Appendix
to the resolution of the Senate of the WAT No. 115/WAT/2023
dated on the 22nd of June, 2023

MILITARY UNIVERSITY OF TECHNOLOGY
named after Jarosław Dąbrowski

CURRICULUM

Level of education: second cycle programme

Field of study: **electronics and telecommunications**
Profile of study: **general academic**
Mode of study: **full-time programme**

Resolution of the Senate of the Military University of Technology named after Jarosław Dąbrowski No. 115/WAT/2023 dated on the 22nd of June, 2023

Effective from the academic year 2023/2024

Warsaw

2023

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CURRICULUM
organizational assumptions

for the field of study „electronics and telecommunications”

Level of education **second cycle programme**

Profile of study **general academic**

Mode(s) of study **full-time programme**

Qualification and title conferred on graduates **master engineer**

Polish Qualification Framework level **level 7**

Field of study is assigned to:

Field of science **engineering and technology**

Scientific disciplines **automatic control, electronics, electrical engineering and space technologies (70%)**
technical informatics and telecommunications (30%)

Leading discipline[1] **automatic control, electronics, electrical engineering and space technologies**

Language of instruction **English**

Number of semesters **3**

Total number of hours

telecommunications technologies: **924**
modern electronics engineering: **910**

Number of ECTS credits required to graduate **90**

Total number of ECTS credits a student is required to obtain for the course

- **conducted with direct participation of academic staff or other instructors**

telecommunications technologies: **59.0**
modern electronics engineering: **58.5**

- **in the humanities and social sciences**[2] **5**

[1] *In case of assigning the field of study to more than one scientific discipline*
[2] *does not apply to fields of study which are assigned to disciplines within the disciplines of humanities or social sciences respectively.*

Dimension, number of ECTS credits, rules and form of apprenticeship

Each student pursuing studies in the field of "electronics and telecommunications" is required to complete apprenticeship in the amount of at least: **2 weeks** The total number of ECTS credits that the student must obtain during the apprenticeship: **2 ECTS**.

The apprenticeship is an integral part of the implemented learning process in the field of "electronics and telecommunications". Passing it is a condition for passing a given year of study. It is carried out after the 6th semester.

The rules for completing the apprenticeship are regulated by the *Regulations of Studies at the Military University of Technology named after Jarosław Dąbrowski* and the *Order of the Rector of the Military University of Technology on the rules of apprenticeship*. Detailed guidelines specifying the rules for the organization and implementation of the apprenticeship are contained in the document *Principles of completing and crediting internships at the Faculty of Electronics*, available on the website of the Faculty of Electronics. The apprenticeship can be realized through:

1) concluding an agreement on apprenticeship between the university and an entity selected individually by the student (individual apprenticeship),
2) concluding an agreement on apprenticeship between the university and an entity selected by the university (group apprenticeship),
3) confirmation of the learning outcomes assigned in the study program to apprenticeships and obtained in the process of learning outside the study system as part of applying for admission to studies,
4) the student's participation in a science and research camp, if the nature of the tasks performed corresponds to the internship program,
5) implementation of an individual apprenticeship as part of international exchange or an agreement between the university and international institutions,
6) volunteering or internship.

CHARACTERISTICS OF THE FIELD OF STUDY

The second-cycle studies in the field of *electronics and telecommunications* last one and a half years, include 3 semesters and are intended for civilians. To achieve the educational objectives, the balanced nature of studies was adopted. Their concept is based on education in accordance with the choice by students within the specialties profiled with elective classes. A part of classes is common to all students, regardless of the indication of elective subjects, which are focused on developing knowledge and skills for the needs of implementing projects in the field of electronics or telecommunications. The group of common classes includes, among others numerical methods, stochastic processes, computer analysis of electronic systems, neural networks, programmable digital circuits, basics of cybersecurity. As part of the formation of social competences, students are familiarized with the issues of management and entrepreneurship as well as managing human teams. The offer of non-technical subjects also includes language education, the aim of which is to master the skills of active use of a foreign language at the level of the B2+ certificate of the Common European Framework of Reference for Languages. The study program includes at least 2 weeks of professional practice, which takes place in workplaces consistent with the field of study. The studies end with the defense of the diploma thesis, and graduates obtain the title of master engineer. At the same time, they are prepared to study at doctoral schools and conduct scientific research.

IMPLEMENTATION OF STUDIES

The Faculty of Electronics of the Military University of Technology is responsible for conducting studies in the field of *electronics and telecommunications*. The Faculty offers a modern and comprehensively prepared educational and scientific base, providing the opportunity to carry out attractive didactic activities and conduct scientific research. The resources of the Faculty consist of the resources of organizational units – 3 institutes, 1 scientific and educational center and 1 accredited laboratory. The Faculty also receives support from the laboratories of other organizational units of the University, which are involved in the process of education in the field. The buildings in which the classes take place are located on campus at a short distance from each other. Education in the field of *electronics and telecommunications,* based on modern university infrastructure and the results of scientific research, which allow for conducting high-level didactic activities attractive to future employees of various sectors of the national economy, is consistent with the development strategy of the Military University of Technology and the Faculty of Electronics. Economic development and the growing mobility of entrepreneurs, workers and students, resulting from the general progress and membership of Polish in the European Union, give rise to a strong need for education adapted to the requirements of the modern economy based on knowledge and modern technologies. An important feature of the implementation of studies at the Military University of Technology in the field of *electronics and telecommunications* is to treat this fact as a strategic activity, resulting from the high demand for specialists in this field, as well as due to the trends and tendencies characterizing the labor market in the region and the whole country. The implementation of studies in the field of *electronics and telecommunications* is a response to the growing demand for engineers – specialists educated and prepared to create technical progress. It is strategic for the development of the Polish economy and is a natural response to the constantly observed deficit of technical graduates. A significant impact on the implementation of studies, especially in the field of specialist content, have scientific and research work carried out at the Faculty of Electronics. The experience of

academic staff gained during conducting and participating in such work naturally enriches the subject matter of classes with the latest trends in electronics and telecommunications, which allows to increase the topicality and diversity of education, manifested in a wide range of elective content. Preparation of students for scientific work is carried out through laboratory projects and exercises, within which students perform research tasks, both individual and team, tasks within the framework of diploma theses, some of which are included in research projects carried out at the Faculty and are experimental in nature. Students, working in scientific teams, also have access to the equipment and can implement their own research ideas. For students showing special directional or specialist talents and obtaining good and very good results in education, the Faculty of Electronics organizes studies according to an individual study program. These studies satisfy students' aspirations to acquire expanded knowledge and prepare them for positions requiring competences and skills that go beyond the typical ones outlined by curricula and study plans, and are acquired through the development of personal interests. Thanks to them, they are prepared to high extent to undertake scientific and didactic work in higher education, in scientific and research institutes and research and development departments of enterprises.

