marcin Habrych, marcin.habrych@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Odnawialne Źródła Energii** |
| Name of subject in English: | **Renewable Energy Sources** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2331 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | | 15 |
| Number of hours of total student workload (CNPS): | 60 | | | | 30 |
| Form of crediting: | examination | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | | 0.70 |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a basic knowledge in the field of the theory of electric circuits.
2. Has a basic knowledge of power system operation and electricity generation and transmission techniques.
3. Has sufficient range of language means at his/her disposal to relatively flawlessly speak out (orally and written), formulate and justify opinions, explain his/her position, show advantages and disadvantages of different solutions, participate in discussion and present general, scientific and technical subject matter.
4. Can use basic hardware and software, create and edit a text on basic level, create computer presentations.
5. Understands a need and knows possibilities of continuous education, increasing of professional, personal and social competences.
6. Has awareness of responsibility for own work.

### SUBJECT OBJECTIVES

C1. Getting to know principles of electric energy generation from renewable energy sources.
C2. Possession a knowledge from range of technical, economic and environmental aspects of renewable energy sources utilization for electric energy generation.
C3. Getting to know applicable technologies and real solutions for electric energy generation with utilization of renewable energy sources.
C4. Identification disadvantages and advantages of different renewable energy sources.
C5. Acquisition of abilities to solve problems connected with renewable energy sources.
C6. Interpreting processes of electric energy generation with utilization of renewable energy sources.
C7. Acquisition of abilities to analyze technical, economical and environmental aspects of renewable energy sources utilization for electric energy generation.
C8. Acquisition of abilities to design systems for electric energy generation with utilization of renewable energy source.

| SUBJECT EDUCATIONAL EFFECTS | |
|---|---|
| *relating to knowledge:* | |
| PEU_W01 | Knows principles of electric energy generation from renewable energy sources. |
| PEU_W02 | Possesses a knowledge from range of technical, economic and environmental aspects of renewable energy sources utilization for electric energy generation. |
| PEU_W03 | Knows applicable technologies and real solutions for electric energy generation with utilization of renewable energy sources. |
| *relating to skills:* | |
| PEU_U01 | Can solve problems connected with renewable energy sources. |
| PEU_U02 | Can interpret processes of electric energy generation with utilization of renewable energy sources. |
| PEU_U03 | Can analyze technical, economical and environmental aspects of renewable energy sources utilization for electric energy generation. |
| *relating to social competences:* | |
| PEU_K01 | Can think and act in creative and enterprising way. He/she is able to rank appropriately the priorities needed for realizing the respective task. |

**PROGRAMME CONTENT**

| | Lecture | Number of hours: |
|---|---|---|
| Lec 1 | Renewable energy sources – introduction, the fundamentals, definitions, glossary, classifications, the potential of renewable energy, development of renewable energy, scientific principles of renewable energy, technical implications. | 2 |
| Lec 2 | Wind energy – introduction, the potential and energy of wind, parameters of wind, measurements of wind, mathematical models of wind, analysis of wind conditions. | 2 |
| Lec 3 | Wind energy - wind turbines (construction, operation principle, basic technical parameters, example calculations, review of solutions), optimising wind farm, connection of wind power plant to the electric power grid. | 2 |
| Lec 4 | Wind energy – assessment of wind power plant impact on the Environment, economic aspects of wind energy, account of costs, tariffs, example economical calculations. | 2 |
| Lec 5 | Wind energy – design of wind plant, examples of solutions of small and medium wind power plant, medium wind power plant, examples of wind farm in Poland and Germany, wind energy market, future of wind energy. | 2 |
| Lec 6 | Solar Energy – introduction, current PV technology, principles of PV cells work; PV cells, modules and arrays; PV systems (classifications, construction, operation principles, production). | 2 |
| Lec 7 | Solar Energy – PV systems (installation, exploitation, standards, review of solutions), connection of PV systems to the electric power grid. | 2 |
| Lec 8 | Solar Energy – solar house, solar energy collectors, systems of solar energy collectors (construction, review of solar energy collectors use, design). | 2 |
| Lec 9 | Hydro energy – introduction, definitions, hydro electric power plants (construction, classifications, operation principles), advantages and disadvantages of hydropower, hydropower resource potential in Poland. | 2 |
| Lec 10 | Biogas energy – introduction, definitions, biogas (kinds, sources, the potential), converting biogas to energy, biogas technologies. | 2 |
| Lec 11 | Biogas energy - applications, review of solutions, environmental aspects, economical aspects of biogas utilization, advantages and disadvantages, future of biogas. | 2 |
| Lec 12 | Biomass energy – introduction, definitions, biomass (kinds, sources, the potential), converting biomass to energy, biomass technologies. | 2 |
| Lec 13 | Biomass energy – applications, review of solutions, environmental aspects, economical aspects of biomass utilization, advantages and disadvantages, future of biomass. | 2 |
| Lec 14 | Geothermal energy – introduction, the potential, kinds of geothermal energy sources, review of geothermal sources utilization to electric energy production, examples of real solutions, economical aspects of geothermal energy utilization. | 2 |
| Lec 15 | Wave energy – introduction, principles of wave energy conversion, advantages and disadvantages, market barriers, impact on the Environment, technology, review of real solutions of sea waves utilization to electric energy production. | 2 |
| | Total hours: | **30** |

| | Seminar | Number of hours: |
|---|---|---|
| Sem 1 | Analysis of wind, geographical, technical, economical and legal conditions for wind power plant. Perspectives of development of wind energy and other renewable energy sources. | 2 |
| Sem 2 | Review of applied wind turbines in Europe. Analysis of possibility of wind farm connection to the electric power grid. | 2 |
| Sem 3 | Analysis of costs for wind power plant. Some aspects of wind farm project. Schedule of investor's procedure at build wind power plant. | 2 |
| Sem 4 | Design of photovoltaic systems. Review of current solutions od photovoltaic systems. | 2 |
| Sem 5 | Review of solar heating systems. Selected aspects of solar house project. | 2 |
| Sem 6 | Analysis of small-scale and large hydro electric power plant. Review of solutions of sea waves energy utilization. | 2 |
| Sem 7 | Review of current solutions in range of biomass energy utilization to electric energy production. Case study of biomass utilization in energy project. | 2 |
| Sem 8 | Analysis of costs for geothermal power solutions Review of projects of geothermal energy utilization. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
| --- |
| N1. Lecture with the use of audiovisual techniques, multimedia presentations.<br>N2. Multimedia presentation.<br>N3. Problem discussion.<br>N4. Case study. |

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| Evaluation<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | Learning outcomes code | Way of evaluating learning outcomes achievement |
| --- | --- | --- |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_K01 | Test. |
| P(W) | P=F1 | |
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_U03 | Activity on seminar classes. |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_U03 | Preparing and presenting a presentation. |
| P(S) | P=0.2*F1+0.8*F2 | |

**PRIMARY AND SECONDARY LITERATURE**


**PRIMARY LITERATURE:**

[1] Boyle G., Renewable Energy – Power for a sustainable future, Second Edition, Oxford University Press Inc. New York, 2004.
[2] Twidell J., Weir T., Renewable Energy Resources, Seventh Edition, Spon Press, London, 2005.
[3] Burton T., Sharpe D., Jenkins N., Bossanyi E., Wind Energy Handbook, John Wiley and Sons Ltd. Chichester, England, 2001.
[4] Luque A., Hegedus S., Handbook of photovoltaic science and engineering, John Wiley and Sons Ltd. Chichester, England, 2003.

**SECONDARY LITERATURE:**

[1] Manwell J.F., McGowan J.G., Rogers A.L., Wind Energy Explained: Theory, Design and Application, John Wiley and Sons Ltd. Chichester, England, 2002.
[2] Markvart T.: Solar electricity, Second Edition, UNESCO, John Wiley and Sons Ltd. New York, 2000.


**SUBJECT SUPERVISOR**


Waldemar Dołęga, waldemar.dolega@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Zaawansowane stacje i urządzenia elektroenergetyczne** |
| Name of subject in English: | **Advanced Substations and Electrical Equipment** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM2335 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | 15 | |
| Number of hours of total student workload (CNPS): | 90 | | | 30 | |
| Form of crediting: | examination | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | | | 1 | |
| including number of ECTS points for practical (P) classes : | | | | 1 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | | | 0.70 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knows physical phenomena occurred in electrical devices.
2. Has a basic knowledge in the field of the theory of electric circuits.
3. Can correctly and effectively apply a knowledge of linear algebra and analytical geometry to qualitative and quantitative analysis of mathematical issues connected with studied engineering branch.
4. Can apply a mathematical apparatus to analysis of linear electric circuits with sinusoidal AC force.
5. Can apply a mathematical apparatus to analysis of temporary states in linear electrical circuits.
6. Understands a need and knows possibilities of continuous education, increasing of professional, personal and social competences.
7. Has awareness of responsibility for own work.

## SUBJECT OBJECTIVES

C1. Possession a knowledge of physical phenomena occurred in electrical devices.
C2. Possession a knowledge of important parameters of electrical devices in aspect of their designing.
C3. Getting to know of principles of electrical devices designing.
C4. Getting to know of relations between construction, correct exploitation, reliability and effectiveness of use of electrical devices in power network.
C5. Possession a knowledge of function of power substations.
C6. Acquisition of abilities to design low voltage electrical installation for supply of different electricity receivers in objects with varied character of use.
C7. Acquisition of abilities to design MV electrical installation for supply of object with varied character of use.
C8. Acquisition of abilities to selection of LV and MV switchgears and MV/LV container transformer substations for required work conditions.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Knows physical phenomena occurred in electrical devices.

PEU_W02 Knows of principles of electrical devices designing.

PEU_W03 Possesses a knowledge of function of power substations.

*relating to skills:*

PEU_U01 Can design low voltage electrical installation for supply of different electricity receivers in objects with varied character of use.

PEU_U02 Can design MV electrical installation for supply of object with varied character of use.

PEU_U03 Can select LV and MV switchgears and MV/LV container transformer substations for required work conditions.

*relating to social competences:*

PEU_K01 Can think and act in creative and enterprising way. He/she is able to rank appropriately the priorities needed for realizing the respective task.

## PROGRAMME CONTENT

| Lecture | | Number of hours: |
|---|---|---|
| Lec 1 | Short circuit currents in power electric systems, characteristic values and parameters, ways of their calculation. | 2 |
| Lec 2 | Thermal effects of normal and short circuit currents. | 2 |
| Lec 3 | Electro-dynamical effects of short circuit currents. | 2 |
| Lec 4 | Electric arc – physical properties, extinguishing methods of arc. | 2 |
| Lec 5 | Switching apparatus - basic terminology and functions in power electrical networks. Low voltage switching apparatus. | 2 |
| Lec 6 | High voltage switching apparatus – classification, construction, main parameters. | 2 |
| Lec 7 | Power transformers in power substations. | 2 |
| Lec 8 | Current and voltage transformers in electrical power substations. | 2 |
| Lec 9 | Over-voltages and over-voltage protection. | 2 |
| Lec 10 | Limitation of fault currents. Short-circuit reactors. | 2 |
| Lec 11 | Structures of main circuits in high-voltage electrical power substations. Supplying of industrial and residential load. | 2 |
| Lec 12 | Constructional solutions of air and SF6 insulated indoor power substations. | 2 |
| Lec 13 | Earthing systems in power substations. | 2 |
| Lec 14 | Auxiliary devices in high-voltage power substations. Protection against electric shock in power substations. | 2 |
| Lec 15 | Principles of correct operation in power substations. | 2 |
| | Total hours: | **30** |

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | Description of the project task. Planning of the supply of object with varied character of use and structure of the installation. | 2 |
| Proj 2 | Project of general lighting in the object. | 2 |
| Proj 3 | Calculation of the power demand for the object. Calculation of reactive power compensation. Selection of capacitor bank. Selection of power transformers. | 2 |
| Proj 4 | Selection of main cable supplied the object with varied character of use. | 2 |
| Proj 5 | Calculation of selected circuits of power installation. | 2 |
| Proj 6 | Selection of LV switchgears in the object with varied character of use. | 2 |
| Proj 7 | Selection of MV/LV container power substations. | 2 |
| Proj 8 | Project documentation. | 1 |
| | Total hours: | **15** |

## TEACHING TOOLS USED

N1. Lecture with the use of audiovisual techniques, multimedia presentations.

N2. Multimedia presentation.

N3. Problem discussion.

N4. Presentation of the project.

N5. Consultations.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_K01 | Exam in written form. |
| P(W) | P=F1 | |
| F1(P) | PEU_U01<br>PEU_U02<br>PEU_U03 | Assessment of project preparing. |
| F2(P) | PEU_U01<br>PEU_U02<br>PEU_U03 | Defence of the project. |
| P(P) | P=0.6*F1+0.4*F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Dołęga W., Advanced substations and electrical equipment. Wrocław University of Technology, Wrocław, 2011.
[2] McDonald J.D., Electric Power Substations Engineering, Wiley, 2003.
[3] Seip G., Electrical Installations Handbook, Springer Verlag, 2001.
[4] ABB Switchgear Manual, 10th edition, Düasseldorf, Cornelsen Verlag, 1999.


**SECONDARY LITERATURE:**


[1] Garzon R.D., High Voltage Circuit Breakers, Wiley, 2002.
[2] Switching, Protection and Distribution in Low-Voltage Networks, Siemens handbook, 1994.


## SUBJECT SUPERVISOR


Waldemar Dołęga, waldemar.dolega@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Kierowanie i sterowanie systemem elektroenergetycznym** |
| Name of subject in English: | **Electric Power System Operation and Control** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2531 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | | 15 |
| Number of hours of total student workload (CNPS): | 60 | | | | 30 |
| Form of crediting: | crediting with grade | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | | 0.70 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of basics of power system control and three-phase and single-phase electric circuits analysis
2. Practical skills of using MATLAB
3. The student can build on Ohm's low and Kirchhoff's lows and matrix calculus for the steady-state and transient short circuit linear analysis

## SUBJECT OBJECTIVES

C1. Acquaintance of knowledge related to transmission and distribution of electricity

C2. Practical skills to analyze and design of modeling of a power system under normal and abnormal states

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Knows the rules of the functioning of the power system

PEU_W02 The student has a thorough knowledge of power system calculations performed under normal, abnormal states and short-circuits

*relating to skills:*

PEU_U01 Is able to develop the equivalent circuit of power systems in the steady state, short-circuit and transient states and calculate equivalent circuit parameters

PEU_U02 Student is able to apply results of computer simulation to analyse of static electric circuits

*relating to social competences:*

PEU_K01 Student can act independently and cooperate within a group working on a complex engineering project.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Setting rules of course crediting. Historical perspective, development of electrical power systems | 2 |
| Lec 2 | Models of basic elements of electrical power systems | 2 |
| Lec 3 | Mathematical background of load flow analysis | 2 |
| Lec 4 | Iterative solution of active and reactive power flows using Matlab | 2 |
| Lec 5 | Example of hand and computer calculations of load flow | 2 |
| Lec 6 | Voltage and reactive power regulation | 2 |
| Lec 7 | Voltage stability of power system using Matlab - detailed algorithms | 2 |
| Lec 8 | Symmetrical short-circuit in electrical power systems | 2 |
| Lec 9 | Analysis of unbalanced faults using the symmetrical component transformation | 2 |
| Lec 10 | IEC method of short-circuit analysis. Example of short-circuit analysis | 2 |
| Lec 11 | Short-circuit analysis using Matlab | 2 |
| Lec 12 | Synchronous generator models in stability analysis | 2 |
| Lec 13 | Transient stability of a synchronous generator connected to a large power system. Differential equations of generator and voltage and speed regulators | 2 |
| Lec 14 | Design of small disturbance stability of a synchronous generator connected to a large electric power system | 2 |
| Lec 15 | Final test | 2 |
| | Total hours: | **30** |

| **Seminar** | | **Number of hours:** |
|---|---|---|
| Sem 1 | Acquaintance with program, requirements and way of completion, selection of problems itself | 1 |
| Sem 2 | Indiwidual tasks and projects for presentation of selected problems related to steady-state analysis, voltage stability, local and transient stability of the power system using MATLAB | 2 |
| Sem 3 | Project ideas presentations related to the steady-state analysis, voltage stability, local and transient stability of the power system using. | 10 |
| Sem 4 | Summary of seminar and classification | 2 |
| | Total hours: | **15** |

## TEACHING TOOLS USED

N1. General lecture
N2. Seminar with use of audiovisual techniques, multimedia presentation
N3. Problem discussion, consultation

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|
| F(W) | PEU_W01<br>PEU_W02 | Oral or written test |
| P(W) | P=F1 | |
| F1(S) | PEU_U01<br>PEU_U02 | Evaluation of individual presentation and students ability |
| F2(S) | PEU_U01 | Assessment of student activities under seminar |
| P(S) | P = 0,7F1 + 0,3F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] Sobierajski M, Łabuzek M., Lis R, Electric Power System Analysis in Matlab.. Wrocław, Wyd. PWr, 2007
[2] Machowski J., Białek J.,Bumby J., Power System Dynamics and Stability, Wiley, 2005.
[3] Kremens Z., Sobierajski M., Analiza systemów elektroenergetycznych. Warszawa. WNT 1996.

**SECONDARY LITERATURE:**

[1] Selected articles published in refereed or reputable academic journals

## SUBJECT SUPERVISOR

Robert Lis, robert.lis@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Zarządzanie w elektroenergetyce** |
| Name of subject in English: | **Electrical Power Systems Management** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2532 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | 15 |
| Number of hours of total student workload (CNPS): | 30 | | | | 30 |
| Form of crediting: | crediting with grade | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | | 0.70 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. The student should has a basic knowledge of linear electrical circuit theory
2. The student should has a basic knowledge of the power system operation and electricity generating technologies and electric power transmission.
3. The student should has a basic knowledge of the steady-state and transient short circuit linear analysis applied in modern power systems.
4. It has sufficient range of language tools to correct pronouncement and write, formulate and motivate opinions, to explain his point of view, to present disadvantages and advantages of various solutions, to participate in discussion and to present general, scientific and technical problems.
5. Can use basic hardware and software, create, edit texts and create computer presentations.
6. He has an awareness of responsibility for his work.

## SUBJECT OBJECTIVES

C1. Getting to know the problems of organization and management of the electricity sector and energy company.
C2. The student should demonstrate the ability to analyze the key strategies of deregulation and restructuring of the electricity sector and the development of electricity markets.
C3. The student should learn the basic problems of power system control applications.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Student has knowledge on the scope of organizing and management power sector companies.
PEU_W02 Knows the market mechanisms for electricity trading.
PEU_W03 Has a knowledge of power system operation risk assessment.

*relating to skills:*

PEU_U01 Student can identify, analyze and evaluate complex management problems under different operating conditions of the power system.
PEU_U02 He can make a strategic analysis of the organization and its environment. He can performs the audit functioning of the organization.

*relating to social competences:*

PEU_K01 Student show the readiness to identify, critical analyze and decide the appearing problems in the site of work. Student be able to evaluate of effect of taking up decisions.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Structure of power sector, components of this structure, definition and their function. | 1 |
| Lec 2 | Electrical power system management, what is management. Define of the term management, planning, organizing, directing and controlling. | 1 |
| Lec 3 | Electricity reform, main steps in this reform - restructuring, deregulation, competition and markets, ownership. | 1 |
| Lec 4 | Management of the power system in normal operation condition. | 2 |
| Lec 5 | Legal regulations concerning the operation of the power sector. | 1 |
| Lec 6 | Crisis management of the power system - in pre-fault, fault states. | 1 |
| Lec 7 | The development of electricity markets, examples of the markets models. | 2 |
| Lec 8 | Crisis management of the power system - post-fault states. | 2 |
| Lec 9 | The role of independent system operators and energy regulators | 1 |
| Lec 10 | System planning under competition, integrated resources planning, demand side management. | 2 |
| Lec 11 | Final test | 1 |
| | Total hours: | **15** |

| **Seminar** | | **Number of hours:** |
|---|---|---|
| Sem 1 | Acquainted with the program of the seminar, requirements and formative assessment. Seminar topic selection. | 1 |
| Sem 2 | Project ideas presentations related to the organization of the electricity power sector - part 1. | 2 |
| Sem 3 | Project ideas presentations related to the organization of the electricity power sector - part 2. | 2 |
| Sem 4 | Project ideas presentations related to the organization of the electricity power sector - part 3. | 2 |
| Sem 5 | Project ideas presentations related to the organization of the electricity power sector - part 4. | 2 |
| Sem 6 | Project ideas presentations related to the organization of the electricity power sector - part 5. | 2 |
| Sem 7 | Project ideas presentations related to the organization of the electricity power sector - part 6. | 2 |
| Sem 8 | Repetition and summing up. | 2 |
| | Total hours: | **15** |

## TEACHING TOOLS USED

N1. Lecture with the use of audiovisual techniques, multimedia presentations.
N2. Case study.
N3. Problem discussion.

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_K01 | Final test |
| P(W) | P=F1 | |
| F1(S) | PEU_U01<br>PEU_U02 | Activity on seminar classes. |
| F1(S) | PEU_U01<br>PEU_U02 | Preparing and presenting a presentation. |
| P(S) | P=0.2F1+0.8F2 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] Malko J., Wilczyński A., Rynki energii – działania marketingowe. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2006.
[2] S. Hunt, G. Shuttleworth: Competition and choice in electricity, John Wiley & Sons, Chichester - New York - Weinheim - Brisbane - Singapore - Toronto, 1997.
[3] M. Ilic, F. Galiana, L. Fink: Power systems restructuring, engineering and economics, KLUWER Academic Publishers, Boston - Dordrecht - London, 1998.
[4] Directive 2003/54/EC of the European Parliament and of the Council, of 26 June 2003, concerning common rules for the internal market in electricity and repealing Directive 96/92/EC.
[5] Philipson L., Willis H. L.: Understanding Electric Utilities and De-Regulation. Marcel Dekker, Inc., New York 1999.

**SECONDARY LITERATURE:**

[1] Chochowski A, Krawiec Fr., Zarządzanie w energetyce. Difin, Warszawa 2008.
[2] Czasopisma: Rynek Energii, IEEE Power & Energy, Power Engineering

| SUBJECT SUPERVISOR |
| --- |
| Artur Wilczyński, artur.wilczynski@pwr.edu.pl |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Modelowanie systemu elektroenergetycznego** |
| Name of subject in English: | **Power System Modelling** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM2534 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | 15 | |
| Number of hours of total student workload (CNPS): | 90 | | | 30 | |
| Form of crediting: | examination | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | | | 1 | |
| including number of ECTS points for practical (P) classes : | | | | 1 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | | | 0.70 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of basics of mathematical analysis and linear algebra.
2. Knowledge of basics of power systems.
3. Abilities of developing computer programs and performing calculation in the Matlab environment.

## SUBJECT OBJECTIVES

C1. Acquiring knowledge in the scope of modern concepts of power system modelling.

C2. Acquiring competence in solving the problems of the power system state estimation and estimation of loads in distribution system.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 The student has knowledge on models for different states of power systems.

PEU_W02 The student knows principles of power system model reduction.

PEU_W03 The student knows principles of real-time modelling of power system.

*relating to skills:*

PEU_U01 The student is able to choose models of power system elements for given case of calculations.

PEU_U02 The student is able to determine required power-system-model reduction for given case of calculations.

PEU_U03 The student is able to evaluate a process of real-time power-system modeling.

*relating to social competences:*

PEU_K01 The student is able to think and act creatively

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | An introduction to the lecture, program of the lecture, requirements. General principles of modelling. | 2 |
| Lec 2 | Models for steady states analyses scope of utilisation. | 2 |
| Lec 3 | Models for transient analyses scope of utilisation. | 2 |
| Lec 4 | Power system model reduction: types of equivalents. Network transformation. | 2 |
| Lec 5 | Power system model reduction: aggregation of generating units, equivalent model of the external subsystem. | 2 |
| Lec 6 | Real-time modelling of power system: need of real-time modelling, main problems, general approaches. | 2 |
| Lec 7 | Summation of modelling for different power system analyses. Test. | 2 |
| Lec 8 | Weighted least squares (WLS) power system state estimation. Alternative formulations of the power system state estimation. | 2 |
| Lec 9 | Network observability analysis. | 2 |
| Lec 10 | Bad data detection and identification. | 2 |
| Lec 11 | Network parameter estimation. Topology error processing. | 2 |
| Lec 12 | State estimation using ampere measurements. | 2 |
| Lec 13 | State estimation of distribution system specific problems. | 2 |
| Lec 14 | Estimation of loads in distribution system. | 2 |
| Lec 15 | Summation of estimation problems for power system. Test | 2 |
| | Total hours: | **30** |

| **Project** | | **Number of hours:** |
|---|---|---|
| Proj 1 | Power system model reduction | 2 |
| Proj 2 | Weighted least squares power system state estimation in the polar coordinate system. | 4 |
| Proj 3 | Weighted least squares power system state estimation in the rectangular coordinate system | 4 |
| Proj 4 | Network observability analysis | 2 |
| Proj 5 | Bad data identification. | 1 |
| Proj 6 | Topology verification. | 2 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Multimedia presentation.<br>N2. Information lecture.<br>N3. Preparation in the form of reports.<br>N4. The Matlab programs. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | activity at the classes |
| F2(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | tests |
| F3(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | exam |
| P(W) | P=0.1 F1 + 0.2 F2 + 0.7 F3 | |
| F1(P) | PEU_U01<br>PEU_U02<br>PEU_U03 | activity at the classes |
| F2(P) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | reports from the classes |
| P(P) | P=0.3 F1 + 0.7 F2 | |

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE:**<br>[1] Łukomski R., Okoń T., Wilkosz K., Power system modelling. Wrocław University of Technology, 2011.<br>[2] Abur A., Exposito A. G., Power system state estimation. New York, Marcel Dekker, Inc. 2004.<br>[3] Machowski J., Białek J.W.,Bumby J. R., Power system dynamics and stability, New York, John Willey & Sons 1997.<br>**SECONDARY LITERATURE:**<br>Publikacje w czasopismach z zakresu elektroenergetyki |

| SUBJECT SUPERVISOR |
|---|
| Kazimierz Wilkosz, kazimierz.wilkosz@pwr.edu.pl |

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Sterowanie komputerowe systemami elektroenergetycznymi** |
| Name of subject in English: | **Computer Control of Power System** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM2535 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | | 15 |
| Number of hours of total student workload (CNPS): | 90 | | | | 30 |
| Form of crediting: | examination | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | | | | 0.70 |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of basic problems of computer science.
2. Knowledge of basics of power systems.

### SUBJECT OBJECTIVES

C1. Knowing problems of computer control of modern power system.
C2. Familiarizing with modern computer control of power system.
C3. Familiarizing with modern techniques used in computer control of power system.
C4. Enhancing practical skills in preparing presentation.
C5. Enhancing practical skills in participating in discussion.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 student knows problems of power system control.
PEU_W02 The student knows solutions of problems of power system control.

*relating to skills:*

PEU_U01 The student is able to perform analyses of power systems from the view-point of their control.
PEU_U02 The student is able to evaluate different solutions of problems of computer control of power system.

*relating to social competences:*

PEU_K01 The student is able to prepare presentation in a problem manner.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | An introduction to the lecture, program of the lecture, requirements. Basic notions. | 2 |
| Lec 2 | Open-system standard. Formulation of the problem of power system control. | 2 |
| Lec 3 | Characteristics of system of power system control. | 2 |
| Lec 4 | Problems of dispatcher power system control. | 2 |
| Lec 5 | Characteristics of real-time power system modelling. The power system monitoring - generating topology model. | 2 |
| Lec 6 | The power system monitoring - intelligent validation of measurement data and topology model. | 2 |
| Lec 7 | Summation of problems of control and managing of a power system. Test. | 2 |
| Lec 8 | Power system state estimation. | 2 |
| Lec 9 | Utilization of current and voltage phasors for monitoring and controlling power system. | 2 |
| Lec 10 | Utilization of artificial intelligence in computer systems for power system control: artificial neural network, expert systems. | 2 |
| Lec 11 | Utilization of artificial intelligence in computer systems for power system control: fuzzy sets, genetic algorithms. | 2 |
| Lec 12 | Elements of structural analysis of computer systems for power system control. | 2 |
| Lec 13 | Elements of structural design of computer systems for power system control. | 2 |
| Lec 14 | Cybersecurity of computer systems for power system control. | 2 |
| Lec 15 | Summation of problems of utilizing of computers for monitoring and control of a power system. Test. | 2 |
| | Total hours: | **30** |

| **Seminar** | | **Number of hours:** |
|---|---|---|
| Sem 1 | Modern dispatcher centers of power system control. | 2 |
| Sem 2 | Implementation of EMS systems. | 2 |
| Sem 3 | Implementation of SCADA and MINISCADA systems. | 2 |
| Sem 4 | Implementation of computer control of a substation. | 2 |
| Sem 5 | Computer control in a power station. | 2 |
| Sem 6 | Control of active power and frequency in a power system. | 2 |
| Sem 7 | Control of voltage and reactive power in a power system. | 2 |
| Sem 8 | Utilization of artificial intelligence in computer systems of power systems control. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Multimedia presentation.<br>N2. Information lecture. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | activity at the classes |
| F2(W) | PEU_W01<br>PEU_W02 | tests |
| F3(W) | PEU_W01<br>PEU_W02 | exam |
| P(W) | P=0.1 F1 + 0.2 F2 + 0.7 F3 | |
| F1(S) | PEU_U01<br>PEU_U02 | activity at the classes |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | preparing seminar presentation |
| P(S) | P=0.3 F1 + 0.7 F2 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] Murty P.S.R., Operation and Control in Power Systems, CRC Press, 2011.
[2] Milano F., Advances in power system modelling control and stability analysis, IET, London 2016.
[3] Strauss C., Practical electrical network automation and communication systems, Elsevier 2003.
[4] Waha J. P. (Ed.), Control of power plants and power systems, Elsevier 2000.
[5] Wood A.J., Wollenberg B.F., Sheblé G.B., Power Generation, Operation, and Control, John Wiley & Sons, Inc., Hoboken, New Jersey 2013

**SECONDARY LITERATURE:**

[1] Donald G. Fink, Standard Handbook for Electrical Engineers. Section 10: Power-System Components/SCADA. McGraw-Hill Professional 1999.
[2] Flynn D. (Ed.), Thermal Power Plant Simulation and Control, The Institution of Engineering and Technology 2003.
[3] Artykuły w czasopismach technicznych takich jak np.: Energetyka, Biuletyn Miesięczny PSE itd.


## SUBJECT SUPERVISOR


Kazimierz Wilkosz, kazimierz.wilkosz@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

Name of subject in Polish **Dynamika i sterowanie napędami prądu stałego i przemiennego**
Name of subject in English: **Dynamics and Control of AC and DC Drives**
Main field of study (if applicable): **Electrical Engineering**
Specialization (if applicable): **Control in Electrical Power Engineering**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: W05ETK-SM3225
Group of courses: **NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 15 | 15 | |
| Number of hours of total student workload (CNPS): | 120 | | 30 | 30 | |
| Form of crediting: | examination | | crediting with grade | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 4 | | 1 | 1 | |
| including number of ECTS points for practical (P) classes : | | | 1 | 1 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.80 | | 0.70 | 0.70 | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has knowledge in the control theory (basics), informatics and fundamentals of electrical drives.

### SUBJECT OBJECTIVES

C1. Consolidate knowledge and/or filling the knowledge gap in the field of torque and speed control of the DC and AC (induction motors and PMSM) motor drives.
C2. Familiarizing students with the extended knowledge on the application of advanced control theory methods in controlled converter-fed motor drives, including adaptive and sensorless control.
C3. The acquisition of practical knowledge and skills for design, testing and analysis of advanced control structures for DC and AC motor drives, including sensorless drives.
C4. Perfecting skills for the understanding, analysis and interpretation of steady-state and transient processes in chosen controlled DC and AC drive systems.
C5. Acquisition and fixing the social competences related to work in teams, solving engineering problems together; responsibility, honesty and fairness, observance of manners which are obligatory for academia and society.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has matured knowledge on the torque and speed control methods of the converter-fed DC motor drives ], including adaptive systems.
PEU_W02 Has matured and in-depth knowledge on modern control methods of converter-fed induction motor drives (including scalar and vector methods, sensorless control).
PEU_W03 Has matured and in-depth knowledge on modern control methods of converter-fed brushless DC and AC motors drives (including vector methods and sensorless control).

*relating to skills:*

PEU_U01 Can realize the simulation tests of chosen controlled electrical drive in Matlab/Simulink environment using delivered software and can make analysis of the obtained results.
PEU_U02 Can realize the experimental tests of chosen controlled electrical drive in laboratory set-up and can make analysis of the obtained results.
PEU_U03 Can design and test in simulation a chosen structure of speed or position control of electrical drive.

*relating to social competences:*

PEU_K01 Student can act independently and cooperate within a group working on a complex engineering project.

**PROGRAMME CONTENT**

| Lecture | | Number of hours: |
|---|---|---|
| Lec 1 | Introduction. Basics of control system synthesis problems for electrical drives; control quality indexes for electrical drives. | 2 |
| Lec 2 | Static and dynamical optimization for electric motor drives. Torque control structures of electrical drives: classification, characteristic features, performance. | 2 |
| Lec 3 | Adjustment criteria for linear controllers, integral criteria, modulus and symmetry criteria, pole-placement method. | 2 |
| Lec 4 | Static optimization conditions for DC motor; constant and variable flux control, dynamical properties for constant and variable excitation flux. | 2 |
| Lec 5 | Speed control methods of converter-fed DC motor drives: series and parallel speed control structure; dynamical performance comparison. | 2 |
| Lec 6 | Influence of static rectifier to the DC motor drive dynamical performance; adaptive control structures. | 2 |
| Lec 7 | Induction motor – mathematical model using vector representation, state equations. | 2 |
| Lec 8 | Frequency controlled induction motor drives – conditions of static optimization. Torque control methods of the induction motor. | 2 |
| Lec 9 | Influence of the control method to the static mechanical characteristic of the induction motor drive. Influence of the control orientation to dynamical performance of the induction motor drive. | 2 |
| Lec 10 | Scalar control methods for induction motor drives; constant flux and constant slip frequency methods. | 2 |
| Lec 11 | Field-oriented control methods and structures for the induction motor drive - part 1. | 2 |
| Lec 12 | Field-oriented control methods and structures for the induction motor drive - part 2. | 2 |
| Lec 13 | Direct torque control methods and structures for the induction motor drive. | 2 |
| Lec 14 | Control methods of brushless DC and AC permanent magnet motors. Field-oriented and direct torque control methods. | 2 |
| Lec 15 | Sensorless drives, state variables estimation methods and structures for AC motor drives. | 2 |
| | Total hours: | **30** |

| Laboratory | | Number of hours: |
|---|---|---|
| Lab 1 | Introduction. Modeling of basic drive system elements using Matlab/Simulink - repetition. | 1 |
| Lab 2 | Simulation tests of the cascade control structure for chosen dynamical object. Application of different design methods for the PI/PID controllers. Anti-windup systems. | 2 |
| Lab 3 | Testing of the cascade control structure of DC motor drive; simulation and experimental tests. | 2 |
| Lab 4 | Testing of the scalar control method for the induction motor. | 2 |
| Lab 5 | Testing of the vector control methods for the induction motor - the FOC metod. Part 1 - simulation tests. | 2 |
| Lab 6 | Testing of the vector control methods for the induction motor - the FOC metod. Part 2 - experimental tests. | 2 |
| Lab 7 | Testing of the direct torque control method for the induction motor drive. | 2 |
| Lab 8 | Testing of the chosen sensorless control structure of the induction motor drive. Crediting with grade. | 2 |
| | Total hours: | **15** |

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | Introduction, basic requirements for course assessment. Methodology for project realization. Description of the project topics and distribution the project between student groups. | 1 |
| Proj 2 | Description of the modeling methodology of chosen elements of the drive systems in Matlab/Simulink. Implementation of basic mathematical and simulation models (DC motor, induction motor. AC/DC and DC/AC converter, modulator for DC/AC converter). | 2 |
| Proj 3 | Realization of the projects in students groups. Presentation and continuous consultations on project results. | 10 |
| Proj 4 | Project presentation. Crediting with grade. | 2 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Lecture with multimedia tools combined with classical lecture (problem oriented).
N2. Consultations.
N3. Laboratory exercises in student groups; testing of student knowledge with short test before laboratory exercises.
N4. Assessment of the laboratory exercises by reports.
N5. Project presentation and its evaluation.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Participation in lectrures. |
| F2(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Exam. |
| P(W) | P=0,1F1+0,9F2 | |
| F1(L) | PEU_U01<br>PEU_U02<br>PEU_K01 | Activity during laboratory exercises (including short written test). |
| F2(L) | PEU_U01<br>PEU_U02<br>PEU_K01 | Preparationn of the reports. |
| P(L) | P=0,3F1+0,7F2 | |
| F1(P) | PEU_U03<br>PEU_K01 | Evaluation of the activity during classes. |
| F2(P) | PEU_U03<br>PEU_K01 | Evaluation of the project and the form of its presentation. |
| P(P) | P=0,3F1+0,7F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] M.P. Kazmierkowski, F. Blaabjerg, R. Krishnan, Control in Power Electronics - Selected Problems, Academic Press, USA, 2002
[2] P. Vas, Sensorless Vector and Direct Torque Control, Oxford University Press, 1998
[3J M.D. Murphy, F.G.Turnbull, Power Electronic Control of AC Drives, Pergamon Press, Oxford, 1988
[4] W. Leonhard, Control of Electrical Drives, Springer Verlag, 1990
[5] K. Ogata, Modern Control Engineering


**SECONDARY LITERATURE:**


[1] Kaźmierkowski M.P., Tunia H., Automatyka napędu przekształtnikowego. PWN, 1987
[2] Orlowska-Kowalska T., Bezczujnikowe układy napędowe z silnikami indukcyjnymi. Oficyna Wydawnicza P.Wr., Wrocław, 2003
[3] Orlowska-Kowalska T., Automatyka napędu elektrycznego - podstawy. Oficyna Wydawnicza P.Wr., Wrocław, w druku
[4] Zawirski K., Deskur J., Kaczmarek T., Automatyka napędu elektrycznego, Wyd. Polit. Poznańskiej, 2012
[5] T. Kaczorek, A. Dzieliński, W Dobrowolski, R. Łopatka. Podstawy teorii sterowania, WNT, 2005


## SUBJECT SUPERVISOR


Teresa Orłowska-Kowalska, teresa.orlowska-kowalska@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Sterowanie rozmyte** |
| Name of subject in English: | **Fuzzy Logic Control** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM3226 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has basic knowledge in automation, informatics and modeling.

## SUBJECT OBJECTIVES

C1. The acquisition of knowledge in the field of fuzzy sets, fuzzy controllers structures of different types and aspects of industrial applications of fuzzy systems.

C2. Acquire skills in the design and testing of various types of fuzzy systems.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 He has knowledge of fuzzy sets, different types of fuzzy controllers.

PEU_W02 has knowledge of adaptive fuzzy system.

*relating to skills:*

PEU_U01 Can design different types of the fuzzy controllers, define operations in fuzzyfication, interference and defuzzyfication parts as well as define the base rules.

PEU_U02 can test the control system with fuzzy controller.

*relating to social competences:*

PEU_K01 Can solve different problem in creative way.

## PROGRAMME CONTENT

| Lecture | | Number of hours: |
|---|---|---|
| Lec 1 | Introduction to fuzzy logic. | 2 |
| Lec 2 | Classical and fuzzy controllers. | 2 |
| Lec 3 | Mamdani fuzzy system type, blocks, blurring, sharpening, and inference. | 2 |
| Lec 4 | Significant features of the rules, and the rule base fuzzy system. | 2 |
| Lec 5 | TSK-type fuzzy systems, Tsukamoto and others. | 2 |
| Lec 6 | Adaptive fuzzy system. | 2 |
| Lec 7 | Industrial applications of fuzzy systems. | 2 |
| Lec 8 | Summary. | 1 |
| | Total hours: | **15** |

| Laboratory | | Number of hours: |
|---|---|---|
| Lab 1 | Organizational matters. Introduction to the software. | 2 |
| Lab 2 | Design of selected classical controllers. | 2 |
| Lab 3 | Design of Mamdani type fuzzy controller, design and tests of the fuzzy controller working with the selected types of the plant, the selection of the control parameters. | 4 |
| Lab 4 | Designing a TSK fuzzy system for the selected plant. | 2 |
| Lab 5 | Deign of adaptive fuzzy system. | 4 |
| Lab 6 | Summary. | 1 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Multimedia Lecture with elements of traditional and problematic lectures
N2. Written tests
N3. Raports

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester)* *P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01 PEU_W02 | written and/or oral tests |
| P(W) | P=F1 | |
| F1(L) | PEU_U01 PEU_U02 PEU_K01 | raports |
| P(L) | P=F1 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] Michels K., Klawonn F., Kruse R., Nurnberger A., Fuzzy Control: Fundamentals, Stability and Design of Fuzzy Controllers (Studies in Fuzziness and Soft Computing), Springer 2006.
[2] Piegat A., Fuzzy Modeling and Control (Studies in Fuzziness and Soft Computing), Physica-Verlag HD, 2010.