PERSONAL AND PROFESSIONAL PROFILE OF THE GRADUATE

Graduates of second-cycle studies in the field *of electronics and telecommunications* obtain qualifications in accordance with the Polish Qualifications Framework at level 7. They know and understand in depth the physical phenomena underlying the description of electronic components, the analysis of the operation of electrical circuits and analog and digital systems, as well as electronic and telecommunications systems, including systems containing programmable circuits. They have knowledge of development trends and new developments in the field of electronics, telecommunications and IT. They are able, using appropriate methods, techniques, materials and tools, to design, manufacture, launch and test electronic or telecommunications systems and systems intended for various applications, taking into account given performance criteria. They know the processes occurring in the life cycle of electronic and telecommunications devices and systems and are able to assess them on the basis of an analysis of their functioning. They are competent in the use of computer simulations and measurement technology in planning and conducting experiments. They also know the general principles of creating and developing various forms of individual entrepreneurship and the principles of managing human teams, including the use of IT teamwork tools. The assumed effect of conducting studies in the field of *electronics and telecommunications* is to prepare graduates for creative engineering and managerial work in the field of applications of electronics, telecommunications, automation and computer science to solve technical problems occurring in it. Thanks to this, graduates obtain the competences necessary to undertake professional work in accordance with their qualifications in companies in the broadly understood electronic circuits and systems industry, ICT companies dealing with telecommunications and computer networks, telecommunications and multimedia service operators and others, including research and development departments of enterprises. They also have the competences required to undertake scientific work in scientific and research institutes and higher education.

DESCRIPTION OF THE ASSUMED LEARNING OUTCOMES

Description of the assumed learning outcomes takes into account:

- a first-degree universal characteristics set out in the Annex to the Act of 22 December 2015 on the Integrated Qualifications System (Dz. U. from 2020 pos. 226, with further changes),
- a second-degree characteristics set out in the Annex to the Regulation of the Minister of Science and Higher Education of 14 November 2018 on second-degree characteristics of learning outcomes for qualifications at levels 6-8 of the Polish Qualification Framework, including those, which allow for acquiring engineering competence,

and is included in three categories:

- a **knowledge** category **(W)**, which specifies:
  - breadth and depth (**G**) - completeness of cognitive perspective and relationships,
  - context (**K**) - conditions, outcomes.
- a **skills** category **(U)**, which specifies:
  - in term of knowledge application (**W**) - problems solved and tasks performed,
  - in terms of communication (**K**) - receiving and creating statements, disseminating knowledge in a scientific environment and using a foreign language,
  - in terms of work organisation (**O**) - planning and teamwork,
  - in terms of learning (**U**) - planning one's own development and development of others.
- a **social competence** category **(K)** - which specifies:
  - in terms of assessments (**K**) - a critical approach,
  - in terms of responsibility (**O**) - fulfilling social obligations and acting in the public in- terest,
  - in relation to the professional role (**R**) - independence and ethos of development.

Explanation of designations:

- in ***a symbol and outcome number*** column:
  - K – field-related learning outcomes;
  - W, U, K (after the underscore) - category - respectively: knowledge, skills, social competence;
  - 01, 02, 03 …. – a number of learning outcome.
- in *a* ***code of description component*** column – Inż[3]_P7S_WG – a code of description component of the second-degree characteristics for qualification at level 7 of the Polish Qualification Framework.

[3] *Applies to the fields of study, the graduates of which get a degree of eng., MSc eng.*

symbol and outcome number	description of the intended learning outcomes	code of description component
KNOWLEDGE	**the graduate:**	
K_W01	has extended and in-depth knowledge in some branches of mathematics, including elements of mathematical analysis, stochastic processes, optimization methods and numerical methods, necessary for: 1) modeling and analysis of advanced electronic and telecommunications devices and systems as well as physical phenomena occurring in them; 2) description and analysis of the operation and synthesis of complex electronic and telecommunications systems; 3) description, analysis and synthesis of information and signal processing algorithms	P7S_WG
K_W02	has an expanded and in-depth knowledge in the field of physics, covering the basics of quantum physics and solid state physics, including the knowledge necessary to understand physical phenomena that significantly affect the properties of new materials and the operation of advanced electronic components	P7S_WG
K_W03	has in-depth knowledge in the field of equipment included in telecommunications systems	P7S_WG Inż._P7S_WG
K_W04	has in-depth, theoretically supported knowledge in the field of signal theory, including stochastic signals and methods of their processing	P7S_WG
K_W05	understands the methodology of designing complex electronic circuits and systems (also in the integrated version, including programmable and specialized circuits); knows hardware description languages and computer tools for designing and simulating devices or systems	P7S_WG Inż_P7S_WG
K_W06	has structured and theoretically based knowledge in the field of designing high-frequency systems, has structured knowledge in the field of electromagnetic compatibility	P7S_WG Inż_P7S_WG
K_W07	knows and understands algorithms used in electronic or telecommunications systems from the area of specialization	P7S_WK Inż_P7S_WK
K_W08	knows and understands advanced methods of artificial intelligence used in the design of electronic circuits and systems as well as in the processing of information in telecommunications systems	P7S_WK Inż_P7S_WK
K_W09	has knowledge of development trends and the most important new developments in the field of electronics, telecommunications and IT	P7S_WG Inż_P7S_WG
K_W10	has in-depth knowledge in the field of information processing and security in telecommunications systems	P7S_WG Inż_P7S_WG
K_W11	has knowledge in the field of reliability and organization of the process of equipment operation, including modern diagnostic methods	P7S_WG
K_W12	has a structured and in-depth knowledge of techniques and technologies used in electronic or telecommunications systems	Inż_P7S_WG
K_W13	has basic knowledge in the field of legal provisions regulating telecommunications activities and quality management systems	P7S_WG
K_W14	has knowledge in selected issues of law, standardization, protection of industrial property, copyright and the operation of the patent system	Inż_P7S_WG

symbol and outcome number	description of the intended learning outcomes	code of description component
K_W15	knows the general principles of creating and developing forms of individual business, using knowledge in the field of electronics and telecommunications	P7S_WK
K_W16	has an extended knowledge of the nature of social sciences and humanities, their place in the system of sciences and relations to other sciences	P7S_WK
SKILLS	**the graduate:**	
K_U01	can obtain information from literature, databases and other sources; is able to integrate the information obtained, interpret and critically evaluate it, as well as draw conclusions and formulate and comprehensively justify opinions	P7S_UW P7S_UK
K_U02	can work individually and in a team; can assess the time-consuming of the task; can manage a small team in a way that ensures the implementation of the task within the assumed deadline	P7S_UO
K_U03	can develop detailed documentation of the results of the experiment, design or research task; can prepare a study containing a discussion of these results	P7S_UW P7S_UK
K_U04	can prepare and make a presentation on the implementation of a project or research task and lead a discussion on the presented material	P7S_UW P7S_UK
K_U05	can speak a foreign language at B2+ level of the Common European Framework of Reference for Languages, to a degree that allows for spoken and written communication in general and to a higher degree in the field of specialized terminology	P7S_UK
K_U06	is able to use the learned mathematical methods and models, if necessary modifying them accordingly, to implement projects in the field of electronics or telecommunications	P7S_UW
K_U07	can analyze and synthesize complex signals and signal processing systems, using analog and digital techniques and appropriate tools	P7S_UW Inż_P7S_UW
K_U08	can assess and compare design solutions and manufacturing processes of electronic components and systems, due to the given functional and economic criteria	P7S_UW Inż_P7S_UW
K_U09	can plan and conduct research experiments, including testing, simulation and measurement of characteristics as well as extraction of parameters characterizing technical solutions of electronic or telecommunications systems	P7S_UO Inż_P7S_UO
K_U10	is able to formulate a design specification of a complex system, electronic or telecommunications system, taking into account legal aspects, including the protection of intellectual property and other non-technical aspects using available normative acts	P7S_UK Inż_P7S_UK
K_U11	can design electronic or telecommunications systems and systems taking into account the given functional and economic criteria, if necessary using computer-aided design (CAD) tools	P7S_UW Inż_P7S_UW
K_U12	can design electronic circuits for a variety of applications, including high-frequency systems and digital signal processing systems	P7S_UW Inż_P7S_UW
K_U13	is able to integrate knowledge in the field of electronics, telecommunications and other disciplines, using a systemic approach, taking into account non-technical aspects (including economic and legal)	P7S_UW Inż_P7S_UW
K_U14	is able to integrate knowledge from various sources in the formulation and solution of tasks related to the design of electronic or	P7S_UW Inż_P7S_UW