**SECONDARY LITERATURE:**

[1] J Yager R.R., Filev D.P., Essential of Fuzzy Modelling and Control, John Wiley & Sons, Inc., 1994
[2] Driankov D, Hellendoorn H., Reinfrank M, An Introduction to fuzzy control. Springer 2010.

**SUBJECT SUPERVISOR**

Krzysztof Szabat, krzysztof.szabat@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Sterowanie przekształtnikami energoelektronicznymi** |
| Name of subject in English: | **Control of Power Electronic Converters** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM3227 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. It has a basic knowledge of analysis and synthesis of linear and nonlinear circuits.
2. It has a basic knowledge of the construction and operation electronic systems and power electronics basics.
3. It has a basic knowledge of electrical machines and electromechanical drive systems.
4. It has a basic knowledge of theory automatic control systems.
5. Able to perform basic measurements of electrical devices using analog and digital oscilloscope.
6. He can verify the results of laboratory measurements with theoretical knowledge.

### SUBJECT OBJECTIVES

C1. Familiarize students with the basic control systems and control of power converters.
C2. Familiarize students with basic mathematical models and how to analyze the response of the converter control.
C3. Familiarize students with the basic characteristics of practical power electronic converters control systems.
C4. Acquiring the ability to develop research results, their interpretation and the interpretation and critical evaluation

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 It has an knowledge of the control of power semiconductor devices.
PEU_W02 He knows the basics of control systems and automatic control power electronic converters.
PEU_W03 He knows the basic methods of mathematical description of control systems of power converters.

*relating to skills:*

PEU_U01 Able to organize test of industrial power electronic systems.
PEU_U02 It can determine the basic characteristics of the power converters working as part of the control system.
PEU_U03 It can present the results in numerical and graphical form and to interpret them. He can draw conclusions from the measurements.

*relating to social competences:*

PEU_K01 He can think and act in a creative and enterprising.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Optimization of SCR thyristor triggering. | 2 |
| Lec 2 | SCR thyristor drivers, TRIAC drivers, GTO drivers. | 2 |
| Lec 3 | Optimization of BJ transistor control. | 2 |
| Lec 4 | BJ power transistor drivers, MOSFET power transistor drivers, IGBTO transistor drivers. | 2 |
| Lec 5 | Control systems of controlled rectifiers, AC controllers, cycloconverters. | 2 |
| Lec 6 | Control systems of DC AC converters. | 2 |
| Lec 7 | Control systems of DC-DC converters. | 2 |
| Lec 8 | Course credit. | 1 |
| | Total hours: | **15** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Introduction. The organization of classes. Conditions of gaining credit. | 2 |
| Lab 2 | Testing of triggering and phase control systems of thyristor. | 2 |
| Lab 3 | Testing of control systems of thyristor rectifiers and cycloconverters. | 2 |
| Lab 4 | Testing of control systems of AC- voltage controllers. | 2 |
| Lab 5 | Testing of control systems of three phase thyristor inverter. | 2 |
| Lab 6 | Testing of control systems of three phase transistor PWM inverter. | 2 |
| Lab 7 | Test of inverter control system of cooperates with the network of alternating current. | 2 |
| Lab 8 | Course credit. | 1 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Informative lecture using presentation slides.
N2. Job self, self-preparation of the laboratory.
N3. Consultation.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01 PEU_W02 PEU_W03 PEU_K01 | Final test. |
| P(W) | P=F1 | |
| F1(L) | PEU_U01 PEU_U02 PEU_U03 | Check preparation for classes. |
| F2(L) | PEU_U01 PEU_U02 PEU_U03 PEU_K01 | Activity in the conduct of laboratory measurements. |
| F3(L) | PEU_U01 PEU_U02 PEU_U03 PEU_K01 | Appraisal reports made |
| P(L) | P=0,25*F1+0,25*F2+0,5*F3 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] Yuriy Rozanov: Power Electronics Basics: Operating Principles, Design, Formulas, and Applications, ORC, 2015
[2] Branko L. Dokic: Power Electronics: Converters and Regulators, Springer, 2015.
[3] Bogdan M. Wilamowski, J. David Irwin: Power Electronics and Motor Drives (The Industrial Electronics Handbook) CRC Press 2011
[4] A. Trzynadlowski: Introduction to Modern Power Electronics, CRC, 2002


**SECONDARY LITERATURE:**


[1] Adrian Ioinovici: Power Electronics and Energy Conversion Systems: Fundamentals and Hard-switching Converters, Volume 1, Wiley 2013.
[2] Mukund R. Patel: Introduction to Electrical Power and Power Electronics, CRC Press, 2012
[3] Muhammad Rashid: POWER ELECTRONICS HANDBOOK, ORC, 2010
[4] Euzeli dos Santos: Advanced Power Electronics Converters: PWM Converters Processing AC Voltages (IEEE Press Series on Power Engineering), 2014
[5] Marian P. Kazmierkowski, Ramu Krishnan: Control in Power Electronics: Selected Problems. 2004

| SUBJECT SUPERVISOR |
| --- |
| Leszek Pawlaczyk, leszek.pawlaczyk@pwr.edu.pl |

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Kompatybilność elektromagnetyczna** |
| Name of subject in English: | **Electromagnetic Compatibility** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM3311 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. He has basic knowledge in the field of linear circuits with sinusoidal waveforms. He knows the rules for creating circuit models and their mathematical description.
2. He or she has knowledge in the analysis of transients in linear electric circuits. He has knowledge of the macroscopic electromagnetic field approach
3. He has a basic knowledge of metrology and measurement units, knows basic metrological characteristics of measuring instruments, are knowledgeable about the design of measurement known calculation methods used in developing the measurement results, a knowledge of the latest measurement technology
4. He or she is able to do basic measurements of electrical devices using analog and digital oscilloscope. Can set on the basis of measurements of nonlinear characteristics of the elements. Able to present the results in the form of numerical tables and graphics to make their interpretations and draw conclusions.

### SUBJECT OBJECTIVES

C1. Understanding the concepts of electromagnetic compatibility
C2. Understanding the principles of interaction between the elements of the power system
C3. Knowledge of voltage quality parameters, evaluation of the impact of power quality on loads and the impact on the quality of the loads
C4. Knowing regulations and standardization of components which improve power quality
C5. Getting the practical skills in the assessment of power quality and surge protection
C6. Acquisition and consolidation of social skills including emotional intelligence skills involving the cooperation of a group of students with a view to effective problem solving. Responsibility, honesty and fairness in the procedure observance force in academia and society

| SUBJECT EDUCATIONAL EFFECTS | |
|---|---|
| *relating to knowledge:* | |
| PEU_W01 | He or she knows the key concepts in the field of electromagnetic compatibility. He has extensive knowledge in the field of power quality |
| PEU_W02 | He knows the power requirements of the law and regulations relating to electromagnetic compatibility standards - in particular the power quality |
| PEU_W03 | He or she has knowledge of the location and control the interference sources and their affect on the device. Know the methods of overvoltage protection.He or she knows methods to improve the power quality and ways to reduce disturbances |
| *relating to skills:* | |
| PEU_U01 | He can determine and evaluate the power quality parameters |
| PEU_U02 | He knows the procedure for carrying out the immunity tests of the loads (equipment) on power system disturbances. |
| PEU_U03 | He has the skills to assess the disturbances emissions from loads |
| *relating to social competences:* | |
| PEU_K01 | He or she is aware of their own responsibility for their work and a willingness to comply with the principles of teamwork. He searches information and its critical analysis, properly identifies and resolves the dilemmas of working in the profession |

**PROGRAMME CONTENT**

| Lecture | | Number of hours: |
|---|---|---|
| Lec 1 | Electromagnetic Compatibility. Power quality parameters | 2 |
| Lec 2 | Definitions of parameters determining the power quality - the conditions of measurement, presentation the impact of the distortion on electric loads | 2 |
| Lec 3 | Power quality standards | 2 |
| Lec 4 | Sources and external parameters of electromagnetic interference. Lightning as a source of interference, Elements lightning protection, the basic parameters of the varistor, varistor assembly rules | 2 |
| Lec 5 | Design rules for hybrid security systems, information transmission systems. | 2 |
| Lec 6 | Voltage variation. Long and short term flicker. | 2 |
| Lec 7 | Methods of reducing the voltage distortion - examples | 2 |
| Lec 8 | Measurement methods of harmonics and interharmonics. | 2 |
| Lec 9 | Shielding. The effectiveness of shielding against electromagnetic interference and electrical. Shielding low-frequency magnetic fields, the materials for the construction of the shield | 2 |
| Lec 10 | Harmonic filters. Examples of calculating analysis of the effectiveness of filters. | 2 |
| Lec 11 | Electric energy losses due to voltage distortion. | 2 |
| Lec 12 | EMC issues in control systems | 2 |
| Lec 13 | Methods of immunity test of electric loads. Measurement of disturbances emmision | 2 |
| Lec 14 | Electromagnetic Compatibility i radio frequency range. Electrostatic discharge (ESD) Fast transients (BURST) and high – energy surges (SURGE) | 2 |
| Lec 15 | test knowledge gained | 2 |
| | Total hours: | **30** |

| Laboratory | | Number of hours: |
|---|---|---|
| Lab 1 | Presentation of the safety rules and principles of assessment laboratory. Presentation of laboratory | 1 |
| Lab 2 | Voltage quality – measurement of voltage variation, frequency, unbalance, dips, and short interruption, harmonics and interharmonics, mains signalling voltage | 2 |
| Lab 3 | Current and voltage waveforms analysis – determining of harmonics and interharmonics contents | 2 |
| Lab 4 | Testing of nonlinear loads influence on waveform distortion | 2 |
| Lab 5 | Voltage variation, dips and short interruption immunity tests | 2 |
| Lab 6 | Measurement of harmonics emission of electric equipments | 2 |
| Lab 7 | Harmonic analysis of active, reactive and apparent power in circuits with non-sinusoidal voltage and current waveforms | 2 |
| Lab 8 | Spectrum Analyzer | 2 |
| | Total hours: | **15** |

| TEACHING TOOLS USED | |
|---|---|
| N1. | Traditional Lecture with audio-visual techniques |
| N2. | Laboratory run in the traditional manner of exercises + student groups, a report |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester)* *P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01 PEU_W02 PEU_W03 | test |
| P(W) | P=F1 | |
| F1(L) | PEU_U01 PEU_U02 PEU_U03 PEU_K01 | Average assessment of laboratory reports |
| P(L) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] Hasse P.: Overvoltage protection of low voltage systems, TJ International, Padstown, 2000
[2] Pradas Kodali V.: Engineering Electromagnetic Compatibility Principles, Measurments and Technology, IEEE Press, New York, 1996
[3] Baggini A., Handbook of Power Quality, John Wiley&Sons, Ltd, 2008
[4] PN-EN 50160:2010, Voltage Characteristics in Public Distribution Systems
[5] Henry W. Ott, Electromagnetic Compatibility Engineering, John Wiley & Sons, Inc., Hoboken, New Jersey 2009

**SECONDARY LITERATURE:**

[1] IEEE Std 1159-2009: IEEE Recommended Practice for Monitoring Electric Power Quality
[2] Dugan R.C., Mc Gramaghan M.F., Beaty H. W., Santoso S: Electrical Power System Quality, Wyd 2. MC Graw-Hill 2002
[3] Standler R. B.: Protection of electronic circuits from overvoltages John Wiley & Sons, New York, 1989
[4] Clayton R. P.: Introduction to electromagnetic compatibility John Wiley & Sons, New York, 1992
[5] Arrillaga J. Watson N. R.: Power System Quality Assessment, John Wiley & Sons, New York, 2000


## SUBJECT SUPERVISOR


Grzegorz Kosobudzki, grzegorz.kosobudzki@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Metody i techniki pomiarowe** |
| Name of subject in English: | **Measurement methods and techniques** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM3312 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 30 | | |
| Number of hours of total student workload (CNPS): | 60 | | 60 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 2 | | |
| including number of ECTS points for practical (P) classes : | | | 2 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 1.40 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a knowledge of electrical circuits theory.
2. Has a basic knowledge of measurement technique and basis of electronic .
3. Is able to do measurements of electrical quantities using analogue and digital instruments or oscilloscope.
4. Is able to designate nonlinear elements characteristics, present given results in numerical, tabular and graphical form. Can calculate results using uncertainty theory, correctly interpret the result and draw the right conclusions.

## SUBJECT OBJECTIVES

C1. Familiarize student with knowledge of measurement systems architecture and design principles.
C2. Understanding the properties of selected converters and measuring circuits
C3. Practical skills to: transducers tests, measuring circuit components, analysis the tests results and draw the correct conclusions.
C4. Acquisition practical skills of measurement systems use containing transducers, AD converters, data acquisition cards, autonomous instruments connected via standard measuring interfaces in order to perform a specific measurement task.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has a knowledge of electrical signal processing in measurement systems

PEU_W02 Can identify measurement ditortions and knows it minimalization methods in systems with data acquisition cards.

PEU_W03 Knows the principles of design and construction of measuring systems.

*relating to skills:*

PEU_U01 Can do tests of measuring line properties consist of transducers, sensors and instruments

PEU_U02 Can write basic programs in LabView, can do virtual instrument visualization. Can design automatic measurement stand to tests parameters and characteristics of chosen elements consist of autonomic instruments and data acquisition cards.

*relating to social competences:*

PEU_K01 Understands the need to work in a team, is aware of the responsibility for the work.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Basic terms of metrology. Error theory and uncertainty theory. Uncertainty propagation law. | 2 |
| Lec 2 | Measurement systems architecture. Signal processing in measuring systems. | 2 |
| Lec 3 | Linear normalize converters. Properties of inverting, non-inverting, differential amplifiers and voltage follower. Common mode rejection ratio CMRR. | 2 |
| Lec 4 | Instrumental amplifiers. | 2 |
| Lec 5 | Insulation amplifiers, parameters and applications. Transimpedance amplifiers. Rail-to-rail amplifiers. | 2 |
| Lec 6 | Inductive methos of power line frequency current and voltage processing. | 2 |
| Lec 7 | Active and reactive power measurements. High-voltage power measurements. Geometrical interpretation of power. | 2 |
| Lec 8 | Non-linear operational converters. Multi-functional operational analogue converter. | 2 |
| Lec 9 | TDM multiplier. RMS value converters. Chosen converters of electrical quantities . | 2 |
| Lec 10 | Classification, structure and organization of Digital Measurement Systems. Universal data acquisition card construction. | 2 |
| Lec 11 | Introduction to LabView environment. Front panel and diagram of virtual instrument. Programming structures. Autonomic instruments control. Designing methodology of virtual instruments. | 2 |
| Lec 12 | Chosen A/D and D/A converters. | 2 |
| Lec 13 | Methods of measurement noise reduction in DAQ systems. | 2 |
| Lec 14 | Smart sensors. Stray measurement systems. | 2 |
| Lec 15 | Test. | 2 |
| | Total hours: | **30** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Presentation the Procedure Health and Safety Rules and Laboratory Rules. Establish rules for passing. Presentation of measuring stands. | 2 |
| Lab 2 | Test of measurement circuit with transducer XTR-103. | 2 |
| Lab 3 | Properties tests of mean and RMS value integrated converters. | 2 |
| Lab 4 | Amplifier with carrier-wave generator tests. | 2 |
| Lab 5 | Geometrical interpretation of power. | 2 |
| Lab 6 | Properties of current inductive transducers with homogoneous magnetic circuit. | 2 |
| Lab 7 | Virtual Instrument application to measure of distorted signals. | 2 |
| Lab 8 | Introduction to LabView. The program implements a predetermined mathematical operation.. Basis programming structures. | 2 |
| Lab 9 | Type A virtual instrument. Instrument control with GPIB or USB interface program realization with uses given driver. Programming structures. | 2 |
| Lab 10 | System realization with uses of autonomic instruments connected via standard interfaces. Table operations, reading and writing data from or to file. | 2 |
| Lab 11 | Automatic measurement system to determine characteristics of chosen electronic elements. | 2 |
| Lab 12 | Tybe B Virtual Instrument. DAQ cards application in measeurement system. | 2 |
| Lab 13 | Application with DAQ card. | 2 |
| Lab 14 | Stray measurement system. | 2 |
| Lab 15 | Assessment and complement laboratory arreas. | 2 |
| | Total hours: | **30** |

| TEACHING TOOLS USED |
|---|
| N1. Traditional lecture, multimedia presentations. |
| N2. Laboratory – check knowledge in oral answer form, report preparation, presentation wrote program and discussion, office hours. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Test |
| P(W) | P=F1 | |
| F1(L) | PEU_U01<br>PEU_U02 | Check preparation to laboratory. |
| F2(L) | PEU_U01<br>PEU_U02 | Activity on laboratory |
| F3(L) | PEU_U01<br>PEU_U02 | Report preparation |
| P(L) | P=0,3F1+0,1F2+0,6F3 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Nawrocki Z., Dusza D., Analogue and digital measurement systems, Wrocław, 2011
[2] Tumański S., Principles of electrical measurements, New York ; London : Taylor & Francis, 2006
[3] Lyons R.G., Understanding Digital Signal Processing, Pearson Education; 1996.
[4] Morris A.S., Measurement and Instrumentation Principles, Butterworth-Heinemann, 2001.
[5] Van de Plassche R., CMOS integrated analog to digital and digital to analog converters, Kluwer Academic Publishers, 2003
[6] Lyons R.G., Understanding Digital Signal Processing, Pearson Education; 1996.
[7] J.Mc.Ghee, I.A. Henderson, M.J. Korczyński, W.Kulesza: Scientific metrology, Technical University of Lodz, Lodz, 1998.


**SECONDARY LITERATURE:**


[1] Clayton G., Winder S.: Operational amplifiers, Newnes, Oxford, 2003.
[2] Kester W., Jung W., Op AMP structures, Op AMP applications, Analog Devices, Norwood, 2002.
[3] Kester W., Analog to Digital Conversion, Analog Devices, 2004.
[4] Nawrocki Z., Dusza D., Kosobudzki G, Metrological analysis of integrated analog RMS converters described by explicit and implicit functions, Measurement (London). 2009, vol. 42, nr 2, s. 308-313
[5] Mc.Ghee, I.A. Henderson, M.J. Korczyński, W.Kulesza: Measurement data handling, vol. 1 and vol.2 , Technical University of Lodz, Lodz, 2001


## SUBJECT SUPERVISOR


Daniel Dusza, daniel.dusza@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Praktyka dyplomowa (4-tygodniowa)** |
| Name of subject in English: | **Diploma placement 4 weeks** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5105 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 160 | |
| Number of hours of total student workload (CNPS): | | | | 120 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 4 | |
| including number of ECTS points for practical (P) classes : | | | | 4 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 2.80 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Allow for the implementation of placement by the Commissioner for practice.

## SUBJECT OBJECTIVES

C1. Acquisition of knowledge useful for the implementation of a Master's thesis.
C2. Gaining industrial experience, learning of basic technical equipment and technology of companies, knowledge of the manager specific work and higher technical personel.
C3. Expanding the knowledge gained during education and developing the skills to use it.
C4. Getting to know the specifics of the professional and development of specific skills directly related to the place of performance of the practice.
C5. Getting to know the organizational structure of company, principles of work organization and distribution of competences, procedures, work planning and work control.
C6. Improving the organization of individual and team work, effective time management, conscientiousness and responsibility for assigned tasks.
C7. Improving skills in using foreign languages in professional situations.
C8. Professionalization of professional behavior, compliance with the rules of professional conduct and respect for technical and cultural diversity.
C9. Establish professional contacts, particularly useful when looking for work.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 He has an ability to use the gained knowledge to creatively analyze and solving various engineering problems.

PEU_U02 Skills in estimation of the time needed to carry out the ordered task or project.

*relating to social competences:*

PEU_K01 Getting the skills of behavior in a professional manner, compliance with the rules of professional conduct and respect for technical and cultural diversity.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Project** | | **Number of hours:** |
| Proj 1 | Individual program practices, adapted to the specific implemented thesis. | 160 |
| | Total hours: | **160** |

| TEACHING TOOLS USED |
|---|
| N1. Keynote presentation at the company's operations. |
| N2. Consultation. |
| N3. Specialized equipment and measuring technology used in the company. |
| N4. Specialized computer programs to support the company. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester)* *P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(P) | PEU_U01 PEU_U02 PEU_K01 | Individual rating (2.0....5.5) on the basis of a written report just completed practice and requirements contained in the "Rules of Practice". |
| P(P) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Nawrocki Z., Dusza D., Analogue and digital measurement systems, Wrocław, 2011
[2] Tumański S., Principles of electrical measurements, New York ; London : Taylor & Francis, 2006
[3] Lyons R.G., Understanding Digital Signal Processing, Pearson Education; 1996.
[4] Morris A.S., Measurement and Instrumentation Principles, Butterworth-Heinemann, 2001.
[5] Van de Plassche R., CMOS integrated analog to digital and digital to analog converters, Kluwer Academic Publishers, 2003
[6] Lyons R.G., Understanding Digital Signal Processing, Pearson Education; 1996.
[7] J.Mc.Ghee, I.A. Henderson, M.J. Korczyński, W.Kulesza: Scientific metrology, Technical University of Lodz, Lodz, 1998.


**SECONDARY LITERATURE:**


[1] Clayton G., Winder S.: Operational amplifiers, Newnes, Oxford, 2003.
[2] Kester W., Jung W., Op AMP structures, Op AMP applications, Analog Devices, Norwood, 2002.
[3] Kester W., Analog to Digital Conversion, Analog Devices, 2004.
[4] Nawrocki Z., Dusza D., Kosobudzki G, Metrological analysis of integrated analog RMS converters described by explicit and implicit functions, Measurement (London). 2009, vol. 42, nr 2, s. 308-313
[5] Mc.Ghee, I.A. Henderson, M.J. Korczyński, W.Kulesza: Measurement data handling, vol. 1 and vol.2 , Technical University of Lodz, Lodz, 2001


## SUBJECT SUPERVISOR


Piotr Serkies, piotr.serkies@pwr.edu.pl

Zał. nr 5 do ZW 16/2020

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Seminarium dyplomowe** |
| Name of subject in English: | **Diploma seminar** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5108 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | | 30 |
| Number of hours of total student workload (CNPS): | | | | | 90 |
| Form of crediting: | | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | | 3 |
| including number of ECTS points for practical (P) classes : | | | | | 3 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | | 2.10 |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Student has the well-ordered theoretical knowledge to meet requirements of MSc work in the specialization of Control in Electrical Power Engineering.
2. Student is capable of using the learned knowledge for the realization of MSc work in the specialization of Control in Electrical Power Engineering
3. Student can work in a team and understand the need to improve one's skill all the time.

### SUBJECT OBJECTIVES

C1. To assimilate ability to present the results of computations, experiments and analysis made in the frame of MSc work.
C2. To become skillful at the critical assessment of the results of computations, experiments and analysis made in the frame of MSc work.
C3. To be able to take part in group discussion on the problems considered in MSc works.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 Student can acquire information from literature and data base concerning the theme associated with the realization of the MSc work.

PEU_U02 Has the ability of synthetic and effective presentation of research results and their interpretation, drawing conclusions, and preparing and delivering presentations on the realized thesis.

PEU_U03 Student can reliably evaluate the results of the other student, formulate questions and take active participation in discussion on the subjects related to the completed master’s theses.

*relating to social competences:*

PEU_K01 Student has a sense of responsilibity of their own work and is open to the exchange of ideas and new challenges.

### PROGRAMME CONTENT

| Seminar | | Number of hours: |
|---|---|---|
| Sem 1 | To make oneself acquainted with program, requirements and way of receiving a credit for a class. | 2 |
| Sem 2 | Presentation of investigation results related to MSc works. | 28 |
| | Total hours: | **30** |

| TEACHING TOOLS USED |
|---|
| N1. Seminar with using the audio-video technique and multimedia presentation.<br>N2. Relevant problem's discussion of presented materials. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Mark for individual presentation. |
| F2(S) | PEU_U03<br>PEU_K01 | Mark for class activity |
| P(S) | P=0,7F1+0,3F2 | |

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE:**<br>Literature recommended by MSc thesis supervisor.<br>**SECONDARY LITERATURE:**<br>MSc related literature collected by student. |

| SUBJECT SUPERVISOR |
|---|
| Robert Lis, robert.lis@pwr.edu.pl |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Projekt dyplomowy** |
| Name of subject in English: | **Diploma Project** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5117 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 120 | |
| Number of hours of total student workload (CNPS): | | | | 240 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 8 | |
| including number of ECTS points for practical (P) classes : | | | | 8 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 5.60 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | xx | 120 |
| | Total hours: | **120** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** *F – forming (during semester)* *P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

Literature recommended by MSc thesis supervisor.

**SECONDARY LITERATURE:**

MSc related literature collected by student.

## SUBJECT SUPERVISOR

,

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Praca dyplomowa magisterska** |
| Name of subject in English: | **Master's thesis** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5119 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 180 | |
| Number of hours of total student workload (CNPS): | | | | 540 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 18 | |
| including number of ECTS points for practical (P) classes : | | | | 18 | |
| including number of ECTS points for direct teacher-student contact (BK) classes: | | | | 12.60 | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

### SUBJECT OBJECTIVES

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

### PROGRAMME CONTENT

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | xx | 180 |
| | Total hours: | **180** |

### TEACHING TOOLS USED

### EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

| PRIMARY AND SECONDARY LITERATURE |
| --- |
| **PRIMARY LITERATURE:** |
| Literature recommended by MSc thesis supervisor. |
| **SECONDARY LITERATURE:** |
| MSc related literature collected by student. |

| SUBJECT SUPERVISOR |
| --- |
| , |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Projekt dyplomowy** |
| Name of subject in English: | **Diploma Project** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5127 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 120 | |
| Number of hours of total student workload (CNPS): | | | | 240 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 8 | |
| including number of ECTS points for practical (P) classes : | | | | 8 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 5.60 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | xx | 120 |
| | Total hours: | **120** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

| PRIMARY AND SECONDARY LITERATURE |
| --- |
| **PRIMARY LITERATURE:**<br>Literature recommended by MSc thesis supervisor.<br>**SECONDARY LITERATURE:**<br>MSc related literature collected by student. |

| SUBJECT SUPERVISOR |
| --- |
| , |

Zał. nr 5 do ZW 16/2020

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Praca dyplomowa magisterska** |
| Name of subject in English: | **Master's thesis** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5129 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 180 | |
| Number of hours of total student workload (CNPS): | | | | 540 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 18 | |
| including number of ECTS points for practical (P) classes : | | | | 18 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 12.60 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | xx | 180 |
| | Total hours: | **180** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|

| PRIMARY AND SECONDARY LITERATURE |
| --- |
| **PRIMARY LITERATURE:**<br>Literature recommended by MSc thesis supervisor.<br>**SECONDARY LITERATURE:**<br>MSc related literature collected by student. |

| SUBJECT SUPERVISOR |
| --- |
| , |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Projekt dyplomowy** |
| Name of subject in English: | **Diploma Project** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5137 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 120 | |
| Number of hours of total student workload (CNPS): | | | | 240 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 8 | |
| including number of ECTS points for practical (P) classes : | | | | 8 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 5.60 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| | Project | Number of hours: |
|---|---|---|
| Proj 1 | xx | 120 |
| | Total hours: | **120** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE:**<br>Literature recommended by MSc thesis supervisor.<br>**SECONDARY LITERATURE:**<br>MSc related literature collected by student. |

| SUBJECT SUPERVISOR |
|---|
| , |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Praca dyplomowa magisterska** |
| Name of subject in English: | **Master's thesis** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5139 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 180 | |
| Number of hours of total student workload (CNPS): | | | | 540 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 18 | |
| including number of ECTS points for practical (P) classes : | | | | 18 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 12.60 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | xx | 180 |
| | Total hours: | **180** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

| PRIMARY AND SECONDARY LITERATURE |
| --- |
| **PRIMARY LITERATURE:** |
| Literature recommended by MSc thesis supervisor. |
| **SECONDARY LITERATURE:** |
| MSc related literature collected by student. |

| SUBJECT SUPERVISOR |
| --- |
| , |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Zaawansowane technologie produkcji energii elektrycznej** |
| Name of subject in English: | **Advanced Technology in Electrical Power Generation** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W09ETK-SM1501 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | 15 | | | |
| Number of hours of total student workload (CNPS): | 90 | 30 | | | |
| Form of crediting: | crediting with grade | crediting with grade | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | 1 | | | |
| including number of ECTS points for practical (P) classes : | | 1 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | 0.70 | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knows basic laws of physics, chemistry, has the knowledge of the description of processes and properties for ideal gases including thermodynamic processes for water vapor and basic knowledge in the field of fuel
2. Is able apply the knowledge of differential and integral calculus of functions of one variable and use mass and energy balance

## SUBJECT OBJECTIVES

C1. Getting the knowledge the fundamental processes describing the generation of electricity and methods for assessing the energy balance of energy production systems

C2. Acquire practical skills of efficiency and energy balance determination for advanced energy production system from conventional and renewable energy sources.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Have knowledge of fundamental principles of different power production systems at high efficiency.

PEU_W02 Knows principles of power production systems configurations including conventional unit depending on primary energy carrier

*relating to skills:*

PEU_U01 Is able to perform critical analysis of advanced concept of power systems especially near zero emission technology using different types of primary Energy sources.

PEU_U02 Is able to perform of thermodynamics efficiency calculation for thermal, cogeneration and combined power unit.

*relating to social competences:*

PEU_K01 Assess the energy needs of countries depending on local resources.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Energy in the future Challenges for the 21st Century | 2 |
| Lec 2 | Impact of climate changes on progress low emission power production technology. | 2 |
| Lec 3 | Physical and Chemical fundamentals of power production. | 2 |
| Lec 4 | Combustion and Gasification of fuels | 2 |
| Lec 5 | Thermodynamical fundamentals of power production | 2 |
| Lec 6 | Vapor Power Cycle – improvement of efficiency | 2 |
| Lec 7 | Super critical boilers in advanced power unit | 2 |
| Lec 8 | Cogeneration system of energy production | 2 |
| Lec 9 | Fundamental of combined power plant. | 2 |
| Lec 10 | IGCC – Integrated gasification coal combined plants - fundamentals. | 2 |
| Lec 11 | Advanced power unit integrated with SOFC- fuel cel. | 2 |
| Lec 12 | Fundamentals of CCS technology – carbon capture and storage | 2 |
| Lec 13 | Nuclear Power Plants | 2 |
| Lec 14 | Hybrid power unit , polygeneration with RES | 2 |
| Lec 15 | Test (crediting with grade) | 2 |
| | Total hours: | **30** |

| **Classes** | | **Number of hours:** |
|---|---|---|
| Cl 1 | Calculation of combustion air and the quantities and composition of exhaust gases from fuel combustion in thermal power plants | 2 |
| Cl 2 | Calculation of cycle efficiency thermal power plant for sub-critical parameters | 2 |
| Cl 3 | Calculation of cycle efficiency thermal power plant for sub-critical parameters with reheated of steam system. | 2 |
| Cl 4 | Calculation of cycle efficiency thermal power plant for sub-critical parameters with reheated of steam system and regeneration system. | 2 |
| Cl 5 | Calculation of cogeneration cycle efficiency. | 2 |
| Cl 6 | Calculation of cycle efficiency of combined power unit. | 2 |
| Cl 7 | The calculation of the balance of coal-fired thermal power plant with CO2 capture by amine absorption. | 2 |
| Cl 8 | Test (crediting with grade) | 1 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Lectures with multimedia presentation
N2. Students own work
N3. Classes
N4. Discussion of results
N5. Colloquium

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | test |
| P(W) | P=F1 | |
| F1(C) | PEU_U01<br>PEU_U02<br>PEU_K01 | Evaluation of home works |
| F2(C) | PEU_U01<br>PEU_U02<br>PEU_K01 | Test |
| P(C) | P=0,3F1+0,7F2 | |

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE:**<br>[1] Advanced Power Genertion technology, RES, H. Pawlak-Kruczek, 2011<br>[2] Yunus A. Cengel, Michael A. Boles , Thermodynamics, An Engineering Approach. McGraw –Hill Higher Education ,2009<br>[3] Theory And Problems Of Thermodynamics For Engineers, Merle C. Potter, Craig W,Somerton, Ph,D.,Associate Professor Of Mechanical Engineering,Michigan State University, Schaum's Outline Series, Mcgraw-Hill, 2008<br>[4] Prabir Basu , Cen Kefa, Louis Jestin, Boilers and Burners , Design and Theory , Springer, 2013<br>**SECONDARY LITERATURE:**<br>[1] Steam/its generation and use - 42nd Edition, Copyright © 2015 by The Babcock & Wilcox Company Forty-second edition<br>[2]J.M. Beer, High efficiency electric power generation: The environmental role; Progress in Energy and Combustion Science 33 (2007), 107–134 |

| SUBJECT SUPERVISOR |
|---|
| Halina Pawlak-Kruczek, halina.kruczek@pwr.edu.pl |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Etyka w biznesie** |
| Name of subject in English: | **Ethics in bussiness** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W08ETK-SM1721 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | | 15 |
| Number of hours of total student workload (CNPS): | | | | | 50 |
| Form of crediting: | | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | | 2 |
| including number of ECTS points for practical (P) classes : | | | | | 2 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | | 1.40 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Text interpretation ability
2. Basic abilities in performing analysis and synthesis

## SUBJECT OBJECTIVES

C1. Analysis of the significance and role of ethics in modern business
C2. Resolve problems relating to social responsibility to the surroundings
C3. The appearance and analysis of the situation in which ethical problems may arise
C4. Sensitize students to the ethical problems

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 Student has the ability to understand social, economic, legal and others non technical conditions of engineering activities.

PEU_U02 The student is able to formulate and thoroughly justify opinions, prepare and make presentations related to the problems from the scope of topics of the studied discipline as well as to the topics related to the environment of work. Is also able to take part in scientific and professional discussions.

*relating to social competences:*

PEU_K01 The student is able to think critically and to argue their position, allowing it properly determine the priorities for implementing specified by himself or other tasks, taking into account issues of social responsibility.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Seminar** | | **Number of hours:** |
| Sem 1 | Introduction to business ethics | 1 |
| Sem 2 | Ethics in economic activity | 1 |
| Sem 3 | Protection of intellectual property versus ethics | 1 |
| Sem 4 | Economic crises as a source of change in moral values | 2 |
| Sem 5 | Ethical trade | 1 |
| Sem 6 | Corporate Social Responsibility | 2 |
| Sem 7 | Ecoethic | 2 |
| Sem 8 | Ethics in Marketing | 2 |
| Sem 9 | Areas of of modern ethical finance | 1 |
| Sem 10 | Manipulation, corruption, lies and abuses in business | 2 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Information lecture
N2. Interactive lecture
N3. Multimedia presentation
N4. Discussion

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Presentation |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Activity on the lectures |
| P(S) | P=0,8F1+0,2F2 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] B. Klimczak, Etyka gospodarcza, Wrocław 1996.
[2] P. M. Minus, Etyka w biznesie, Warszawa 1995.
[3] E. Sternberg, Czysty biznes. Etyka biznesu w działaniu, Warszawa 1998.

**SECONDARY LITERATURE:**

[1] G. D. Chrissides, J. H. Kaler, Wprowadzenie do etyki biznesu, Warszawa 1999.
[2] A. Chaufen, Kradzież a rozwój gospodarczy, Warszawa 2006.
[3] C. Porębski, Czy etyka się opłaca, Kraków 1997.
[4] Podstawy marketingu, pod red. J. Altkorna, Kraków 2004.
[5] M. Bąk, P. Kulawczuk, A. Szcześniak, Strategia polskiego biznesu wobec korupcji, Warszawa 2001.

**SUBJECT SUPERVISOR**

Adriana Merta-Staszczak, Andrzej Postawa, adriana.merta-staszczak@pwr.edu.pl, andrzej.postawa@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish | **Język obcy B2+ lub C1+** |
| Name of subject in English: | **Foreign language B2+ or C1+** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | SJO000-SM00 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | 15 | | | |
| Number of hours of total student workload (CNPS): | | 30 | | | |
| Form of crediting: | | crediting with grade | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | 1 | | | |
| including number of ECTS points for practical (P) classes : | | 1 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | 0.70 | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Classes | | Number of hours: |
|---|---|---|
| Cl 1 | xx | 15 |
| | Total hours: | **15** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

| PRIMARY AND SECONDARY LITERATURE |
| --- |

**PRIMARY LITERATURE:**

[1] B. Klimczak, Etyka gospodarcza, Wrocław 1996.
[2] P. M. Minus, Etyka w biznesie, Warszawa 1995.
[3] E. Sternberg, Czysty biznes. Etyka biznesu w działaniu, Warszawa 1998.

**SECONDARY LITERATURE:**

[1] G. D. Chrissides, J. H. Kaler, Wprowadzenie do etyki biznesu, Warszawa 1999.
[2] A. Chaufen, Kradzież a rozwój gospodarczy, Warszawa 2006.
[3] C. Porębski, Czy etyka się opłaca, Kraków 1997.
[4] Podstawy marketingu, pod red. J. Altkorna, Kraków 2004.
[5] M. Bąk, P. Kulawczuk, A. Szcześniak, Strategia polskiego biznesu wobec korupcji, Warszawa 2001.

| SUBJECT SUPERVISOR |
| --- |
| , |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Język obcy A1lub A2** |
| Name of subject in English: | **Foreign language A1 or A2** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | SJO000-SM00 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | 45 | | | |
| Number of hours of total student workload (CNPS): | | 60 | | | |
| Form of crediting: | | crediting with grade | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | 2 | | | |
| including number of ECTS points for practical (P) classes : | | 2 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | 1.40 | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Classes | | Number of hours: |
|---|---|---|
| Cl 1 | xx | 45 |
| | Total hours: | **45** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] B. Klimczak, Etyka gospodarcza, Wrocław 1996.
[2] P. M. Minus, Etyka w biznesie, Warszawa 1995.
[3] E. Sternberg, Czysty biznes. Etyka biznesu w działaniu, Warszawa 1998.


**SECONDARY LITERATURE:**


[1] G. D. Chrissides, J. H. Kaler, Wprowadzenie do etyki biznesu, Warszawa 1999.
[2] A. Chaufen, Kradzież a rozwój gospodarczy, Warszawa 2006.
[3] C. Porębski, Czy etyka się opłaca, Kraków 1997.
[4] Podstawy marketingu, pod red. J. Altkorna, Kraków 2004.
[5] M. Bąk, P. Kulawczuk, A. Szcześniak, Strategia polskiego biznesu wobec korupcji, Warszawa 2001.


## SUBJECT SUPERVISOR

,

FACULTY OF ELECTRICAL
ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Sztuka wystąpień publicznych** |
| Name of subject in English: | **The art of public speaking** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W08ETK-SM3721 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | | 15 |
| Number of hours of total student workload (CNPS): | | | | | 50 |
| Form of crediting: | | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | | 2 |
| including number of ECTS points for practical (P) classes : | | | | | 2 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | | 1.40 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge from the area of Humanities and Social Sciences area

## SUBJECT OBJECTIVES

C1. Student acquires basic knowledge of the functioning in the society
C2. Student acquires skills in interpersonal communication and social interaction
C3. Student acquires basic competence in critical thinking and positive argumentation.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 The student has the ability to understand social, economic, legal, and other non technical conditions of engineering activities.