symbol and outcome number	description of the intended learning outcomes	code of description component
	telecommunications devices and systems and tasks related to the design of their production process	
K_U15	can estimate the costs of the process of designing and implementing an electronic or telecommunications device/system	P7S_UW Inż_P7S_UW
K_U16	can propose improvements or alternatives to existing design solutions and models of electronic or telecommunications devices and systems	P7S_UW Inż_P7S_UW
K_U17	is able to assess the usefulness and possibility of using new developments in the field of materials, elements, design and manufacturing methods (including microelectronic technologies) for the design and manufacture of electronic or telecommunications devices and systems containing solutions of an innovative nature	P7S_UW Inż_P7S_UW
K_U18	can determine the directions of further learning and implement the process of self-education	P7S_UU Inż_P7S_UU
K_U19	has the necessary preparation to work in an industrial environment and knows the safety rules related to this work	P7S_UO Inż_P7S_UO
K_U20	is able to observe and interpret the humanistic, legal and social phenomena surrounding her/him	P7S_UK
SOCIAL COMPETENCES	**the graduate:**	
K_K01	understands the need for lifelong learning; can inspire and organize the learning process of others	P7S_KK P7S_KO P7S_KR
K_K02	is aware of the importance and understands non-technical aspects and effects of engineering activities, including their impact on the environment	P7S_KO P7S_KR
K_K03	is able to interact and work in a group, taking on different roles in it	P7S_KO P7S_KR
K_K04	can properly define priorities for the implementation of a task specified by him or others	P7S_KK P7S_KO
K_K05	correctly identifies and resolves dilemmas related to the exercise of the profession	P7S_KR
K_K06	can think and act in a creative and entrepreneurial way	P7S_KK P7S_KR
K_K07	understands the need to formulate and communicate to the public – e.g. through the mass media – information and opinions on the achievements of electronics and telecommunications, strives to convey such information and opinions in a universally understandable way, presenting different points of view	P7S_KO
K_K08	understands the need for critical evaluation of the received content, recognizing the importance of knowledge in solving cognitive and practical problems	P7S_KK

LIST OF CLASSES

Groups of classes / subjects[4] , their short descriptions (outline programs), ECTS credits allocated to them and learning outcomes (reference to the field-related outcomes)

No.	name of class group name of subject[5], short description (outline program)	No. of ECTS credits	discipline code	reference to field-related outcomes
	content group of general education general subjects			
1.	***OCCUPATIONAL HEALTH AND SAFETY*** Outline program: *OHS in the current legal status. Principles of occupational health and safety (in work and education) - rules of safe conduct, required when performing a specific work (activity), resulting from scientific and technical premises. Protection against threats to the health and safety of students. The use of personal protective equipment in classes (exercises). Accident insurance. Dealing with accidents and emergency situations. Rules for providing pre-medical first aid.*	0.0	AEEiTK	K_W16 K_U19 K_U20 K_K02
2.	***ENTREPRENEURSHIP AND MANAGEMENT*** Outline program: *The essence, meaning and types of entrepreneurship. Features of a good entrepreneur. Entrepreneurship and innovation. Legal and organizational forms of enterprises in Poland. Principles of creating small and medium-sized companies. Organization management: planning activities and making decisions, organizing, directing people and controlling. Analysis of the company's environment. Rules for the preparation of business plans. Finance and marketing in the management of small and medium-sized companies.*	2.0	NZJ	K_W15 K_W16 K_U13 K_U19 K_U20 K_K02 K_K05 K_K06
3.	***TEAMWORK TOOLS*** Outline program: *Purpose and application of teamwork tools. Popular techniques for moderating team work. Project time frame - Gantt chart. Workload balance. Stages of implementation of the telecommunications system project. Types: projects, meetings of project teams, reports. Overview of hardware and software tools for effective project management: Leanstack, Moodle, Doodle, Phabricator, GitLab, Wrike, Kan.Bo. Open source and enterprise tools. Virtualization of the work environment / VPN. Own resources/enterprise resources. Communication in the team based on instant messaging: Slack, Join.me, Google Hangouts, Skype, WebEx. Laboratory: work in teams on the configuration and practical use of software and hardware tools to develop: design assumptions, balance the workload, implementation, versioning, archiving and distribution of software and for communication in the team.*	2.0	ITT	K_W03 K_W06 K_W09 K_W15 K_U02 K_U04 K_U07 K_U11 K_U13 K_K01 K_K03 K_K06

[4] course information sheets shall be drawn up and made available 30 days before the beginning of the semester in which the course is taught

[5] groups of classes / subjects

No.	name of class group name of subject[5], short description (outline program)	No. of ECTS credits	discipline code	reference to field-related outcomes
4.	***LAW ISSUES IN ELECTRONICS AND TELECOMMUNICATIONS*** Outline program: *Communications administration, conduct of telecommunications activities, provision of universal service, management of frequencies and numbering, telecommunications secrecy and protection of end-user privacy, obligations of telecommunications undertakings for defence, security and public security and order, requirements for the management of an accredited laboratory, construction and implementation of a management system in a testing laboratory, requirements for technical competence of the testing laboratory, accreditation of the calibration laboratory, audits, assessment of products for compliance with the essential requirements on the example of the European Union directive on electromagnetic compatibility (EMC).*	2.5	AEEiTK	K_W06 K_W13 K_W14 K_U10 K_U13 K_U20 K_K02 K_K03 K_K04 K_K05 K_K07
5.	***FOREIGN LANGUAGE*** Outline program: *Language / style / academic vocabulary level B2+. Consolidation of grammar for reading, listening, speaking and academic writing: reading comprehension of technical texts (definitions, abstracts, scientific publications, articles, etc.). The art of oral presentation.*	2.0	J	K_U01 K_U05 K_K01 K_K07
6.	***TEAM LEADERSHIP*** Outline program: *Introduction of students to the basic issues of managing people in contemporary organizations. Presentation of methods and techniques of working with people, used in managerial practice and ways to improve the skills of managing human teams.*	3.0	NZJ	K_W16 K_U02 K_U20 K_K03 K_K05 K_K04 K_K07
content group of basic education basic subjects				
1.	***NUMERICAL AND OPTIMIZATION METHODS*** Outline program: *The essence of the numerical algorithm. Numerical mathematical models. Methods of solving basic mathematical models using computer technology - development into a Taylor series, solving a system of linear equations, searching for roots of a nonlinear equation. Interpolation. Approximation. Integration and numerical differentiation. Application of numerical methods in electronics. Basic concepts of optimization, formulation of the optimization task, optimization without and with limitations, single- and multi-criteria tasks. Analytical and numerical methods for solving optimization tasks. Linear programming task - Simplex method. Gradient methods of optimization without restrictions - the method of the greatest slope, the Newton method. Non-graduate minimization methods without restrictions - Gauss-Seidel method, Powell method. Methods of minimization with limitations - the method of the saddle point, the method of the penalty function. Multi-criteria optimization methods. Genetic algorithms in solving optimization tasks.*	3.5	AEEiTK	K_W01 K_W04 K_W07 K_U01 K_U04 K_U06 K_U18 K_K01 K_K02