PEU_U02 The student is able to formulate and thoroughly justify opinions, prepare and make presentations related to the problems from the scope of topics of the studied discipline as well as to the topics related to the environment of work. Is also able to take part in scientific and professional discussions.

*relating to social competences:*

PEU_K01 The student is able to think critically and to argue their position, allowing it properly determine the priorities for implementing specified by himself or other tasks, taking into account issues of social responsibility.

## PROGRAMME CONTENT

| Seminar | | Number of hours: |
|---|---|---|
| Sem 1 | Introduction to social communication | 2 |
| Sem 2 | Visual communication | 2 |
| Sem 3 | Nonverbal communication – authority, trust and faith | 2 |
| Sem 4 | Nonverbal communication – technical ascpects | 4 |
| Sem 5 | Stage, space and technical support | 2 |
| Sem 6 | Auditory – strategies of group dynamic | 2 |
| Sem 7 | Mass communication | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Informational lecture<br>N2. Multimedia presentation<br>N3. Interactive lecture |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Presentation |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Active participation |
| P(S) | P=0,8F1+0,2F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Lucas S., The art of public speaking, (2012), McGraw-Hill, New York.
[2] Parrish A. C., Adaptive Rhetoric. Evolution, Culture, and the Art of Persuasion, (2014), Routledge, New York.
[3] Sobczak B., Zgółkowa H. (red.), Dydaktyka retoryki, (2011), Wydawnictwo Poznańskie, Poznań.
[4] Arystoteles, Retoryka. Poetyka. (1988), Przeł. H. Podbielski, Wydawnictwo Naukowe PWN, Warszawa.


**SECONDARY LITERATURE:**


[1] Esenwein J. B., Carnegey D., (1915), The art. of public speaking, The Home Correspondence School, Springfield, Mass..
[2] Dąbrowski Ł., (2012), 101 porad dla prezenterów, Helion, Warszawa.
[3] Bugajski M. (2007), Język w komunikowaniu, Wydawnictwo Naukowe PWN, Warszawa.
Kuziak M., (2008), Jak mówić, rozmawiać, przemawiać? Wydawnictwo Szkolne PWN, Warszawa.


## SUBJECT SUPERVISOR


Adriana Merta-Staszczak, Andrzej Postawa, adriana.merta-staszczak@pwr.edu.pl, andrzej.postawa@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Komunikacja społeczna** |
| Name of subject in English: | **Social communication** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W08ETK-SM3821 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | | 15 |
| Number of hours of total student workload (CNPS): | | | | | 50 |
| Form of crediting: | | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | | 2 |
| including number of ECTS points for practical (P) classes : | | | | | 2 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | | 1.40 |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge from the area of Humanities and social sciences area
2. Basic knowledge from the area of Humanities and social sciences area

### SUBJECT OBJECTIVES

C1. Student acquires basic knowledge of the functioning in the society.
C1. Student acquires basic knowledge of the functioning in the society
C2. Student acquires skills in interpersonal communication and social interaction
C2. Student acquires skills in interpersonal communication and social interaction
C3. Tthe student acquires basic social competences in interpersonal communication.
C3. Student acquires basic competence in critical thinking and positive argumentation

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 The student has the abillity to understand social, economic, legal and others non technical conditions of engineering activities

PEU_U01 The student has the abillity to understand social, economic, legal and others non technical conditions of engineering activities

PEU_U02 The student is able to formulate and thoroughly justify opinions, prepare and make presentations related to the problems from the scope of topics of the studied discipline as well as to the topics related to the environment of work. Is also able to take part in scientific and professional discussions.

PEU_U02 The student is able to formulate and thoroughly justify opinions, prepare and make presentations related to the problems from the scope of topics of the studied discipline as well as to the topics related to the environment of work. Is also able to take part in scientific and professional discussions.

*relating to social competences:*

PEU_K01 The student is able to think critically and to argue their position, allowing it properly determine the priorities for implementing specified by himself or other tasks, taking into account issues of social responsibility.

PEU_K01 The student is able to think critically and to argue their position, allowing it properly determine the priorities for implementing specified by himself or other tasks, taking into account issues of social responsibility.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Seminar** | | **Number of hours:** |
| Sem 1 | Introduction to the social communication. | 1 |
| Sem 1 | Introduction to the social communication. | 1 |
| Sem 2 | Verbal communication | 2 |
| Sem 2 | Verbal communication | 2 |
| Sem 3 | Nonverbal communication. | 2 |
| Sem 3 | Nonverbal communication. | 2 |
| Sem 4 | Visual communication | 2 |
| Sem 4 | Visual communication | 2 |
| Sem 5 | Audial communication | 3 |
| Sem 5 | Audial communication | 3 |
| Sem 6 | Mediated communication | 2 |
| Sem 6 | Mediated communication | 2 |
| Sem 7 | Mass communication - advertising | 1 |
| Sem 7 | Mass communication – advertising | 1 |
| Sem 8 | Praxis of communication and PR | 1 |
| Sem 8 | Praxis of communication and PR | 1 |
| Sem 9 | Netiquette electronic communication | 1 |
| Sem 9 | Netiquette electronic communication | 1 |
| | Total hours: | **30** |

**TEACHING TOOLS USED**

N1. Multimedia presentation
N1. Multimedia presentation
N2. Informational lecture
N2. Informational lecture
N3. Interactive lecture
N3. Interactive lecture

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|
| F1(S) | PEU_U01 PEU_U02 PEU_K01 | Presentation |
| F1(S) | PEU_U01 PEU_U02 PEU_K01 | Presentation |
| F2(S) | PEU_U01 PEU_U02 PEU_K01 | Active participation |
| F2(S) | PEU_U01 PEU_U02 PEU_K01 | Active participation |
| P(S) | P=0,8F1+0,2F2 | |
| P(S) | P=0,8F1+0,2F2 | |

**PRIMARY AND SECONDARY LITERATURE**


**PRIMARY LITERATURE:**

[1] Goban-Klas T. (2009) Media i komunikowanie masowe: Teorie i analizy radia, prasy, telewizji i internetu, Wydawnictwo Naukowe PWN, Warszawa.
[2] Hopfinger M. (red.) (2002) Nowe media w komunikacji społecznej XX wieku, Oficyna Naukowa, Warszawa.
[3] Kluszczyński R. W. (2001) Społeczeństwo informacyjne. Cyberkultura. Sztuka multimediów, Rabid, Kraków.
[4] Leathers D. G. (2007) Komunikacja niewerbalna, Wydawnictwo Naukowe PWN, Warszawa.

**SECONDARY LITERATURE:**

[1] van Dijk J., (2010) Społeczne aspekty nowych mediów, Wydawnictwo Naukowe PWN, Warszawa.
[2] McLuhan M. (2001) Wybór tekstów, Zysk i Spółka, Poznań.
[3] Rothert A. (2003) Technopolis. Wirtualne sieci polityczne, Elipsa, Warszawa.
[4] Sieńko M. (2002) Człowiek w pajęczynie: Internet jako zjawisko kulturowe, Atut, Wrocław.
[5] Bugajski M. (2007) Język w komunikowaniu, Wydawnictwo Naukowe PWN, Warszaw

| SUBJECT SUPERVISOR |
| --- |
| Adriana Merta-Staszczak, Andrzej Postawa, adriana.merta-staszczak@pwr.edu.pl, andrzej.postawa@pwr.edu.pl |

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Prawo własności intelektualnej na świecie** |
| Name of subject in English: | **Intellectual property rights in the world** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W05ETK-SM1231 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 25 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of legal concepts.
2. The ability to thinking independely, searching and analyzing information.
3. The understanding of self-education need and continuous improvement of the knowledge.

### SUBJECT OBJECTIVES

C1. Gaining knowledge of the legal protection of intellectual property in the field of industrial property and copyright.
C2. Understanding the rules of intellectual property protection within international procedures.
C3. Awareness of the importance of intellectual property protection in the world.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Student is able to define the concept of industrial property rights, its types, scope of protection and limitations.

PEU_W02 The student is able to characterize the concept of copyright, its types and scope of protection, the methods copyright management (licenses).

PEU_W03 Student knows the rules of intellectual property protection within the international procedures.

*relating to skills:*

*relating to social competences:*

PEU_K01 He understands the importance of intellectual property protection in the contemporary world.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction to the law. The concept of intellectual property. Sources of industrial property rights and copyright in the world. International agreements. | 2 |
| Lec 2 | Patents, utility models, industrial designs, know-how- definitions, scope of protection, duration, limitations of rights. | 2 |
| Lec 3 | Granting a patent in the regional and international procedures. | 2 |
| Lec 4 | Trademarks. Trademark protection systems in the EU, the U.S.A., Latin America and Asia. | 2 |
| Lec 5 | Subject and object of copyright law in international law. Categories and types of works protected by copyright. Exclusions from copyright protection of certain categories of work. The obtaining of copyright protection. | 2 |
| Lec 6 | Economic copyrights - the content, disposal of the work. Management of copyright property rights (licenses). Limitations of copyright - fair use. | 2 |
| Lec 7 | The rules of intellectual property protection within regional and international procedures. | 2 |
| Lec 8 | Written test. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Traditional lecture. |
| N2. Multi-media presentation. |
| N3. Consultations. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_K01 | Written test. |
| P(W) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Kotarba W., Ochrona własności intelektualnej", Oficyna Wydawnicza Politechniki warszawskiej, Warszawa 2012
[2] Sieńczyło-Chlabicz, Prawo własności intelektualnej, Wydawnictwo prawnicze LexisNexis, Warszawa 2013
[3] Nowińska E., Promińska U. de Vall M., Prawo własności przemysłowej, Wydawnictwo prawnicze LexisNexis, Warszawa 2008
[4] Grzywińska A., Okoń S., Marki, wynalazki, wzory użytkowe: ochrona własności przemysłowej, Wydawnictwo Helion, Gliwice 2010
[5] Poradnik wynalazcy. Zasady sporządzania dokumentacji zgłoszeń wynalazków i wzorów użytkowych. Urząd Patentowy R.P. www.uprp.gov.pl
[6] Ustawa z dn. 30.06.2000 r. Prawo własności przemysłowej. Dz. U. z 2001 r. nr 49, poz. 508 z późniejszymi zmianami


**SECONDARY LITERATURE:**


[1] Żakowska-Henzler H., Wynalazek biotechnologiczny. Przedmiot patentu., Wydawnictwo Naukowe Scholar, Warszawa 2006
[2] de Vall M, Prawo patentowe, Wolters Kluwer, Warszawa 2008
[3] Adamczak A., du Vall M., Ochrona własności intelektualnej, UOTT, Warszawa 2010.


## SUBJECT SUPERVISOR


Michał Lisowski, michal.lisowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Wynalazki i patenty** |
| Name of subject in English: | **Inventions and patents** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W05ETK-SM1232 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 25 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of legal concepts.
2. The ability to thinking independely, searching and analyzing information.
3. The understanding of self-education need and continuous improvement of the knowledge.

## SUBJECT OBJECTIVES

C1. Understanding the concepts of inventions, their classification and characteristics.
C2. Understanding the principles of patent protection.
C3. Gaining knowledge about the process of obtaining a patent in the national, regional and international procedure.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 He is able to define the concept of the invention, describe its features and types.
PEU_W02 He is able to determine what is a patent, characterize its content. scope, duration and limitations.
PEU_W03 He has knowledge how to grant a patent in the national, regional and international procedures.

*relating to skills:*

*relating to social competences:*

PEU_K01 He is able to think creatively.

## PROGRAMME CONTENT

| | Lecture | Number of hours: |
|---|---|---|
| Lec 1 | Introduction.The most important theories of patent protection and the basic sources of patent law at international, EU and national level. | 2 |
| Lec 2 | The concept of the invention and its features (terms of patentability). Inventions excluded from protection. | 2 |
| Lec 3 | Types of inventions. The specificity of a biotechnological invention. | 2 |
| Lec 4 | Patent - content, scope of protection, duration, limitations. | 2 |
| Lec 5 | The concept of patent author and his rights. License agreements. | 2 |
| Lec 6 | Patent application in the national, European and international procedure. | 2 |
| Lec 7 | Patent databases as a source of information. Terms of use of patent databases. | 2 |
| Lec 8 | Written test. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
| --- |
| N1. Traditional lecture.<br>N2. Multi-media presentation.<br>N3. Consultations. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
| --- | --- | --- |
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Written test. |
| P(W) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Kotarba W., Ochrona własności intelektualnej", Oficyna Wydawnicza Politechniki warszawskiej, Warszawa 2012
[2] „Prawo własności przemysłowej", Wydawnictwo C.H. Beck 2010
[3[3] Nowińska E., Promińska U. de Vall M., Prawo własności przemysłowej, Wydawnictwo prawnicze LexisNexis, Warszawa 2008
[4] Grzywińska A., Okoń S., Marki, wynalazki, wzory użytkowe: ochrona własności przemysłowej, Wydawnictwo Helion, Gliwice 2010
[5] Poradnik wynalazcy. Zasady sporządzania dokumentacji zgłoszeń wynalazków i wzorów użytkowych. Urząd Patentowy R.P. www.uprp.gov.pl
[6] Ustawa z dn. 30.06.2000 r. Prawo własności przemysłowej. Dz. U. z 2001 r. nr 49, poz. 508 z późniejszymi zmianami


**SECONDARY LITERATURE:**


[1] Nowicka A., Wynalazek, Prawo własności przemysłowej, Wyd. Difin, Warszawa 2005
[2] Żakowska-Henzler H., Wynalazek biotechnologiczny. Przedmiot patentu., Wydawnictwo Naukowe Scholar, Warszawa 2006
[3] de Vall M, Prawo patentowe, Wolters Kluwer, Warszawa 2008
[4] Adamczak A., du Vall M., Ochrona własności intelektualnej, UOTT, Warszawa 2010.


## SUBJECT SUPERVISOR


Michał Lisowski, michal.lisowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Prawo własności przemysłowej i prawo autorskie dla inżynierów** |
| Name of subject in English: | **Industrial property and copyright for engineers** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W05ETK-SM1233 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 25 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of legal concepts
2. The ability to thinking independely, searching and analyzing information.
3. The understanding of self-education need and continuous improvement of the knowledge.

### SUBJECT OBJECTIVES

C1. Gaining knowledge of the legal protection of intellectual property in the field of industrial property and copyright.
C2. Gaining knowledge about the protection of inventions, utility models and industrial designs.
C3. Awareness of the importance of protection of intellectual property in engineering activities.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Student is able to define the concept of industrial property rights, its types, scope of protection and limitations.

PEU_W02 Student is able to characterize the concept of copyright, its types and scope of protection, the methods of copyright management (licenses).

*relating to skills:*

*relating to social competences:*

PEU_K01 He is able to think creatively.

### PROGRAMME CONTENT

| | Lecture | Number of hours: |
|---|---|---|
| Lec 1 | The concept of intellectual property. Sources of industrial property law. Industral property - its types and scope. | 2 |
| Lec 2 | The concept of the invention and its features (terms of patentability). The specificity of a biotechnological invention. Inventions excluded from protection. | 2 |
| Lec 3 | Patents, utility models, industrial designs - the content, the scope of protection, duration, limitations. Principles of preparation of patent specification and the use of patent databases. | 2 |
| Lec 4 | Subject of copyright law - the concept of copyright work, its categories and types. Exclusions from the copyright protection. | 2 |
| Lec 5 | The copyright subject - the concept of the creator, co-creator and others copyright holders. Moral and economic copyrights- the content and infringement of protection. | 2 |
| Lec 6 | The limitatios of economic copyrights – time duration and fair use. Managament of economic copyrights (licenses). | 2 |
| Lec 7 | Copyright protection of databases. Copyright and the Internet. Copyright infringement on the Internet. | 2 |
| Lec 8 | Written test. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Traditional lecture.<br>N2. Multi-media presentation.<br>N3. Consultations. |

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| Evaluation<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_K01 | Written test. |
| P(W) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] Kotarba W., Ochrona własności intelektualnej", Oficyna Wydawnicza Politechniki warszawskiej, Warszawa 2012
[2] Sieńczyło-Chlabicz, Prawo własności intelektualnej, Wydawnictwo prawnicze LexisNexis, Warszawa 2013
[3] Nowińska E., Promińska U. de Vall M., Prawo własności przemysłowej, Wydawnictwo prawnicze LexisNexis, Warszawa 2008
[4] Grzywińska A., Okoń S., Marki, wynalazki, wzory użytkowe: ochrona własności przemysłowej, Wydawnictwo Helion, Gliwice 2010
[5] Poradnik wynalazcy. Zasady sporządzania dokumentacji zgłoszeń wynalazków i wzorów użytkowych. Urząd Patentowy R.P. www.uprp.gov.pl
[6] Ustawa z dn. 30.06.2000 r. Prawo własności przemysłowej. Dz. U. z 2001 r. nr 49, poz. 508 z późniejszymi zmianami

**SECONDARY LITERATURE:**

[1] Żakowska-Henzler H., Wynalazek biotechnologiczny. Przedmiot patentu., Wydawnictwo Naukowe Scholar, Warszawa 2006
[2] de Vall M, Prawo patentowe, Wolters Kluwer, Warszawa 2008
[3] Adamczak A., du Vall M., Ochrona własności intelektualnej, UOTT, Warszawa 2010.


## SUBJECT SUPERVISOR


Michał Lisowski, michal.lisowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Ochrona własności intelektualnej** |
| Name of subject in English: | **Protection of Intellectual Property** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W05ETK-SM1007 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 25 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a basic knowledge about legislative issues.

## SUBJECT OBJECTIVES

C1. Getting the knowledge in the field of intellectual property protection.
C2. Skills of determination of patent procedures, introduction of utility models, industrial, trade marks.
C3. Forming of attitudes of the respect for the law of the intellectual property.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has a basic knowledge about elements of patent protection, trademarks, utility models, industrial designs.
PEU_W02 Has a basic knowledge about copyright .

*relating to skills:*

*relating to social competences:*

PEU_K01 He understands the need of protection of the copyright and following them.

## PROGRAMME CONTENT

| | Lecture | Number of hours: |
|---|---|---|
| Lec 1 | The notion and meaning of the intellectual property in the activity of companies and the everyday life. Protection systems of the intellectual property and types of protective laws. | 2 |
| Lec 2 | Industrial property law - kinds of the knowledge of PWP being protected, comprehending the invention, the patent and the patent ability, procedures of the patent protection (PL, EU, international), costs of the procedures patent, world trends in the patent protection. | 2 |
| Lec 3 | Utility models, industrial designs definitions and procedures of the protection. | 2 |
| Lec 4 | Trademarks and service - definitions and procedures of the protection | 2 |
| Lec 5 | The copyright and related rights: protection of scientific, literary, artistic works, computer programs and databases. The object and the subject of laws, duration of the protection | 2 |
| Lec 6 | The access and ways of using information bases about the protected intellectual property - cells and examples of using patent information | 2 |
| Lec 7 | The transfer of knowledge and agreements in trading with laws of the intellectual property | 2 |
| Lec 8 | Test | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lectures with multimedia presentation supplemented by traditional form<br>N2. Individual work of students<br>N3. Consultation |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_K01 | Test |
| P(W) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Bently L., B. Sherman Intellectual property law. Oxford, New York , Oxford University Press, cop. 2009.
[2] Lewis J.A. Intellectual property protection: promoting innovation in a global information economy, Washington: Center for Strategic and International Studies, 2008.
[3] C. Junghans, A. Levy, Intellectual Property Management: A Guide for scientists, engineers, financiers and managers, Wiley-VCH 2006.


**SECONDARY LITERATURE:**


[1] Internet portals dedicated to intellectual property: www.uprp.pl, www.epo.org, www.uspto.gov, www.wipo.org, OHIM etc


## SUBJECT SUPERVISOR


Aldona Dereń, aldona.deren@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Prawo międzynarodowe** |
| Name of subject in English: | **International Law** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W05ETK-SM1008 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 25 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a basic knowledge about legislative issues.

## SUBJECT OBJECTIVES

C1. Getting of basic knowledge in the field of international law.
C2. Skills for understanding and interpretation of the existing provisions in the area of international law
C3. Acquisition and persisting social competence in respecting the provisions of international law.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 He knows the basic functioning of the international community and the international legal order.

PEU_W02 He knows the principles of cooperation through international organizations.

*relating to skills:*

*relating to social competences:*

PEU_K01 He understands the need of the development of the activity of an engineer in technical and legal and control aspects

## PROGRAMME CONTENT

| | Lecture | Number of hours: |
|---|---|---|
| Lec 1 | The international law and his sources. Principles shaping contemporary international relations. Processes and international structures. | 2 |
| Lec 2 | International agreements and their meaning for integration processes international and of globalization. | 2 |
| Lec 3 | Legal subjectivity of international organizations. | 2 |
| Lec 4 | Sources and principles of the international protection of human rights | 2 |
| Lec 5 | Foreign economic relations - characteristics of regulations being in force. Legal bases of international funds. International economic transactions. | 2 |
| Lec 6 | Civil law and commercial in the international exchange. | 2 |
| Lec 7 | Legal grounds of international marketing. | 2 |
| Lec 8 | Test | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lectures with multimedia presentation supplemented by traditional form |
| N2. Individual work of students |
| N3. Consultation |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_K01 | Test |
| P(W) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] “Polish Yearbook of International Law, Wydawnictwo Instytutu nauk Prawnych Warszawa 2010.
[2] I. Brownlie, Principles of Public International Law, (OUP 2008).
[3] I. Slomanson, W. William, Fundamental Perspectives on Internationa Law, Boston 2011.
[4] The Free Dictionary Definition of Human Rights”, The American Heritage® Dictionary of the English Language, Fourth Edition copyright ©2000 by Houghton Mifflin Company. Updated in 2009.. Retrieved 13 September 2011.
[5] R. Filipek, Protection of Human Rights in the EU – Meeting the Standards of a European Human Rights System?, A. Bodnar et al. (red.) The Emerging Constitutional Law of the European Union. German and Polish Perspectives, Heidelberg 2003.

**SECONDARY LITERATURE:**

[1] L. Antonowicz, Podręcznik prawa międzynarodowego, Wydawnictwo LexisNexis Warszawa 2003.
[2] W. Czapliński, A. Wyrozumska, Prawo międzynarodowe publiczne, Warszawa 2010.
[3] „ Przegląd prawa europejskiego i międzynarodowego” , Wydawnictwo Wolters Kluwer Polska – ABC, Warszawa 2011.
[4] A. Przyborowska-Klimczak, D. Pyć, Leksykon prawa międzynarodowego publicznego, Wydawnictwo C.H. Beck Warszawa 2012
[5] J. Ciszewski, Obrót prawny z zagranicą w sprawach cywilnych i karnych, Wydawnictwo LexisNexis Warszawa 2012.

## SUBJECT SUPERVISOR

Aldona Dereń, aldona.deren@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Mechanizmy rynkowe w energetyce o strukturze rozproszonej** |
| Name of subject in English: | **Market Mechanisms in Power Systems with Distributed Energy Sources** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W05ETK-SM2538 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 50 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knows the principles a power system operation and control, is familiar with electricity generation and transmission techniques.
2. Has a basic knowledge in the field of renewable energy sources.
3. Understands a need and knows possibilities of continuous education, increasing of professional, personal and social competences.

## SUBJECT OBJECTIVES

C1. Possession a knowledge of function of electric energy sector including renewable energy sources.
C2. Getting to know market and regulatory mechanisms in power sector.
C3. Possession a knowledge of electric energy market.
C4. Possession a knowledge of goals of national and union energy policy.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Knows function of electric energy sector including renewable energy sources.
PEU_W02 Knows market and regulatory mechanisms in power sector.
PEU_W03 Possesses a knowledge of electric energy market.

*relating to skills:*

*relating to social competences:*

PEU_K01 Can think and act in creative and enterprising way. He/she is able to rank appropriately the priorities needed for realizing the respective task.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Specific features of energy supply sector. Evolution of structural forms - from vertical integration to restructuring and liberalization. | 2 |
| Lec 2 | Mechanisms of energy market. | 2 |
| Lec 3 | Regulation of energy market. | 2 |
| Lec 4 | State' interventionism and market rules. Regulatory mechanisms on energy market. | 2 |
| Lec 5 | Infrastructural multi-energy utilities. | 2 |
| Lec 6 | Financial relations between market entities. | 2 |
| Lec 7 | Realization of the European energy policy goals: effectiveness, use of renewable energy sources, counteraction of climate changes. | 2 |
| Lec 8 | Test. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lecture with the use of audiovisual techniques, multimedia presentations. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_K01 | Test. |
| P(W) | P=F1 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] Kowalska A., Wilczyński A., Źródła rozproszone w systemie elektroenergetycznym. Wydawnictwo Kaprint, Lublin, 2007.
[2] Malko J. Wilczyński A., Rynki energii – działania marketingowe. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2006.
[3] W.Joerss, M. Uyterlinde, P. Loeffler, P.E. Morthost, Decentralised Power Generation in the Liberalised EU Energy Markets, Springer-Verlag Berlin Heidelberg, 2003.
[4] B. Murray, Power Markets and Economics: Energy Costs, Trading, Emissions, John Wiley and Sons Ltd. Chichester, England, 2009.

**SECONDARY LITERATURE:**

[1] M. Shahidehpour, H. Yamin, Zuyi Li, Market Operations in Electric Power Systems: Forecasting, Scheduling, and Risk Management, John Wiley and Sons Ltd. New York, 2002.
[2] Czasopisma: Rynek Energii, IEEE Power & Energy, Power Engineering, Renewable Energy World.

**SUBJECT SUPERVISOR**

Waldemar Dołęga, waldemar.dolega@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Podstawy Zarządzania** |
| Name of subject in English: | **Fundamentals of Management** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Control in Electrical Power Engineering** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W05ETK-SM1499 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 50 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a basic knowledge about management processes, functions, principles and tools and identifies the basic management issues.

## SUBJECT OBJECTIVES

C1. To ensure fundamental knowledge (including application aspects) about: setting up the business
C2. To ensure fundamental knowledge (including application aspects) about: organization as a system
C3. To ensure fundamental knowledge (including application aspects) about: organizational development dynamics and characteristics of the organization in various development phases
C4. To ensure fundamental knowledge (including application aspects) about: change and project management

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has a basic knowledge about setting up and running the business.
PEU_W02 Has a basic knowledge about managing organization as a system.
PEU_W03 Has a basic knowledge about introducing changes in organizations

*relating to skills:*

*relating to social competences:*

PEU_K01 aware how important is the cooperation in completing complex tasks.

## PROGRAMME CONTENT

| Lecture | | Number of hours: |
|---|---|---|
| Lec 1 | Scope of lecture, conditions of crediting and literature Introduction: challenges of contemporary management | 2 |
| Lec 2 | How to set up the business? The essence of entrepreneurship. | 2 |
| Lec 3 | Organization as a system of functions, processes and operations. | 2 |
| Lec 4 | Managing organizational environment. | 2 |
| Lec 5 | Organizational transformations: birth, growth, decline, and death. Change management | 2 |
| Lec 6 | Project management | 2 |
| Lec 7 | Effective teams building | 2 |
| Lec 8 | Final assessment | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
| --- |
| N1. Traditional lecture with multimedia presentations<br>N2. Case studies presented during lecture<br>N3. Self-study: final assessment preparation |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
| --- | --- | --- |
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Final assessment |
| F2(W) | PEU_K01 | Scoring students' involvement during lecture |
| P(W) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] McKee A.: Management: a focus on leaders, Pearson , Boston 2012.


**SECONDARY LITERATURE:**


[1] Griffin R.W.: Management, Houghton Mifflin Company, New York 2008.
[2] Jones G.R., George J.M., Essentials of contemporary management, McGraw-Hill Irwin, Boston 2007 (2006).
[3] Osterwalder A., Pigneur Y., Business model generation: a handbook for visionaries, game changers, and challengers, John Wiley & Sons, 2010.
[4] Robbins S.P., DeCenzo D.: Fundamentals of management: essential concepts and applications, Pearson/Prentice Hall, 2008.


## SUBJECT SUPERVISOR


Anna Zgrzywa-Ziemak, anna.zgrzywa-ziemak@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Graficzne środowiska inżynierskie i języki programowania wizualnego** |
| Name of subject in English: | **Visual Engineering Environments and Graphical Languages** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM1230 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | 30 | | |
| Number of hours of total student workload (CNPS): | 30 | | 90 | | |
| Form of crediting: | examination | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | 3 | | |
| including number of ECTS points for practical (P) classes : | | | 3 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | 2.10 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has the basic knowledge related to programming languages including data types and structures, operators, functions and procedures as well as objects.
2. Is computer-literate and has the high comfort level with using MS Windows operating system.
3. Is able to speak English and is familiar with English technical terminology at intermediate level required to comprehend and understand information and matters given during lectures and laboratory tutorials as well as well to communicate effectively and to discuss technical issues with lecturer as well as with other students.

## SUBJECT OBJECTIVES

C1. To make a student acquainted with methodology and rules of graphical object-oriented programming language using selected development environment.

C2. To let a student acquire practical knowledge and skills required for writing computer applications using graphical programming language.

C3. Promotion of teamwork and team programming.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Being able to explain and describe the concept of object-oriented graphical programming.

PEU_W02 Being able to characterize basic and advanced objects and graphical functional blocks offered by a selected visual object-oriented programming language.

*relating to skills:*

PEU_U01 Being able to develop an algorithm to solve computational and remote-control-related problem taking into account specific requirements of visual object-oriented programming language.

PEU_U02 Being able to implement the develop algorithm in the form of a program prepared, run, tested and optimized in the selected visual object-oriented programming language.

*relating to social competences:*

PEU_K01 Is open to team work idea and is determined to co-operate in a team.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introductory information: basic requirements, rules and forms of credition. Review on the "visual" software packages: high-level languages, process visualization tools, integrated programming and development environments, graphical languages. Concept of object-oriented graphical programming. Objects and their mutual connections as the syntax of graphical programming. Rules of data flow, sequencing, multithreading. | 2 |
| Lec 2 | Local and global variables, registers, containers, input and output terminals. Data types and structures. Data conversion and promotion/demotion rules. Functions and user objects, user objects nesting and dependency. | 2 |
| Lec 3 | Basic objects and functional blocks: their classification, inputs and outputs, functionality and hints on their use. | 2 |
| Lec 4 | Advanced mathematical, statistical and signal processing objects and functions. Text and binary file processing objects. | 2 |
| Lec 5 | Data exchange and control of external programs: ActiveX automation, .NET compliancy, Matlab engine control, network solutions. Communication and control of external devices, control of digital communication interfaces. | 2 |
| Lec 6 | Communication and device control using SCPI, VISA, ModBus. IVI device standards. Virtual instrument idea, instrument drivers. Graphical user interface and data visualization. | 2 |
| Lec 7 | Principles, tips and tricks helpful in designing data processing and control programs. Efficiency and speed optimization issues. Special solutions for improving execution speed and numerical processing power, „embedded" and „real-time" applications. | 2 |
| Lec 8 | Overview of selected practical applications and realizations (related e.g. to data manipulation, image processing and computer-controlled measurement and automation). | 1 |
| | Total hours: | **15** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Basic operations within visual engineering environment package. Program editing (loading, linking and deleting objects, creation of new user objects and user functions), edition of terminals and definition of data types. Running a program, searching for and correction of errors, preview of container content and data flow. | 2 |
| Lab 2 | Practical presentation of application and operation of basic objects and functional blocks offered by the visual programming environment – students are requested to fulfill mini-programming tasks (including puzzle game, reaction speed tester, primes generator, visualize computing results, create files documenting measurements, processing of data read from a file). | 16 |
| Lab 3 | Presentation of the test tasks and their allocation for student groups. Preparation of test task application: elaboration of algorithms, implementation in the visual object-oriented programming environment. | 10 |
| Lab 4 | Group presentation of the application implementing the allocated test tasks. An overview and discussion of the developed algorithms and programming solutions. | 2 |
| | Total hours: | **30** |

| TEACHING TOOLS USED |
|---|
| N1. Lectures given using traditional as well as modern audiovisual techniques (including multimedia presentations).<br>N2. Demonstration of device functionality and operation, demonstration of software package functionality, configuration and options.<br>N3. Hands-on computing experience with software package during laboratory tutorials supervised by the lecturer.<br>N4. Consultation (with the lecturer).<br>N5. Team work and working on one's own using demo version of the visual software package made available to students. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | Oral examination. |
| P(W) | P=F1 | |
| F1(L) | PEU_U01<br>PEU_U02 | Assessment of the completed algorithm, its implementation in a selected graphical programming language and operation of the completed program. |
| F2(L) | PEU_K01 | Assessment of the incurred workload into achievements of the student group. |
| P(L) | P=0,7F1+0,3F2 | |

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE:**<br>[1] R. Helsel, Graphical programming-a tutorial for HP Vee, Prentice Hall PTR, London, 1995.<br>[2] W. Tłaczała, Środowisko LabView w eksperymencie wspomaganym komputerowo, WNT, Warszawa 2002.<br>[3] R. H. Bishop, LabView Student edition 6i, Upper Sadle River, Prentice-Hall 2001.<br>**SECONDARY LITERATURE:**<br>[1] W. Winiecki, Organizacja komputerowych systemów pomiarowych. WPW, Warszawa 1997.<br>[2] L. U. Wells, LabView for everyone: graphical programming made even easier, Upper Saddle River, Prentice Hall 1997.<br>[3] related information and services provided by Agilent and National Instruments companies available at their websites. |

| SUBJECT SUPERVISOR |
|---|
| Paweł Żyłka, pawel.zylka@pwr.edu.pl |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Metody numeryczne i metody optymalizacji** |
| Name of subject in English: | **Numerical and Optimization Methods** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM1330 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge about the properties of multivariable functions
2. Basic knowledge in the field of calculus
3. Basic knowledge in the field of matrix algebra

## SUBJECT OBJECTIVES

C1. Transfer of the basic knowledge and skills needed for correct formulation of optimization problems
C2. Ordered presentation of various optimization methods
C3. Training the skills in practical use of software packages for solving optimization problems

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 knows the rules of mathematical formulation of optimization problems
PEU_W02 knows basic methods and algorithms used to solve an optimization problem relating to skills

*relating to skills:*

PEU_U01 is able to formulate an optimization problem in mathematical terms
PEU_U02 is able to solve an optimization problem correctly selecting the solving algorithm

*relating to social competences:*

PEU_K01 creativity in searching for the solution of a given problem

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Basic terms. Goal function, constrains, problem parameters. Formulation and classification of optimization tasks. Examples of problems. | 2 |
| Lec 2 | Elements of calculus and matrix algebra related to optimization problems. Convex sets and convex functions | 2 |
| Lec 3 | Nonlinear optimization without constrains. Sufficient and necessary conditions for optimization of unconstrained problems | 2 |
| Lec 4 | Algorithms for unconstrained problems used for minimum search. Steepest descent algorithm. Conjugate gradient algorithm. Newton algorithm and quasi Newton methods | 2 |
| Lec 5 | Minimum search of a one variable function. Golden section search algorithm | 2 |
| Lec 6 | Nonlinear optimization with constrains. Kuhn-Tucker conditions. Lagrange function. Duality formulation | 2 |
| Lec 7 | Penalty function methods. Linear optimization. Integer numbers optimization | 2 |
| Lec 8 | Final test | 1 |
| | Total hours: | **15** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | H&S regulations. Laboratory working rules. Rules for working in a group. Rules for final crediting. Preliminary conditions. Presentation of subsequent labs contents | 1 |
| Lab 2 | Constructing a mathematical model of an optimization problem. Analytical determination of the extremum of a function | 4 |
| Lab 3 | Research on the effectiveness of numerical algorithms dedicated for problems without constrains | 4 |
| Lab 4 | Solving problems with constrains | 2 |
| Lab 5 | Applying the Optimization Toolbox of Matlab | 4 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lecture with multimedia presentations |
| N2. Computer laboratory suitable for group working |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | Written final test |
| P(W) | P=F1 | |
| F1(L) | PEU_U01<br>PEU_U02<br>PEU_K01 | Grading the correctness of optimization problem solutions |
| P(L) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] .K.P. Chong, S.H. Żak: An Introduction to Optimization, 2nd edition, New York, John Wiley, 2001
[2] J.F. Bonnans: Numerical optimization: theoretical and practical aspects, Springer-Verlag, 2003
[3] M. Asghar Bhatti: Practical Optimization Methods, Berlin, Springer-Verlag 2000


**SECONDARY LITERATURE:**


[1] J. Nocedal, S. J. Wright, Numerical Optimization, Springer-Verlag, 2000


## SUBJECT SUPERVISOR


Przemysław Janik, przemyslaw.janik@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Ocena jakości energii** |
| Name of subject in English: | **Power Quality Assessment** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM1331 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 15 | | |
| Number of hours of total student workload (CNPS): | 90 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | | 0.70 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knows basic lows of electrical engineering and electrical quantity.
2. Is able to implement fundamental mathematical formulation in software environment as Matlab etc.
3. Understands the need and possibility of lifelong learning, achieving new skills professional as well as personal and social.

## SUBJECT OBJECTIVES

C1. Getting the knowledge about different power quality disturbances, origin and impact of power quality disturbances
C2. Getting the knowledge about power quality indices as well as standards and regulations dedicated to limits and methods of power quality assessment
C3. Acquire practical skills of application of fundamental algorithms used in identification of power quality parameters as well as method of assessment and reporting

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Have general knowledge about power quality issues including relations to electromagnetic compatibility
PEU_W02 Know legislative formulation and regulation concerning limits in power quality
PEU_W03 Know the structure and range of power quality report

*relating to skills:*

PEU_U01 Decide and select limits of power quality disturbances for particular electrical equipments
PEU_U02 Implement fundamental algorithms used in calculation of parameters of the power quality disturbances
PEU_U03 Is able to join the origin of power quality disturbances with its potential influence on condition of work of electrical equipment

*relating to social competences:*

PEU_K01 Is responsible for entrusted task, exhibits creative attitude and cooperation in team

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Initial issues, definitions of power quality, standards and implementing institutions. Quality of electricity supply. | 2 |
| Lec 2 | Power quality disturbances in relations to electromagnetic compatibility. Review and classification of power quality disturbances. | 2 |
| Lec 3 | Methods of measurement and algorithms for disturbances of main frequency. Origin of power quality disturbances and potential impact on the operation of electrical power systems elements. | 2 |
| Lec 4 | Methods of measurement and algorithms for disturbances of voltage. Origin of power quality disturbances and potential impact on the operation of electrical power systems elements. Example of emission and immunity test of the electrical equipments. | 2 |
| Lec 5 | Methods of measurement and algorithms for disturbances of voltage and current waveform. Origin of power quality disturbances and potential impact on the operation of electrical power systems elements. Example of emission and immunity test of the electrical equipments. | 2 |
| Lec 6 | Methods of measurement and algorithms for disturbances of symmetry and power balance. Origin of power quality disturbances and potential impact on the operation of electrical power systems elements. | 2 |
| Lec 7 | Methods of measuring and assessment of the quality of electricity supply in low voltage and medium voltage power systems, the limits for the power quality disturbances, meaning of quality of the supply for distribution system operator. | 2 |
| Lec 8 | Methods of measuring and assessment of the quality of electricity supply in high voltage power systems, the limits for the power quality disturbances, meaning of quality of the supply for transmission system operator. | 2 |
| Lec 9 | Review of power quality recorders. Scope of the report of power quality, distribution of real measurements for the power quality report. | 2 |
| Lec 10 | Discussion of exemplary power quality report. Examples of power quality disturbances finder. | 2 |
| Lec 11 | Power quality monitoring systems, distributed measurement systems, time synchronization, on-line access. | 2 |
| Lec 12 | Power quality monitoring systems, data based tools in the evaluation of the multipoint measurement data. | 2 |
| Lec 13 | Selected methods of reducing or elimination of voltage disturbances. | 2 |
| Lec 14 | Selected methods of reducing or elimination of voltage and current waveform disturbances. | 2 |
| Lec 15 | Oral test, assessment of power quality report | 2 |
| | Total hours: | **30** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Information about the regulation of work in the laboratory, requirements for passing the course, distribution of the instructions and additional materials | 1 |
| Lab 2 | Algorithms for voltage dips assessment. Part 1. | 2 |
| Lab 3 | Algorithms for voltage dips assessment. Part 2. | 2 |
| Lab 4 | Algorithms for harmonics assessment. Part 1. | 2 |
| Lab 5 | Algorithms for harmonics assessment. Part 2. | 2 |
| Lab 6 | Configuration of power quality recorder and assessment of the selected power quality parameters on the basis of real measurement at the laboratory setup. Part 1. | 2 |
| Lab 7 | Configuration of power quality recorder and assessment of the selected power quality parameters on the basis of real measurement at the laboratory setup. Part 2. | 2 |
| Lab 8 | Discussion the reports on particular laboratories, final marks, additional term of the laboratory. | 2 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lectures with multimedia presentation |
| N2. Organization of the laboratory work in subgroup |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Oral test, assessment of power quality report |
| P(W) | P=F1 | |
| F1(L) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Evaluation of preparing for laboratories |
| F2(L) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Evaluation of reports of particular laboratories |
| P(L) | P=0,2*F1+0,8*F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Arrillaga J. Watson N. R.: Power System Quality Assessment, John Wiley & Sons, New York, 2000.
[2] Bollen M. H. J.: Understanding Power Quality Problems Voltage Sags and Interruptions, IEEE Press, New York, USA, 2000.
[3] Dugan R. C., McGranaghan M. F., Beaty H. W.: Electrical Power Systems Quality, McGraw-Hill, New York, USA, 1986.