No.	name of class group name of subject[5], short description (outline program)	No. of ECTS credits	discipline code	reference to field-related outcomes
2.	***THEORY OF ELECTROMAGNETIC FIELD*** Outline program: *Maxwell's equations in harmonic approximation: Fourier transform of Maxwell's equations, symmetric form of Maxwell's equations with fictitious charge and magnetic current, duality principle, constitutive equations, combined electrical and magnetic permeability, heterogeneous vector Helmholtz equation. Electromagnetic (EM) waves in an anisotropic medium: propagation of a flat wave EM in a medium with uniaxial dielectric and magnetic anisotropy, Poynting's theorem for magnetodielectric centers approximately harmonic. Boundary conditions: at the boundary between two dielectrics and the limit of the perfect electrical conductor (PEC), radiation, impedance and damping boundary conditions. EM waves in stratified media: TE and TM modes, boundary problem for the layered medium, transition matrix, reflectance and power transmission coefficients. Electrodynamic potentials: magnetic and electric vector and scalar potentials, Hertz potentials, the role of potentials in determining fields from sources, Green's function for the Helmholtz equation. Elements of the theory of electromagnetic wave scattering: scattering active cross-section (SCS) and scattering amplitude, integral representations of scattering amplitude and absorption active cross-section, selected long-wave (Born, Rayleigh and WKB approximation) and short-wave (approximation of physical optics and geometric optics) approximate methods of SCS determination.*	2.0	AEEiTK	K_W01 K_W02 K_W03 K_W06 K_W12 K_U01 K_U06 K_U12 K_K01
3.	***DATABASES*** Outline program: *The subject is served to learn about issues related to the collection, storage, processing and issuance of information in databases as well as the design and use of databases. In addition, it concerns the database environment and applications as well as security aspects of information management.*	2.0	AEEiTK	K_W07 K_W10 K_W13 K_U04 K_U06 K_U13 K_K03 K_K04
4.	***STOCHASTIC PROCESSES*** Outline program: *Definition of stochastic process based on probabilistic space. Continuous and discrete processes and their measures and characteristics. Classification of random processes. Markov chains and transition matrix properties. Homogeneous Markov chain and ergodic theorem. Sequential detection. Markov processes and processes with independent increments. Homogeneous Poisson process. Asynchronous and synchronous binary processes. Data transmission signal models Processes with queuing and loss - Erlang formula. Telecommunications traffic models. Parameters and characteristics of the mass service system. Probabilistic measures of the effectiveness of telecommunications services. The Wienner process as a statistical model of thermal noise.*	2.0	AEEiTK	K_W04 K_W07 K_U07 K_U09 K_U18 K_K01
5.	***NEURAL NETWORKS*** Outline program: *Multilayer perceptron neural networks (MLP), radial base function (RBF) networks, support vector machine networks (SVMs), recursive networks, Kohonen, PCA and ICA networks, fuint networks, learning structures and methods, examples of applications in measurement systems.*	3.0	AEEiTK	K_W01 K_W08 K_U06 K_U07 K_U09 K_U18 K_K03

No.	name of class group name of subject[5], short description (outline program)	No. of ECTS credits	discipline code	reference to field-related outcomes
content group of field-related education field-related subjects				
1.	***COMPUTER ANALYSIS OF ELECTRONIC CIRCUITS*** Outline program: *The module is used to learn about computational techniques (mathematical formulas and computer algorithms) designed to solve (simulation and analysis) electronic circuits. The presented techniques are applicable to both DC and AC circuits, analyzed in the time and frequency domains.*	3	AEEiTK	K_W01 K_W02 K_W05 K_W11 K_U03 K_U06 K_U08 K_U09 K_U10 K_U11 K_U17 K_K02 K_K03
2.	***PROGRAMMABLE LOGIC DEVICES*** Outline program: *Architektury złożonych cyfrowych układów programowalnych. Dedykowane bloki wbudowane (bloki zegarowe, pamięci, bloki DSP). Bloki funkcjonalne IP, procesory programowe i sprzętowe. Projektowanie systemów mikroprocesorowych w układach programowalnych. Systemowe narzędzia diagnostyczne, metody weryfikacji projektowanych układów.*	4.0	AEEiTK	K_W05 K_W09 K_W11 K_U08 K_U09 K_U11 K_U12 K_U14 K_U18 K_K01 K_K03
3.	***SENSOR TECHNIQUE*** Outline program: *Ultrasonic and optical sensors. Pyrometers. Thermal imaging cameras. Acoustic rangefinders. Optical rangefinders. Radar rangefinders. Sonar, Sodar, Lidar. Solutions.*	2.0	AEEiTK	K_W01 K_W02 K_U01 K_U16 K_K02
4.	***PROPAGATION OF ELECTROMAGNETIC WAVES*** Outline program: *Electrodynamic determinants of the propagation of electromagnetic waves. Analytical relationships of the field of real antennas in one-way and two-way propagation. Multi-way propagation. Drop-outs. Propagation models. Radiation field of antennas with electronic control of the position of radiation characteristics. Shaping radiation characteristics in adaptive antennas. Radiation field in antenna systems in MIMO and mMIMO systems. Modeling of EM wave propagation in the ICS-Telecom tool.*	2.0	AEEiTK	K_W01 K_W03 K_W04 K_W12 K_U01 K_U03 K_U04 K_K01 K_K02 K_K03
5.	***RADIO EQUIPMENT PROGRAMMING*** Outline program: *SDR device architecture. Introduction to GNU Radio. Overview of SDR hardware platforms and software. Familiarization with GNU Radio and UHD environments. Implementation and testing of integration of radio transmitter/receiver components on the USRP platform. Generation and reception of signals modulated on the USRP platform.*	2.0	AEEiTK	K_W03 K_W06 K_W09 K_U05 K_U07 K_U17 K_K01 K_K03 K_K04

No.	name of class group name of subject[5], short description (outline program)	No. of ECTS credits	discipline code	reference to field-related outcomes
6.	***VIRTUALIZATION IN NETWORKS AND SYSTEMS*** Outline program: *Introduction to virtualization. Overview of virtualization techniques. Hardware infrastructure that supports virtualization. Virtualization tools and platforms. Virtualization of data storage. Cloud computing. Creating cloud computing. Create, configure, and manage virtualization platforms.*	2.0	ITT	K_W03 K_W08 K_W09 K_W10 K_W12 K_U09 K_U10 K_U14 K_U16 K_U17
7.	***BASICS OF CYBERSECURITY*** Outline program: *Types of information cybersecurity services implemented on the basis of cryptographic systems: confidentiality, authentication of entities (messages, network devices), digital signature using various hashing algorithms and ciphers, message integrity. Hazard assessment through information flight. IP network security support protocols (IPsec, IKE).*	2.0	ITT	K_W09 K_W10 K_W12 K_U02 K_U04 K_K06
content group of elective subjects				
TELECOMMUNICATIONS TECHNOLOGIES				
1.	***TELETRANSMISSION SIGNAL ENCODING*** Outline program: *The issues concerning teletransmission signal encoding in radio channels. Data transmission system. Interference and errors in radio channels. Binary data transmission channel models. Forward error correction codes (FEC codes), structure of block codes, code error-detecting and code error-correcting capabilities, codes geometric structure, syndrome, code gain. Convolutional codes structure. Convolutional codes description ways. Convolutional code error-correcting capabilities. Punctured convolutional codes. Maximum likelihood decoding of convolutional codes. The Viterbi algorithm. Block, convolutional, helical and pseudo random interleaving process. Scramblers. Rationale for scramblers use. Scrambler implementation examples. Examples of data radio transmission systems. Computer simulation of binary data transmission channel models and coding channels. Measurement of FEC efficiency in radio channels.*	3.0	ITT	K_W03 K_W07 K_W12 K_U05 K_U06 K_U09 K_K01

No.	name of class group name of subject[5], short description (outline program)	No. of ECTS credits	discipline code	reference to field-related outcomes
2.	***MODULATION AND DEMODULATION*** Outline program: *Digital Amplitude Phase Shift Keying (APSK), Quadrature Modulation (QAM). Vector constellations. Multitone modulations, Orthogonal Frequency Division Multiplexing (OFDM), statistic performance – CREST/PAPR ratio, Digital Predistortion, IFFT/ FFT based OFDM modulator/demodulator. Examples of applied standards. Sampling theorem for real lowpass, bandpass and complex baseband signals. Pulse modulations (PAM, PPM, PWM). Spread Spectrum Systems: Direct Sequence, Frequency Hopping, Time Hopping and hybrid Spread Spectrum systems. Shannon channel capacity. Spreading factor and processing gain. Analog demodulators output signal to noise ratio. Optimum detection (coherent, noncoherent) and suboptimum receivers. Matched Filter. Binary and multilevel modulations error probabilities. Synchronization in communication systems – carrier phase synchronization, symbol timing recovery, frame synchronization, synchronization sequences. Barker Codes. Basic properties of transmission channel – additive noise, narrowband interferences, intermodulations, multipath propagation and Doppler effect. Channel delay profile and Doppler spectrum. Methods of the received signal quality enhancement. Channel encoding. Channel equalizers. Training sequences.*	3.0	AEEiTK	K_W01 K_W04 K_W12 K_U01 K_U02 K_U05 K_U07 K_K03
3.	***RADIOCOMMUNICATION SYSTEMS*** Outline program: *Classification of wireless systems. Denotations of radio emissions. Basic distortions of radio signal. Medium Access Control. Mobile cellular systems. Selected technical solutions in the transmitting and receiving path. HF communications and basic technical solutions. Trunking systems. VHF communications. Relay line systems.*	2.0	ITT	K_W03 K_W09 K_W10 K_W12 K_U01 K_U04 K_U05 K_K01 K_K02 K_K07
4.	***SATELLITE SYSTEMS AND NETWORKS*** Outline program: *This course covers the design and analysis of satellite communication systems and networks. It provides an introduction to satellite communication (SATCOM) systems and design, satellite link budget analysis, the SATCOM channel, modulation, coding and performance analysis of SATCOM systems and satellite networks, limitations and throughput efficiency.*	2.0	ITT	K_W03 K_W09 K_W12 K_U01 K_U02 K_U05 K_U06 K_U10 K_K03
5.	***WIRELESS LOCAL AREA NETWORKS*** Outline program: *This course is designed to give the knowledge needed to enter into or advance within the wireless networking industry. From basic RF theory and regulatory requirements to implementation of the latest wireless technologies. This course aims to provide a solid theoretical and practical understanding of Bluetooth, ZigBee and WiFi technologies. The course content includes network architectures, media access algorithms, how data is organized, protocols, security issues and improvements extending the data rate, QoS as well as the future applications of wireless networks.*	2.0	ITT	K_W03 K_W09 K_W12 K_U01 K_U04 K_U05 K_U09 K_U18 K_K01 K_K08

No.	name of class group name of subject[5], short description (outline program)	No. of ECTS credits	discipline code	reference to field-related outcomes
6.	***IP NETWORKING PROTOCOLS AND TECHNOLOGIES*** Outline program: *The Internet protocol suite – standardization rules, standards and technologies. Local Area Network protocols. The Internet Protocol version 4 (IPv4) and 6 (IPv6) characteristics. IP addressing architectures. Neighbor discovery and control protocols. IPv4 and IPv6 networks integration techniques. IP routing techniques and protocols. Transport layer protocols. Quality of service in IP-based networks. TCP/IP protocol stack in wireless and sensor networks. Network programming principles – socket-based API. Software Defined Networking and Network Function Virtualization principles.*	2.0	ITT	K_W03 K_W09 K_W12 K_U01 K_U02 K_U03 K_U05 K_U09 K_K01 K_K08
telecommunications technologies: specialized content no 1 (2 items selected from a group of 5)				
1.	***SOFTWARE DEFINED RADIO*** Outline program: *Definition of Software Defined Radio concept. Structural solutions of SDR. Digital processing in SDR. Waverorms and theirs engineering. SDR architectures: hardware, software. SDR solutions examples. SDR applications.*	2.0	AEEiTK	K_W03 K_W06 K_W12 K_U01 K_U05 K_K02 K_K03 K_K08
2.	***DATA HIDING FUNDAMENTALS*** Outline program: *A glossary of data hiding techniques will be discussed. An overview of practical applications for data hiding in multimedia, speech, radio and network protocols will be reviewed. Differentiation of the basic types of algorithms: watermarking and steganography and their basic features. The classification of data hiding methods will be presented. Basic data embedding and extraction algorithms and their properties will be discussed. Assumptions for the designed system and the selection of the method of embedding and extracting hidden data will be discussed. Perceptual models for the Human Auditory and Visual Model will be presented. The procedure of correcting the additional signal to the JND level will be discussed. Methods for the evaluation of perceptual transparency, resistance and steganoanalytical susceptibility will be discussed. Examples of software and hardware implementation of data hiding systems will be given. New methods of hiding data will be discussed - cases and scenarios of operation and copyright DRM systems.*	2.0	AEEiTK	K_W01 K_W03 K_W04 K_W07 K_W08 K_W09 K_W10 K_W12 K_W15 K_U01 K_U02 K_U04 K_U07 K_U11 K_U18 K_K01 K_K02 K_K08
3.	***LTE NETWORK APPLICATIONS*** Outline program: *The Long Term Evolution (LTE) as a fourth-generation (4G) system is the core of the cellular telephony currently used in most countries. On the other hand, with its LTE-Advance (LTE-A) and LTE-A Pro extensions, it is an introduction to the fifth-generation (5G) systems. As part of the course, the architecture of LTE networks, changes introduced by LTE-A and LTE-A Pro, used radio technologies (e.g., OFDM, SC-FDMA, MIMO, E-UTRAN), signal structure, and radio resources used in the LTE system will be presented. As part of the laboratory exercises, the basic issues in the field of physical (PHY) and medium access control (MAC) layers will be presented, based on software in Matlab.*	2.0	ITT	K_W01 K_W03 K_W04 K_W07 K_W09 K_W12 K_U01 K_U02 K_U03 K_U04 K_U05 K_K01 K_K02 K_K03 K_K08