**SECONDARY LITERATURE:**


[1] Electrical Power Quality and Utilization - Journal
[2] Leonardo Energy – Power Quality Guide


## SUBJECT SUPERVISOR


Tomasz Sikorski, tomasz.sikorski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Obwody i układy** |
| Name of subject in English: | **Circuits and Systems** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM1332 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | 15 | | | |
| Number of hours of total student workload (CNPS): | 90 | 30 | | | |
| Form of crediting: | examination | crediting with grade | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | 1 | | | |
| including number of ECTS points for practical (P) classes : | | 1 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | 0.70 | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knows basic lows of electrical engineering and recognize electrical quantity.
2. Knows differential and integral calculus of one variable function, linear algebra and mathematic calculation in complex domain.
3. Can implement basic differential calculation, linear algebra and calculation on complex number.
4. Can recognize fundamental electrical problems and tools for its solution.

## SUBJECT OBJECTIVES

C1. Getting the knowledge techniques used in synthesis of electrical circuits.
C2. Acquire skills of nonlinear circuit analysis.
C3. Getting the knowledge about state variable matrix application.
C4. Getting the knowledge about application of continuous representation of signals, transfer function in operator and frequency form.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Have knowledge about circuit synthesis
PEU_W02 Knows elements of nonlinear circuits analysis including stability issues
PEU_W03 ormulate general theory of system description using state variable matrix. Formulate genera theory of system description using transfer function in operator and frequency form

*relating to skills:*

PEU_U01 Decide and select method of circuit synthesis on the basis of immittance function
PEU_U02 Is able to analyze fundamental circuits with nonlinear elements
PEU_U03 Is able to use state variable matrix in system description. Is able to use transfer function in operator and frequency form in system description

*relating to social competences:*

PEU_K01 Is responsible for entrusted task, exhibits creative attitude in selection of calculation techniques

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction to circuits and electrical systems. Properties of circuits General problems description of the circuits according to the circuit components and operating state. General issues concerning signal transfer through the system. | 2 |
| Lec 2 | Selected issues of circuits synthesis. positive rational functions, immittance function of driving point impedance. | 2 |
| Lec 3 | Selected issues of circuits synthesis. Techniques for synthesis of passive RC, RL, LC circuits, Foster and Cauer synthesis. Part 1. | 2 |
| Lec 4 | Selected issues of circuits synthesis. Techniques for synthesis of passive RC, RL, LC circuits, Foster and Cauer synthesis. Part 2. | 2 |
| Lec 5 | Selected issues of nonlinear circuits analysis. Characteristics of driving point nonlinear elements. | 2 |
| Lec 6 | Selected issues of nonlinear circuits analysis. Selected methods of nonlinear circuits analysis. | 2 |
| Lec 7 | Selected issues of nonlinear circuits analysis. Stability of nonlinear circuits, phase plane. | 2 |
| Lec 8 | Selected issues of nonlinear circuits analysis. Stability of nonlinear circuits, stability in Lapunov theory. | 2 |
| Lec 9 | Selected issues of time series and matrix functions. differential and integral operation of matrix functions. | 2 |
| Lec 10 | Selected issues of time series and matrix functions. State variable, transfer matrix, excitation matrix, output matrix. | 2 |
| Lec 11 | Selected issues of time series and matrix functions. Application of engine values. | 2 |
| Lec 12 | Selected issues of continuous representation of deterministic signals. Two-side Laplace transform, convergence area, inverse transformation. | 2 |
| Lec 13 | Selected issues of continuous representation of deterministic signals. Fourier transform, relation of two-sides Laplace and Fourier transforms, signal parameters in time and frequency domain. | 2 |
| Lec 14 | Selected issues of continuous representation of deterministic signals. Transfer function of LTI circuits, elements of filter synthesis. Hilbert compound. | 2 |
| Lec 15 | Selected issues of continuous representation of deterministic signals. Elements of filter synthesis. | 2 |
| | Total hours: | **30** |

| **Classes** | | **Number of hours:** |
|---|---|---|
| Cl 1 | Information about the regulation of time schedule and requirements for passing the course. Application of synthesis of linear circuit - introduction | 2 |
| Cl 2 | Application of synthesis of linear circuit | 2 |
| Cl 3 | Application of methods of nonlinear circuits analysis. Part 1 | 2 |
| Cl 4 | Application of methods of nonlinear circuits analysis. Part 2 | 2 |
| Cl 5 | Application of state variable matrix in analysis of the circuits analysis. Part 1 | 2 |
| Cl 6 | Application of state variable matrix in analysis of the circuits analysis. Part 2 | 2 |
| Cl 7 | Application of transfer function of LTI circuits | 2 |
| Cl 8 | Crediting test | 1 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Lectures with multimedia presentation

N2. Classes work in subgroup

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Examination |
| P(W) | P=F1 | |
| F1(C) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Crediting test |
| P(C) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] A. Papoulis – Obwody i układy, WKiŁ, 1998 (PL) / A. Papoulis – Circuits and Systems: A modern approach, The Oxford Series in Electrical and Computer Engineering (EN)
[2] S. Haykin, B. Van Veen – Signals and systems, John Wiley & Sons, Inc., 1999.
[3] S T.H. Glisson – Introduction to system analysis, McGraw-Hill, Inc, 1985.
[4] G. E. Carlson – Signal and linear system analysis, John Wiley & Sons, Inc., 1998.
[5] Ch.T. Chen – System and signal analysis, Oxford University Press, 1994.


**SECONDARY LITERATURE:**


[1] A. D. Poularikas - The handbook of formulas and tables for signal processing, CRC Press, 2000
[2] Materiały pomocnicze: http://eportal.eny.pwr.wroc.pl/


## SUBJECT SUPERVISOR


Tomasz Sikorski, tomasz.sikorski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Sygnały i Systemy** |
| Name of subject in English: | **Signal and Systems** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM1334 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | 15 | | | |
| Number of hours of total student workload (CNPS): | 90 | 30 | | | |
| Form of crediting: | examination | crediting with grade | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | 1 | | | |
| including number of ECTS points for practical (P) classes : | | 1 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | 0.70 | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knows basic lows of electrical engineering and recognize electrical quantity.
2. Knows differential and integral calculus of one variable function, linear algebra and mathematic calculation in complex domain.
3. Can implement basic differential calculation, linear algebra and calculation on complex number.
4. Can recognize fundamental electrical problems and tools for its solution.
5. Understands the need and possibility of lifelong learning, achieving new skills professional as well as personal and social.

## SUBJECT OBJECTIVES

C1. Getting the knowledge about using of delta Dirac function and step function in description of system
C2. Learn possible application of state variable matrix, system matrix and engine values.
C3. Getting the knowledge about graphical representation of circuit’s equations.
C4. Getting the knowledge about of stability formulation.
C5. Acquire skills of digital circuit description.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Have a knowledge in using of delta Dirac function and step function in description of system. Knows methods of system descriptions using state variable matrix.

PEU_W02 Knows methods of graphical representations of system equations Knows the methods of define system stability criterions

PEU_W03 Knows the techniques of digital systems description

*relating to skills:*

PEU_U01 Apply delta Dirac function and step function in description of system. Use the method of system description based on state variable matrix.

PEU_U02 Select the method of graphical system representation using graph and block scheme techniques. Is able to select stability criteria and conclude about the stability.

*relating to social competences:*

PEU_K01 Is responsible for entrusted task, exhibits creative attitude in selection of calculation techniques

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Selected issues of system description. The basic properties of systems. The basic signals used in the system analysis. Elements of the theory of distribution. Step and Dirac impulse. Differentiation in terms of distribution theory. | 2 |
| Lec 2 | Selected issues system description. Impulse and step response of linear time-invariant systems. Duhamel integral and convolution. Calculation of convolution of positive-time side signals. | 2 |
| Lec 3 | Selected issues of description. Determination of impulse response, step response, and response for given excitation. | 2 |
| Lec 4 | Selected issues of time series and matrix functions. Differential and integral operation of matrix functions. | 2 |
| Lec 5 | Selected issues of time series and matrix functions. State variable, transfer matrix, excitation matrix, output matrix. | 2 |
| Lec 6 | Selected issues of time series and matrix functions. Application of engine values. | 2 |
| Lec 7 | Selected issues of graphical representation of circuit equations. flow graphs, block schemes, reduction of scheme blocks. Part 1. | 2 |
| Lec 8 | Selected issues of graphical representation of circuit equations. flow graphs, block schemes, reduction of scheme blocks. Part 2. | 2 |
| Lec 9 | Selected issues of graphical representation of circuit equations. flow graphs, block schemes, reduction of scheme blocks. Part 3. | 2 |
| Lec 10 | Selected issues of system stability. Definition of stability of transmission element, stability conditions, Hurwitz polynomial. | 2 |
| Lec 11 | Selected issues of system stability. Algebraic criteria, frequency criteria of linear stationary systems. Part 1. | 2 |
| Lec 12 | Selected issues of system stability. Algebraic criteria, frequency criteria of linear stationary systems.Part 2. | 2 |
| Lec 13 | Selected issues of digital system description. Impulse signal and his meaning in digitalization process, two-side ‘Z” transform, relation of ‘Z” transform with Laplace and Fourier technique. | 2 |
| Lec 14 | Selected issues of digital system description. sampling theory, spectrum of digital signals, stationarity, causality, stability of digital systems. | 2 |
| Lec 15 | Selected issues of digital system description. Frequency characteristic of digital systems. | 2 |
| | Total hours: | **30** |

| **Classes** | | **Number of hours:** |
|---|---|---|
| Cl 1 | Information about the regulation of time schedule and requirements for passing the course. Determination of impulse and step response of the systems. | 2 |
| Cl 2 | Application of theory of distribution in determination of step, impulse response and response for given excitations. | 2 |
| Cl 3 | Application of state variable matrix in determination of step and impulse response | 2 |
| Cl 4 | Application of state variable matrix in determination of system response for given excitations. Application of engine values for stability criterion. | 2 |
| Cl 5 | Application of graphical system representation using flow graphs | 2 |
| Cl 6 | Application of graphical system representation using block schemes | 2 |
| Cl 7 | Application of stability criterions | 2 |
| Cl 8 | Crediting test | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lectures with multimedia presentation |
| N2. Classes work in subgroup |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Examination |
| P(W) | P=F1 | |
| F1(C) | PEU_U01<br>PEU_U02<br>PEU_K01 | Crediting test |
| P(C) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] S. Haykin, B. Van Veen – Signals and systems, John Wiley & Sons, Inc., 1999.
[2] S T.H. Glisson – Introduction to system analysis, McGraw-Hill, Inc, 1985.
[3] G. E. Carlson – Signal and linear system analysis, John Wiley & Sons, Inc., 1998.
[4] Ch.T. Chen – System and signal analysis, Oxford University Press, 1994.

**SECONDARY LITERATURE:**

[1] A. D. Poularikas - The .handbook of formulas and tables for signal processing, CRC Press, 2000.
[2] Additional educational supplies http://eportal.eny.pwr.wroc.pl/

## SUBJECT SUPERVISOR

Tomasz Sikorski, tomasz.sikorski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Zaawansowane metody przetwarzania sygnałów** |
| Name of subject in English: | **Advanced Signal Processing Methods** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM1335 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | 15 | | | |
| Number of hours of total student workload (CNPS): | 90 | 30 | | | |
| Form of crediting: | examination | crediting with grade | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | 1 | | | |
| including number of ECTS points for practical (P) classes : | | 1 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | 0.70 | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge in the fields of calculus and linear algebra
2. Basic knowledge of the C language
3. Ability of systematic work and individual problem solving

## SUBJECT OBJECTIVES

C1. Understanding and proper application of digital signal processing methods
C2. Presentation of tools for description and analysis of digital systems in time and frequency domain
C3. Ability to design and implement simple digital systems

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 knows mathematical methods for description and analysis of digital systems in time and frequency domain
PEU_W02 knows algorithms for digital filter design

*relating to skills:*

PEU_U01 is able to provide a spectral analysis of a signal
PEU_U02 is able to design a simple digital filter

*relating to social competences:*

PEU_K01 creativity in searching for the solution of a given problem

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Discrete signal and systems – examples, mathematical notation, sampling, aliasing. Part I. | 2 |
| Lec 2 | Discrete signal and systems – examples, mathematical notation, sampling, aliasing. Part II. | 2 |
| Lec 3 | Description and analysis of digital systems in time domain: difference equation, convolution, impulse response, block schemes, state space variables, system classification. Part I. | 2 |
| Lec 4 | Description and analysis of digital systems in time domain: difference equation, convolution, impulse response, block schemes, state space variables, system classification. Part II. | 2 |
| Lec 5 | Z transform: definition of Z transform, the correlation of Z transform to Laplace transform, basic properties of Z transform , inverse Z transform (methods and computational examples), the area of convergence and its meaning, computations. Part I. | 2 |
| Lec 6 | Z transform: definition of Z transform, the correlation of Z transform to Laplace transform, basic properties of Z transform , inverse Z transform (methods and computational examples), the area of convergence and its meaning, computations. Part II. | 2 |
| Lec 7 | Applications of the Z transform: solving of difference equations, the transfer function, casuality and stability of systems. Part I. | 2 |
| Lec 8 | Applications of the Z transform: solving of difference equations, the transfer function, casuality and stability of systems. Part II. | 2 |
| Lec 9 | Discrete Fourier transform: Definition of DFT (introduction, examples, properties), correlation of DFT to Z transform, inverse DFT, elimination of leakage with the window method, resolution of FFT. Part I. | 2 |
| Lec 10 | Discrete Fourier transform: Definition of DFT (introduction, examples, properties), correlation of DFT to Z transform, inverse DFT, elimination of leakage with the window method, resolution of FFT. Part II. | 2 |
| Lec 11 | Digital filters: introduction, methods of description, examples, classification. Finite impulse response filters -FIR. Design of FIR, window method. Part I. | 2 |
| Lec 12 | Digital filters: introduction, methods of description, examples, classification. Finite impulse response filters -FIR. Design of FIR, window method. Part II. | 2 |
| Lec 13 | Fast Fourier transform FFT. Correlation between FFT and DFT. Part I. | 2 |
| Lec 14 | Fast Fourier transform FFT. Correlation between FFT and DFT. PartII. | 2 |
| Lec 15 | Algorithm for FFT: computational scheme, implementation example, butterfly structures for FFT | 2 |
| | Total hours: | **30** |

| **Classes** | | **Number of hours:** |
|---|---|---|
| Cl 1 | Mathematical description, generation and sampling for discrete signals. Part I. | 2 |
| Cl 2 | Mathematical description, generation and sampling for discrete signals. Part II. | 2 |
| Cl 3 | Z transform, Inverse Z transform. Part I. | 2 |
| Cl 4 | Z transform, Inverse Z transform. Część II. | 2 |
| Cl 5 | Transfer function, impulse response, difference equation, block scheme. Part I. | 2 |
| Cl 6 | Transfer function, impulse response, difference equation, block scheme. Part II. | 2 |
| Cl 7 | Fourier Transform - implementation. Part I. | 2 |
| Cl 8 | Fourier Transform - implementation. Part II. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lecture with multimedia presentations |
| N2. Classes with problems for individual solving |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | exam |
| P(W) | P=F1 | |
| F1(C) | PEU_U01<br>PEU_U02<br>PEU_K01 | written final test |
| P(C) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] S. Haykin, B. Van Veen – Signals and Systems, John Wiley & Sons, Inc., 1999
[2] D. F. Elliot – Handbook of Digital Signal Processing, Academic Press, Inc., 1987
[3] S. M. Kay – Modern Spectral Estimation, Prentice Hall, Signal Processing Series, Englewood Cliffs, 1988

**SECONDARY LITERATURE:**

[1] M. Vetterli, J. Kovacevic - Wavelets and Subband Coding, Englewood Cliffs, Prentice Hall, 1994


## SUBJECT SUPERVISOR


Przemysław Janik, przemyslaw.janik@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Fotowoltaika** |
| Name of subject in English: | **Photovoltaic Cells** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM1337 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | examination | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge in the field of electrical installations
2. Basic knowledge in the field of circuit theory
3. Basic knowledge of electrical properties of solids

## SUBJECT OBJECTIVES

C1. Transfer of the basic knowledge and skills in the field of photovoltaic engineering
C2. Training the practical skills associated with photovoltaic systems

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 knows the photovoltaic system types and their characteristics
PEU_W02 knows the rules how to select and attune elements of the PV system

*relating to skills:*

PEU_U01 Is able to characterize operational parameters of PV
PEU_U02 is able to select PV system elements

*relating to social competences:*

PEU_K01 creativity in thinking and handling enabling an professional problem solving

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Basic terms and definitions: solar irradiation – spectral and energy characteristics | 2 |
| Lec 2 | Photovoltaic cells – semiconductors types, additions, photovoltaic effect | 2 |
| Lec 3 | Construction of photovoltaic sell – V-I characteristic | 2 |
| Lec 4 | Technologies for PV cell production | 2 |
| Lec 5 | Assembly of production steps of PV modules | 2 |
| Lec 6 | PV systems – elements, characteristics | 2 |
| Lec 7 | Energy storage devices dedicated for PV systems | 2 |
| Lec 8 | Testing, calibration, normalization – selected issues | 2 |
| Lec 9 | Island systems – rules for elements selection and sizing | 2 |
| Lec 10 | Grid connected systems – elements selection and sizing, valuation of energy production | 2 |
| Lec 11 | Monitoring and SCADA for PV systems | 2 |
| Lec 12 | Computer aided design of PV system – software solutions | 2 |
| Lec 13 | Standards and legal rules for PV systems | 2 |
| Lec 14 | Policy and finacing schemes supporing the developemnet of PV systems | 2 |
| Lec 15 | Summary, presentation of examination topics | 2 |
| | Total hours: | **30** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Assessment of mean irradiation and energy production potential for different geographical localizations | 2 |
| Lab 2 | Recording of V-I characteristics for different types of cell technologies | 2 |
| Lab 3 | Statistical analysis of energy production corralled to meteorological data | 2 |
| Lab 4 | Monitoring of a PV system | 4 |
| Lab 5 | Simulation of faults in a PV system | 2 |
| Lab 6 | Power Quality measurement and assessment in a PV system | 3 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Traditional lecture with multimedia presentations
N2. Laboratory adapted for activities in small groups

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | written examination |
| P(W) | P=F1 | |
| F1(L) | PEU_U01<br>PEU_U02<br>PEU_K01 | grading the students self-preparation to lab tasks |
| P(L) | P=F1 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] S.R. Wenham, M.A. Greek, M.E. Watt, R. Corkish,, Applied Photovoltaics, Earthscan, London 2009

**SECONDARY LITERATURE:**

[1] .D. Myers, Solar Applications In Industry and Commerce, Prentice-Hall, New Jersey 1984
[2] V.D. Hunt , Handbook of Conservation nad Solar Energy, Van Nostrand Reinhold, New York 1982

**SUBJECT SUPERVISOR**

Przemysław Janik, przemyslaw.janik@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

Name of subject in Polish: **Ekologia przemysłowa – wybrane zagadnienia**
Name of subject in English: **Industrial ecology - selected problems**
Main field of study (if applicable): **Electrical Engineering**
Specialization (if applicable): **Renewable Energy Systems**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: W05ETK-SM1338
Group of courses: **NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | 15 |
| Number of hours of total student workload (CNPS): | 30 | | | | 30 |
| Form of crediting: | crediting with grade | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | | 0.70 |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of biology at the secondary school level
2. Can efficiently and effectively apply the knowledge from publicly available sources of information.

### SUBJECT OBJECTIVES

C1. Knowledge of various aspects of industrial ecology.
C2. Capability of analysis and recognition of problems related to waste reduction and modeling of industrial processes in accordance with principles of laws of nature.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Knows the basic principles of ecology. Has a basic knowledge of environmental issues and the design of industrial systems modelled on biological systems.

PEU_W02 Has knowledge of the science of environmental sustainability and industrial engineering. Knows the tools to analyze the impact of industrial processes on the environment.

PEU_W03 Has ordered knowledge of the application of industrial ecology in the business, cost reduction, organizational optimization and integration of new technologies

*relating to skills:*

PEU_U01 The ability to identify and analyze the problems relating to the reduction of environmental burden and development of industrial processes in accordance with the environment.

PEU_U02 Knows how to use tools for the life cycle assessment, life cycle inventory and impact assessment.

*relating to social competences:*

PEU_K01 Is aware of the importance and understanding of non-technical aspects and impacts of engineering, including its impact on the environment, and consequently the responsibility for decisions.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | General presentation of industrial ecology. The role of biodiversification in human activity. Industry as living system within living systems. | 2 |
| Lec 2 | Capability of imitation of the nature. Fundamental laws of industrial ecology | 2 |
| Lec 3 | Dynamics of ecosystems, its limitations in industry. Ecological systems and natural systems. | 2 |
| Lec 4 | Methods and tools of industrial ecology. | 2 |
| Lec 5 | Industrial metabolism. Modeling of input/output dynamics. Waste prevention, examples | 2 |
| Lec 6 | New opportunities for administration, policy and regulations, local government, government's role. | 2 |
| Lec 7 | Strategies and implementation of IE. Decentralized processes, social and economic control. public/private dialogue, research. | 2 |
| Lec 8 | Test. | 1 |
| | Total hours: | **15** |

| **Seminar** | | **Number of hours:** |
|---|---|---|
| Sem 1 | Introduction. Presentation topics for discussion. The division into research groups. Discuss and prepare presentations on the topics discussed in the lecture. | 2 |
| Sem 2 | The lifetime of the product, business services, applications in the future. | 2 |
| Sem 3 | New perspectives related to the application of industrial ecology in business, cost reduction, new markets, marketing, organizational change, the integration of new technologies. | 2 |
| Sem 4 | Industrial ecosystems and ecological industrial parks. Costs, risks and challenges associated with the creation of EIP (Eco-Industrial Parks). | 2 |
| Sem 5 | Examples in the field of energy and transportation, etc. | 2 |
| Sem 6 | Examples in the field of production, telecommunications, construction, etc. | 2 |
| Sem 7 | Evaluation of the possibility of transformation of selected industries in the spirit of industrial ecology. | 2 |
| Sem 8 | Evaluation of students' work | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lecture using traditional techniques, audiovisual, multimedia presentations, transparencies |
| N2. Seminar using traditional techniques, audiovisual, multimedia presentations, transparencies. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Written test |
| P(W) | P = F1 | |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Presentation |
| P(S) | P = F2 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] Graedel T E, Allenby B.: Industrial Ecology and Sustainable Engineering, Pearson Education, Inc., 2010.
[2] Allenby B, Allenby R, Deanna J.: The Greening of Industrial Ecosystems, National Academy Press, Washington, 1994.
[3] IEEE White Paper on Sustainable Development and Industrial Ecology, IEEE 1995.


**SECONDARY LITERATURE:**

Literature provided by the lecturer

**SUBJECT SUPERVISOR**


Zbigniew Leonowicz, zbigniew.leonowicz@pwr.wroc.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Zwarcia w systemie elektroenergetycznym** |
| Name of subject in English: | **Power Systems Faults** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2131 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | | |
| Number of hours of total student workload (CNPS): | 120 | | | | |
| Form of crediting: | examination | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 4 | | | | |
| including number of ECTS points for practical (P) classes: | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.80 | | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has basic knowledge on a power system operation.
2. Knowledge of complex number calculations.

## SUBJECT OBJECTIVES

C1. Gaining knowledge on faults occurring in power systems.
C2. Familiarization with methods for analysis of fault waveforms and for fault identification.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has knowledge on faults occurring in high voltage networks.
PEU_W02 Has knowledge on faults occurring in medium voltage networks.
PEU_W03 Has knowledge on analysis of fault waveforms and on fault identification.

*relating to skills:*

*relating to social competences:*

PEU_K01 Is able to independent thinking and to performing analysis of technical information.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Establishing conditions for passing and marking the lecture. Causes and consequences of faults, classifications of faults, aims of fault calculations. | 2 |
| Lec 2 | Fault identification - digital algorithms for fault detection. | 2 |
| Lec 3 | Fault identification - digital algorithms for fault direction discrimination and fault classification. | 2 |
| Lec 4 | Fault calculations - application of per units, method of symmetrical components, calculations in phase co-ordinates. | 2 |
| Lec 5 | Models of generators and power transformers in fault calculations. | 2 |
| Lec 6 | Equivalent circuit diagrams of overhead and cable lines for symmetrical components. Modal transformation, calculations in phase co-ordinates. | 2 |
| Lec 7 | Analysis of three-phase symmetrical faults. Analysis of single phase faults. | 2 |
| Lec 8 | Analysis of phase-to-phase faults. Analysis of phase-to-phase-to-earth faults. | 2 |
| Lec 9 | Analysis of broken conductor failure and broken conductor failure combined with phase-to-earth fault. | 2 |
| Lec 10 | Requirements of international standards for fault calculations. | 2 |
| Lec 11 | Earth faults in networks with isolated neutral point. | 2 |
| Lec 12 | Earth faults in networks with neutral point earthed through compensating reactor and through resistor. | 2 |
| Lec 13 | Microprocessor-based fault recorders and fault locators – application basics. | 2 |
| Lec 14 | Fault location on power lines with use of local and two-end measurements. | 2 |
| Lec 15 | Transformation of fault voltages and currents by instrument protective transformers. | 2 |
| | Total hours: | **30** |

| TEACHING TOOLS USED |
|---|
| N1. Informative lecture. |
| N2. Student's own work. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester)* *P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01 PEU_W02 PEU_W03 | Presence at the lectures |
| F2(W) | PEU_W01 PEU_W02 PEU_W03 PEU_K01 | Written or oral examination |
| P(W) | P=0,1F1+0,9F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] Iżykowski J., Power system faults. PRINTPAP, 2011, p. 190.

**SECONDARY LITERATURE:**

[1] Glover J. D., Sarma M., Power system analysis and design. PWS Publishing Company Boston, second edition, 1994.
[2] Michalik M., Rosołowski E., Simulation and analysis of power system transients. PRINTPAP, 2011.
[3] Saha M.M., Iżykowski J., Rosołowski E., Fault location on power networks. Springer-Verlag London, Series: Power Systems, 2010, 425 p.

## SUBJECT SUPERVISOR

Jan Iżykowski, jan.izykowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Komputerowa analiza elektromagnetycznych stanów przejściowych** |
| Name of subject in English: | **Simulation and Analysis of Power System Transients** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2133 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | 30 | | |
| Number of hours of total student workload (CNPS): | 30 | | 60 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | 2 | | |
| including number of ECTS points for practical (P) classes : | | | 2 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | 1.40 | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Student should have the basic knowledge of fundamentals of circuit theory and basics of differential calculus.
2. Student should know how to formulate digital models of electrical circuits and to conduct analyses regarding accuracy, stability and frequency characteristics.
3. Student should know how to calculate the parameters of basic elements of the line.

### SUBJECT OBJECTIVES

C1. To provide knowledge of methods for solving differential equations describing electrical circuits.
C2. Learning how to formulate digital models of electrical circuits and to conduct analyses regarding accuracy, stability and frequency characteristics.
C3. To provide knowledge of modelling a power line with distributed parameters.
C4. Familiarization with methods of modelling and simulation of wind and photovoltaic power stations.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Student gets the knowledge on description of models for linear electrical circuits with use of differential equations and their numerical solution applying different numerical procedures of integration.

PEU_W02 Student gets the knowledge regarding evaluation of accuracy and stability of the solution of a differential equation in a numerical way.

*relating to skills:*

PEU_U01 Student is able to model linear elements and branches and also a power transmission line with distributed parameters, in particular, applying a graphical editor of this program, forms a structure of a simulative model, sets simulation parameters, conducts a simulation and analyses waveforms of signals from a modelled system.

PEU_U02 Student is able to apply results of computer simulation to analyse of dynamic electric circuits.

*relating to social competences:*

PEU_K01 Student can act independently and cooperate within a group working on a complex engineering project.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction, syllabus of the course, basic definitions. Computer programs for electromagnetic transients simulations - general description. | 2 |
| Lec 2 | Digital models of linear elements (R, L, C) of an electric network | 2 |
| Lec 3 | Basic concept of numerical solution of a dynamic network equations | 2 |
| Lec 4 | Line model with distributed parameters. | 2 |
| Lec 5 | Numerical oscillation and limitations of using the computer tools to simulation of electromagnetic transients. | 2 |
| Lec 6 | Modelling of relays, measuring algorithms and instrument transformers | 2 |
| Lec 7 | Modelling of power electronic converters | 2 |
| Lec 8 | Qualified test | 1 |
| | Total hours: | **15** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Presentation of health and safety rules, and general regulations of the laboratory. Establishing conditions for passing and marking the project course. General familiarization with the ATP-EMTP program. | 2 |
| Lab 2 | Simulation of a 3-phase network with line, load and a fault. | 2 |
| Lab 3 | Simulation of 3-phase transformer with magnetizing characteristic. Test of the transformer energising. | 2 |
| Lab 4 | Simulation of the instrument transformers with the relay input chain. | 2 |
| Lab 5 | Modelling of faults in 3-phase network with transformer and instrument transformers. | 2 |
| Lab 6 | Modelling of digital measuring algorithms applied in relay protection units. | 2 |
| Lab 7 | Simulation of the induction motors. Test of start and load changing. | 2 |
| Lab 8 | Testing of the synchronous generation with excitation control scheme. | 2 |
| Lab 9 | Simulation of generation station with control scheme; fault analysis | 2 |
| Lab 10 | Modelling of DFIG driven by wind turbine. | 2 |
| Lab 11 | Modelling of DFIG with power control system. | 2 |
| Lab 12 | Simulation of ride-through faults on the line connected wind generator. | 2 |
| Lab 13 | Modelling of the photovoltaic source. | 2 |
| Lab 14 | Simulation of the interconnection between the photovoltaic source with the utility network. | 2 |
| Lab 15 | Additional term. | 2 |
| | Total hours: | **30** |

| TEACHING TOOLS USED |
|---|
| N1. Informative lecture.<br>N2. ATP-EMTP simulation program.<br>N3. Lab reports. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | Attendance on lectures |
| F2(W) | PEU_W01<br>PEU_W02 | Qualified test |
| P(W) | P=0,1*F1+0,9*F2 | |
| F1(L) | PEU_U01<br>PEU_U02<br>PEU_K01 | Activity in the project work |
| F2(L) | PEU_U01<br>PEU_U02<br>PEU_K01 | Project reports |
| P(L) | P=0,3*F1+0,7*F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] N. Watson, J. Arrillaga: Power systems electromagnetic transients simulation. The Institution of Electrical Engineers, London 2003.
[2] H.W. Dommel: Electromagnetic Transients Program. Reference Manual. BPA, Portland, 1986.
[3] J. D. Glover, M. Sarma: Power system analysis and design, PWS Publishing Company Boston, second edition, 2002.
[4] W. D. Stevenson: Elements of Power System Analysis (4th Ed.). McGrawHill, New York, 1982.
[5] J-P. Barret, P. Bornard, B. Meyer: Power system simulation: Chapman and Hall, London 1997.


**SECONDARY LITERATURE:**


[1] Alternative Transients Program. Rule Book. K.U. Leuven, EMTP Center, 1987.
[2] P. Kacejko P., J. Machowski: Faults in power systems, WNT Warszawa 2002 (in polish).
[3] Materials available at: http://www.rose.pwr.wroc.pl/


## SUBJECT SUPERVISOR


Eugeniusz Rosołowski, eugeniusz.rosolowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Techniki sztucznej inteligencji** |
| Name of subject in English: | **Artificial Intelligence Techniques** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2135 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | 15 | |
| Number of hours of total student workload (CNPS): | 60 | | | 30 | |
| Form of crediting: | crediting with grade | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | 1 | |
| including number of ECTS points for practical (P) classes : | | | | 1 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | 0.70 | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of basics of power system control, digital signal processing and numerical methods.
2. Practical skills of using MATLAB and ATP-EMTP software.

### SUBJECT OBJECTIVES

C1. Acquaintance of knowledge related artificial intelligence techniques application to digital power system protection and control systems.
C2. Acquiring practical skills to design and analyze control and protection units for power systems, with application of artificial intelligence techniques.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Possesses knowledge related to expert systems: basic features, structure, inference methods, conflict resolution strategies, application fields.

PEU_W02 Possesses knowledge related to fuzzy logic systems: fuzzy signals, membership functions, fuzzy settings, fuzzyfication and defuzzyfication methods, realization of multi-criteria algorithms.

PEU_W03 Possesses knowledge related to artificial neural networks (features, neurone types, activation functions, neural network structures, learning methods, application fields) as well as genetic algorithms (evolutionary strategies, genetic modifications).

*relating to skills:*

PEU_U01 Is able to apply expert systems for power system control and protection purposes.

PEU_U02 Is able to apply fuzzy logic technique for power system control and protection purposes.

PEU_U03 Is able to apply artificial neural networks and genetic algorithms for power system control and protection purposes.

*relating to social competences:*

PEU_K01 Is able to carry out a complex engineering project in a competent way, unaided, undertaking multi-criterial analysis.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Setting rules of course crediting. Definition of artificial intelligence (AI), AI as a branch of science, AI techniques in power systems, statistics of AI application in power system protection and control. | 2 |
| Lec 2 | AI approach to protection and control tasks – problems of contemporary digital protection systems, protection relay as a classifying unit, protection tasks as pattern recognition tasks. | 2 |
| Lec 3 | Expert Systems (ES) – definitions, knowledge base, data base, inference mechanisms. | 2 |
| Lec 4 | ES – semantic rules and structures, acquisition of rules, inference methods, conflict resolving strategies. | 2 |
| Lec 5 | Expert Systems – application fields, examples. | 2 |
| Lec 6 | Fuzzy Logic (FL) – basics of fuzzy sets theory, operations on fuzzy sets, fuzzy arithmetic. Linguistic variables, operators of aggregation, fuzzy reasoning. | 2 |
| Lec 7 | Elements of FL in power system protection – fuzzy criteria signals, fuzzy settings, fuzzy comparison, amount of information, multi-criterial decision making. | 2 |
| Lec 8 | Examples of FL technique application in power system protection. | 2 |
| Lec 9 | Artificial Neural Networks (ANN) – neurone models, activation functions, multilayer perceptrons, feed-forward networks. | 2 |
| Lec 10 | ANN architectures: feed-forward networks, ANNs with feedback connections, Hopfield networks, Kohonen networks. | 2 |
| Lec 11 | ANN design problems – network structure selection, generation of training patterns, training algorithms with and without the teacher, learning process acceleration techniques, knowledge generalisation vs. overfitting. | 2 |
| Lec 12 | Examples of ANN application in power system control. | 2 |
| Lec 13 | Genetic algorithms – evolutionary strategies, genetic modification of individuals, genetic optimisation, application examples. | 2 |
| Lec 14 | Comparison of described AI techniques, hybrid structures, examples. | 2 |
| Lec 15 | Crediting test. | 2 |
| | Total hours: | **30** |

| **Project** | | **Number of hours:** |
|---|---|---|
| Proj 1 | Design and implementation of an expert system for chosen decision task. | 4 |
| Proj 2 | Design and evaluation of the fuzzy logic based measurement/decision unit. | 4 |
| Proj 3 | Design and evaluation of the neural network based measurement/decision unit. | 4 |
| Proj 4 | Implementation of genetic optimization procedures for selected measurement/decision task. | 2 |
| Proj 5 | Presentations of executed projects, crediting. | 1 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Informative lecture.
N2. Matlab and ATP-EMTP programmes.
N3. Project presentation.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01 PEU_W02 PEU_W03 | Participation in the course. |
| F2(W) | PEU_W01 PEU_W02 PEU_W03 | Crediting test. |
| P(W) | P = 0,1F1 + 0,9F2 | |
| F1(P) | PEU_U01 PEU_U02 PEU_U03 PEU_K01 | Activity during the classes. |
| F2(P) | PEU_U01 PEU_U02 PEU_U03 PEU_K01 | Presentation of the projects done. |
| P(P) | P = 0,2F1 + 0,8F2 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] Rebizant W., Szafran J., Wiszniewski A., Digital signal processing in power system protection and control, Springer, London 2011
[2] Russel S.J., Norvig P., Artificial intelligence: a modern approach, Prentice Hall, Pearson, 2010
[3] James J. Buckley, Esfandiar Eslami, An introduction to fuzzy logic and fuzzy sets, Heidelberg Physica-Verlag, 2002
[4] Dillon T.S. and Niebur D. (edited by), Neural Network Applications in Power Systems, CRL Publishing Ltd., London 1996
[5] Liebowitz J., The Handbook of applied expert systems, Boca Raton, CRC Press, 1998

**SECONDARY LITERATURE:**

[1] Gottlob G. And Nejdl W. (ed. by), Expert Systems in Engineering: Principles and Applications, Proceedings of the International Workshop, Vienna, Austria, Sept. 1990
[2] Cichocki A., Unbehauen R., Neural Networks for Optimization and Signal Processing, John Wiley & Sons, 1993
[3] Yager R.R. and Filev D.P., Essentials of Fuzzy Modelling and Control, J. Wiley & Sons, Inc., New York, USA, 1994
[4] Ringland G.A. and Duce D.A. (ed. By), Approaches to Knowledge Representation: An Introduction, Research Studies Press Ltd., Wiley & Sons, Chichester, England, 1988
[5] Pao Y.A., Adaptive Pattern Recognition and Neural Networks, Addison-Wesley, Reading, MA, 1989


## SUBJECT SUPERVISOR


Waldemar Rebizant, waldemar.rebizant@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Projektowanie układów logicznych** |
| Name of subject in English: | **Design of logic circuits** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM2136 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. To be familiar with fundamentals of digital circuits.
2. To know how to practically interconnect simple digital circuits and verify their operation.
3. To be able to think and act in a creative way.
4. To be able to work in a team.

## SUBJECT OBJECTIVES

C1. Gaining theoretical and practical knowledge on combinatorial logic circuits: canonical form, Karnaugh maps method, phenomenon of hazards.
C2. Gaining theoretical and practical knowledge on sequential logic circuits: the method of consecutive switching tables, Moore and Mealy type automata, races phenomenon.
C3. Familiarization with methods concerning: presenting a logic circuit operation, selecting of design methods, practical analysis/synthesis methods and ways of implementing logic circuits.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has knowledge on operation, analysis and synthesis methods of combinatorial logic circuits.
PEU_W02 Has knowledge on operation, analysis and synthesis methods of sequential logic circuits.

*relating to skills:*

PEU_U01 Is able to conduct both analysis and synthesis, as well as to implement combinatorial logic circuits with use of the Karnaugh maps method, with eliminating a hazard phenomenon.
PEU_U02 Student is able to conduct both analysis and synthesis, as well as to implement asynchronous logic circuits with use of the method of consecutive switching tables, in particular Moore and Mealy types, with eliminating of races phenomenon.
PEU_U03 Student is able to conduct both analysis and synthesis, as well as to implement synchronous logic circuits.

*relating to social competences:*

PEU_K01 Student is able to act independently and cooperate within a group working on a complex engineering project.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Conditions for passing and marking the course. Basics of Boole algebra. Typical logic gates and circuits and their graphic symbols. | 2 |
| Lec 2 | Design of combinatorial logic circuits. | 2 |
| Lec 3 | Sequential automata – types, general characteristic, design principles. | 2 |
| Lec 4 | Design of sequential automata with the method of consecutive switching tables. | 2 |
| Lec 5 | Sequential automata – description of Moore and Mealy type automata. | 2 |
| Lec 6 | Sequential automata – design steps. | 2 |
| Lec 7 | Implementation of asynchronous sequential automata, elimination of races phenomenon and hazards. | 2 |
| Lec 8 | Pass test | 1 |
| | Total hours: | **15** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Presentation of health and safety rules, and general regulations of the laboratory. Conditions for passing and marking the course. General familiarization with the laboratory stands and simulative software. | 2 |
| Lab 2 | Design of asynchronous sequential logic circuits with use of the transition tables and output maps. Implementation of circuits with use of logic gates - part 1. | 2 |
| Lab 3 | Design of asynchronous sequential logic circuits with use of the transition tables and output maps. Implementation of circuits with use of logic gates - part 2. | 2 |
| Lab 4 | Design of asynchronous sequential logic circuits with use of the transition tables and output maps. Implementation of circuits with use of flip-flops. | 2 |
| Lab 5 | Design of asynchronous sequential logic circuits with the method of consecutive switching tables. | 2 |
| Lab 6 | Multiplexers, de-multiplexers and code conversion circuits, adders, subtractors, comparators, counters and memory registers - investigation of selected circuit. | 2 |
| Lab 7 | Design of synchronous sequential logic circuits. | 2 |
| Lab 8 | Summary of laboratory excercises. | 1 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Informative lecture.
N2. Didactic models of digital circuits.
N3. Programme for simulating digital circuits.
N4. Report on performed laboratory excercise.
N5. Student's own work.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | Presence at the lectures |
| F2(W) | PEU_W01<br>PEU_W02 | Crediting test |
| P(W) | P=0,1F1+0,9F2 | |
| F1(L) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Activity at the laboratory |
| F2(L) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Reports from the laboratory assignements |
| P(L) | P=0,3F1+0,7F2 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] Mano M. Morris, Digital design (second edition), Prentice-Hall Int., Inc., Englewood Cliffs, New Jersey, 1991.
[2] M. Morris Mano, C. R. Kime: Logic and computer design fundamentals, Pearson Prentice-hall Int., 2004, 3rd ed.
[3] Tocci R.J., Digital Systems. Principles and applications, Prentice-Hall Int., Inc., London, 1988.

**SECONDARY LITERATURE:**

[1] Układy logiczne. Ćwiczenia laboratoryjne. Skrypt Politechniki Wrocławskiej pod red. Mirosława Łukowicza. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław, 2002
[2] Wilkinson B., Układy cyfrowe. WKŁ, Warszawa, 2000
[3] Skorupski A., Podstawy techniki cyfrowej. WKŁ, Warszawa, 2001
[4] Kamionka-Mikuła H., Małysiak H., Pochopień B., Układy cyfrowe. Teoria i przykłady. Wydawnictwo Pracowni Komputerowej Jacka Skalmierskiego. Wydanie III poszerzone. Gliwice 2001.


## SUBJECT SUPERVISOR


Justyna Herlender, justyna.herlender@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Zabezpieczanie i sterowanie rozproszonymi źródłami energii 1** |
| Name of subject in English: | **Protection and Control of Distributed Energy Sources 1** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2137 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Student should have the basic knowledge of fundamentals of circuit theory and basics of differential calculus.
2. Student should know how to analyse steady states and transients in linear circuit
3. Student should have ability to think and act in a creative way. Student should have ability to work in a team.

## SUBJECT OBJECTIVES

C1. To provide knowledge of methods related to electric power network protection.
C2. Learning how to formulate criteria and schemes for fault detection in power networks.
C3. To provide knowledge of modelling and simulation of transient phenomena in electric power lines.
C4. Learning how to control of distributed generation system.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Student gets the knowledge on description of phenomena accompanying faults in power networks.
PEU_W02 Student gets the knowledge regarding the applied criteria in protective relays.

*relating to skills:*

PEU_U01 Student is able to model linear elements and branches and also a power transmission line with distributed parameters, in particular, applying the ATP-EMTP programme.
PEU_U02 Student is able to define basic fault detection criteria for protection of distributed generation networks.

*relating to social competences:*

PEU_K01 Student can act independently and cooperate within a group working on a complex engineering project.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | General introduction – aims of the course. Establishing conditions for passing and marking the course. Principle of the line and generators protection. | 2 |
| Lec 2 | Principle of the MV network protection depending on neutral grounding.. | 2 |
| Lec 3 | Methods of distributed generation interconnection with the network. | 2 |
| Lec 4 | Influence of distributed generation connection with the network from the protection point of view. | 2 |
| Lec 5 | Methods applied for loss of mains detection.. | 2 |
| Lec 6 | Protection and control of the photovoltaic generation station. | 2 |
| Lec 7 | Algorithms applied for DFIG and wind turbine control. | 2 |
| Lec 8 | Pass test. | 1 |
| | Total hours: | **15** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Presentation of health and safety rules, and general regulations of the laboratory. Establishing conditions for passing and marking the project course. General familiarization with the ATP-EMTP program. | 2 |
| Lab 2 | Simulation of transmission line with distributed parameters. Analysis of interconnection between distributed generation and the utility network. | 2 |
| Lab 3 | Testing of the synchronous generation with excitation control scheme. | 2 |
| Lab 4 | Simulation of double fed induction generator connection to the network. | 2 |
| Lab 5 | Simulation analysis of the algorithms applied for loss of mains detection. | 2 |
| Lab 6 | Simulation analysis of the over-current protection. | 2 |
| Lab 7 | Simulation analysis of the over-current transformer protection. | 2 |
| Lab 8 | Additional term | 1 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Informative lecture.
N2. Simulation program ATP-EMTP.
N3. Lab reports.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | Attendance on lectures |
| F2(W) | PEU_W01<br>PEU_W02 | test |
| P(W) | P=0,1*F1+0,9*F2 | |
| F1(L) | PEU_U01<br>PEU_U02 | Project reports |
| F2(L) | PEU_U01<br>PEU_U02 | Activity in the project work |
| P(L) | P=0,3*F1+0,7*F2 | |

**PRIMARY AND SECONDARY LITERATURE**


**PRIMARY LITERATURE:**

[1] ELMOR W.A., PROTECTIVREE LAYING THEORYAN D APPLICATIONS. MARCELD EKKEIRN,C . D E., 2004
[2] http://www.rose.pwr.wroc.pl/index_a.htm - materiały do kursu
[3] LUND H., Renewable Energy Systems. Elsevier Inc. 2010.

**SECONDARY LITERATURE:**

[1] QUASCHNING V., Understanding Renewable Energy Systems. Earthscan 2005.
[2] JENKINS N. ALLAN R., CROSSLEY P., KIRSCHEN D., STRBACET G., Embedded generation. The Institution of Electrical Engineers, London 2000.
[3] ACKERMANN T. (editor), Wind power in power systems. John Wiley & Sons, Ltd, Chichester 2005

| SUBJECT SUPERVISOR |
| --- |
| Eugeniusz Rosołowski, eugeniusz.rosolowski@pwr.edu.pl |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Elektroenergetyka-zajęcia terenowe** |
| Name of subject in English: | **Electrical Power Engineering – excursionary activities** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM2138 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | 15 |
| Number of hours of total student workload (CNPS): | 60 | | | | 30 |
| Form of crediting: | crediting with grade | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | | 0.70 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. The student has ordered theoretical knowledge necessary to develop a detailed topic in the broadly understood power system and control systems area.
2. Can properly apply the knowledge learned to prepare an article and a multimedia presentation.
3. Can cooperate in an international group.

## SUBJECT OBJECTIVES

C1. Extension and transplantation of knowledge in the field of electrical power engineering in the context of industrial practice.
C2. Expansion of skills to develop independently and present selected topics in power engineering.
C3. Acquisition of skills related to active participation in the discussion on presented of results.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 He knows about methods of control of RES systems, in particular those related to real industrial objects.

PEU_W02 He knows about algorithms of control of RES systems, in particular those related to real industrial objects.

*relating to skills:*

PEU_U01 He can independently characterize and evaluate the utility values of basic RES systems in relation to the problems of functioning in the electric power system.

PEU_U02 He can evaluate the importance of RES control systems for cooperation with the power network.

*relating to social competences:*

PEU_K01 He can translate general principles and values of academic community into practical attitudes and behaviours during the international educational trip.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Principles of work and credit. Papers characteristics. | 2 |
| Lec 2 | Characteristics of RES objects - in relation to visited industrial objects (field activities) part.1. | 2 |
| Lec 3 | Characteristics of RES objects - in relation to visited industrial objects (field activities) part.2. | 2 |
| Lec 4 | Methods of control of RES objects - in relation to visited industrial objects (field activities) part 1. | 2 |
| Lec 5 | Methods of control of RES objects - in relation to visited industrial objects (field activities) part 2. | 2 |
| Lec 6 | Practical restrictions on the control of RES objects - in relation to visited industrial objects (field activities) part.1. | 2 |
| Lec 7 | Practical restrictions on the control of RES objects - in relation to visited industrial objects (field activities) part.2. | 2 |
| Lec 8 | Summary. Discussion of the results of written assignments. | 1 |
| | Total hours: | **15** |

| **Seminar** | | **Number of hours:** |
|---|---|---|
| Sem 1 | Requirements, individual subjects, nature of work, division into groups, conditions of credit. | 2 |
| Sem 2 | Se2-8. Presentation of the performed analysis for a given problem in the field of power engineering. | 13 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Field courses in industry, power plants, etc. and a seminar using multimedia presentations.
N2. Substantive discussion on the presented issues.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | Evaluation of the article / written report (distinguished works recommended to KNS) |
| P(W) | P=F1 | |
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Evaluation of multimedia presentation. |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Active participation in the didactic trip related to power engineering. |
| P(S) | P=0.7*F1+0.3*F2 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] Ehrlich, Robert (1938- ). Renewable energy : a first course / Boca Raton [etc.] : CRC Press/Taylor & Francis Group, cop. 2013
[2] Goodstal, Gary. Electrical theory for renewable energy Clifton Park : Delmar Cengage Learning, cop. 2013
[3] Thomashow, Mitchell. The nine elements of a sustainable campus / Cambridge, Mass. London, The MIT Press, cop. 2014

**SECONDARY LITERATURE:**

[1] Literature related directly to the individual subject of student work

**SUBJECT SUPERVISOR**

Przemysław Janik, przemyslaw.janik@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

Name of subject in Polish: **Obliczenia zwarciowe**
Name of subject in English: **Fault Calculations**
Main field of study (if applicable): **Electrical Engineering**
Specialization (if applicable): **Renewable Energy Systems**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: W05ETK-SM2139
Group of courses: **NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 30 | |
| Number of hours of total student workload (CNPS): | | | | 60 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 2 | |
| including number of ECTS points for practical (P) classes : | | | | 2 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 1.40 | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has basic knowledge on power system operation.
2. Has basic knowledge on programming in Matlab.
3. Is able to state and verify simple calculation algorithms.
4. Is able to think and act in a creative way.
5. Is able to work in a team.

### SUBJECT OBJECTIVES

C1. Gaining knowledge on power system faults.
C2. Familiarization with methods for analysis of fault signals and fault identification.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 Is able to analyse fault signals obtained from computer simulation.
PEU_U02 Is able to conduct fault identification and to determine its characteristic features.

*relating to social competences:*

PEU_K01 Is able to act independently and cooperate within a group working on a complex engineering project.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Project** | | **Number of hours:** |
| Proj 1 | Presentation of health and safety rules and general regulations of the laboratory. Establishing conditions for passing and marking the project course. Introduction - aim and contents of the projects to be performed. | 2 |
| Proj 2 | Familiarization with loading the simulation data from ATP-EMTP simulation into the Matlab programme and visualisation of the signals. | 2 |
| Proj 3 | Digital filtering of fault signals from ATP-EMTP simulation. | 2 |
| Proj 4 | Digital algorithms for fault detection. | 2 |
| Proj 5 | Digital algorithm for fault direction discrimination. | 2 |
| Proj 6 | Digital algorithm for fault classification - part 1. | 2 |
| Proj 7 | Digital algorithm for fault classification - part 2. | 2 |
| Proj 8 | Distance protection - digital measurement of fault-loop impedance and reflection of MHO decision characteristic - part 1. | 2 |
| Proj 9 | Distance protection - digital measurement of fault-loop impedance and reflection of MHO decision characteristic - part 2. | 2 |
| Proj 10 | One-end fault location - the sample solution applied in modern protection terminal for power line - part 1. | 2 |
| Proj 11 | One-end fault location - the sample solution applied in modern protection terminal for power line - part 2. | 2 |
| Proj 12 | Fault location on power line with use of measurements of voltage and current from both line ends - part 1. | 2 |
| Proj 13 | Fault location on power line with use of measurements of voltage and current from both line ends - part 2. | 2 |
| Proj 14 | Calculation of fault currents in a given faulted network. | 2 |
| Proj 15 | Summary and description of the performer projects. | 2 |
| | Total hours: | **30** |

**TEACHING TOOLS USED**

N1. Matlab software.
N2. Report on performed project.
N3. Student's own work.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(P) | PEU_U01<br>PEU_U02<br>PEU_K01 | Activity at the project classes |
| F2(P) | PEU_U01<br>PEU_U02<br>PEU_K01 | Marks of the reports on the performer reports |
| P(P) | P=0,3F1+0,7F2 | |

**PRIMARY AND SECONDARY LITERATURE**


**PRIMARY LITERATURE:**

[1] Iżykowski J., Power system faults. PRINTPAP, 2011, p. 190.

**SECONDARY LITERATURE:**

[1] Glover J. D., Sarma M., Power system analysis and design. PWS Publishing Company Boston, second edition, 1994.
[2] Michalik M., Rosołowski E., Simulation and analysis of power system transients. PRINTPAP, 2011.
[3] Saha M.M., Iżykowski J., Rosołowski E., Fault location on power networks. Springer-Verlag London, Series: Power Systems, 2010, 425 p.


**SUBJECT SUPERVISOR**


Jan Iżykowski, jan.izykowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Zabezpieczanie i sterowanie rozproszonymi źródłami energii 2** |
| Name of subject in English: | **Protection and Control of Distributed Energy Sources 2** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2141 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | | 15 |
| Number of hours of total student workload (CNPS): | | | | | 30 |
| Form of crediting: | | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | | 0.70 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. 1. Student should have the basic knowledge of fundamentals of circuit theory and basics of differential calculus. 2. Student should know how to analyse steady states and transients in linear circuit 3. Student should have ability to think and act in a creative way. Student should have ability to work in a team.

## SUBJECT OBJECTIVES

C1. To provide knowledge of methods related to electric power network protection.
C2. Learning how to formulate criteria and schemes for fault detection in power networks.
C3. To provide knowledge of modelling and simulation of transient phenomena in electric power lines.
C4. Learning how to control of distributed generation system.
C5. Self preparation and delivering a poster presentation.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 Student gets the knowledge on preparation of presentation on protection of distributed generation networks.

PEU_U02 Student is able to deliver a presentation on some selected problems related to protection and automation of distributed power generation.

*relating to social competences:*

PEU_K01 Student can act independently and have an attitude of openness of participants towards new problems, controversial issues and demanding professional tasks.

## PROGRAMME CONTENT

| | Seminar | Number of hours: |
|---|---|---|
| Sem 1 | Introduction. Establishing conditions for passing and marking the seminar subject. | 2 |
| Sem 2 | Individual presentation by students of the prepared subjects. | 12 |
| Sem 3 | Summary, pass. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Presentation of the prepared theme by using of a computer and projector. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester)* *P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Presentation of the prepared theme |
| F2(S) | PEU_U01<br>PEU_U02 | Activity in the seminar work |
| P(S) | P=0,1*F2+0,9*F1 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] ELMOR W.A., PROTECTIVREE LAYING THEORYAN D APPLICATIONS. MARCELD EKKEIRN,C . D E., 2004
[2] http://www.rose.pwr.wroc.pl/index_a.htm - materiały do kursu
[3] LUND H., Renewable Energy Systems. Elsevier Inc. 2010.

**SECONDARY LITERATURE:**

[1] QUASCHNING V., Understanding Renewable Energy Systems. Earthscan 2005.
[2] JENKINS N. ALLAN R., CROSSLEY P., KIRSCHEN D., STRBACET G., Embedded generation. The Institution of Electrical Engineers, London 2000.
[3] ACKERMANN T. (editor), Wind power in power systems. John Wiley & Sons, Ltd, Chichester 2005


## SUBJECT SUPERVISOR


Eugeniusz Rosołowski, eugeniusz.rosolowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **PLC oraz bezprzewodowa komunikacja dla potrzeb monitoringu i pomiarów** |
| Name of subject in English: | **PLC and Wireless Communications for Monitoring and Metering** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM2234 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | | 15 |
| Number of hours of total student workload (CNPS): | 90 | | | | 30 |
| Form of crediting: | examination | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | | | | 0.70 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Student has structured and theoretically founded knowledge necessary to understand phenomena related with as wire as well as wireless processing and transmission
2. Has a basic knowledge on electromagnetic field theory
3. Is able to apply properly knowledge of modern physics to analyze the efficiency of operation of communication systems employed in monitoring and metering
4. Is able to exploit properly common rules and laws of physics to the qualitative and quantitative analysis of an engineering issues
5. Able to conduct work in a team and understands the need for continuous education

## SUBJECT OBJECTIVES

C1. Acquaintance with basic knowledge necessary to understand phenomena accompanying both wire and wireless transmission of analog and digital signals

C2. Acquaintance with opportunities to use PLC technique and wire communication in monitoring and metering

C3. Creation of skills and ability to use PLC and wireless communication for monitoring and metering in automated electric power systems

C4. The acquisition of a knowledge related on current trends in signal transmission technology for industrial applications

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has knowledge on physical basis of operation, implementation and use of PLC technology

PEU_W02 Has knowledge on physical basis of operation, implementation and use of both wire and wireless telecommunication technology

*relating to skills:*

PEU_U01 Able to extract information from literature and database on selected problem in field of reliability of PLC technology and/or wireless telecommunication for selected monitoring and metering systems

PEU_U02 Has the ability of analyzing the results and formulating conclusions, as well as preparation and delivering presentation

*relating to social competences:*

PEU_K01 Has a sense of responsibility for his own work and willingness to comply with the principles of teamwork

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Acquaintance with the subject and requirements of completion | 2 |
| Lec 2 | PLC and wireless telecommunication tasks, basic functions | 2 |
| Lec 3 | Standardization of PLC technology – advantages and disadvantages | 2 |
| Lec 4 | Architecture of electric network, modeling of electric devices, layered architecture OSI | 2 |
| Lec 5 | Transmission channel functionality, synchronization, frame control, management, frame priorities | 2 |
| Lec 6 | Overview of network security issues | 2 |
| Lec 7 | Network mode functionality, master-save, peer-to-peer, centralized | 2 |
| Lec 8 | Areas of application, voice, video, multimedia, equipment for different modems, PLC modems | 2 |
| Lec 9 | Coupling problems; transformers and metering devices | 2 |
| Lec 10 | Choice of transmission cabling | 2 |
| Lec 11 | Application problems of selected sensors | 2 |
| Lec 12 | Control of environment conditions and automated meter reading | 2 |
| Lec 13 | Architecture of LAN and WAN wireless networks, advantages and disadvantages | 2 |
| Lec 14 | Architecture of LAN and WAN wire networks, advantages and disadvantages | 2 |
| Lec 15 | Repetition and discussion of exam issues | 2 |
| | Total hours: | **30** |

| **Seminar** | | **Number of hours:** |
|---|---|---|
| Sem 1 | Acquaintance with program, requirements and way of completion | 1 |
| Sem 2 | Individual projects and presentations (with use of audiovisual techniques) on application of PLC and telecommunication networks | 14 |
| | Total hours: | **15** |

## TEACHING TOOLS USED

N1. Lecture with use of audiovisual techniques, multimedia presentation, transparences
N2. Seminar with use of audiovisual techniques, multimedia presentation, transparences
N3. Discussion on presented material

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_K01 | Written exam |
| P(W) | P=F1 | |
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Individual performance evaluation |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Assesment of student activities during seminar |
| P(S) | P=0,8F1+0,2F2 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] Xavier Carcelle, Power Line Communication in Practice, Artec House, Boston London 2006
[2] Yang Xiao, Yi Pan, Emerging Wireless LANs, Wireless PANs, Wireless MANs, Willey&Sons, Inc. Pub. 2009

**SECONDARY LITERATURE:**

[1] Selected papers published in recognized international journals and/or presented in internet


## SUBJECT SUPERVISOR


Marcin Habrych, marcin.habrych@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Odnawialne Źródła Energii** |
| Name of subject in English: | **Renewable Energy Sources** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2331 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | | 15 |
| Number of hours of total student workload (CNPS): | 60 | | | | 30 |
| Form of crediting: | examination | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | | 0.70 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a basic knowledge in the field of the theory of electric circuits.
2. Has a basic knowledge of power system operation and electricity generation and transmission techniques.
3. Has sufficient range of language means at his/her disposal to relatively flawlessly speak out (orally and written), formulate and justify opinions, explain his/her position, show advantages and disadvantages of different solutions, participate in discussion and present general, scientific and technical subject matter.
4. Can use basic hardware and software, create and edit a text on basic level, create computer presentations.
5. Understands a need and knows possibilities of continuous education, increasing of professional, personal and social competences.
6. Has awareness of responsibility for own work.

## SUBJECT OBJECTIVES

C1. Getting to know principles of electric energy generation from renewable energy sources.
C2. Possession a knowledge from range of technical, economic and environmental aspects of renewable energy sources utilization for electric energy generation.
C3. Getting to know applicable technologies and real solutions for electric energy generation with utilization of renewable energy sources.
C4. Identification disadvantages and advantages of different renewable energy sources.
C5. Acquisition of abilities to solve problems connected with renewable energy sources.
C6. Interpreting processes of electric energy generation with utilization of renewable energy sources.
C7. Acquisition of abilities to analyze technical, economical and environmental aspects of renewable energy sources utilization for electric energy generation.
C8. Acquisition of abilities to design systems for electric energy generation with utilization of renewable energy source.

| SUBJECT EDUCATIONAL EFFECTS | |
|---|---|
| *relating to knowledge:* | |
| PEU_W01 | Knows principles of electric energy generation from renewable energy sources. |
| PEU_W02 | Possesses a knowledge from range of technical, economic and environmental aspects of renewable energy sources utilization for electric energy generation. |
| PEU_W03 | Knows applicable technologies and real solutions for electric energy generation with utilization of renewable energy sources. |
| *relating to skills:* | |
| PEU_U01 | Can solve problems connected with renewable energy sources. |
| PEU_U02 | Can interpret processes of electric energy generation with utilization of renewable energy sources. |
| PEU_U03 | Can analyze technical, economical and environmental aspects of renewable energy sources utilization for electric energy generation. |
| *relating to social competences:* | |
| PEU_K01 | Can think and act in creative and enterprising way. He/she is able to rank appropriately the priorities needed for realizing the respective task. |

**PROGRAMME CONTENT**

| | Lecture | Number of hours: |
|---|---|---|
| Lec 1 | Renewable energy sources – introduction, the fundamentals, definitions, glossary, classifications, the potential of renewable energy, development of renewable energy, scientific principles of renewable energy, technical implications. | 2 |
| Lec 2 | Wind energy – introduction, the potential and energy of wind, parameters of wind, measurements of wind, mathematical models of wind, analysis of wind conditions. | 2 |
| Lec 3 | Wind energy - wind turbines (construction, operation principle, basic technical parameters, example calculations, review of solutions), optimising wind farm, connection of wind power plant to the electric power grid. | 2 |
| Lec 4 | Wind energy – assessment of wind power plant impact on the Environment, economic aspects of wind energy, account of costs, tariffs, example economical calculations. | 2 |
| Lec 5 | Wind energy – design of wind plant, examples of solutions of small and medium wind power plant, medium wind power plant, examples of wind farm in Poland and Germany, wind energy market, future of wind energy. | 2 |
| Lec 6 | Solar Energy – introduction, current PV technology, principles of PV cells work; PV cells, modules and arrays; PV systems (classifications, construction, operation principles, production). | 2 |
| Lec 7 | Solar Energy – PV systems (installation, exploitation, standards, review of solutions), connection of PV systems to the electric power grid. | 2 |
| Lec 8 | Solar Energy – solar house, solar energy collectors, systems of solar energy collectors (construction, review of solar energy collectors use, design). | 2 |
| Lec 9 | Hydro energy – introduction, definitions, hydro electric power plants (construction, classifications, operation principles), advantages and disadvantages of hydropower, hydropower resource potential in Poland. | 2 |
| Lec 10 | Biogas energy – introduction, definitions, biogas (kinds, sources, the potential), converting biogas to energy, biogas technologies. | 2 |
| Lec 11 | Biogas energy - applications, review of solutions, environmental aspects, economical aspects of biogas utilization, advantages and disadvantages, future of biogas. | 2 |
| Lec 12 | Biomass energy – introduction, definitions, biomass (kinds, sources, the potential), converting biomass to energy, biomass technologies. | 2 |
| Lec 13 | Biomass energy – applications, review of solutions, environmental aspects, economical aspects of biomass utilization, advantages and disadvantages, future of biomass. | 2 |
| Lec 14 | Geothermal energy – introduction, the potential, kinds of geothermal energy sources, review of geothermal sources utilization to electric energy production, examples of real solutions, economical aspects of geothermal energy utilization. | 2 |
| Lec 15 | Wave energy – introduction, principles of wave energy conversion, advantages and disadvantages, market barriers, impact on the Environment, technology, review of real solutions of sea waves utilization to electric energy production. | 2 |
| | Total hours: | **30** |

| | Seminar | Number of hours: |
|---|---|---|
| Sem 1 | Analysis of wind, geographical, technical, economical and legal conditions for wind power plant. Perspectives of development of wind energy and other renewable energy sources. | 2 |
| Sem 2 | Review of applied wind turbines in Europe. Analysis of possibility of wind farm connection to the electric power grid. | 2 |
| Sem 3 | Analysis of costs for wind power plant. Some aspects of wind farm project. Schedule of investor’s procedure at build wind power plant. | 2 |
| Sem 4 | Design of photovoltaic systems. Review of current solutions od photovoltaic systems. | 2 |
| Sem 5 | Review of solar heating systems. Selected aspects of solar house project. | 2 |
| Sem 6 | Analysis of small-scale and large hydro electric power plant. Review of solutions of sea waves energy utilization. | 2 |
| Sem 7 | Review of current solutions in range of biomass energy utilization to electric energy production. Case study of biomass utilization in energy project. | 2 |
| Sem 8 | Analysis of costs for geothermal power solutions Review of projects of geothermal energy utilization. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
| --- |
| N1. Lecture with the use of audiovisual techniques, multimedia presentations.<br>N2. Multimedia presentation.<br>N3. Problem discussion.<br>N4. Case study. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
| --- | --- | --- |
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_K01 | Test. |
| P(W) | P=F1 | |
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_U03 | Activity on seminar classes. |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_U03 | Preparing and presenting a presentation. |
| P(S) | P=0.2*F1+0.8*F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Boyle G., Renewable Energy – Power for a sustainable future, Second Edition, Oxford University Press Inc. New York, 2004.
[2] Twidell J., Weir T., Renewable Energy Resources, Seventh Edition, Spon Press, London, 2005.
[3] Burton T., Sharpe D., Jenkins N., Bossanyi E., Wind Energy Handbook, John Wiley and Sons Ltd. Chichester, England, 2001.
[4] Luque A., Hegedus S., Handbook of photovoltaic science and engineering, John Wiley and Sons Ltd. Chichester, England, 2003.


**SECONDARY LITERATURE:**


[1] Manwell J.F., McGowan J.G., Rogers A.L., Wind Energy Explained: Theory, Design and Application, John Wiley and Sons Ltd. Chichester, England, 2002.
[2] Markvart T.: Solar electricity, Second Edition, UNESCO, John Wiley and Sons Ltd. New York, 2000.


## SUBJECT SUPERVISOR


Waldemar Dołęga, waldemar.dolega@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Elektrownie wodne 1** |
| Name of subject in English: | **Water Power Plants 1** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2332 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | | |
| Number of hours of total student workload (CNPS): | 60 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. 1. Has knowledge for the selection of electrical low voltage installation and equipment in normal and fault conditions
2. He can read the design intent
3. He can able to make use of regulations and norms
4. He can use basic computer hardware and software
5. He can work in group and understand the needs of recurrent self education.

### SUBJECT OBJECTIVES

C1. To make student acquaintance with rules of design, built and exploitation of hydro power station

C2. To make student acquaintance with basic rules of hydro power station control.

C3. To make student acquaintance with legal and economy analysis required for the design of small hydro power station.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 He has knowledge of the classification and construction of hydroelectric power plants.

PEU_W02 He has knowledge about the principles for the design and operation of hydroelectric power plants.

*relating to skills:*

*relating to social competences:*

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction to subject, programme, requirements and way of testing. Introduction: general definition, classification of hydro power stations, European drivers of SHP development, state of the hydro-energy in Europe and Poland. | 2 |
| Lec 2 | Water and energy potential: analysis of water resources and production: hydrological parameters river basin, electrical power and energy, flow duration curves. | 2 |
| Lec 3 | Types and characteristics of the SHP: hydraulic structures, hydro-technical equipment, | 2 |
| Lec 4 | Types and characteristics of the SHP: basic turbine types of, turbine technology and parameters. | 2 |
| Lec 5 | Types and energy parameters of the turbines: Pelton, Banki-Michell, Kaplan, | 2 |
| Lec 6 | Types and energy parameters of the turbines: Francis, Kinetic turbines; electrical diagrams | 2 |
| Lec 7 | Automation and control of hydro power: Introduction to hydro power control, control of hydro power in electro-energy system. | 2 |
| Lec 8 | Control of turbines. | 2 |
| Lec 9 | Voltage control of in hydro power stations | 2 |
| Lec 10 | Protection, tests, exploitations remarks. | 2 |
| Lec 11 | Project analysis of hydro power stations: analysis of hydrological potential of the site, turbine choice, selection of generator, automation and protection. | 2 |
| Lec 12 | Project analysis of small hydro power stations: Economy and Financing. | 2 |
| Lec 13 | Water Law, Environment, Research &Development | 2 |
| Lec 14 | Practical examples, good practice cases. | 2 |
| Lec 15 | Summary of lectures and classification | 2 |
| | Total hours: | **30** |

**TEACHING TOOLS USED**

N1. Lecture using audio video techniques, multimedia presentations, foliograms.
N2. Knowledge checking in written and unwritten form

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | Written test or checking messages in the oral form |
| P(W) | P=F1 | |

**PRIMARY AND SECONDARY LITERATURE**


**PRIMARY LITERATURE:**

[1] Stawski P., Herlender K., Bobrowicz W., Water Power Plants, Wrocław University of Technology, Wrocław 2011.

**SECONDARY LITERATURE:**

[1] Bobrowicz W., Small Hydro Power – Investor Guide Leonardo Energy, Utilisation Guide Section 8 – Distributed Generation, Autumn 2006.
[2] Harvey A., Micro-hydro power, 2004.
[3] Shannon R., Water Wheel Engineering. 1997.
[4] Allan. Undershot, Water Wheel. 2008.
[5] Damazy Laudyn, Maciej Pawlik, Franciszek Strzelczyk: Elektrownie, WNT, Warszawa 2007.
[6] Kremens Z., Sobierajski M.: Analiza systemów elektroenergetycznych, WNT, Warszawa 1996.
[7] Jackowski K.: Elektrownie wodne, WNT, Warszawa 1971.
[8] Kacejko P.: Generacja rozproszona w systemie energetycznym. Wyd. PL, Lublin 2004.
[9] Marian Hoffman, Małe elektrownie wodne – poradnik, Wydawnictwo Nabba, Warszawa 1992 r.


**SUBJECT SUPERVISOR**


Kazimierz Herlender, kazimierz.herlender@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Sposoby magazynowania energii elektrycznej** |
| Name of subject in English: | **Energy Storage Systems** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2334 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | 15 | |
| Number of hours of total student workload (CNPS): | 60 | | | 30 | |
| Form of crediting: | examination | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | 1 | |
| including number of ECTS points for practical (P) classes : | | | | 1 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | 0.70 | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has knowledge for the selection of electrical low voltage installation and equipment in normal and fault conditions
2. Is able to read project assumptions
3. Is able to make use of regulations and norms
4. Can work in group and understand the needs of recurrent self education

### SUBJECT OBJECTIVES

C1. Familiarize students with the classification and main characteristic different kinds of electrical energy storage in the power system
C2. Practical skills of modeling daily load curves for the distribution network nodes
C3. Practical skills of determining the basic parameters of battery energy storage to compensate for the load curves in the nodes in the distribution network
C4. Skills determine of optimal solutions

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has knowledge in the field of energy storage devices in the power system
PEU_W02 He has knowledge of the use of battery energy storage in the power system

*relating to skills:*

PEU_U01 It can determine the basic parameters of battery energy storage to compensate for load curves in the nodes low voltage distribution network
PEU_U02 It can determine the optimum battery energy storage units
PEU_U03 Able to present the results of the design calculations in the form of project documentation

*relating to social competences:*

PEU_K01 It has a sense of responsibility for their own work and a willingness to comply with the principles of teamwork

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Acquainted with the subject , program and requirements and the way credit | 1 |
| Lec 2 | Classification and general characteristics of the devices that enable storage of electricity in the power system. | 2 |
| Lec 3 | Pumped storage power plants | 2 |
| Lec 4 | Compressed gas storage tanks and the kinetic energy of rotating masses . | 2 |
| Lec 5 | Fuel cells | 2 |
| Lec 6 | Superconducting energy storage (SMES) and capacitors | 2 |
| Lec 7 | Electrochemical batteries. Battery energy storages. | 2 |
| Lec 8 | Summary of lecture and discussion of problems examination. | 2 |
| | Total hours: | **15** |

| **Project** | | **Number of hours:** |
|---|---|---|
| Proj 1 | Deal project assumptions and discussion of how to do the project. | 1 |
| Proj 2 | Modelling of daily load curves for selected energy consumers. | 2 |
| Proj 3 | Determination of model curves loads at specified nodes low-voltage distribution network. | 2 |
| Proj 4 | Determination of actual load curves at specified nodes of the low voltage distribution network. | 2 |
| Proj 5 | Determination of power and energy of battery storage in nodes set for the designated distribution network load curves on these nodes . | 2 |
| Proj 6 | Determining the optimum energy storage battery modules that meet design calculations carried out | 2 |
| Proj 7 | Conducting unification for the designated optimum energy storage battery modules | 2 |
| Proj 8 | Assessment of the project. | 2 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Lecture with audio-visual technology, multimedia presentations.
N2. Discussion problematic.
N3. Computer Laboratory conducted for a group of students - each student with a separate computer.
N4. Checking messages in the form of oral or written.
N5. Preparation of project documentation.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | Written exam and / or oral |
| P(W) | P=F1 | |
| F1(P) | PEU_U01<br>PEU_U02<br>PEU_K01 | Activity classes |
| F2(P) | PEU_U03 | Ewaluation of design documentation |
| P(P) | P=0,4F1+0,6F2 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] Haubrich (Editor): Bartery Energy Storage. Handbook, ISBN 3-89653-188-3, Achen 1996 *)
[2] Proceedings of EU-Project ICOP-DISS-2140-96, Distributed Energy Storage for Power Systems, Pod red. Feser K., Styczyński Z. A., Verlag Mainz, Aachen 1998. *)
*) Pozycje udostępniane przez prowadzącego.


**SECONDARY LITERATURE:**


[1] Batterie-Energiespeicher in der Elektrizitatsversorgung - Kompendium, H.-J. Haubrich [Hrsg], Verlag Mainz, Aachen 1996.
[2] Markiewicz H. Urządzenia elektroenergetyczne. Wyd. 4, WNT, Warszawa 2008.


**SUBJECT SUPERVISOR**


Kazimierz Herlender, kazimierz.herlender@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

Name of subject in Polish: **Zaawansowane stacje i urządzenia elektroenergetyczne**
Name of subject in English: **Advanced Substations and Electrical Equipment**
Main field of study (if applicable): **Electrical Engineering**
Specialization (if applicable): **Renewable Energy Systems**
Level and form of studies: **2nd level, full-time**
Kind of subject: **optional**
Subject code: W05ETK-SM2335
Group of courses: **NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | 15 | |
| Number of hours of total student workload (CNPS): | 90 | | | 30 | |
| Form of crediting: | examination | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | | | 1 | |
| including number of ECTS points for practical (P) classes : | | | | 1 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | | | 0.70 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Possesses a knowledge in the field of the fundamentals of electrotechnics.
2. Has a basic knowledge in the field of the theory of electric circuits.
3. Can correctly and effectively apply a knowledge of linear algebra and analytical geometry to qualitative and quantitative analysis of mathematical issues connected with studied engineering branch.
4. Can apply a mathematical apparatus to analysis of linear electric circuits with sinusoidal AC force.
5. Can apply a mathematical apparatus to analysis of temporary states in linear electrical circuits.
6. Understands a need and knows possibilities of continuous education, increasing of professional, personal and social competences.
7. Has awareness of responsibility for own work.

## SUBJECT OBJECTIVES

C1. Possession a knowledge of physical phenomena occurred in electrical devices.
C2. Possession a knowledge of important parameters of electrical devices in aspect of their designing.
C3. Getting to know of principles of electrical devices designing.
C4. Getting to know of relations between construction, correct exploitation, reliability and effectiveness of use of electrical devices in power network.
C5. Possession a knowledge of function of power substations.
C6. Acquisition of abilities to design low voltage electrical installation for supply of different electricity receivers in objects with varied character of use.
C7. Acquisition of abilities to design MV electrical installation for supply of object with varied character of use.
C8. Acquisition of abilities to selection of LV and MV switchgears and MV/LV container transformer substations for required work conditions.

| SUBJECT EDUCATIONAL EFFECTS | |
|---|---|
| *relating to knowledge:* | |
| PEU_W01 | Knows physical phenomena occurred in electrical devices. |
| PEU_W02 | Knows of principles of electrical devices designing. |
| PEU_W03 | Possesses a knowledge of function of power substations. |
| *relating to skills:* | |
| PEU_U01 | Can design low voltage electrical installation for supply of different electricity receivers in objects with varied character of use. |
| PEU_U02 | Can design MV electrical installation for supply of object with varied character of use. |
| PEU_U03 | Can select LV and MV switchgears and MV/LV container transformer substations for required work conditions. |
| *relating to social competences:* | |
| PEU_K01 | Can think and act in creative and enterprising way. He/she is able to rank appropriately the priorities needed for realizing the respective task. |

**PROGRAMME CONTENT**

| | Lecture | Number of hours: |
|---|---|---|
| Lec 1 | Short circuit currents in power electric systems, characteristic values and parameters, ways of their calculation. | 2 |
| Lec 2 | Thermal effects of normal and short circuit currents. | 2 |
| Lec 3 | Electro-dynamical effects of short circuit currents. | 2 |
| Lec 4 | Electric arc – physical properties, extinguishing methods of arc. | 2 |
| Lec 5 | Switching apparatus - basic terminology and functions in power electrical networks. Low voltage switching apparatus. | 2 |
| Lec 6 | High voltage switching apparatus – classification, construction, main parameters. | 2 |
| Lec 7 | Power transformers in power substations. | 2 |
| Lec 8 | Current and voltage transformers in electrical power substations. | 2 |
| Lec 9 | Over-voltages and over-voltage protection. | 2 |
| Lec 10 | Limitation of fault currents. Short-circuit reactors. | 2 |
| Lec 11 | Structures of main circuits in high-voltage electrical power substations. Supplying of industrial and residential load. | 2 |
| Lec 12 | Constructional solutions of air and SF6 insulated indoor power substations. | 2 |
| Lec 13 | Earthing systems in power substations. | 2 |
| Lec 14 | Auxiliary devices in high-voltage power substations. Protection against electric shock in power substations. | 2 |
| Lec 15 | Principles of correct operation in power substations. | 2 |
| | Total hours: | **30** |

| | Project | Number of hours: |
|---|---|---|
| Proj 1 | Description of the project task. Planning of the supply of object with varied character of use and structure of the installation. | 2 |
| Proj 2 | Project of general lighting in the object. | 2 |
| Proj 3 | Calculation of the power demand for the object. Calculation of reactive power compensation. Selection of capacitor bank. Selection of power transformers. | 2 |
| Proj 4 | Selection of main cable supplied the object with varied character of use. | 2 |
| Proj 5 | Calculation of selected circuits of power installation. | 2 |
| Proj 6 | Selection of LV switchgears in the object with varied character of use. | 2 |
| Proj 7 | Selection of MV/LV container power substations. | 2 |
| Proj 8 | Project documentation. | 1 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Lecture with the use of audiovisual techniques, multimedia presentations.
N2. Multimedia presentation.
N3. Problem discussion.
N4. Presentation of the project
N5. Consultations.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_K01 | Exam in written form. |
| P(W) | P=F1 | |
| F1(P) | PEU_U01<br>PEU_U02<br>PEU_U03 | Assessment of project preparing. |
| F2(P) | PEU_U01<br>PEU_U02<br>PEU_U03 | Defence of the project. |
| P(P) | P=0.6*F1+0.4*F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] Dołęga W., Advanced substations and electrical equipment. Wrocław University of Technology, Wrocław, 2011.
[2] McDonald J.D., Electric Power Substations Engineering, Wiley, 2003.
[3] Seip G., Electrical Installations Handbook, Springer Verlag, 2001.
[4] ABB Switchgear Manual, 10th edition, Düasseldorf, Cornelsen Verlag, 1999.