No.	name of class group name of subject[5], short description (outline program)	No. of ECTS credits	discipline code	reference to field-related outcomes
4.	***BROADCASTING SYSTEMS*** Outline program: *Satellite broadcasting systems (Digital TV, Navigation). Broadcasting terrestrial systems (analogue and digital radio, digital TV, navigation support systems). Form a transport stream on digital TV. Discussing the stages of creating a transport stream for digital TV. Construction of a television head-end.*	2.0	AEEiTK	K_W03 K_W06 K_W12 K_U01 K_U04 K_U05 K_U09 K_K01 K_K03
5.	***OPTICAL TRANSPORT SYSTEMS*** Outline program: *Modern optical networks (based on telecommunication fiber) protect the implementation of most of the world's telecommunication traffic. This transmission medium is characterized by good parameters, including low attenuation and high throughput. This determines their widespread use in the creation of intercontinental connection networks, the country's network infrastructure, the core network in cellular systems, or the local access network for providers of the Internet and cable TV. Modern optical transport systems are increasingly based on Dense Wavelength Division Multiplexing (DWDM) technology. The DWDM is a technique for multiplexing multiple optical signals on a single fiber optic link, assigning each signal a different light wavelength (frequency). DWDM is a special case of a more general transmission technique, i.e., Wavelength Division Multiplexing (WDM). As part of the course, an introduction to the DWDM networks, physical layer, architecture and design, cybersecurity, standardization, quality of service monitoring, and management in optical transport networks will be presented. As part of the laboratory exercises, physical layer parameters, path assembly, designing optical nodes, and infrastructure of optical DWDM transport networks will be analyzed. As part of the seminar, the design and management in optical transport networks will be discussed.*	2.0	ITT	K_W03 K_W09 K_W10 K_W12 K_U05 K_U07 K_U13 K_U14 K_U16 K_K01 K_K02 K_K07
telecommunications technologies: specialized content no 2 (2 items selected from a group of 4)				
1.	***DEEP LEARNING IN APPLICATIONS*** Outline program: *As part of the introduction, information on the architecture of deep neural networks and the process of training them will be presented. Then, the convolutional neural networks (CNN) will be discussed in detail in the context of solving the classification problems, including the basic pre-trained CNN architectures used in transfer learning such as: AlexNet, Inception, Res-Net, both in digital images processing as in audio signals processing. The recurrent neural networks in the context of solving problems of sequence data pre-diction will be also discussed. The latest achievements in the field of deep learning will also be presented.*	3.0	AEEiTK	K_W08 K_W09 K_W12 K_U02 K_U05 K_U06 K_U07 K_K01 K_K04

No.	name of class group name of subject[5], short description (outline program)	No. of ECTS credits	discipline code	reference to field-related outcomes
2.	***5G NETWORK APPLICATIONS*** Outline program: *Fifth-generation (5G) systems are currently implemented by mobile operators. The evolution to 5G is sometimes called a revolution, because the standard developed by 3GPP covers not only cellular telephony, but also satellite, Wi-Fi networks, wired and optical connectivity, etc. As part of the course, 5G cellular network architecture, new radio technologies (i.a., massive-MIMO, millimeter wave, device-to-device (D2D), machine-to-machine (M2M), vehicular-to-everything (V2X) communications, radio-access, network slicing, etc.), and radio resources used in the 5G system will be presented. As part of the laboratory exercises, based on software in Matlab, the basic issues in the field of physical (PHY) and medium access control (MAC) layers, and machine-to-machine communication topics will be presented. As part of the seminar, the selected topics, the newest, innovative trends, and applications in the 5G and beyond technologies will be discussed.*	3.0	ITT	K_W01 K_W03 K_W04 K_W07 K_W09 K_W12 K_U01 K_U02 K_U03 K_U04 K_U05 K_K01 K_K02 K_K03 K_K08
3.	***METROLOGY OF ELECTROMAGNETIC FIELDS*** Outline program: *The general classification of the metrology of electromagnetic field (EM) depending on the frequency, amplitude and polarization. Metrological parameters of the EM field. EM field meters and measurement systems. Narrow- and wide-wideband signals measurements. Measurements in the frequency ranges like industrial, RF, microwave and terahertz. Measurements of electrical parameters in time and frequency domain. Measurements of the EM field as part of health protection of employees and the environment. Specificity of EM field measurements within electromagnetic compatibility. Modern metrology with the use of high-power microwave pulses.*	3.0	AEEiTK	K_W02 K_W06 K_W12 K_U05 K_U09 K_U10 K_U11 K_K03 K_K03
4.	***MODERN ANTENNAS AND ANTENNA SYSTEMS*** Outline program: *Evaluation of antenna patterns depending on the demands and applications. Antenna characteristics used in cellular communications. Modern methods of shaping the radiation characteristics in antenna systems. Smart antennas. Control algorithms in smart antennas. MIMO systems and antennas for special applications. Textronic antennas and ultra-broadband antennas. Spatially split multi-access techniques using smart antennas in mobile telephony.*	3.0	ITT	K_W01 K_W03 K_W07 K_U01 K_U02 K_U05 K_U07 K_U13 K_K02 K_K03 K_K08
MODERN ELECTRONICS ENGINEERING				
1.	***EMBEDDED ENERGY SOURCES AND POWER ELECTRONICS*** Outline program: *Chemical sources of DC electrical energy. Renewable and alternative energy sources (renewable and alternative energy sources, wind power plant, fuel cells). Advanced power electronics: AC/DC converters, AC/AC converters, DC/AC converters and DC/DC converters. Power electronics applications: motor drive, heating, connectors, stabilizers, compensators, active filters.*	3.0	AEEiTK	K_W02 K_W09 K_W12 K_U03 K_U05 K_U09 K_U11 K_U12 K_K02 K_K05