**SECONDARY LITERATURE:**

[1] Garzon R.D., High Voltage Circuit Breakers, Wiley, 2002.
[2] Switching, Protection and Distribution in Low-Voltage Networks, Siemens handbook, 1994.

## SUBJECT SUPERVISOR

Waldemar Dołęga, waldemar.dolega@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

Name of subject in Polish: **Elektrownie wodne 2**
Name of subject in English: **Water Power Plants 2**
Main field of study (if applicable): **Electrical Engineering**
Specialization (if applicable): **Renewable Energy Systems**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: W05ETK-SM2336
Group of courses: **NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | | 15 |
| Number of hours of total student workload (CNPS): | | | | | 30 |
| Form of crediting: | | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | | 0.70 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has knowledge for the selection of electrical low voltage installation and equipment in normal and fault conditions
2. He can read the design intent
3. He can able to make use of regulations and norms
4. He can use basic computer hardware and software
5. He can work in group and understand the needs of recurrent self education.

## SUBJECT OBJECTIVES

C1. To make student acquaintance with rules of design, built and exploitation of hydro power station
C2. To make student acquaintance with basic rules of hydro power station control.
C3. To make student acquaintance with legal and economy analysis required for the design of small hydro power station.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*
*relating to skills:*
PEU_U01 Is able to pre-design basic elements of small of hudro power stations.
PEU_U02 Is able to law adn economy analysis inthe proces of small hydro power station design.
PEU_U03 Is able to prepare report concerning design, building and exploitation of hydro power station.
*relating to social competences:*
PEU_K01 Has cognisance of responsibility for his work and is ready to compliance of the team work rules.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Seminar** | | **Number of hours:** |
| Sem 1 | Discussion of problematic aspects of seminar, the way if realisation, the way of programme, requirements and way of classification. | 1 |
| Sem 2 | Dispensing of assumptions of SHP projects using software provided by attending person – team work. | 2 |
| Sem 3 | Reports from the scope: Analysis of water potential, hydrological parameters of rivers and basins, electrical power and energy, flow duration curves. | 2 |
| Sem 4 | Reports from the scope: Types and characteristics of the SHP: hydraulic structures, hydrotechnical equipment, basic turbine types of, turbine technology and parameters | 2 |
| Sem 5 | Reports from the scope: Automation and control of hydro power: introduction to hydro power control, control of hydro power in electro-energy system, control of turbines, voltage control of in hydro power stations, protection, tests, exploitations remarks. | 2 |
| Sem 6 | Reports from the scope: Project analysis of small hydro power stations (SHP): analysis of hydrological potential of the site, turbine choice, selection of generator, automation and protection; economy and financing, feasibility study | 2 |
| Sem 7 | Reports from the scope: Water Law, Environment, Research &Development, practical examples, good practice cases. | 2 |
| Sem 8 | Summary of seminar and classification. | 2 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Seminar - preparing and giving a speech reports
N2. Knowledge checking in written and unwritten form
N3. Preparing of the initial SHP project in teams.

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Evaluation of the pre-project of-SHP- teamwork |
| F2(S) | PEU_U03<br>PEU_K01 | Evaluation of the paper, developed and delivered by each student |
| P(S) | P=0.5 F1 + 0.5 F2 | |

**PRIMARY AND SECONDARY LITERATURE**


**PRIMARY LITERATURE:**

[1] Stawski P., Herlender K., Bobrowicz W., Water Power Plants, Wrocław University of Technology, Wrocław 2011.

**SECONDARY LITERATURE:**

[1] Bobrowicz W., Small Hydro Power – Investor Guide Leonardo Energy, Utilisation Guide Section 8 – Distributed Generation, Autumn 2006.
[2] Harvey A., Micro-hydro power, 2004.
[3] Shannon R., Water Wheel Engineering. 1997.
[4] Allan. Undershot, Water Wheel. 2008.
[5] Damazy Laudyn, Maciej Pawlik, Franciszek Strzelczyk: Elektrownie, WNT, Warszawa 2007.
[6] Kremens Z., Sobierajski M.: Analiza systemów elektroenergetycznych, WNT, Warszawa 1996.
[7] Jackowski K.: Elektrownie wodne, WNT, Warszawa 1971.
[8] Kacejko P.: Generacja rozproszona w systemie energetycznym. Wyd. PL, Lublin 2004.
[9] Marian Hoffman, Małe elektrownie wodne – poradnik, Wydawnictwo Nabba, Warszawa 1992 r.


**SUBJECT SUPERVISOR**


Kazimierz Herlender, kazimierz.herlender@pwr.edu.pl

FACULTY OF ELECTRICAL
ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Modelowanie systemu elektroenergetycznego** |
| Name of subject in English: | **Power System Modelling** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM2534 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | 15 | |
| Number of hours of total student workload (CNPS): | 90 | | | 30 | |
| Form of crediting: | examination | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | | | 1 | |
| including number of ECTS points for practical (P) classes : | | | | 1 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | | | 0.70 | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of basics of mathematical analysis and linear algebra.
2. Knowledge of basics of power systems.
3. Abilities of developing computer programs and performing calculation in the Matlab environment.

### SUBJECT OBJECTIVES

C1. Acquiring knowledge in the scope of modern concepts of power system modelling.
C2. Acquiring competence in solving the problems of the power system state estimation and estimation of loads in distribution system.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 The student has knowledge on models for different states of power systems.
PEU_W02 The student knows principles of power system model reduction.
PEU_W03 The student knows principles of real-time modelling of power system.

*relating to skills:*

PEU_U01 The student is able to choose models of power system elements for given case of calculations.
PEU_U02 The student is able to determine required power-system-model reduction for given case of calculations.
PEU_U03 The student is able to evaluate a process of real-time power-system modeling.

*relating to social competences:*

PEU_K01 The student is able to think and act creatively

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | An introduction to the lecture, program of the lecture, requirements. General principles of modelling. | 2 |
| Lec 2 | Models for steady states analyses scope of utilisation. | 2 |
| Lec 3 | Models for transient analyses scope of utilisation. | 2 |
| Lec 4 | Power system model reduction: types of equivalents. Network transformation. | 2 |
| Lec 5 | Power system model reduction: aggregation of generating units, equivalent model of the external subsystem. | 2 |
| Lec 6 | Real-time modelling of power system: need of real-time modelling, main problems, general approaches. | 2 |
| Lec 7 | Summation of modelling for different power system analyses. Test. | 2 |
| Lec 8 | Weighted least squares (WLS) power system state estimation. Alternative formulations of the power system state estimation. | 2 |
| Lec 9 | Network observability analysis. | 2 |
| Lec 10 | Bad data detection and identification. | 2 |
| Lec 11 | Network parameter estimation. Topology error processing. | 2 |
| Lec 12 | State estimation using ampere measurements. | 2 |
| Lec 13 | State estimation of distribution system specific problems. | 2 |
| Lec 14 | Estimation of loads in distribution system. | 2 |
| Lec 15 | Summation of estimation problems for power system. Test | 2 |
| | Total hours: | **30** |

| **Project** | | **Number of hours:** |
|---|---|---|
| Proj 1 | Power system model reduction | 2 |
| Proj 2 | Weighted least squares power system state estimation in the polar coordinate system. | 4 |
| Proj 3 | Weighted least squares power system state estimation in the rectangular coordinate system | 4 |
| Proj 4 | Network observability analysis | 2 |
| Proj 5 | Bad data identification. | 1 |
| Proj 6 | Topology verification. | 2 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Multimedia presentation.<br>N2. Information lecture.<br>N3. Preparation in the form of reports.<br>N4. The Matlab programs. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | activity at the classes |
| F2(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | tests |
| F3(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | exam |
| P(W) | P=0.1 F1 + 0.2 F2 + 0.7 F3 | |
| F1(P) | PEU_U01<br>PEU_U02<br>PEU_U03 | activity at the classes |
| F2(P) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | reports from the classes |
| P(P) | P=0.3 F1 + 0.7 F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Łukomski R., Okoń T., Wilkosz K., Power system modelling. Wrocław University of Technology, 2011.
[2] Abur A., Exposito A. G., Power system state estimation. New York, Marcel Dekker, Inc. 2004.
[3] Machowski J., Białek J.W.,Bumby J. R., Power system dynamics and stability, New York, John Willey & Sons 1997.


**SECONDARY LITERATURE:**


Publikacje w czasopismach z zakresu elektroenergetyki


## SUBJECT SUPERVISOR


Kazimierz Wilkosz, kazimierz.wilkosz@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Sterowanie komputerowe systemami elektroenergetycznymi** |
| Name of subject in English: | **Computer Control of Power System** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM2535 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | | 15 |
| Number of hours of total student workload (CNPS): | 90 | | | | 30 |
| Form of crediting: | examination | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | | | | 0.70 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of basic problems of computer science.
2. Knowledge of basics of power systems.

## SUBJECT OBJECTIVES

C1. Knowing problems of computer control of modern power system.
C2. Familiarizing with modern computer control of power system.
C3. Familiarizing with modern techniques used in computer control of power system.
C4. Enhancing practical skills in preparing presentation.
C5. Enhancing practical skills in participating in discussion.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 The student knows problems of power system control.
PEU_W02 The student knows solutions of problems of power system control.

*relating to skills:*

PEU_U01 The student is able to perform analyses of power systems from the view-point of their control.
PEU_U02 The student is able to evaluate different solutions of problems of computer control of power system.

*relating to social competences:*

PEU_K01 The student is able to prepare presentation in a problem manner.

## PROGRAMME CONTENT

| Lecture | | Number of hours: |
|---|---|---|
| Lec 1 | An introduction to the lecture, program of the lecture, requirements. Basic notions. | 2 |
| Lec 2 | Open-system standard. Formulation of the problem of power system control. | 2 |
| Lec 3 | Characteristics of system of power system control. | 2 |
| Lec 4 | Problems of dispatcher power system control. | 2 |
| Lec 5 | Characteristics of real-time power system modelling. The power system monitoring - generating topology model. | 2 |
| Lec 6 | The power system monitoring - intelligent validation of measurement data and topology model. | 2 |
| Lec 7 | Summation of problems of control and managing of a power system. Test. | 2 |
| Lec 8 | Power system state estimation. | 2 |
| Lec 9 | Utilization of current and voltage phasors for monitoring and controlling power system. | 2 |
| Lec 10 | Utilization of artificial intelligence in computer systems for power system control: artificial neural network, expert systems. | 2 |
| Lec 11 | Utilization of artificial intelligence in computer systems for power system control: fuzzy sets, genetic algorithms. | 2 |
| Lec 12 | Elements of structural analysis of computer systems for power system control. | 2 |
| Lec 13 | Elements of structural design of computer systems for power system control. | 2 |
| Lec 14 | Cybersecurity of computer systems for power system control. | 2 |
| Lec 15 | Summation of problems of utilizing of computers for monitoring and control of a power system. Test. | 2 |
| | Total hours: | **30** |

| Seminar | | Number of hours: |
|---|---|---|
| Sem 1 | Modern dispatcher centers of power system control. | 2 |
| Sem 2 | Implementation of EMS systems. | 2 |
| Sem 3 | Implementation of SCADA and MINISCADA systems. | 2 |
| Sem 4 | Implementation of computer control of a substation. | 2 |
| Sem 5 | Computer control in a power station. | 2 |
| Sem 6 | Control of active power and frequency in a power system. | 2 |
| Sem 7 | Control of voltage and reactive power in a power system. | 2 |
| Sem 8 | Utilization of artificial intelligence in computer systems of power systems control. | 1 |
| | Total hours: | **15** |

## TEACHING TOOLS USED

N1. Multimedia presentation.
N2. Information lecture.

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|
| F1(W) | PEU_W01<br>PEU_W02 | activity at the classes |
| F2(W) | PEU_W01<br>PEU_W02 | tests |
| F3(W) | PEU_W01<br>PEU_W02 | exam |
| P(W) | P=0.1 F1 + 0.2 F2 + 0.7 F3 | |
| F1(S) | PEU_U01<br>PEU_U02 | activity at the classes |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | preparing seminar presentation |
| P(S) | P=0.3 F1 + 0.7 F2 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] Murty P.S.R., Operation and Control in Power Systems, CRC Press, 2011.
[2] Milano F., Advances in power system modelling control and stability analysis, IET, London 2016.
[3] Strauss C., Practical electrical network automation and communication systems, Elsevier 2003.
[4] Waha J. P. (Ed.), Control of power plants and power systems, Elsevier 2000.
[5] Wood A.J., Wollenberg B.F., Sheblé G.B., Power Generation, Operation, and Control, John Wiley & Sons, Inc., Hoboken, New Jersey 2013.

**SECONDARY LITERATURE:**

[1] Donald G. Fink, Standard Handbook for Electrical Engineers. Section 10: Power-System Components/SCADA. McGraw-Hill Professional 1999.
[2] Flynn D. (Ed.), Thermal Power Plant Simulation and Control, The Institution of Engineering and Technology 2003.
[3] Artykuły w czasopismach technicznych takich jak np.: Energetyka, Biuletyn Miesięczny PSE itd


## SUBJECT SUPERVISOR


Kazimierz Wilkosz, kazimierz.wilkosz@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Integracja zasobów rozproszonych w systemach elektroenergetycznych** |
| Name of subject in English: | **Integration of Distributed Resources in Power Systems** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2536 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | examination | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a basic knowledge of electricity systems operation
2. Has basic knowledge concerning a three-phase and single-phase electric circuits analysis in phase coordinates A, B, C and symmetrical components 0, 1, 2

### SUBJECT OBJECTIVES

C1. Adoption of theoretical knowledge concerning an integration of distributed resources in power systems
C2. Development and progress of practical ability to analysis and design and modeling of a power system under normal and abnormal states

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Explains the standards in practice of wind farms electrical connection to the power system
PEU_W02 Has knowledge concerning the impact of distributed generation on a power system and on a smart grid operation

*relating to skills:*

PEU_U01 Is able to model and examine an electric power system with embedded generation
PEU_U02 Is able to model and make analysis of a power systems

*relating to social competences:*

PEU_K01 Is able to prepare complex the electric power calculations in a competent way

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Structures of modern power system. | 2 |
| Lec 2 | Definitions and classification of distributed energy resources (DER) | 2 |
| Lec 3 | Technical requirements for wind generation | 2 |
| Lec 4 | Diagrams of connection of dispersed generators into electric power system | 2 |
| Lec 5 | Technical requisites for dispersed generators connection to the public electric power grids | 2 |
| Lec 6 | Modeling of dispersed generators in power system analysis | 2 |
| Lec 7 | Impact of dispersed generators on power load flow and voltage changes in electrical power network | 2 |
| Lec 8 | Impact of dispersed generators on short-circuit currents in electrical power network | 2 |
| Lec 9 | Dispersed generator contribution to voltage regulation in electrical power system | 2 |
| Lec 10 | Dispersed generator contribution to frequency regulation in electrical power system | 2 |
| Lec 11 | Impact of dispersed generators on relay protection of electrical power network | 2 |
| Lec 12 | The effect of dispersed generators on power quality and reliability of electrical power network. | 2 |
| Lec 13 | Autonomous generation of DER | 2 |
| Lec 14 | Microgrids | 2 |
| Lec 15 | Practical analysis of the impact of wind farms on transmission or distribution network | 2 |
| | Total hours: | **30** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Regulations in the laboratory and conditions and regulations to pass | 2 |
| Lab 2 | Static and short circuit models of DER | 2 |
| Lab 3 | Modeling of distribution network with dispersed generation for computer simulation | 2 |
| Lab 4 | Load flow simulation in distribution network with DER | 2 |
| Lab 5 | Examination of the effect of dispersed generation on power load flow and voltage changes in distribution network | 2 |
| Lab 6 | Short circuit simulation and analysis in distributed network with DER | 2 |
| Lab 7 | Examination of effect of dispersed generation on power quality of distribution network | 2 |
| Lab 8 | Reserve | 1 |
| | Total hours: | **15** |

## TEACHING TOOLS USED

N1. Academic lecture using AV facilities and multimedia presentations
N2. Matlab program
N3. Reports from assignments

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | Exam |
| P(W) | P=F1 | |
| F1(L) | PEU_U01<br>PEU_U02 | Activity during labs |
| F2(L) | PEU_U01<br>PEU_U02 | Assessment of individual lab project |
| P(L) | P = 0.3F1 + 0.7F2 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] Robert Lis, Marian Sobierajski: Integration of distributed resources in power systems, Wydawnictwo Politechniki Wrocławskiej, Wrocław 2011.
[2] Piotr Kacejko.: Generacja rozproszona w systemie elektroenergetycznym. Wydawnictwo Politechniki Lubelskiej, Lublin 2004.
[3] Jenkins N., Allan R., Crossley P., Kirschen D., Strbac G.: Embeded Generation. Power & Energy 2000.


**SECONDARY LITERATURE:**


[1] Sobierajski M., Łabuzek M., Lis R., Electrical Power System Analysis In Matlab, Oficyna Wydawnicza Politechniki Wrocławskiej, 2006.
[2] Bergen A. R., Power Systems Analysis, Prentice-Hall, 2000.
[3] IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems.
[4] Selected articles published in refereed or reputable academic journals.

| SUBJECT SUPERVISOR |
| --- |
| Robert Lis, robert.lis@pwr.edu.pl |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Regulacje prawne i inwestycje w energetyce o strukturze rozproszonej** |
| Name of subject in English: | **Legal Regulations and Investments in Power Systems with Distributed Energy Sources** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM2537 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | | | 15 |
| Number of hours of total student workload (CNPS): | 60 | | | | 30 |
| Form of crediting: | crediting with grade | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | | 0.70 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knows the principles a power system operation and control, is familiar with electricity generation and transmission techniques.
2. Has sufficient range of language means at his/her disposal to relatively flawlessly speak out (orally and written), formulate and justify opinions, explain his/her position, show advantages and disadvantages of different solutions, participate in discussion and present general, scientific and technical subject matter.
3. Can use basic hardware and software, create and edit a text on basic level, create computer presentations.
4. Understands a need and knows possibilities of continuous education, increasing of professional, personal and social competences.
5. Has awareness of responsibility for own work.

## SUBJECT OBJECTIVES

C1. Getting to know national and union legal regulations in the field of utilization of renewable energy sources.
C2. Getting to know principles of well-balanced development.
C3. Possession a knowledge of energy and heat markets in aspect of renewable energy sources.
C4. Possession a knowledge of investment processes in renewable distributed generation.
C5. Acquisition of abilities to analyze legal, technical and economical aspects of construction of distributed and dispersed generation objects using renewable energy sources.
C6. Acquisition of abilities to design investments in distributed and dispersed generation.
C7. Acquisition of abilities to assess support mechanisms for investment of distributed and dispersed generation using renewable energy sources.

| SUBJECT EDUCATIONAL EFFECTS | |
|---|---|
| *relating to knowledge:* | |
| PEU_W01 | Knows national and union legal regulations in the field of utilization of renewable energy sources. |
| PEU_W02 | Possession a knowledge of energy and heat markets in aspect of renewable energy sources. |
| PEU_W03 | Knows investment processes in renewable distributed generation. |
| *relating to skills:* | |
| PEU_U01 | Can analyze legal, technical and economical aspects of construction of distributed and dispersed generation objects using renewable energy sources. |
| PEU_U02 | Can design investments in distributed and dispersed generation. |
| PEU_U03 | Can assess support mechanisms for investment of distributed and dispersed generation using renewable energy sources. |
| *relating to social competences:* | |
| PEU_K01 | Can think and act in creative and enterprising way. He/she is able to rank appropriately the priorities needed for realizing the respective task. |

**PROGRAMME CONTENT**

| | Lecture | Number of hours: |
|---|---|---|
| Lec 1 | The fundamentals of creating of legal regulations in the field of utilization of renewable energy sources. | 2 |
| Lec 2 | The Union legal regulations in the field of utilization of renewable energy sources (documents of the European Union). | 2 |
| Lec 3 | National legal regulations in the field of utilization of renewable energy sources (national documents). | 2 |
| Lec 4 | Review of legal regulations in area of renewable energy sources in selected countries of the European Union and in the world. | 2 |
| Lec 5 | Review of applied support mechanisms of development of renewable energy sources. | 2 |
| Lec 6 | National support mechanism in range of utilization of energy from renewable sources. | 2 |
| Lec 7 | Principles of well-balanced development and natural compensation and expansion of distributed and dispersed generation using renewable energy sources. | 2 |
| Lec 8 | Energy and heat markets in aspect of renewable energy sources. | 2 |
| Lec 9 | Formal and legal requirements for planning of construction of objects using renewable energy sources. | 2 |
| Lec 10 | Connection of renewable energy sources to the electric power grid. | 2 |
| Lec 11 | Formal and legal requirements connected with construction and modernization of power network infrastructure. | 2 |
| Lec 12 | Financial requirements for construction of objects using renewable energy sources. | 2 |
| Lec 13 | Preliminary study of investments using renewable energy sources in distributed generation. | 2 |
| Lec 14 | Example projects of investments in area of renewable energy sources. | 2 |
| Lec 15 | Test. | 2 |
| | Total hours: | **30** |

| | Seminar | Number of hours: |
|---|---|---|
| Sem 1 | The Union legal regulations in the field of utilization of renewable energy sources. | 2 |
| Sem 2 | National legal regulations in the field of utilization of renewable energy sources. | 2 |
| Sem 3 | Formal and legal regulations for using renewable energy sources in different countries of the European Union. | 2 |
| Sem 4 | Support mechanisms for investment of distributed generation using renewable energy sources and electricity and heat markets. | 2 |
| Sem 5 | Completion of preliminary study of investment for selected objects of distributed generation using renewable energy sources. | 2 |
| Sem 6 | Guidelines for dealing with investors that plan to construct objects of distributed generation using renewable energy sources. | 2 |
| Sem 7 | Technological systems using renewable energy sources for the environment and legal regulations in this field. | 2 |
| Sem 8 | Repetition and summing up. | 1 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Lecture with the use of audiovisual techniques, multimedia presentations.
N2. Multimedia presentation.
N3. Problem discussion.
N4. Case study.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01 PEU_W02 PEU_W03 PEU_K01 | Test. |
| P(W) | P=F1 | |
| F1(S) | PEU_U01 PEU_U02 PEU_U03 | Activity on seminar classes. |
| F2(S) | PEU_U01 PEU_U02 PEU_U03 | Preparing and presenting a presentation. |
| P(S) | P=0.2*F1+0.8*F2 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] Dyrektywa 2009/28/WE Parlamentu Europejskiego i Rady z dnia 23 kwietnia 2009 r. w sprawie promowania stosowania energii ze źródeł odnawialnych zmieniająca i w następstwie uchylająca dyrektywy 2001/77/WE oraz 2003/30/WE (Dz.Urz. WE L 140 z 5.06.2009).
[2] Dyrektywa 2009/72/WE Parlamentu Europejskiego i Rady z 13 lipca 2009 dotycząca wspólnych zasad rynku wewnętrznego energii elektrycznej i uchylająca dyrektywę 2003154/WE (Dz.U. UE L 211z 14.08.2009).
[3] Ustawa z dnia 10 kwietnia 1997 r. – Prawo Energetyczne (Dz. U. z 2006 r. Nr 89, poz. 625 z późn.zm.).
[4] Ustawa z dnia 20 lutego 2015 r. o odnawialnych źródłach energii (Dz. U. z 2015 r poz. 478).
[5] Kowalska A., Wilczyński A., Źródła rozproszone w systemie elektroenergetycznym. Wydawnictwo Kaprint, Lublin, 2007.
[6] Lewandowski W., Proekologiczne źródła energii odnawialnej. WNT, Warszawa, 2008.

**SECONDARY LITERATURE:**

[1] Rozporządzenia Ministra Gospodarki dotyczące funkcjonowania sektora elektroenergetycznego
[2] Boyle G., Renewable Energy – Power for a sustainable future, Second Edition, Oxford University Press Inc. New York, 2004.


## SUBJECT SUPERVISOR


Waldemar Dołęga, waldemar.dolega@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Modelowanie maszyn elektrycznych** |
| Name of subject in English: | **Modelling of Electrical Machines** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM3110 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | 30 | |
| Number of hours of total student workload (CNPS): | 30 | | | 60 | |
| Form of crediting: | crediting with grade | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | 2 | |
| including number of ECTS points for practical (P) classes : | | | | 2 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | 1.40 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of Electrical Engineering Fundamentals
2. Knowledge of Electrical Machines Fundamentals

## SUBJECT OBJECTIVES

C1. The achievement of grounds of field-circuit modeling of electrical machines
C2. Knowledge of possibility application of modern numerical techniques for modeling of induction machines

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Student is able to formulate two-dimensional magnetic field problem in regions containing current sources by Maxwell's equations

PEU_W02 Student is able to formulate two-dimensional field-circuit model of an induction machine

*relating to skills:*

PEU_U01 Student is able to create two-dimensional model of an induction machine using Flux 2D software

PEU_U02 Student is able to determine performance characteristics of the induction machine in motoring and generating mode of operation using Flux2D sofware

*relating to social competences:*

PEU_K01 Acquirement of active attitude and skills of systematic study and work while doing project tasks

**PROGRAMME CONTENT**

| Lecture | | Number of hours: |
|---|---|---|
| Lec 1 | Course schedule and requirements. Mathematical basics of field modeling of electrical machines. The basic electromagnetic field quantities and equations. | 2 |
| Lec 2 | Electrostatic, magnetostatic and magnetodynamic fields. | 2 |
| Lec 3 | Outline of the finite element method (FEM).The FEM applied to 2D electromagnetic field problems. | 2 |
| Lec 4 | The two dimensional FE model of induction machine. Field-circuit equations of an induction machine. | 2 |
| Lec 5 | Accounting for movement and skew effect in modeling of induction machines. Methods of electromagnetic torque calculation. | 2 |
| Lec 6 | Flux linkages and inductance of windings. | 2 |
| Lec 7 | Calculation of losses and efficiency. | 1 |
| Lec 8 | Written test. | 2 |
| | Total hours: | **15** |

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | Course schedule and requirements. Instruction on a structure and usage of the Flux2D software. | 2 |
| Proj 2 | Construction of geometrical model of the single-phase induction machine. | 4 |
| Proj 3 | Modelling of the magnetic circuit of the stator and rotor. | 4 |
| Proj 4 | Modelling of the stator and rotor windings. | 4 |
| Proj 5 | FE discretization of the geometrical model of the induction machine. | 4 |
| Proj 6 | Simulation of dynamic operation of the single-phase induction machine (motoring or/and generating mode). | 4 |
| Proj 7 | Simulation of steady-state performance of the single-phase induction machine (motoring or/and generating mode). | 4 |
| Proj 8 | Calculation of losses and efficiency. | 2 |
| Proj 9 | Evaluation of the project. | 2 |
| | Total hours: | **30** |

**TEACHING TOOLS USED**

N1. Multimedia and traditional presentation.
N2. Modelling and computer simulation.

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|
| F1(W) | PEU_W01 PEU_W02 | Written test |
| P(W) | P=F1 | |
| F1(P) | PEU_U01 PEU_U02 PEU_K01 | Preconditioning test. |
| F2(P) | PEU_U01 PEU_U02 PEU_K01 | Evaluation of a project. |
| P(P) | P=0.25F1+0.75F2 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


1. Hameyer K., Belmans R.: Numerical modeling and design of electrical machines and devices, WITT Press, Southampton, 1999
2. Di Barbra P., Savini A., Wiak S. : Field models in electricity and magnetism, Springer, 2008
3. Sadiku Matthew N.O. : Numerical techniques in electromagnetics, CRC Press, 2001
4. Jianming Jin: The finite element method in electromagnetics, John Wily &Sons, Inc.,2002
5. Bianchi Nicola: Electrical machine analysis using finite elements, CRC Taylor & Francis Group, 2005.
6. Meunier Gerard : The finite element method for electromagnetic modeling, John Wily &Sons, Inc.,2008
7. Sadiku Matthew N.O.: Numerical techniques in electromagnetics with Matlab, CRC Press, 2009
8. Flux 2D v. 11.1, User guide, CEDRAT, 2012


**SECONDARY LITERATURE:**


1. Chapman S.J.: Electric machinery fundamentals, McGraw-Hill, N.Y., 2005
2. Zienkiewicz O.C., Taylor R.L., Zhu J.Z.: The finite element methods: its basis and fundamentals, Elsevier B-H, Amsterdam, 2005


**SUBJECT SUPERVISOR**


Krzysztof Makowski, krzysztof.makowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Dynamika i sterowanie napędami prądu stałego i przemiennego** |
| Name of subject in English: | **Dynamics and Control of AC and DC Drives** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM3225 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 15 | 15 | |
| Number of hours of total student workload (CNPS): | 120 | | 30 | 30 | |
| Form of crediting: | examination | | crediting with grade | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 4 | | 1 | 1 | |
| including number of ECTS points for practical (P) classes : | | | 1 | 1 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.80 | | 0.70 | 0.70 | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has knowledge in the control theory (basics), informatics and fundamentals of electrical drives.

### SUBJECT OBJECTIVES

C1. Consolidate knowledge and/or filling the knowledge gap in the field of torque and speed control of the DC and AC (induction motors and PMSM) motor drives.

C2. Familiarizing students with the extended knowledge on the application of advanced control theory methods in controlled converter-fed motor drives, including adaptive and sensorless control.

C3. The acquisition of practical knowledge and skills for design, testing and analysis of advanced control structures for DC and AC motor drives, including sensorless drives.

C4. Perfecting skills for the understanding, analysis and interpretation of steady-state and transient processes in chosen controlled DC and AC drive systems.

C5. Acquisition and fixing the social competences related to work in teams, solving engineering problems together; responsibility, honesty and fairness, observance of manners which are obligatory for academia and society.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has matured knowledge on the torque and speed control methods of the converter-fed DC motor drives, including adaptive systems.

PEU_W02 Has matured and in-depth knowledge on modern control methods of converter-fed induction motor drives (including scalar and vector methods, sensorless control).

PEU_W03 Has matured and in-depth knowledge on modern control methods of converter-fed brushless DC and AC motors drives (including vector methods and sensorless control)

*relating to skills:*

PEU_U01 Can realize the simulation tests of chosen controlled electrical drive in Matlab/Simulink environment using delivered software and can make analysis of the obtained results.

PEU_U02 Can realize the experimental tests of chosen controlled electrical drive in laboratory set-up and can make analysis of the obtained results.

PEU_U03 Can design and test in simulation a chosen structure of speed or position control of electrical drive.

*relating to social competences:*

PEU_K01 Student can act independently and cooperate within a group working on a complex engineering project.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction. Basics of control system synthesis problems for electrical drives; control quality indexes for electrical drives. | 2 |
| Lec 2 | Static and dynamical optimization for electric motor drives. Torque control structures of electrical drives: classification, characteristic features, performance. | 2 |
| Lec 3 | Adjustment criteria for linear controllers, integral criteria, modulus and symmetry criteria, pole-placement method. | 2 |
| Lec 4 | Static optimization conditions for DC motor; constant and variable flux control, dynamical properties for constant and variable excitation flux. | 2 |
| Lec 5 | Speed control methods of converter-fed DC motor drives: series and parallel speed control structure; dynamical performance comparison. | 2 |
| Lec 6 | Influence of static rectifier to the DC motor drive dynamical performance; adaptive control structures. | 2 |
| Lec 7 | Induction motor – mathematical model using vector representation, state equations. | 2 |
| Lec 8 | Frequency controlled induction motor drives – conditions of static optimization. Torque control methods of the induction motor. | 2 |
| Lec 9 | Influence of the control method to the static mechanical characteristic of the induction motor drive. Influence of the control orientation to dynamical performance of the induction motor drive. | 2 |
| Lec 10 | Scalar control methods for induction motor drives; constant flux and constant slip frequency methods. | 2 |
| Lec 11 | Field-oriented control methods and structures for the induction motor drive - part 1. | 2 |
| Lec 12 | Field-oriented control methods and structures for the induction motor drive - part 2. | 2 |
| Lec 13 | Direct torque control methods and structures for the induction motor drive. | 2 |
| Lec 14 | Control methods of brushless DC and AC permanent magnet motors. Field-oriented and direct torque control methods. | 2 |
| Lec 15 | Sensorless drives, state variables estimation methods and structures for AC motor drives. | 2 |
| | Total hours: | **30** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Introduction. Modeling of basic drive system elements using Matlab/Simulink - repetition. | 1 |
| Lab 2 | Simulation tests of the cascade control structure for chosen dynamical object. Application of different design methods for the PI/PID controllers. Anti-windup systems. | 2 |
| Lab 3 | Testing of the cascade control structure of DC motor drive; simulation and experimental tests. | 2 |
| Lab 4 | Testing of the scalar control method for the induction motor. | 2 |
| Lab 5 | Testing of the vector control methods for the induction motor - the FOC metod. Part 1 - simulation tests. | 2 |
| Lab 6 | Testing of the vector control methods for the induction motor - the FOC metod. Part 2 - experimental tests. | 2 |
| Lab 7 | Testing of the direct torque control method for the induction motor drive. | 2 |
| Lab 8 | Testing of the chosen sensorless control structure of the induction motor drive. Crediting with grade. | 2 |
| | Total hours: | **15** |

| **Project** | | **Number of hours:** |
|---|---|---|
| Proj 1 | Introduction, basic requirements for course assessment. Methodology for project realization. Description of the project topics and distribution the project between student groups. | 1 |
| Proj 2 | Description of the modeling methodology of chosen elements of the drive systems in Matlab/Simulink. Implementation of basic mathematical and simulation models (DC motor, induction motor. AC/DC and DC/AC converter, modulator for DC/AC converter). | 2 |
| Proj 3 | Realization of the projects in students groups. Presentation and continuous consultations on project results. | 10 |
| Proj 4 | Project presentation. Crediting with grade. | 2 |
| | Total hours: | **15** |

| TEACHING TOOLS USED | |
|---|---|
| N1. | Lecture with multimedia tools combined with classical lecture (problem oriented). |
| N2. | Consultations. |
| N3. | Laboratory exercises in student groups; testing of student knowledge with short test before laboratory exercises. |
| N4. | Assessment of the laboratory exercises by reports. |
| N5. | Project presentation and its evaluation. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Participation in lectures. |
| F2(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Exam. |
| P(W) | P=0,1F1+0,9F2 | |
| F1(L) | PEU_U01<br>PEU_U02<br>PEU_K01 | Activity during laboratory exercises (including short written tests). |
| F2(L) | PEU_U01<br>PEU_U02<br>PEU_K01 | Preparation of the reports. |
| P(L) | P=0,3F1+0,7F2 | |
| F1(P) | PEU_U03<br>PEU_K01 | Evaluation of the activity during classes. |
| F2(P) | PEU_U03<br>PEU_K01 | Evaluation of the project and the form of its presentation. |
| P(P) | P=0,3F1+07F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] M.P. Kazmierkowski, F. Blaabjerg, R. Krishnan, Control in Power Electronics - Selected Problems, Academic Press, USA, 2002
[2] P. Vas, Sensorless Vector and Direct Torque Control, Oxford University Press, 1998
[3J M.D. Murphy, F.G.Turnbull, Power Electronic Control of AC Drives, Pergamon Press, Oxford, 1988
[4] W. Leonhard, Control of Electrical Drives, Springer Verlag, 1990
[5] K. Ogata, Modern Control Engineering

**SECONDARY LITERATURE:**

[1] Kaźmierkowski M.P., Tunia H., Automatyka napędu przekształtnikowego. PWN, 1987
[2] Orlowska-Kowalska T., Bezczujnikowe układy napędowe z silnikami indukcyjnymi. Oficyna Wydawnicza P.Wr., Wrocław, 2003
[3] Orlowska-Kowalska T., Automatyka napędu elektrycznego - podstawy. Oficyna Wydawnicza P.Wr., Wrocław, w druku
[4] Zawirski K., Deskur J., Kaczmarek T., Automatyka napędu elektrycznego, Wyd. Polit. Poznańskiej, 2012
[5] T. Kaczorek, A. Dzieliński, W Dobrowolski, R. Łopatka. Podstawy teorii sterowania, WNT, 2005

## SUBJECT SUPERVISOR

Teresa Orłowska-Kowalska, teresa.orlowska-kowalska@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

Name of subject in Polish: **Sterowanie rozmyte**
Name of subject in English: **Fuzzy Logic Control**
Main field of study (if applicable): **Electrical Engineering**
Specialization (if applicable): **Renewable Energy Systems**
Level and form of studies: **2nd level, full-time**
Kind of subject: **optional**
Subject code: W05ETK-SM3226
Group of courses: **NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has basic knowledge in automation, informatics and modeling.

## SUBJECT OBJECTIVES

C1. The acquisition of knowledge in the field of fuzzy sets, fuzzy controllers structures of different types and aspects of industrial applications of fuzzy systems.
C2. Acquire skills in the design and testing of various types of fuzzy systems.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*
PEU_W01 He has knowledge of fuzzy sets, different types of fuzzy controllers
PEU_W02 has knowledge of adaptive fuzzy system
*relating to skills:*
PEU_U01 Can design different types of the fuzzy controllers, define operations in fuzzyfication, interference and defuzzyfication parts as well as define the base rules.
PEU_U02 Can test the control system with fuzzy controller
*relating to social competences:*
PEU_K01 Can solve different problem in creative way.

## PROGRAMME CONTENT

| | Lecture | Number of hours: |
|---|---|---|
| Lec 1 | Introduction to fuzzy logic. | 2 |
| Lec 2 | Classical and fuzzy controllers. | 2 |
| Lec 3 | Mamdani fuzzy system type, blocks, blurring, sharpening, and inference. | 2 |
| Lec 4 | Significant features of the rules, and the rule base fuzzy system. | 2 |
| Lec 5 | TSK-type fuzzy systems, Tsukamoto and others. | 2 |
| Lec 6 | Adaptive fuzzy system. | 2 |
| Lec 7 | Industrial applications of fuzzy systems. | 2 |
| Lec 8 | Summary. | 1 |
| | Total hours: | **15** |

| Laboratory | | Number of hours: |
|---|---|---|
| Lab 1 | Organizational matters. Introduction to the software. | 2 |
| Lab 2 | Design of selected classical controllers. | 2 |
| Lab 3 | Design of Mamdani type fuzzy controller, design and tests of the fuzzy controller working with the selected types of the plant, the selection of the control parameters. | 4 |
| Lab 4 | Designing a TSK fuzzy system for the selected plant. | 2 |
| Lab 5 | Deign of adaptive fuzzy system. | 4 |
| Lab 6 | Summary. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Multimedia Lecture with elements of traditional and problematic lectures |
| N2. Written tests |
| N3. Raports |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01 PEU_W02 | written and/or oral tests |
| P(W) | P=F1 | |
| F1(L) | PEU_U01 PEU_U02 PEU_K01 | raports |
| P(L) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] Michels K., Klawonn F., Kruse R., Nurnberger A., Fuzzy Control: Fundamentals, Stability and Design of Fuzzy Controllers (Studies in Fuzziness and Soft Computing), Springer 2006.
[2] Piegat A., Fuzzy Modeling and Control (Studies in Fuzziness and Soft Computing), Physica-Verlag HD, 2010.

**SECONDARY LITERATURE:**

[1] J Yager R.R., Filev D.P., Essential of Fuzzy Modelling and Control, John Wiley & Sons, Inc., 1994
[2] Driankov D, Hellendoorn H., Reinfrank M, An Introduction to fuzzy control. Springer 2010.

## SUBJECT SUPERVISOR

Krzysztof Szabat, krzysztof.szabat@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Sterowanie przekształtnikami energoelektronicznymi** |
| Name of subject in English: | **Control of Power Electronic Converters** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM3227 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. It has a basic knowledge of analysis and synthesis of linear and nonlinear circuits.
2. It has a basic knowledge of the construction and operation electronic systems and power electronics basics
3. It has a basic knowledge of electrical machines and electromechanical drive systems
4. It has a basic knowledge of theory automatic control systems.
5. Able to perform basic measurements of electrical devices using analog and digital oscilloscope.
6. He can verify the results of laboratory measurements with theoretical knowledge.

### SUBJECT OBJECTIVES

C1. Familiarize students with the basic control systems and control of power converters.
C2. Familiarize students with basic mathematical models and how to analyze the response of the converter control.
C3. Familiarize students with the basic characteristics of practical power electronic converters control systems.
C4. Acquiring the ability to develop research results, their interpretation and the interpretation and critical evaluation.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 It has an knowledge of the control of power semiconductor devices.
PEU_W02 He knows the basics of control systems and automatic control power electronic converters.
PEU_W03 He knows the basic methods of mathematical description of control systems of power converters.

*relating to skills:*

PEU_U01 Able to organize test of industrial power electronic systems.
PEU_U02 It can determine the basic characteristics of the power converters working as part of the control system.
PEU_U03 It can present the results in numerical and graphical form and to interpret them. He can draw conclusions from the measurements.

*relating to social competences:*

PEU_K01 He can think and act in a creative and enterprising.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Optimization of SCR thyristor triggering. | 2 |
| Lec 2 | SCR thyristor drivers, TRIAC drivers, GTO drivers. | 2 |
| Lec 3 | Optimization of BJT transistor control. | 2 |
| Lec 4 | BJT power transistor drivers, MOSFET power transistor drivers, IGBTO transistor drivers. | 2 |
| Lec 5 | Control systems of controlled rectifiers, AC controllers, cycloconverters. | 2 |
| Lec 6 | Control systems of DC AC converters. | 2 |
| Lec 7 | Control systems of DC-DC converters. | 2 |
| Lec 8 | Course credit. | 1 |
| | Total hours: | **15** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Introduction. The organization of classes. Conditions of gaining credit. | 2 |
| Lab 2 | Testing of triggering and phase control systems of thyristor. | 2 |
| Lab 3 | Testing of control systems of thyristor rectifiers and cycloconverters. | 2 |
| Lab 4 | Testing of control systems of AC- voltage controllers. | 2 |
| Lab 5 | Testing of control systems of three phase thyristor inverter. | 2 |
| Lab 6 | Testing of control systems of three phase transistor PWM inverter. | 2 |
| Lab 7 | Test of inverter control system of cooperates with the network of alternating current. | 2 |
| Lab 8 | Course credit. | 1 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Informative lecture using presentation slides.
N2. Job self, self-preparation of the laboratory.
N3. Consultation.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_K01 | |
| P(W) | P=F1 | |
| F1(L) | PEU_U01<br>PEU_U02<br>PEU_U03 | Check preparation for classes. |
| F2(L) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Activity in the conduct of laboratory measurements. |
| F3(L) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Appraisal reports made. |
| P(L) | P=0,25*F1+0,25*F2+0,5*F3 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] Yuriy Rozanov: Power Electronics Basics: Operating Principles, Design, Formulas, and Applications, ORC, 2015
[2] Branko L. Dokic: Power Electronics: Converters and Regulators, Springer, 2015.
[3] Bogdan M. Wilamowski, J. David Irwin: Power Electronics and Motor Drives (The Industrial Electronics Handbook) CRC Press 2011
[4] A. Trzynadlowski: Introduction to Modern Power Electronics, CRC, 2002

**SECONDARY LITERATURE:**

[1] Adrian Ioinovici: Power Electronics and Energy Conversion Systems: Fundamentals and Hard-switching Converters, Volume 1, Wiley 2013.
[2] Mukund R. Patel: Introduction to Electrical Power and Power Electronics, CRC Press, 2012
[3] Muhammad Rashid: POWER ELECTRONICS HANDBOOK, ORC, 2010
[4] Euzeli dos Santos: Advanced Power Electronics Converters: PWM Converters Processing AC Voltages (IEEE Press Series on Power Engineering), 2014
[5] Marian P. Kazmierkowski, Ramu Krishnan: Control in Power Electronics: Selected Problems. 2004

| SUBJECT SUPERVISOR |
| --- |
| Leszek Pawlaczyk, leszek.pawlaczyk@pwr.edu.pl |

FACULTY OF ELECTRICAL
ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Energoelektronika** |
| Name of subject in English: | **Power Electronics** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM3228 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. 1. He knows the basics of the electrical circuits. Have basic knowledge in the field of linear and nonlinear circuits. He knows the rules for creating models of peripheral and their mathematical description. He has expertise in the analysis of transients in electric circuits.
2. It know the basic knowledge on the description of automatic control systems.
3. It has a basic knowledge in the field of electronic components, describes their function circumferential model. He knows and has a simple analog and digital systems.
4. He can correctly and effectively apply the knowledge of differential and integral calculus of functions of one variable to the qualitative and quantitative analysis of static states of linear and nonlinear circuits containing semiconductor devices.
5. Able to perform basic measurements of electrical devices using analog and digital oscilloscope.
6. He understands the need for further training and knows the (second-and third-degree, postgraduate courses).

## SUBJECT OBJECTIVES

C1. To provide students with the characteristics of static and dynamic core power semiconductor devices.
C2. To provide students with the basic topology of the power systems of power converters.
C3. To provide students with basic mathematical models and methods of analysis of power converters work.
C4. Acquiring basic skills to apply the measurement technique for determining the characteristics of static power converters.
C5. To provide students with the basic characteristics of the real power electronic systems.
C6. Acquiring the ability to develop research results, their interpretation and the interpretation and critical evaluation.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

| | |
|---|---|
| PEU_W01 | It has a basic knowledge of the principles and application of the selected power semiconductor devices. |
| PEU_W02 | It has a basic knowledge of the principles of power electronics systems and their static and dynamic properties. |
| PEU_W03 | Understand the fundamental physical processes occurring during the conversion of electrical energy by means of static converters and their impact on the control parameters and dynamic power electronic converter. |

*relating to skills:*

| | |
|---|---|
| PEU_U01 | It can connect to the scheme basic measurement systems of power converters. |
| PEU_U02 | It can estimate the fundamental values of the elements of the measurement system. |

*relating to social competences:*

| | |
|---|---|
| PEU_K01 | Is aware of the responsibility for their own work as a team and responsible for the whole team. |

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Power Semiconductor Switches: Diodes, Thyristors, Triacs, Gate-Turn-Off thyristors, Bipolar Junction Transistor, Metal Oxide Semiconductors Field Effect Transistor, Insulated Gate Bipolar Transistor | 2 |
| Lec 2 | Drive and snubber Circuits. | 2 |
| Lec 3 | Diode Rectifier. Phase-controlled Rectifiers and Inverters. | 2 |
| Lec 4 | Three Phase Converters. Current Commutation Phenomena. External characteristics rectifiers | 2 |
| Lec 5 | Current and voltage Distortion. Higher harmonic currents mains. | 2 |
| Lec 6 | A-C Voltage Controllers: Single Phase A-C Voltage Controllers, Three Phase A-C Voltage Controllers. Common Applications. | 2 |
| Lec 7 | Cycloconverters. Common Applications. | 2 |
| Lec 8 | Phase Control Systems for Rectifiers, A-C Voltage Controllers and Cycloconvertors. | 2 |
| Lec 9 | DC-DC Switch Mode Converters: Step-Down Choppers, Step-Up Choppers. Four- Quadrant Choppers. | 2 |
| Lec 10 | DC-DC converters with isolated output. | 2 |
| Lec 11 | Voltage Source Inverters. Single Phase Inverters. Three Phase Inverters. | 2 |
| Lec 12 | Pulse width modulation in inverter. | 2 |
| Lec 13 | Resonant Converters. Common Applications. | 2 |
| Lec 14 | Control Systems for DC-DC Converters and Inverters. | 2 |
| Lec 15 | Course credit. | 2 |
| | Total hours: | **30** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Introduction. The organization of classes. Conditions of the course. To familiarize students with the basic apparatus | 2 |
| Lab 2 | Testing of SCR thyristor. | 2 |
| Lab 3 | Testing of triggering systems. | 2 |
| Lab 4 | Testing of thyristor rectifier. | 2 |
| Lab 5 | Testing of AC Voltage Controller. | 2 |
| Lab 6 | Testing of three phase voltage inverter. | 2 |
| Lab 7 | Testing of Three Phase PWM Inverter | 2 |
| Lab 8 | Course credit. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Informative lecture using presentation slides.<br>N2. Own work, individual preparation for laboratory classes.<br>N3. Consultation. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_K01 | Final test. |
| P(W) | P=F1 | |
| F1(L) | PEU_U01<br>PEU_U02 | Check preparation for classes. |
| F2(L) | PEU_U01<br>PEU_U02<br>PEU_K01 | Activity in the conduct of laboratory measurements. |
| F3(L) | PEU_U01<br>PEU_U02<br>PEU_K01 | Appraisal reports made |
| P(L) | P=0,25*F1+0,25*F2+0,5*F3 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] Yuriy Rozanov: Power Electronics Basics: Operating Principles, Design, Formulas, and Applications, ORC, 2015
[2] Branko L. Dokic: Power Electronics: Converters and Regulators, Springer, 2015.
[3] Bogdan M. Wilamowski, J. David Irwin: Power Electronics and Motor Drives (The Industrial Electronics Handbook) CRC Press 2011
[4] A. Trzynadlowski: Introduction to Modern Power Electronics, CRC, 2002

**SECONDARY LITERATURE:**

[1] Adrian Ioinovici: Power Electronics and Energy Conversion Systems: Fundamentals and Hard-switching Converters, Volume 1, Wiley 2013.
[2] Mukund R. Patel: Introduction to Electrical Power and Power Electronics, CRC Press, 2012
[3] Muhammad Rashid: POWER ELECTRONICS HANDBOOK, ORC, 2010
[4] Euzeli dos Santos: Advanced Power Electronics Converters: PWM Converters Processing AC Voltages (IEEE Press Series on Power Engineering), 2014
[5] Marian P. Kazmierkowski, Ramu Krishnan: Control in Power Electronics: Selected Problems. 2004


## SUBJECT SUPERVISOR


Leszek Pawlaczyk, leszek.pawlaczyk@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Systemy Elektromechaniczne w Odnawialnych Źródłach Energii** |
| Name of subject in English: | **Electromechanical Systems in Renewable Energy** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM3229 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | 15 |
| Number of hours of total student workload (CNPS): | 30 | | | | 30 |
| Form of crediting: | crediting with grade | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | | 1 |
| including number of ECTS points for practical (P) classes : | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | | 0.70 |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Student has the knowledge of fundamental laws of mechanical and electrical engineering. Student has the knowledge in the range of analysis of electric circuits and construction and operations of electrical machines.
2. Student has the basic knowledge of the theory of electrical drives, power electronic devices, converter systems and control systems.
3. Student has the ability to analyze mechanical systems, electrical circuits and systems with power electronic converters.
4. Student has the ability of critical analysis of the operations of selected mechanical systems, electrical circuits and electromechanical systems.
5. Student is able to work in groups and describe the results of his work.

### SUBJECT OBJECTIVES

C1. Presentation of electromechanical systems used in renewable energy systems and methods for their modeling and analysis
C2. Knowledge of systems and methods for controlling of electromechanical systems used in renewable energy systems.

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Student is able to describe and explain the construction of electromechanical systems and principles of modeling and analysis of selected types of turbines and electrical machines used in renewable energy systems

PEU_W02 Student is able to define the concepts of electromechanical energy conversion in conventional and converter systems of renewable energy

*relating to skills:*

PEU_U01 The student can realize an analysis of systems and control methods for selected electromechanical systems for renewable energy conversion

PEU_U02 The student is able to prepare a critical comparison of the properties of electromechanical systems for renewable energy in the form of written report and multimedia presentation

*relating to social competences:*

PEU_K01 The student has positive attitude and understands the need to develop multi-disciplinary knowledge and skills

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Classification of electromechanical systems used in renewable energy systems | 2 |
| Lec 2 | Constructions and mathematical models of wind turbines and other elements of electromechanical systems | 2 |
| Lec 3 | Constructions and mathematical models of electric generators used in electromechanical renewable energy systems | 2 |
| Lec 4 | Power electronic converter systems of energy conversion applied in the systems of the renewable energy conversion | 2 |
| Lec 5 | Fixed and variable-speed electromechanical systems with squirrel cage induction generators | 2 |
| Lec 6 | Variable-speed electromechanical systems with doubly fed induction generators | 2 |
| Lec 7 | Variable-speed electromechanical systems with synchronous generators | 2 |
| Lec 8 | Test | 1 |
| | Total hours: | **15** |

| Seminar | | Number of hours: |
|---|---|---|
| Sem 1 | Multimedia presentation of selected constructions and control of wind turbines and discussion | 2 |
| Sem 2 | Multimedia presentation of selected electromechanical systems with conventional synchronous generators and PMSG generators and discussion | 2 |
| Sem 3 | Multimedia presentation of selected electromechanical systems with induction generators feeding into an AC grid and discussion | 2 |
| Sem 4 | Multimedia presentation of selected electromechanical systems with autonomous induction generators and discussion | 2 |
| Sem 5 | Multimedia presentation of controlled electromechanical systems with application of power electronics converters and discussion | 2 |
| Sem 6 | Multimedia presentation of selected electromechanical systems with DFIG induction generators and discussion | 2 |
| Sem 7 | Multimedia presentation of selected electromechanical systems with energy accumulation and discussion | 2 |
| Sem 8 | Presentation of critical comparison of electromechanical systems for renewable energy | 1 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Lecture with multimedia presentation
N2. Multimedia presentation on selected seminar subject
N3. Student discussion on selected subjects

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | Written test |
| P(W) | P=F1 | |
| F1(S) | PEU_U01<br>PEU_U02 | Evaluation of a student multimedia presentation |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Evaluation of student activity on seminar classes |
| P(S) | P=0,6*F1+0,4*F2 | |

**PRIMARY AND SECONDARY LITERATURE**


**PRIMARY LITERATURE:**

[1] Anaya-Lara O., Jenkins N., Ekanayake J., Cartwright P., Hughes M.: Wind Energy Generation. Modelling and Control. John Wiley & Sons, 2009.
[2] Burton T., Sharpe D., Jenkins N., Bossanyi E.: WIND ENERGY HANDBOOK. John Wiley & Sons, 2001.
[3] Wu B., Power Conversion and Control of Wind Energy Systems. John Wiley & Sons, 2011.

**SECONDARY LITERATURE:**

[1] Johnson G. L.: WIND ENERGY SYSTEMS. Manhattan, KS. Electronic Edition, 2001.
[2] Krause P.C.: Analysis of electric machinery. McGraw Hill, 1986

| SUBJECT SUPERVISOR |
| --- |
| Krzysztof Pieńkowski, krzysztof.pienkowski@pwr.edu.pl |

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Kompatybilność elektromagnetyczna** |
| Name of subject in English: | **Electromagnetic Compatibility** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM3311 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 15 | | |
| Number of hours of total student workload (CNPS): | 60 | | 30 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 1 | | |
| including number of ECTS points for practical (P) classes : | | | 1 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 0.70 | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. He has basic knowledge in the field of linear circuits with sinusoidal waveforms. He knows the rules for creating circuit models and their mathematical description.
2. He or she has knowledge in the analysis of transients in linear electric circuits. He has knowledge of the macroscopic electromagnetic field approach
3. He has a basic knowledge of metrology and measurement units, knows basic metrological characteristics of measuring instruments, are knowledgeable about the design of measurement known calculation methods used in developing the measurement results, a knowledge of the latest measurement technology
4. He or she is able to do basic measurements of electrical devices using analog and digital oscilloscope. Can set on the basis of measurements of nonlinear characteristics of the elements. Able to present the results in the form of numerical tables and graphics to make their interpretations and draw conclusions

### SUBJECT OBJECTIVES

C1. Understanding the concepts of electromagnetic compatibility
C2. Understanding the principles of interaction between the elements of the power system
C3. Knowledge of voltage quality parameters, evaluation of the impact of power quality on loads and the impact on the quality of the loads
C4. Knowing regulations and standardization of components which improve power quality
C5. Getting the practical skills in the assessment of power quality and surge protection
C6. Acquisition and consolidation of social skills including emotional intelligence skills involving the cooperation of a group of students with a view to effective problem solving. Responsibility, honesty and fairness in the procedure observance force in academia and society

| SUBJECT EDUCATIONAL EFFECTS | |
|---|---|
| *relating to knowledge:* | |
| PEU_W01 | He or she knows the key concepts in the field of electromagnetic compatibility. He has extensive knowledge in the field of power quality |
| PEU_W02 | He knows the power requirements of the law and regulations relating to electromagnetic compatibility standards - in particular the power quality |
| PEU_W03 | He or she has knowledge of the location and control the interference sources and their affect on the device. Know the methods of overvoltage protection.He or she knows methods to improve the power quality and ways to reduce disturbances |
| *relating to skills:* | |
| PEU_U01 | He can determine and evaluate the power quality parameters |
| PEU_U02 | He knows the procedure for carrying out the immunity tests of the loads (equipment) on power system disturbances |
| PEU_U03 | He has the skills to assess the disturbances emissions from loads |
| *relating to social competences:* | |
| PEU_K01 | He or she is aware of their own responsibility for their work and a willingness to comply with the principles of teamwork. He searches information and its critical analysis, properly identifies and resolves the dilemmas of working in the profession |

**PROGRAMME CONTENT**

| Lecture | | Number of hours: |
|---|---|---|
| Lec 1 | Electromagnetic Compatibility. Power quality parameters | 2 |
| Lec 2 | Definitions of parameters determining the power quality - the conditions of measurement, presentation the impact of the distortion on electric loads | 2 |
| Lec 3 | Power quality standards | 2 |
| Lec 4 | Sources and external parameters of electromagnetic interference. Lightning as a source of interference, Elements lightning protection, the basic parameters of the varistor, varistor assembly rules | 2 |
| Lec 5 | Design rules for hybrid security systems, information transmission systems. | 2 |
| Lec 6 | Voltage variation. Long and short term flicker. | 2 |
| Lec 7 | Methods of reducing the voltage distortion - examples | 2 |
| Lec 8 | Measurement methods of harmonics and interharmonics. | 2 |
| Lec 9 | Shielding. The effectiveness of shielding against electromagnetic interference and electrical. Shielding low-frequency magnetic fields, the materials for the construction of the shield | 2 |
| Lec 10 | Harmonic filters. Examples of calculating analysis of the effectiveness of filters. | 2 |
| Lec 11 | Electric energy losses due to voltage distortion. | 2 |
| Lec 12 | EMC issues in control systems | 2 |
| Lec 13 | Methods of immunity test of electric loads. Measurement of disturbances emmision | 2 |
| Lec 14 | Electromagnetic Compatibility i radio frequency range. Electrostatic discharge (ESD) Fast transients (BURST) and high – energy surges (SURGE) | 2 |
| Lec 15 | test | 2 |
| | Total hours: | **30** |

| Laboratory | | Number of hours: |
|---|---|---|
| Lab 1 | Presentation of the safety rules and principles of assessment laboratory. Presentation of laboratory | 1 |
| Lab 2 | Voltage quality – measurement of voltage variation, frequency, unbalance, dips, and short interruption, harmonics and interharmonics, mains signalling voltage | 2 |
| Lab 3 | Current and voltage waveforms analysis – determining of harmonics and interharmonics contents | 2 |
| Lab 4 | Testing of nonlinear loads influence on waveform distortion | 2 |
| Lab 5 | Voltage variation, dips and short interruption immunity tests | 2 |
| Lab 6 | Measurement of harmonics emission of electric equipments | 2 |
| Lab 7 | Harmonic analysis of active, reactive and apparent power in circuits with non-sinusoidal voltage and current waveforms | 2 |
| Lab 8 | Spectrum Analyzer | 2 |
| | Total hours: | **15** |

| TEACHING TOOLS USED | |
|---|---|
| N1. | Traditional Lecture with audio-visual techniques |
| N2. | Laboratory run in the traditional manner of exercises + student groups, a report |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | test |
| P(W) | P=F1 | |
| F1(L) | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01 | Average grade of laboratory reports |
| P(L) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] Hasse P.: Overvoltage protection of low voltage systems, TJ International, Padstown, 2000
[2] Pradas Kodali V.: Engineering Electromagnetic Compatibility Principles, Measurments and Technology, IEEE Press, New York, 1996
[3] Baggini A., Handbook of Power Quality, John Wiley&Sons, Ltd, 2008
[4] PN-EN 50160:2010, Voltage Characteristics in Public Distribution Systems
[5] Henry W. Ott, Electromagnetic Compatibility Engineering, John Wiley & Sons, Inc., Hoboken, New Jersey 2009

**SECONDARY LITERATURE:**

[1] IEEE Std 1159-2009: IEEE Recommended Practice for Monitoring Electric Power Quality
[2] Dugan R.C., Mc Gramaghan M.F., Beaty H. W., Santoso S: Electrical Power System Quality, Wyd 2. MC Graw-Hill 2002
[3] Standler R. B.: Protection of electronic circuits from overvoltages John Wiley & Sons, New York, 1989
[4] Clayton R. P.: Introduction to electromagnetic compatibility John Wiley & Sons, New York, 1992
[5] Arrillaga J. Watson N. R.: Power System Quality Assessment, John Wiley & Sons, New York, 2000


## SUBJECT SUPERVISOR


Grzegorz Kosobudzki, grzegorz.kosobudzki@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Metody i techniki pomiarowe** |
| Name of subject in English: | **Measurement methods and techniques** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W05ETK-SM3312 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | | 30 | | |
| Number of hours of total student workload (CNPS): | 60 | | 60 | | |
| Form of crediting: | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | 2 | | |
| including number of ECTS points for practical (P) classes : | | | 2 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | 1.40 | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a knowledge of electrical circuits theory.
2. Has a basic knowledge of measurement technique and basis of electronic .
3. Is able to do measurements of electrical quantities using analogue and digital instruments or oscilloscope.
4. Is able to designate nonlinear elements characteristics, present given results in numerical, tabular and graphical form. Can calculate results using uncertainty theory, correctly interpret the result and draw the right conclusions.

## SUBJECT OBJECTIVES

C1. Familiarize student with knowledge of measurement systems architecture and design principles.
C2. Understanding the properties of selected transducers and measuring circuits.
C3. Practical skills to: transducers tests, measuring circuit components, analysis the tests results and draw the correct conclusions.
C4. Acquisition practical skills of measurement systems use containing transducers, AD converters, data acquisition cards, autonomous instruments connected via standard measuring interfaces in order to perform a specific measurement task.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has a knowledge of electrical signal processing in measurement systems.
PEU_W02 Identify measurement noises and knows methods of reduction in systems with data acquisition cards.
PEU_W03 Knows the design principles and construction of measurement systems

*relating to skills:*

PEU_U01 Can do tests of measuring line properties consist of transducers, sensors and instruments
PEU_U02 Can write basic programs in LabView, can do virtual instrument visualization. Can design automatic measurement stand to tests parameters and characteristics of chosen elements consist of autonomic instruments and data acquisition cards.

*relating to social competences:*

PEU_K01 Understands the need to work in a team, is aware of the responsibility for the work.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Basic terms of metrology. Error theory and uncertainty theory. Uncertainty propagation law. | 2 |
| Lec 2 | Measurement systems architecture. Signal processing in measuring systems. | 2 |
| Lec 3 | Linear normalize converters. Properties of inverting, non-inverting, differential amplifiers and voltage follower. Common mode rejection ratio CMRR. | 2 |
| Lec 4 | Instrumental amplifiers. | 2 |
| Lec 5 | Insulation amplifiers, parameters and applications. Transimpedance amplifiers. Rail-to-rail amplifiers. | 2 |
| Lec 6 | Inductive methos of power line frequency current and voltage processing. | 2 |
| Lec 7 | Active and reactive power measurements. High-voltage power measurements. Geometrical interpretation of power. | 2 |
| Lec 8 | Non-linear operational converters. Multi-functional operational analogue converter. | 2 |
| Lec 9 | TDM multiplier. RMS value converters. Chosen converters of electrical quantities . | 2 |
| Lec 10 | Classification, structure and organization of Digital Measurement Systems. Universal data acquisition card construction. | 2 |
| Lec 11 | Introduction to LabView environment. Front panel and diagram of virtual instrument. Programming structures. Autonomic instruments control. Designing methodology of virtual instruments. | 2 |
| Lec 12 | Chosen A/D and D/A converters. | 2 |
| Lec 13 | Methods of measurement noise reduction in DAQ systems. | 2 |
| Lec 14 | Smart sensors. Stray measurement systems. | 2 |
| Lec 15 | Test | 2 |
| | Total hours: | **30** |

| **Laboratory** | | **Number of hours:** |
|---|---|---|
| Lab 1 | Presentation the Procedure Health and Safety Rules and Laboratory Rules. Establish rules for passing. Presentation of measuring stands. | 2 |
| Lab 2 | Test of measurement circuit with transducer XTR-103. | 2 |
| Lab 3 | Properties research of mean and RMS value integrated converters. | 2 |
| Lab 4 | Amplifier with carrier-wave generator tests. | 2 |
| Lab 5 | Geometrical interpretation of power. | 2 |
| Lab 6 | Properties of current inductive transducers with homogoneous magnetic circuit. | 2 |
| Lab 7 | Virtual Instrument application to measure of distorted signals. | 2 |
| Lab 8 | Introduction to LabView. The program implements a predetermined mathematical operation.. Basis programming structures. | 2 |
| Lab 9 | Type A virtual instrument. Instrument control with GPIB or USB interface program realization with uses given driver. Programming structures. | 2 |
| Lab 10 | System realization with uses of autonomic instruments connected via standard interfaces. Table operations, reading and writing data from or to file. | 2 |
| Lab 11 | Automatic measurement system to determine characteristics of chosen electronic elements. | 2 |
| Lab 12 | Tybe B Virtual Instrument. DAQ cards application in measeurement system. | 2 |
| Lab 13 | Application with DAQ card. | 2 |
| Lab 14 | Stray measurement system. | 2 |
| Lab 15 | Assessment and complement laboratory arreas. | 2 |
| | Total hours: | **30** |

**TEACHING TOOLS USED**

N1. Traditional lecture, multimedia presentations.
N2. Laboratory – check knowledge in writing or oral answer form, report preparation, presentation and discussion of wrote program, office hours.

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Test |
| P(W) | P=F1 | |
| F1(L) | PEU_U01<br>PEU_U02 | Check preparation to laboratory. |
| F2(L) | PEU_U01<br>PEU_U02 | Activity on laboratory |
| F3(L) | PEU_U01<br>PEU_U02 | Report |
| P(L) | P=0,3F1+0,1F2+0,6F3 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Nawrocki Z., Dusza D., Analogue and digital measurement systems, Wrocław, 2011
[2] Tumański S., Principles of electrical measurements, New York ; London : Taylor & Francis, 2006
[3] Lyons R.G., Understanding Digital Signal Processing, Pearson Education; 1996.
[4] Morris A.S., Measurement and Instrumentation Principles, Butterworth-Heinemann, 2001.
[5] Van de Plassche R., CMOS integrated analog to digital and digital to analog converters, Kluwer Academic Publishers, 2003
[6] Lyons R.G., Understanding Digital Signal Processing, Pearson Education; 1996.
[7] J.Mc.Ghee, I.A. Henderson, M.J. Korczyński, W.Kulesza: Scientific metrology, Technical University of Lodz, Lodz, 1998.


**SECONDARY LITERATURE:**


[1] Clayton G., Winder S.: Operational amplifiers, Newnes, Oxford, 2003.
[2] Kester W., Jung W., Op AMP structures, Op AMP applications, Analog Devices, Norwood, 2002.
[3] Kester W., Analog to Digital Conversion, Analog Devices, 2004.
[4] Nawrocki Z., Dusza D., Kosobudzki G, Metrological analysis of integrated analog RMS converters described by explicit and implicit functions, Measurement (London). 2009, vol. 42, nr 2, s. 308-313
[5] Mc.Ghee, I.A. Henderson, M.J. Korczyński, W.Kulesza: Measurement data handling, vol. 1 and vol.2 , Technical University of Lodz, Lodz, 2001


## SUBJECT SUPERVISOR


Daniel Dusza, daniel.dusza@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Praktyka dyplomowa (4-tygodniowa)** |
| Name of subject in English: | **Diploma placement 4 weeks** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5105 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 160 | |
| Number of hours of total student workload (CNPS): | | | | 120 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 4 | |
| including number of ECTS points for practical (P) classes : | | | | 4 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 2.80 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Allow for the implementation of placement by the Commissioner for practice.

## SUBJECT OBJECTIVES

C1. Acquisition of knowledge useful for the implementation of a Master’s thesis.
C2. Gaining industrial experience, learning of basic technical equipment and technology of companies, knowledge of the manager specific work and higher technical personel.
C3. Expanding the knowledge gained during education and developing the skills to use it.
C4. Getting to know the specifics of the professional and development of specific skills directly related to the place of performance of the practice.
C5. Getting to know the organizational structure of company, principles of work organization and distribution of competences, procedures, work planning and work control.
C6. Improving the organization of individual and team work, effective time management, conscientiousness and responsibility for assigned tasks.
C7. Improving skills in using foreign languages in professional situations.
C8. Professionalization of professional behavior, compliance with the rules of professional conduct and respect for technical and cultural diversity
C9. Establish professional contacts, particularly useful when looking for work.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 He has an ability to use the gained knowledge to creatively analyze and solving various engineering problems.

PEU_U02 Skills in estimation of the time needed to carry out the ordered task or project.

*relating to social competences:*

PEU_K01 He has a sense of responsibility for their own work, he is open to the exchange of ideas and new challenges.

**PROGRAMME CONTENT**

| | Project | Number of hours: |
|---|---|---|
| Proj 1 | Individual program practices, adapted to the specific implemented thesis. | 160 |
| | Total hours: | **160** |

| TEACHING TOOLS USED |
| --- |
| N1. Keynote presentation at the company's operations.<br>N2. Consultation.<br>N3. Specialized equipment and measuring technology used in the company.<br>N4. Specialized computer programs to support the company. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
| --- | --- | --- |
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(P) | PEU_U01<br>PEU_U02<br>PEU_K01 | Individual rating (2.0....5.5) on the basis of a written report just completed practice and requirements contained in the "Rules of Practice". |
| P(P) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Nawrocki Z., Dusza D., Analogue and digital measurement systems, Wrocław, 2011
[2] Tumański S., Principles of electrical measurements, New York ; London : Taylor & Francis, 2006
[3] Lyons R.G., Understanding Digital Signal Processing, Pearson Education; 1996.
[4] Morris A.S., Measurement and Instrumentation Principles, Butterworth-Heinemann, 2001.
[5] Van de Plassche R., CMOS integrated analog to digital and digital to analog converters, Kluwer Academic Publishers, 2003
[6] Lyons R.G., Understanding Digital Signal Processing, Pearson Education; 1996.
[7] J.Mc.Ghee, I.A. Henderson, M.J. Korczyński, W.Kulesza: Scientific metrology, Technical University of Lodz, Lodz, 1998.


**SECONDARY LITERATURE:**


[1] Clayton G., Winder S.: Operational amplifiers, Newnes, Oxford, 2003.
[2] Kester W., Jung W., Op AMP structures, Op AMP applications, Analog Devices, Norwood, 2002.
[3] Kester W., Analog to Digital Conversion, Analog Devices, 2004.
[4] Nawrocki Z., Dusza D., Kosobudzki G, Metrological analysis of integrated analog RMS converters described by explicit and implicit functions, Measurement (London). 2009, vol. 42, nr 2, s. 308-313
[5] Mc.Ghee, I.A. Henderson, M.J. Korczyński, W.Kulesza: Measurement data handling, vol. 1 and vol.2 , Technical University of Lodz, Lodz, 2001


## SUBJECT SUPERVISOR

Piotr Serkies, piotr.serkies@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Seminarium dyplomowe** |
| Name of subject in English: | **Diploma seminar** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5108 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | | 30 |
| Number of hours of total student workload (CNPS): | | | | | 90 |
| Form of crediting: | | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | | 3 |
| including number of ECTS points for practical (P) classes : | | | | | 3 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | | 2.10 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Student has the well-ordered theoretical knowledge to meet requirements of MSc work concerning renewable energy sources.
2. Student is capable of using the learned knowledge for the realization of MSc work concerning renewable energy sources.
3. Student can work in a team and understand the need to improve one's skill all the time.

## SUBJECT OBJECTIVES

C1. To assimilate ability to present the results of computations, experiments and analysis made in the frame of MSc work.
C2. To become skillful at the critical assessment of the results of computations, experiments and analysis made in the frame of MSc work.
C3. To be able to take part in group discussion on the problems considered in MSc works.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 Student can acquire information from literature and data base concerning the theme associated with the realization of the MSc work.

PEU_U02 Has the ability of synthetic and effective presentation of research results and their interpretation, drawing conclusions, and preparing and delivering presentations on the realized thesis.

PEU_U03 Student can reliably evaluate the results of the other student, formulate questions and take active participation in discussion on the subjects related to the completed master’s theses.

*relating to social competences:*

PEU_K01 Student has a sense of responsilibity of their own work and is open to the exchange of ideas and new challemges.

## PROGRAMME CONTENT

| | Seminar | Number of hours: |
|---|---|---|
| Sem 1 | To make oneself acquainted with program, requirements and way of receiving a credit for a class. | 2 |
| Sem 2 | Presentation of investigation results related to MSc works. | 28 |
| | Total hours: | **30** |

| TEACHING TOOLS USED |
|---|
| N1. Seminar with using the audio-video technique and multimedia presentation.<br>N2. Relevant problem's discussion of presented materials. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Mark for individual presentation. |
| F2(S) | PEU_U03<br>PEU_K01 | Mark for class activity |
| P(S) | P=0,7F1+0,3F2 | |

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE:**<br>Literature recommended by MSc thesis supervisor.<br>**SECONDARY LITERATURE:**<br>MSc related literature collected by student. |

| SUBJECT SUPERVISOR |
|---|
| Ryszard Kacprzyk, ryszard.kacprzyk@pwr.edu.pl |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Projekt dyplomowy** |
| Name of subject in English: | **Diploma Project** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5117 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 120 | |
| Number of hours of total student workload (CNPS): | | | | 240 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 8 | |
| including number of ECTS points for practical (P) classes : | | | | 8 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 5.60 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | xx | 120 |
| | Total hours: | **120** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

| PRIMARY AND SECONDARY LITERATURE |
| --- |
| **PRIMARY LITERATURE:**<br>Literature recommended by MSc thesis supervisor.<br>**SECONDARY LITERATURE:**<br>MSc related literature collected by student. |

| SUBJECT SUPERVISOR |
| --- |
| , |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Praca dyplomowa magisterska** |
| Name of subject in English: | **Master's thesis** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5119 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 180 | |
| Number of hours of total student workload (CNPS): | | | | 540 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 18 | |
| including number of ECTS points for practical (P) classes : | | | | 18 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 12.60 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | xx | 180 |
| | Total hours: | **180** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE:** |
| Literature recommended by MSc thesis supervisor. |
| **SECONDARY LITERATURE:** |
| MSc related literature collected by student. |

| SUBJECT SUPERVISOR |
|---|
| , |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Projekt dyplomowy** |
| Name of subject in English: | **Diploma Project** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5127 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 120 | |
| Number of hours of total student workload (CNPS): | | | | 240 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 8 | |
| including number of ECTS points for practical (P) classes : | | | | 8 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 5.60 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | xx | 120 |
| | Total hours: | **120** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

Literature recommended by MSc thesis supervisor.

**SECONDARY LITERATURE:**

MSc related literature collected by student.

## SUBJECT SUPERVISOR

,

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Praca dyplomowa magisterska** |
| Name of subject in English: | **Master's thesis** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5129 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 180 | |
| Number of hours of total student workload (CNPS): | | | | 540 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 18 | |
| including number of ECTS points for practical (P) classes : | | | | 18 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 12.60 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | xx | 180 |
| | Total hours: | **180** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE:** |
| Literature recommended by MSc thesis supervisor. |
| **SECONDARY LITERATURE:** |
| MSc related literature collected by student. |

| SUBJECT SUPERVISOR |
|---|
| , |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

Name of subject in Polish: **Projekt dyplomowy**
Name of subject in English: **Diploma Project**
Main field of study (if applicable): **Electrical Engineering**
Specialization (if applicable): **Renewable Energy Systems**
Level and form of studies: **2nd level, full-time**
Kind of subject: **optional**
Subject code: W05ETK-SM5137
Group of courses: **NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 120 | |
| Number of hours of total student workload (CNPS): | | | | 240 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 8 | |
| including number of ECTS points for practical (P) classes : | | | | 8 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 5.60 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | xx | 120 |
| | Total hours: | **120** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE:** |
| Literature recommended by MSc thesis supervisor. |
| **SECONDARY LITERATURE:** |
| MSc related literature collected by student. |

| SUBJECT SUPERVISOR |
|---|
| , |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Praca dyplomowa magisterska** |
| Name of subject in English: | **Master's thesis** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional** |
| Subject code: | W05ETK-SM5139 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | 180 | |
| Number of hours of total student workload (CNPS): | | | | 540 | |
| Form of crediting: | | | | crediting with grade | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | 18 | |
| including number of ECTS points for practical (P) classes : | | | | 18 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 12.60 | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Project | | Number of hours: |
|---|---|---|
| Proj 1 | xx | 180 |
| | Total hours: | **180** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

| PRIMARY AND SECONDARY LITERATURE |
| --- |
| **PRIMARY LITERATURE:** |
| Literature recommended by MSc thesis supervisor. |
| **SECONDARY LITERATURE:** |
| MSc related literature collected by student. |

| SUBJECT SUPERVISOR |
| --- |
| , |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Zaawansowane technologie produkcji energii elektrycznej** |
| Name of subject in English: | **Advanced Technology in Electrical Power Generation** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **obligatory** |
| Subject code: | W09ETK-SM1501 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 30 | 15 | | | |
| Number of hours of total student workload (CNPS): | 90 | 30 | | | |
| Form of crediting: | crediting with grade | crediting with grade | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 3 | 1 | | | |
| including number of ECTS points for practical (P) classes : | | 1 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 2.10 | 0.70 | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knows basic laws of physics, chemistry, has the knowledge of the description of processes and properties for ideal gases including thermodynamic processes for water vapor and basic knowledge in the field of fuel
2. Is able apply the knowledge of differential and integral calculus of functions of one variable and use mass and energy balance.

## SUBJECT OBJECTIVES

C1. Getting the knowledge the fundamental processes describing the generation of electricity and methods for assessing the energy balance of energy production systems

C2. Acquire practical skills of efficiency and energy balance determination for advanced energy production system from conventional and renewable energy sources.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Have knowledge of fundamental principles of different power production systems at high efficiency.

PEU_W02 Knows principles of power production systems configurations including conventional unit depending on primary energy carrier .

*relating to skills:*

PEU_U01 Is able to perform critical analysis of advanced concept of power systems especially near zero emission technology using different types of primary Energy sources.