No.	name of class group name of subject[5], short description (outline program)	No. of ECTS credits	discipline code	reference to field-related outcomes
2.	***SIGNAL ANALYSIS*** Outline program: *This course describes the basic concepts of digital signal processing. Among others the following topics are described: continuous and discrete signals, theory and practice of signal acquisition, linear signals, superposition and convolution, sampling and quantization theory, Z transform, zeros and poles modeling, digital filtration theory, digital filters designing and prototyping, Fast Fourier Transform and based on FFT algorithms, correlation analysis, windowing and Power Spectrum Density estimation, adaptive algorithms and schemes as well as theory of loose compression and fundamentals of vocoders prototyping. Described topics are exhaustively explained on laboratory experiments based on simulation and prototyping tools: Matlab and Simulink environment.*	3.0	AEEiTK	K_W01 K_W04 K_W05 K_W07 K_U05 K_U06 K_U07 K_U09 K_U11 K_U14 K_K01 K_K08
3.	***ASIC DESIGN*** Outline program: *This course focuses on the design of fundamental digital systems with the use of a CMOS ASIC technology. Both the design process and main design tools are expounded. The following topics are covered: introduction to ASIC, CMOS logic gate physical design, passive elements, interconnections, general purpose methods for circuit optimization, partitioning, floor planning, pin assignment, placement, routing, design and electrical rule checking, parameter extraction, gate level simulation and IC verification, clock signal and power distribution. Standard Cells and Gate Arrays methodologies. EDA tools for front to back end chip design.*	2.0	AEEiTK	K_W03 K_W05 K_W12 K_U01 K_U02 K_U05 K_U10 K_U11 K_K01 K_K02 K_K03
4.	***SIGNAL PROCESSING IN REMOTE SENSING*** Outline program: *Sounding and echo signals models in remote sensing. Basic signal processing chains in remote sensing systems. Signal processing algorithms in remote sensing systems: digital beam-forming, Doppler processing, constant false alarm ratio, suppression of asynchronous pulse interference, non-coherent integration, echo signal detection, time side-lobe suppression. Problems of digital signal processing implementation in software defined radio systems.*	2.0	AEEiTK	K_W01 K_W04 K_U05 K_U06 K_U07 K_K01
5.	***FUNDAMENTALS OF MODULATION AND DEMODULATION*** Outline program: *Basic information about modulation and detection. Mathematical description, spectra and vector graphs of modulated signals. Analog harmonic carrier modulations (AM, DSB-SC, SSB, FM, PM). Discrete harmonic carrier modulations (ASK, FSK, PSK). Analog pulse modulations (PAM, PDM, PPM). Electronic circuits of modulators and demodulators.*	2.0	AEEiTK	K_W01 K_W03 K_W04 K_W07 K_W12 K_U01 K_U02 K_U03 K_U05 K_U06 K_U07 K_U08 K_K02 K_K03

No.	name of class group name of subject[5], short description (outline program)	No. of ECTS credits	discipline code	reference to field-related outcomes
6.	***SOFTWARE DEFINED RADIO*** Outline program: *Definition of Software Defined Radio concept. Structural solutions of SDR. Digital processing in SDR. Waveforms and theirs engineering. SDR architectures: hardware, software. SDR solutions examples. SDR applications.*	2.0	AEEiTK	K_W03 K_W06 K_W12 K_U01 K_U05 K_K02 K_K03 K_K08
modern electronics engineering: specialized content no 1 (2 items selected from a group of 5)				
1.	***SATELLITE SYSTEMS AND NETWORKS*** Outline program: *This course covers the design and analysis of satellite communication systems and networks. It provides an introduction to satellite communication (SATCOM) systems and design, satellite link budget analysis, the SATCOM channel, modulation, coding and performance analysis of SATCOM systems and satellite networks, limitations and throughput efficiency.*	2.0	ITT	K_W03 K_W09 K_W12 K_U01 K_U02 K_U05 K_U06 K_U10 K_K03
2.	***DATA HIDING FUNDAMENTALS*** Outline program: *A glossary of data hiding techniques will be discussed. An overview of practical applications for data hiding in multimedia, speech, radio and network protocols will be reviewed. Differentiation of the basic types of algorithms: watermarking and steganography and their basic features. The classification of data hiding methods will be presented. Basic data embedding and extraction algorithms and their properties will be discussed. Assumptions for the designed system and the selection of the method of embedding and extracting hidden data will be discussed. Perceptual models for the Human Auditory and Visual Model will be presented. The procedure of correcting the additional signal to the JND level will be discussed. Methods for the evaluation of perceptual transparency, resistance and steganoanalitical susceptibility will be discussed. Examples of software and hardware implementation of data hiding systems will be given. New methods of hiding data will be discussed - cases and scenarios of operation and copyright DRM systems.*	2.0	AEEiTK	K_W01 K_W03 K_W04 K_W07 K_W08 K_W09 K_W10 K_W12 K_W15 K_U01 K_U02 K_U04 K_U07 K_U11 K_U18 K_K01 K_K02 K_K08
3.	***PLANAR ANTENNAS*** Outline program: *Items concerning physics of electromagnetism that allows understanding the basic phenomena responsible for antenna radiation and parameters of the process. Methods and techniques of planar antennas geometry and antenna matching circuits design. Microwave connectors ant their physical properties. Manufacturing of planar antennas and basic parameters measurements. Dependence of manufacturing accuracy on final antenna characteristics.*	2.0	AEEiTK	K_W01 K_W02 K_U05 K_U06 K_U09 K_K03 K_K04

No.	name of class group name of subject[5], short description (outline program)	No. of ECTS credits	discipline code	reference to field-related outcomes
4.	***BROADCASTING SYSTEMS*** Outline program: *Satellite broadcasting systems (Digital TV, Navigation). Broadcasting terrestrial systems (analogue and digital radio, digital TV, navigation support systems). Form a transport stream on digital TV. Discussing the stages of creating a transport stream for digital TV. Construction of a television head-end.*	2.0	AEEiTK	K_W03 K_W06 K_W12 K_U01 K_U04 K_U05 K_U09 K_K01 K_K03
5.	***OPTICAL TRANSPORT SYSTEMS*** Outline program: *Modern optical networks (based on telecommunication fiber) protect the implementation of most of the world's telecommunication traffic. This transmission medium is characterized by good parameters, including low attenuation and high throughput. This determines their widespread use in the creation of intercontinental connection networks, the country's network infrastructure, the core network in cellular systems, or the local access network for providers of the Internet and cable TV. Modern optical transport systems are increasingly based on Dense Wavelength Division Multiplexing (DWDM) technology. The DWDM is a technique for multiplexing multiple optical signals on a single fiber optic link, assigning each signal a different light wavelength (frequency). DWDM is a special case of a more general transmission technique, i.e., Wavelength Division Multiplexing (WDM). As part of the course, an introduction to the DWDM networks, physical layer, architecture and design, cybersecurity, standardization, quality of service monitoring, and management in optical transport networks will be presented. As part of the laboratory exercises, physical layer parameters, path assembly, designing optical nodes, and infrastructure of optical DWDM transport networks will be analyzed. As part of the seminar, the design and management in optical transport networks will be discussed.*	2.0	ITT	K_W03 K_W09 K_W10 K_W12 K_U05 K_U07 K_U13 K_U14 K_U16 K_K01 K_K02 K_K07
modern electronics engineering: specialized content no 2 (2 items selected from a group of 4)				
1.	***DEEP LEARNING IN APPLICATIONS*** Outline program: *As part of the introduction, information on the architecture of deep neural networks and the process of training them will be presented. Then, the convolutional neural networks (CNN) will be discussed in detail in the context of solving the classification problems, including the basic pre-trained CNN architectures used in transfer learning such as: AlexNet, Inception, Res-Net, both in digital images processing as in audio signals processing. The recurrent neural networks in the context of solving problems of sequence data pre-diction will be also discussed. The latest achievements in the field of deep learning will also be presented.*	3.0	AEEiTK	K_W08 K_W09 K_W12 K_U02 K_U05 K_U06 K_U07 K_K01 K_K04
2.	***FINITE ELEMENT METHOD*** Outline program: *Fundamentals of Finite Element Method applications in electromagnetics. Basic FEM concepts: discretization and approximate solutions. 2D and 3D linear and higher order elements, mesh generation, mesh adaptation and refinement. Detailed discussion of numerical integration for higher order elements. Software tools.*	3.0	AEEiTK	K_W01 K_W07 K_U05 K_U06 K_U07 K_K01