PEU_U02 Is able to perform of thermodynamics efficiency calculation for thermal, cogeneration and combined power unit

*relating to social competences:*

PEU_K01 Assess the energy needs of countries depending on local resources.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Energy in the future Challenges for the 21st Century | 2 |
| Lec 2 | Impact of climate changes on progress low emission power production technology | 2 |
| Lec 3 | Physical and Chemical fundamentals of power production | 2 |
| Lec 4 | Combustion and Gasification of fuels | 2 |
| Lec 5 | Thermodynamical fundamentals of power production | 2 |
| Lec 6 | Vapor Power Cycle – improvement of efficiency | 2 |
| Lec 7 | Super critical boilers in advanced power unit | 2 |
| Lec 8 | Cogeneration system of energy production | 2 |
| Lec 9 | Fundamental of combined power plant. | 2 |
| Lec 10 | IGCC – Integrated gasification coal combined plants - fundamentals | 2 |
| Lec 11 | Advanced power unit integrated with SOFC- fuel cel. | 2 |
| Lec 12 | Fundamentals of CCS technology – carbon capture and storage | 2 |
| Lec 13 | Nuclear Power Plants | 2 |
| Lec 14 | Hybrid power unit , polygeneration with RES | 2 |
| Lec 15 | Test (crediting with grade) | 2 |
| | Total hours: | **30** |

| **Classes** | | **Number of hours:** |
|---|---|---|
| Cl 1 | Calculation of combustion air and the quantities and composition of exhaust gases from fuel combustion in thermal power plants | 2 |
| Cl 2 | Calculation of cycle efficiency thermal power plant for sub-critical parameters | 2 |
| Cl 3 | Calculation of cycle efficiency thermal power plant for sub-critical parameters with reheated of steam system | 2 |
| Cl 4 | Calculation of cycle efficiency thermal power plant for sub-critical parameters with reheated of steam system and regeneration system. | 2 |
| Cl 5 | Calculation of cogeneration cycle efficiency | 2 |
| Cl 6 | Calculation of cycle efficiency of combined power unit | 2 |
| Cl 7 | The calculation of the balance of coal-fired thermal power plant with CO2 capture by amine absorption | 2 |
| Cl 8 | Test (crediting with grade) | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lectures with multimedia presentation<br>N2. Students own work<br>N3. Classes<br>N4. Discussion of results<br>N5. Colloquium |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02 | test |
| P(W) | P=F1 | |
| F1(C) | PEU_U01<br>PEU_U02<br>PEU_K01 | Evaluation of home works |
| F2(C) | PEU_U01<br>PEU_U02<br>PEU_K01 | Test |
| P(C) | P=0,3F1+0,7F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Advanced Power Genertion technology, RES, H. Pawlak-Kruczek, 2011
[2] Yunus A. Cengel, Michael A. Boles , Thermodynamics, An Engineering Approach. McGraw –Hill Higher Education ,2009
[3] Theory And Problems Of Thermodynamics For Engineers, Merle C. Potter, Craig W,Somerton, Ph,D.,Associate Professor Of Mechanical Engineering,Michigan State University, Schaum's Outline Series, Mcgraw-Hill, 2008
[4] Prabir Basu , Cen Kefa, Louis Jestin, Boilers and Burners , Design and Theory , Springer, 2013


**SECONDARY LITERATURE:**


[1] Steam/its generation and use - 42nd Edition, Copyright © 2015 by The Babcock & Wilcox Company Forty-second edition
[2]J.M. Beer, High efficiency electric power generation: The environmental role; Progress in Energy and Combustion Science 33 (2007), 107–134


## SUBJECT SUPERVISOR


Halina Pawlak-Kruczek, halina.kruczek@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

Name of subject in Polish: **Etyka w biznesie**
Name of subject in English: **Ethics in bussiness**
Main field of study (if applicable): **Electrical Engineering**
Specialization (if applicable): **Renewable Energy Systems**
Level and form of studies: **2nd level, full-time**
Kind of subject: **optional / university-wide**
Subject code: W08ETK-SM1721
Group of courses: **NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | | 15 |
| Number of hours of total student workload (CNPS): | | | | | 50 |
| Form of crediting: | | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | | 2 |
| including number of ECTS points for practical (P) classes : | | | | | 2 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | | 1.40 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Text interpretation ability
2. Basic abilities in performing analysis and synthesis

## SUBJECT OBJECTIVES

C1. Analysis of the significance and role of ethics in modern business
C2. Resolve problems relating to social responsibility to the surroundings
C3. The appearance and analysis of the situation in which ethical problems may arise
C4. Sensitize students to the ethical problems

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 Student has the ability to understand social, economic, legal and others non technical conditions of engineering activities.

PEU_U02 The student is able to formulate and thoroughly justify opinions, prepare and make presentations related to the problems from the scope of topics of the studied discipline as well as to the topics related to the environment of work. Is also able to take part in scientific and professional discussions.

*relating to social competences:*

PEU_K01 The student is able to think critically and to argue their position, allowing it properly determine the priorities for implementing specified by himself or other tasks, taking into account issues of social responsibility.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Seminar** | | **Number of hours:** |
| Sem 1 | Introduction to business ethics | 1 |
| Sem 2 | Ethics in economic activity | 1 |
| Sem 3 | Protection of intellectual property versus ethics | 1 |
| Sem 4 | Economic crises as a source of change in moral values | 2 |
| Sem 5 | Ethical trade | 1 |
| Sem 6 | Corporate Social Responsibility | 2 |
| Sem 7 | Ecoethic | 2 |
| Sem 8 | Ethics in Marketing | 2 |
| Sem 9 | Areas of of modern ethical finance | 1 |
| Sem 10 | Manipulation, corruption, lies and abuses in business | 2 |
| | Total hours: | **15** |

**TEACHING TOOLS USED**

N1. Information lecture
N2. Interactive lecture
N3. Multimedia presentation
N4. Discussion

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(S) | PEU_U01 PEU_U02 PEU_K01 | Presentation |
| F2(S) | PEU_U01 PEU_U02 PEU_K01 | Activity on the lectures |
| P(S) | P=0,8F1+0,2F2 | |

**PRIMARY AND SECONDARY LITERATURE**


**PRIMARY LITERATURE:**

[1] B. Klimczak, Etyka gospodarcza, Wrocław 1996.
[2] P. M. Minus, Etyka w biznesie, Warszawa 1995.
[3] E. Sternberg, Czysty biznes. Etyka biznesu w działaniu, Warszawa 1998.

**SECONDARY LITERATURE:**

[1] G. D. Chrissides, J. H. Kaler, Wprowadzenie do etyki biznesu, Warszawa 1999.
[2] A. Chaufen, Kradzież a rozwój gospodarczy, Warszawa 2006.
[3] C. Porębski, Czy etyka się opłaca, Kraków 1997.
[4] Podstawy marketingu, pod red. J. Altkorna, Kraków 2004.
[5] M. Bąk, P. Kulawczuk, A. Szcześniak, Strategia polskiego biznesu wobec korupcji, Warszawa 2001.


**SUBJECT SUPERVISOR**


Adriana Merta-Staszczak, Andrzej Postawa, adriana.merta-staszczak@pwr.edu.pl, andrzej.postawa@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Język obcy B2+ lub C1+** |
| Name of subject in English: | **Foreign language B2+ or C1+** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | SJO000-SM00 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | 15 | | | |
| Number of hours of total student workload (CNPS): | | 30 | | | |
| Form of crediting: | | crediting with grade | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | 1 | | | |
| including number of ECTS points for practical (P) classes : | | 1 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | 0.70 | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Classes | | Number of hours: |
|---|---|---|
| Cl 1 | xx | 15 |
| | Total hours: | **15** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] B. Klimczak, Etyka gospodarcza, Wrocław 1996.
[2] P. M. Minus, Etyka w biznesie, Warszawa 1995.
[3] E. Sternberg, Czysty biznes. Etyka biznesu w działaniu, Warszawa 1998.

**SECONDARY LITERATURE:**

[1] G. D. Chrissides, J. H. Kaler, Wprowadzenie do etyki biznesu, Warszawa 1999.
[2] A. Chaufen, Kradzież a rozwój gospodarczy, Warszawa 2006.
[3] C. Porębski, Czy etyka się opłaca, Kraków 1997.
[4] Podstawy marketingu, pod red. J. Altkorna, Kraków 2004.
[5] M. Bąk, P. Kulawczuk, A. Szcześniak, Strategia polskiego biznesu wobec korupcji, Warszawa 2001.


## SUBJECT SUPERVISOR

,

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

Name of subject in Polish: **Język obcy A1lub A2**
Name of subject in English: **Foreign language A1 or A2**
Main field of study (if applicable): **Electrical Engineering**
Specialization (if applicable): **Renewable Energy Systems**
Level and form of studies: **2nd level, full-time**
Kind of subject: **optional / university-wide**
Subject code: SJO000-SM00
Group of courses: **NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | 45 | | | |
| Number of hours of total student workload (CNPS): | | 60 | | | |
| Form of crediting: | | crediting with grade | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | 2 | | | |
| including number of ECTS points for practical (P) classes : | | 2 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | 1.40 | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

## SUBJECT OBJECTIVES

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 xx

PEU_U02 xx

*relating to social competences:*

PEU_K01 xx

## PROGRAMME CONTENT

| Classes | | Number of hours: |
|---|---|---|
| Cl 1 | xx | 45 |
| | Total hours: | **45** |

## TEACHING TOOLS USED

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** *F – forming (during semester) P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] B. Klimczak, Etyka gospodarcza, Wrocław 1996.
[2] P. M. Minus, Etyka w biznesie, Warszawa 1995.
[3] E. Sternberg, Czysty biznes. Etyka biznesu w działaniu, Warszawa 1998.

**SECONDARY LITERATURE:**

[1] G. D. Chrissides, J. H. Kaler, Wprowadzenie do etyki biznesu, Warszawa 1999.
[2] A. Chaufen, Kradzież a rozwój gospodarczy, Warszawa 2006.
[3] C. Porębski, Czy etyka się opłaca, Kraków 1997.
[4] Podstawy marketingu, pod red. J. Altkorna, Kraków 2004.
[5] M. Bąk, P. Kulawczuk, A. Szcześniak, Strategia polskiego biznesu wobec korupcji, Warszawa 2001.


## SUBJECT SUPERVISOR

,

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Sztuka wystąpień publicznych** |
| Name of subject in English: | **The art of public speaking** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W08ETK-SM3721 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | | 15 |
| Number of hours of total student workload (CNPS): | | | | | 50 |
| Form of crediting: | | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | | 2 |
| including number of ECTS points for practical (P) classes : | | | | | 2 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | | 1.40 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge from the area of Humanities and Social Sciences area

## SUBJECT OBJECTIVES

C1. Student acquires basic knowledge of the functioning in the society
C2. Student acquires skills in interpersonal communication and social interaction
C3. Student acquires basic competence in critical thinking and positive argumentation.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 The student has the ability to understand social, economic, legal, and other non technical conditions of engineering activities.

PEU_U02 The student is able to formulate and thoroughly justify opinions, prepare and make presentations related to the problems from the scope of topics of the studied discipline as well as to the topics related to the environment of work. Is also able to take part in scientific and professional discussions.

*relating to social competences:*

PEU_K01 The student is able to think critically and to argue their position, allowing it properly determine the priorities for implementing specified by himself or other tasks, taking into account issues of social responsibility.

## PROGRAMME CONTENT

| | Seminar | Number of hours: |
|---|---|---|
| Sem 1 | Introduction to social communication | 2 |
| Sem 2 | Visual communication | 2 |
| Sem 3 | Nonverbal communication – authority, trust and faith | 2 |
| Sem 4 | Nonverbal communication – technical ascpects | 4 |
| Sem 5 | Stage, space and technical support | 2 |
| Sem 6 | Auditory – strategies of group dynamic | 2 |
| Sem 7 | Mass communication | 1 |
| | Total hours: | **15** |

## TEACHING TOOLS USED

N1. Informational lecture
N2. Multimedia presentation
N3. Interactive lecture

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
|---|---|---|
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Presentation |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Active participation |
| P(S) | P=0,8F1+0,2F2 | |

## PRIMARY AND SECONDARY LITERATURE


**PRIMARY LITERATURE:**

[1] Lucas S., The art of public speaking, (2012), McGraw-Hill, New York.
[2] Parrish A. C., Adaptive Rhetoric. Evolution, Culture, and the Art of Persuasion, (2014), Routledge, New York.
[3] Sobczak B., Zgółkowa H. (red.), Dydaktyka retoryki, (2011), Wydawnictwo Poznańskie, Poznań.
[4] Arystoteles, Retoryka. Poetyka. (1988), Przeł. H. Podbielski, Wydawnictwo Naukowe PWN, Warszawa.

**SECONDARY LITERATURE:**

[1] Esenwein J. B., Carnegey D., (1915), The art. of public speaking, The Home Correspondence School, Springfield, Mass..
[2] Dąbrowski Ł., (2012), 101 porad dla prezenterów, Helion, Warszawa.
[3] Bugajski M. (2007), Język w komunikowaniu, Wydawnictwo Naukowe PWN, Warszawa.
Kuziak M., (2008), Jak mówić, rozmawiać, przemawiać? Wydawnictwo Szkolne PWN, Warszawa.


## SUBJECT SUPERVISOR


Adriana Merta-Staszczak, Andrzej Postawa, adriana.merta-staszczak@pwr.edu.pl, andrzej.postawa@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Komunikacja społeczna** |
| Name of subject in English: | **Social communication** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W08ETK-SM3821 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | | | | | 15 |
| Number of hours of total student workload (CNPS): | | | | | 50 |
| Form of crediting: | | | | | crediting with grade |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | | | | | 2 |
| including number of ECTS points for practical (P) classes : | | | | | 2 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | | 1.40 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge from the area of Humanities and social sciences area
2. Basic knowledge from the area of Humanities and social sciences area

## SUBJECT OBJECTIVES

C1. Student acquires basic knowledge of the functioning in the society.
C1. Student acquires basic knowledge of the functioning in the society
C2. Student acquires skills in interpersonal communication and social interaction
C2. Student acquires skills in interpersonal communication and social interaction
C3. Tthe student acquires basic social competences in interpersonal communication.
C3. Student acquires basic competence in critical thinking and positive argumentation

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

*relating to skills:*

PEU_U01 The student has the abillity to understand social, economic, legal and others non technical conditions of engineering activities

PEU_U01 The student has the abillity to understand social, economic, legal and others non technical conditions of engineering activities

PEU_U02 The student is able to formulate and thoroughly justify opinions, prepare and make presentations related to the problems from the scope of topics of the studied discipline as well as to the topics related to the environment of work. Is also able to take part in scientific and professional discussions

PEU_U02 The student is able to formulate and thoroughly justify opinions, prepare and make presentations related to the problems from the scope of topics of the studied discipline as well as to the topics related to the environment of work. Is also able to take part in scientific and professional discussions.

*relating to social competences:*

PEU_K01 The student is able to think critically and to argue their position, allowing it properly determine the priorities for implementing specified by himself or other tasks, taking into account issues of social responsibility.

PEU_K01 The student is able to think critically and to argue their position, allowing it properly determine the priorities for implementing specified by himself or other tasks, taking into account issues of social responsibility.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Seminar** | | **Number of hours:** |
| Sem 1 | Introduction to the social communication. | 1 |
| Sem 1 | Introduction to the social communication. | 1 |
| Sem 2 | Verbal communication | 2 |
| Sem 2 | Verbal communication | 2 |
| Sem 3 | Nonverbal communication. | 2 |
| Sem 3 | Nonverbal communication. | 2 |
| Sem 4 | Visual communication | 2 |
| Sem 4 | Visual communication | 2 |
| Sem 5 | Audial communication | 3 |
| Sem 5 | Audial communication | 3 |
| Sem 6 | Mediated communication | 2 |
| Sem 6 | Mediated communication | 2 |
| Sem 7 | Mass communication - advertising | 1 |
| Sem 7 | Mass communication – advertising | 1 |
| Sem 8 | Praxis of communication and PR | 1 |
| Sem 8 | Praxis of communication and PR | 1 |
| Sem 9 | Netiquette electronic communication | 1 |
| Sem 9 | Netiquette electronic communication | 1 |
| | Total hours: | **30** |

**TEACHING TOOLS USED**

N1. Multimedia presentation
N1. Multimedia presentation
N2. Informational lecture
N2. Informational lecture
N3. Interactive lecture
N3. Interactive lecture

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Presentation |
| F1(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Presentation |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Active participation |
| F2(S) | PEU_U01<br>PEU_U02<br>PEU_K01 | Active participation |
| P(S) | P=0,8F1+0,2F2 | |
| P(S) | P=0,8F1+0,2F2 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] Goban-Klas T. (2009) Media i komunikowanie masowe: Teorie i analizy radia, prasy, telewizji i internetu, Wydawnictwo Naukowe PWN, Warszawa.
[2] Hopfinger M. (red.) (2002) Nowe media w komunikacji społecznej XX wieku, Oficyna Naukowa, Warszawa.
[3] Kluszczyński R. W. (2001) Społeczeństwo informacyjne. Cyberkultura. Sztuka multimediów, Rabid, Kraków.
[4] Leathers D. G. (2007) Komunikacja niewerbalna, Wydawnictwo Naukowe PWN, Warszawa.

**SECONDARY LITERATURE:**

[1] van Dijk J., (2010) Społeczne aspekty nowych mediów, Wydawnictwo Naukowe PWN, Warszawa.
[2] McLuhan M. (2001) Wybór tekstów, Zysk i Spółka, Poznań.
[3] Rothert A. (2003) Technopolis. Wirtualne sieci polityczne, Elipsa, Warszawa.
[4] Sieńko M. (2002) Człowiek w pajęczynie: Internet jako zjawisko kulturowe, Atut, Wrocław.
[5] Bugajski M. (2007) Język w komunikowaniu, Wydawnictwo Naukowe PWN, Warszawa.

| SUBJECT SUPERVISOR |
| --- |
| Adriana Merta-Staszczak, Andrzej Postawa, adriana.merta-staszczak@pwr.edu.pl, andrzej.postawa@pwr.edu.pl |

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Prawo własności intelektualnej na świecie** |
| Name of subject in English: | **Intellectual property rights in the world** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W05ETK-SM1231 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 25 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of legal concepts.
2. The ability to thinking independely, searching and analyzing information.
3. The understanding of self-education need and continuous improvement of the knowledge.

## SUBJECT OBJECTIVES

C1. Gaining knowledge of the legal protection of intellectual property in the field of industrial property and copyright.
C2. Understanding the rules of intellectual property protection within international procedures.
C3. Awareness of the importance of intellectual property protection in the world.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Student is able to define the concept of industrial property rights, its types, scope of protection and limitations.

PEU_W02 The student is able to characterize the concept of copyright, its types and scope of protection, the methods copyright management (licenses).

PEU_W03 Student knows the rules of intellectual property protection within the international procedures.

*relating to skills:*

*relating to social competences:*

PEU_K01 He understands the importance of intellectual property protection in the contemporary world.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Introduction to the law. The concept of intellectual property. Sources of industrial property rights and copyright in the world. International agreements. | 2 |
| Lec 2 | Patents, utility models, industrial designs, know-how- definitions, scope of protection, duration, limitations of rights. | 2 |
| Lec 3 | Granting a patent in the regional and international procedures. | 2 |
| Lec 4 | Trademarks. Trademark protection systems in the EU, the U.S.A., Latin America and Asia. | 2 |
| Lec 5 | Subject and object of copyright law in international law. Categories and types of works protected by copyright. Exclusions from copyright protection of certain categories of work. The obtaining of copyright protection. | 2 |
| Lec 6 | Economic copyrights - the content, disposal of the work. Management of copyright property rights (licenses). Limitations of copyright - fair use. | 2 |
| Lec 7 | The rules of intellectual property protection within regional and international procedures. | 2 |
| Lec 8 | Written test. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Traditional lecture. |
| N2. Multi-media presentation. |
| N3. Consultations. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_K01 | Written test. |
| P(W) | P=F1 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] Kotarba W., Ochrona własności intelektualnej", Oficyna Wydawnicza Politechniki warszawskiej, Warszawa 2012
[2] Sieńczyło-Chlabicz, Prawo własności intelektualnej, Wydawnictwo prawnicze LexisNexis, Warszawa 2013
[3] Nowińska E., Promińska U. de Vall M., Prawo własności przemysłowej, Wydawnictwo prawnicze LexisNexis, Warszawa 2008
[4] Grzywińska A., Okoń S., Marki, wynalazki, wzory użytkowe: ochrona własności przemysłowej, Wydawnictwo Helion, Gliwice 2010
[5] Poradnik wynalazcy. Zasady sporządzania dokumentacji zgłoszeń wynalazków i wzorów użytkowych. Urząd Patentowy R.P. www.uprp.gov.pl
[6] Ustawa z dn. 30.06.2000 r. Prawo własności przemysłowej. Dz. U. z 2001 r. nr 49, poz. 508 z późniejszymi zmianami


**SECONDARY LITERATURE:**


[1] Żakowska-Henzler H., Wynalazek biotechnologiczny. Przedmiot patentu., Wydawnictwo Naukowe Scholar, Warszawa 2006
[2] de Vall M, Prawo patentowe, Wolters Kluwer, Warszawa 2008
[3] Adamczak A., du Vall M., Ochrona własności intelektualnej, UOTT, Warszawa 2010.


**SUBJECT SUPERVISOR**


Michał Lisowski, michal.lisowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Wynalazki i patenty** |
| Name of subject in English: | **Inventions and patents** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W05ETK-SM1232 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 25 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of legal concepts.
2. Zdolność do samodzielnego myślenia, wyszukiwania i analizowania informacji.
3. The understanding of self-education need and continuous improvement of the knowledge.

## SUBJECT OBJECTIVES

C1. Understanding the concepts of inventions, their classification and characteristics.
C2. Understanding the principles of patent protection.
C3. Gaining knowledge about the process of obtaining a patent in the national, regional and international procedure

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 He is able to define the concept of the invention, describe its features and types.
PEU_W02 He is able to determine what is a patent, characterize its content. scope, duration and limits.
PEU_W03 He has knowledge how to grant a patent in the national, regional and international procedures.

*relating to skills:*

*relating to social competences:*

PEU_K01 He is able to think creatively.

**PROGRAMME CONTENT**

| | **Lecture** | **Number of hours:** |
|---|---|---|
| Lec 1 | Introduction. The most important theories of patent protection and the basic sources of patent law at international, EU and national level. | 2 |
| Lec 2 | The concept of the invention and its features (terms of patentability). Inventions excluded from protection. | 2 |
| Lec 3 | Types of inventions. The specificity of a biotechnological invention. | 2 |
| Lec 4 | Patent - content, scope of protection, duration, limitations. | 2 |
| Lec 5 | The concept of patent author and his rights. License agreements. | 2 |
| Lec 6 | Patent application in the national, European and international procedure. | 2 |
| Lec 7 | Patent databases as a source of information. Terms of use of patent databases. | 2 |
| Lec 8 | Written test. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Traditional lecture.<br>N2. Multi-media presentation.<br>N3. Consultations. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_K01 | Written test. |
| P(W) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Kotarba W., Ochrona własności intelektualnej", Oficyna Wydawnicza Politechniki warszawskiej, Warszawa 2012
[2] Sieńczyło-Chlabicz, Prawo własności intelektualnej, Wydawnictwo prawnicze LexisNexis, Warszawa 2013
[3] Nowińska E., Promińska U. de Vall M., Prawo własności przemysłowej, Wydawnictwo prawnicze LexisNexis, Warszawa 2008
[4] Grzywińska A., Okoń S., Marki, wynalazki, wzory użytkowe: ochrona własności przemysłowej, Wydawnictwo Helion, Gliwice 2010
[5] Poradnik wynalazcy. Zasady sporządzania dokumentacji zgłoszeń wynalazków i wzorów użytkowych. Urząd Patentowy R.P. www.uprp.gov.pl
[6] Ustawa z dn. 30.06.2000 r. Prawo własności przemysłowej. Dz. U. z 2001 r. nr 49, poz. 508 z późniejszymi zmianami


**SECONDARY LITERATURE:**


[1] Nowicka A., Wynalazek, Prawo własności przemysłowej, Wyd. Difin, Warszawa 2005
[2] Żakowska-Henzler H., Wynalazek biotechnologiczny. Przedmiot patentu., Wydawnictwo Naukowe Scholar, Warszawa 2006
[3] de Vall M, Prawo patentowe, Wolters Kluwer, Warszawa 2008
[4] Adamczak A., du Vall M., Ochrona własności intelektualnej, UOTT, Warszawa 2010.


## SUBJECT SUPERVISOR


Michał Lisowski, michal.lisowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Prawo własności przemysłowej i prawo autorskie dla inżynierów** |
| Name of subject in English: | **Industrial property and copyright for engineers** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W05ETK-SM1233 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 25 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of legal concepts.
2. The ability to thinking independely, searching and analyzing information.
3. The understanding of self-education need and continuous improvement of the knowledge.

## SUBJECT OBJECTIVES

C1. Gaining knowledge of the legal protection of intellectual property in the field of industrial property and copyright.
C2. Gaining knowledge about the protection of inventions, utility models and industrial designs.
C3. Awareness of the importance of protecting intellectual property in engineering activities.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Student is able to define the concept of industrial property rights, its types, scope of protection and limitations.

PEU_W02 Student is able to characterize the concept of copyright, its types and scope of protection, the methods of copyright management (licenses).

*relating to skills:*

*relating to social competences:*

PEU_K01 He is able to think creatively.

**PROGRAMME CONTENT**

| Lecture | | Number of hours: |
|---|---|---|
| Lec 1 | The concept of intellectual property. Sources of industrial property law. Industral property - its types and scope. | 2 |
| Lec 2 | The concept of the invention and its features (terms of patentability). The specificity of a biotechnological invention. Inventions excluded from protection. | 2 |
| Lec 3 | Patents, utility models, industrial designs - the content, the scope of protection, duration, limitations. Principles of preparation of patent specification and the use of patent databases. | 2 |
| Lec 4 | Subject of copyright law - the concept of copyright work, its categories and types. Exclusions from the copyright protection. | 2 |
| Lec 5 | The copyright subject - the concept of the creator, co-creator and others copyright holders. Moral and economic copyrights- the content and infringement of protection. | 2 |
| Lec 6 | The limitatios of economic copyrights – time duration and fair use. Managament of economic copyrights (licenses). | 2 |
| Lec 7 | Copyright protection of databases. Copyright and the Internet. Copyright infringement on the Internet. | 2 |
| Lec 8 | Written test. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Traditional lecture.<br>N2. Multi-media presentation.<br>N3. Consultations. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_K01 | Written test. |
| P(W) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Kotarba W., Ochrona własności intelektualnej", Oficyna Wydawnicza Politechniki warszawskiej, Warszawa 2012
[2] Sieńczyło-Chlabicz, Prawo własności intelektualnej, Wydawnictwo prawnicze LexisNexis, Warszawa 2013
[3] Nowińska E., Promińska U. de Vall M., Prawo własności przemysłowej, Wydawnictwo prawnicze LexisNexis, Warszawa 2008
[4] Grzywińska A., Okoń S., Marki, wynalazki, wzory użytkowe: ochrona własności przemysłowej, Wydawnictwo Helion, Gliwice 2010
[5] Poradnik wynalazcy. Zasady sporządzania dokumentacji zgłoszeń wynalazków i wzorów użytkowych. Urząd Patentowy R.P. www.uprp.gov.pl
[6] Ustawa z dn. 30.06.2000 r. Prawo własności przemysłowej. Dz. U. z 2001 r. nr 49, poz. 508 z późniejszymi zmianami


**SECONDARY LITERATURE:**


1] Żakowska-Henzler H., Wynalazek biotechnologiczny. Przedmiot patentu., Wydawnictwo Naukowe Scholar, Warszawa 2006
[2] de Vall M, Prawo patentowe, Wolters Kluwer, Warszawa 2008
[3] Adamczak A., du Vall M., Ochrona własności intelektualnej, UOTT, Warszawa 2010.


## SUBJECT SUPERVISOR


Michał Lisowski, michal.lisowski@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

Name of subject in Polish: **Ochrona własności intelektualnej**
Name of subject in English: **Protection of Intellectual Property**
Main field of study (if applicable): **Electrical Engineering**
Specialization (if applicable): **Renewable Energy Systems**
Level and form of studies: **2nd level, full-time**
Kind of subject: **optional / university-wide**
Subject code: W05ETK-SM1007
Group of courses: **NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 25 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a basic knowledge about legislative issues.

## SUBJECT OBJECTIVES

C1. Getting the knowledge in the field of intellectual property protection.
C2. Skills of determination of patent procedures, introduction of utility models, industrial, trade marks
C3. Forming of attitudes of the respect for the law of the intellectual property

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has a basic knowledge about elements of patent protection, trademarks, utility models, industrial designs
PEU_W02 Has a basic knowledge about copyright

*relating to skills:*

*relating to social competences:*

PEU_K01 He understands the need of protection of the copyright and following them.

## PROGRAMME CONTENT

| Lecture | | Number of hours: |
|---|---|---|
| Lec 1 | The notion and meaning of the intellectual property in the activity of companies and the everyday life. Protection systems of the intellectual property and types of protective laws. | 2 |
| Lec 2 | Industrial property law - kinds of the knowledge of PWP being protected, comprehending the invention, the patent and the patent ability, procedures of the patent protection (PL, EU, international), costs of the procedures patent, world trends in the patent protection. | 2 |
| Lec 3 | Utility models, industrial designs definitions and procedures of the protection | 2 |
| Lec 4 | Trademarks and service - definitions and procedures of the protection | 2 |
| Lec 5 | The copyright and related rights: protection of scientific, literary, artistic works, computer programs and databases. The object and the subject of laws, duration of the protection | 2 |
| Lec 6 | The access and ways of using information bases about the protected intellectual property - cells and examples of using patent information | 2 |
| Lec 7 | The transfer of knowledge and agreements in trading with laws of the intellectual property | 2 |
| Lec 8 | Test | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lectures with multimedia presentation supplemented by traditional form<br>N2. Individual work of students<br>N3. Consultation |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_K01 | Test |
| P(W) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] Bently L., B. Sherman Intellectual property law. Oxford, New York , Oxford University Press, cop. 2009.
[2] Lewis J.A. Intellectual property protection: promoting innovation in a global information economy, Washington: Center for Strategic and International Studies, 2008.
[3] C. Junghans, A. Levy, Intellectual Property Management: A Guide for scientists, engineers, financiers and managers, Wiley-VCH 2006.

**SECONDARY LITERATURE:**

[1] Internet portals dedicated to intellectual property: www.uprp.pl, www.epo.org, www.uspto.gov, www.wipo.org, OHIM etc

## SUBJECT SUPERVISOR

Aldona Dereń, aldona.deren@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Prawo międzynarodowe** |
| Name of subject in English: | **International Law** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W05ETK-SM1008 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 25 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 1 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.70 | | | | |

### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a basic knowledge about legislative issues.

### SUBJECT OBJECTIVES

C1. Getting of basic knowledge in the field of international law.
C2. Skills for understanding and interpretation of the existing provisions in the area of international law
C3. Acquisition and persisting social competence in respecting the provisions of international law

### SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 He knows the basic functioning of the international community and the international legal order.

PEU_W02 He knows the principles of cooperation through international organizations.

*relating to skills:*

*relating to social competences:*

PEU_K01 He understands the need of the development of the activity of an engineer in technical and legal and control aspects.

### PROGRAMME CONTENT

| | Lecture | Number of hours: |
|---|---|---|
| Lec 1 | The international law and his sources. Principles shaping contemporary international relations. Processes and international structures. | 2 |
| Lec 2 | International agreements and their meaning for integration processes international and of globalization. | 2 |
| Lec 3 | Legal subjectivity of international organizations. | 2 |
| Lec 4 | Sources and principles of the international protection of human rights. | 2 |
| Lec 5 | Foreign economic relations - characteristics of regulations being in force. Legal bases of international funds. International economic transactions. | 2 |
| Lec 6 | Civil law and commercial in the international exchange. | 2 |
| Lec 7 | Legal grounds of international marketing. | 2 |
| Lec 8 | Test | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lectures with multimedia presentation supplemented by traditional form<br>N2. Individual work of students<br>N3. Consultation |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_K01 | Test |
| P(W) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] "Polish Yearbook of International Law, Wydawnictwo Instytutu nauk Prawnych Warszawa 2010.
[2] I. Brownlie, Principles of Public International Law, (OUP 2008).
[3] I. Slomanson, W. William, Fundamental Perspectives on Internationa Law, Boston 2011.
[4] The Free Dictionary Definition of Human Rights", The American Heritage® Dictionary of the English Language, Fourth Edition copyright ©2000 by Houghton Mifflin Company. Updated in 2009.. Retrieved 13 September 2011.
[5] R. Filipek, Protection of Human Rights in the EU – Meeting the Standards of a European Human Rights System?, A. Bodnar et al. (red.) The Emerging Constitutional Law of the European Union. German and Polish Perspectives, Heidelberg 2003.

**SECONDARY LITERATURE:**

[1] L. Antonowicz, Podręcznik prawa międzynarodowego, Wydawnictwo LexisNexis Warszawa 2003.
[2] W. Czapliński, A. Wyrozumska, Prawo międzynarodowe publiczne, Warszawa 2010.
[3] „ Przegląd prawa europejskiego i międzynarodowego" , Wydawnictwo Wolters Kluwer Polska – ABC, Warszawa 2011.
[4] A. Przyborowska-Klimczak, D. Pyć, Leksykon prawa międzynarodowego publicznego, Wydawnictwo C.H. Beck Warszawa 2012
[5] J. Ciszewski, Obrót prawny z zagranicą w sprawach cywilnych i karnych, Wydawnictwo LexisNexis Warszawa 2012.

## SUBJECT SUPERVISOR

Aldona Dereń, aldona.deren@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

# SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Mechanizmy rynkowe w energetyce o strukturze rozproszonej** |
| Name of subject in English: | **Market Mechanisms in Power Systems with Distributed Energy Sources** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W05ETK-SM2538 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 50 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knows the principles a power system operation and control, is familiar with electricity generation and transmission techniques.
2. Has a basic knowledge in the field of renewable energy sources.
3. Understands a need and knows possibilities of continuous education, increasing of professional, personal and social competences.

## SUBJECT OBJECTIVES

C1. Possession a knowledge of function of electric energy sector including renewable energy sources.
C2. Getting to know market and regulatory mechanisms in power sector.
C3. Possession a knowledge of electric energy market.
C4. Possession a knowledge of goals of national and union energy policy.

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Knows function of electric energy sector including renewable energy sources.
PEU_W02 Knows market and regulatory mechanisms in power sector.
PEU_W03 Possesses a knowledge of electric energy market.

*relating to skills:*

*relating to social competences:*

PEU_K01 Can think and act in creative and enterprising way. He/she is able to rank appropriately the priorities needed for realizing the respective task.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours:** |
| Lec 1 | Specific features of energy supply sector. Evolution of structural forms - from vertical integration to restructuring and liberalization. | 2 |
| Lec 2 | Mechanisms of energy market. | 2 |
| Lec 3 | Regulacja rynku energii. | 2 |
| Lec 4 | State' interventionism and market rules. Regulatory mechanisms on energy market. | 2 |
| Lec 5 | Infrastructural multi-energy utilities. | 2 |
| Lec 6 | Financial relations between market entities. | 2 |
| Lec 7 | Realization of the European energy policy goals: effectiveness, use of renewable energy sources, counteraction of climate changes. | 2 |
| Lec 8 | Test. | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
|---|
| N1. Lecture with the use of audiovisual techniques, multimedia presentations. |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
|---|---|---|
| **Evaluation** *F – forming (during semester)* *P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_K01 | Test. |
| P(W) | P=F1 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] Kowalska A., Wilczyński A., Źródła rozproszone w systemie elektroenergetycznym. Wydawnictwo Kaprint, Lublin, 2007.
[2] Malko J. Wilczyński A., Rynki energii – działania marketingowe. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2006.
[3] W.Joerss, M. Uyterlinde, P. Loeffler, P.E. Morthost, Decentralised Power Generation in the Liberalised EU Energy Markets, Springer-Verlag Berlin Heidelberg, 2003.
[4] B. Murray, Power Markets and Economics: Energy Costs, Trading, Emissions, John Wiley and Sons Ltd. Chichester, England, 2009.

**SECONDARY LITERATURE:**

[1] M. Shahidehpour, H. Yamin, Zuyi Li, Market Operations in Electric Power Systems: Forecasting, Scheduling, and Risk Management, John Wiley and Sons Ltd. New York, 2002.
[2] Czasopisma: Rynek Energii, IEEE Power & Energy, Power Engineering, Renewable Energy World.

## SUBJECT SUPERVISOR

Waldemar Dołęga, waldemar.dolega@pwr.edu.pl

FACULTY OF ELECTRICAL ENGINEERING

## SUBJECT CARD

| | |
|---|---|
| Name of subject in Polish: | **Podstawy Zarządzania** |
| Name of subject in English: | **Fundamentals of Management** |
| Main field of study (if applicable): | **Electrical Engineering** |
| Specialization (if applicable): | **Renewable Energy Systems** |
| Level and form of studies: | **2nd level, full-time** |
| Kind of subject: | **optional / university-wide** |
| Subject code: | W05ETK-SM1499 |
| Group of courses: | **NO** |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU): | 15 | | | | |
| Number of hours of total student workload (CNPS): | 50 | | | | |
| Form of crediting: | crediting with grade | | | | |
| For group of courses mark (X) final course: | | | | | |
| Number of ECTS points: | 2 | | | | |
| including number of ECTS points for practical (P) classes : | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1.40 | | | | |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a basic knowledge about management processes, functions, principles and tools and identifies the basic management issues

## SUBJECT OBJECTIVES

C1. To ensure fundamental knowledge (including application aspects) about: setting up the business
C2. To ensure fundamental knowledge (including application aspects) about: organization as a system
C3. To ensure fundamental knowledge (including application aspects) about: organizational development dynamics and characteristics of the organization in various development phases
C4. To ensure fundamental knowledge (including application aspects) about: change and project management

## SUBJECT EDUCATIONAL EFFECTS

*relating to knowledge:*

PEU_W01 Has a basic knowledge about setting up and running the business.
PEU_W02 Has a basic knowledge about managing organization as a system.
PEU_W03 Has a basic knowledge about introducing changes in organizations.

*relating to skills:*

*relating to social competences:*

PEU_K01 Is aware how important is the cooperation in completing complex tasks.

### PROGRAMME CONTENT

| Lecture | | Number of hours: |
|---|---|---|
| Lec 1 | Scope of lecture, conditions of crediting and literature Introduction: challenges of contemporary management | 2 |
| Lec 2 | How to set up the business? The essence of entrepreneurship. | 2 |
| Lec 3 | Organization as a system of functions, processes and operations. | 2 |
| Lec 4 | Managing organizational environment. | 2 |
| Lec 5 | Organizational transformations: birth, growth, decline, and death. Change management | 2 |
| Lec 6 | Project management | 2 |
| Lec 7 | Effective teams building | 2 |
| Lec 8 | Final assessment | 1 |
| | Total hours: | **15** |

| TEACHING TOOLS USED |
| --- |
| N1. Traditional lecture with multimedia presentations<br>N2. Case studies presented during lecture<br>N3. Self-study: final assessment preparation |

| EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT | | |
| --- | --- | --- |
| **Evaluation**<br>*F – forming (during semester)*<br>*P – concluding (at semester end)* | **Learning outcomes code** | **Way of evaluating learning outcomes achievement** |
| F1(W) | PEU_W01<br>PEU_W02<br>PEU_W03 | Final assessment |
| F2(W) | PEU_K01 | Scoring students' involvement during lecture |
| P(W) | P=0,9F1+0,1F2 | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] McKee A.: Management: a focus on leaders, Pearson , Boston 2012


**SECONDARY LITERATURE:**


[1] Griffin R.W.: Management, Houghton Mifflin Company, New York 2008.
[2] Jones G.R., George J.M., Essentials of contemporary management, McGraw-Hill Irwin, Boston 2007 (2006).
[3] Osterwalder A., Pigneur Y., Business model generation: a handbook for visionaries, game changers, and challengers, John Wiley & Sons, 2010.
[4] Robbins S.P., DeCenzo D.: Fundamentals of management: essential concepts and applications, Pearson/Prentice Hall, 2008.


## SUBJECT SUPERVISOR


Anna Zgrzywa-Ziemak, anna.zgrzywa-ziemak@pwr.edu.pl