No.	name of class group name of subject[5], short description (outline program)	No. of ECTS credits	discipline code	reference to field-related outcomes
3.	***METROLOGY OF ELECTROMAGNETIC FIELDS*** Outline program: *The general classification of the metrology of electromagnetic field (EM) depending on the frequency, amplitude and polarization. Metrological parameters of the EM field. EM field meters and measurement systems. Narrow- and wide-wideband signals measurements. Measurements in the frequency ranges like industrial, RF, microwave and terahertz. Measurements of electrical parameters in time and frequency domain. Measurements of the EM field as part of health protection of employees and the environment. Specificity of EM field measurements within electromagnetic compatibility. Modern metrology with the use of high-power microwave pulses.*	3.0	AEEiTK	K_W02 K_W06 K_W12 K_U05 K_U09 K_U10 K_U11 K_K03 K_K03
4.	***OPTIMAL FILTRATION*** Outline program: *State-space system models. Linear and non-linear, continuous and discrete system models. Discretization of continuous system models. Optimal filtration, prediction and smoothing. Linear Kalman filter. Linearized, extended and unscented Kalman filters. Chosen modifications of Kalman filters. Decentralized optimal filtration. Paticle filters. Examples of use of optimal filtration algorithms..*	3.0	AEEiTK	K_W01 K_W02 K_W03 K_U01 K_U03 K_U05 K_U09 K_K01 K_K02
thesis				
1.	***PRE-GRADUATE SEMINARS*** Outline program: *Rules and procedures for choosing the subject of the diploma thesis, the course of the diploma process, presentations of the subject of diploma theses, the process of selecting the subject of diploma theses, promoters and consultants, requirements for diploma theses.*	1.0	AEEiTK / ITT	K_W14 K_U01 K_K04
2.	***DIPLOMA SEMINARS*** Outline program: *Principles, procedures and the course of the diploma process, the rules for writing diploma theses and the basic requirements related to them, issues related to copyright and their respect, development of schedules, individual presentations of partial work solutions in accordance with subsequent points of tasks, assessment of the current progress of the diploma thesis, consultations and substantive assistance.*	4.0	AEEiTK / ITT	K_W09 K_W14 K_U01 K_U03 K_U04 K_K06 K_K08
3.	***DIPLOMA THESIS*** Outline program: *Developing individual points of the diploma task in accordance with the schedule, making a final work note, obtaining an opinion and review of the work, preparing a computer presentation for the defence of the diploma thesis.*	20.0	AEEiTK / ITT	K_W14 K_U01 K_U09 K_U13 K_K01 K_K04 K_K06 K_K07 K_K08

apprenticeship			
APPRENTICESHIP Outline program: *Familiarization with the OHS and safety regulations in force in the plant and the company's work regulations, the structure of the enterprise, documentation regulating the technical, technological and operational process. Participation in the implementation of selected stages of the technical process, participation in the measurement of parameters of devices and electronic components. Familiarization with the methods of achieving the required reliability and quality of production and with the solutions of measurement technology. Acquaintance with the logistics activities of the plant (storage, supply and activities of technical services).*	2.0	AEEiTK / ITT	K_W11 K_W12 K_W13 K_W14 K_W15 K_U02 K_U05 K_U15 K_U16 K_U19 K_U20 K_K01 K_K02 K_K05
total	90		

METHODS OF VERIFYING AND ASSESSING THE LEARNING OUTCOMES[6] ACHIEVED BY THE STUDENT DURING THE WHOLE EDUCATIONAL CYCLE

Verification of the assumed learning outcomes achieved by the student takes place in many stages – at the level of the subjects (classes) pursued, at the level of the project, apprenticeship, as well as the diploma thesis and diploma exam.

The learning outcomes achieved by the student in the field of general, primary, field-related and specialist education are subject to verification. The training takes place within a framework of a group nature, requiring the direct participation of academic teachers and students (including exercises, laboratory activities, seminars and projects) and of an individual nature in the form of tasks, works and projects carried out by a student without the participation of an academic teacher. Verification of the assumed learning outcomes takes place in the form of: exams (oral and written), graded credits, generalized credits, current answers to control questions, colloquia and tests, individual studies and projects.

Verification of learning outcomes in the field of social competences takes place during exercises, laboratory, seminar and project classes as well as by assessing the student's activities and attitudes during the apprenticeship.

The assessment of the assumed learning outcomes achieved by the student consists in the assessment of achieving their level by the academic teacher. In the field of study "electronics and telecommunications" it is recommended to apply the following level of achievement of the assumed learning outcomes when assessing the student:

a very good grade	is given to a student who has achieved the assumed learning outcomes at the level of 91-100%,
a good plus grade	is given to a student who has achieved the assumed learning outcomes at the level of 81-90%,
a good grade	is given to a student who has achieved the assumed learning outcomes at the level of 71-80%,
a sufficient plus grade	is given to a student who has achieved the assumed learning outcomes at the level of 61-70%,
a sufficient grade	is given to a student who has achieved the assumed learning outcomes at the level of 51-60%,
an insufficient grade	is given to a student who has achieved the assumed learning outcomes at a level equal to or lower than 50%,
a generalized grade zal.	receives a student who has achieved the assumed learning outcomes at a level higher than 50%.
a generalized grade nzal.	is given to a student who has achieved the assumed learning outcomes at a level equal to or lower than 50%.

[6] *general description - details in the information sheets of the items*

PLANS OF STUDIES

Appendix 1: Plan of studies for specialization **telecommunications technologies**
Appendix 2: Plan of studies for specialization **modern electronics engineering**

Military University of Technology

PLAN OF FULL-TIME AND SECOND CYCLE MASTER STUDIES OF GENERAL ACADEMIC PROFILE

SCIENTIFIC DISCIPLINE (LEADING): automatic control, electronics, electrical engineering and space techno

FIELD OF STUDY: electronics and telecommunications

SPECIALIZATION PROFILED BY ELECTIVE SUBJECTS: **telecommunications technologies**

effective from academic year 2023/2024 (first edition - spring in 2024)

	Groups of classes / subjects	hours / ECTS totally		including hours:					hours / assessment / ECTS credits in semester: I		II		III		organizational unit of administration responsible for the subject	notes
		hours	ECTS	lectures	pract. classes	lab.	project	semin.	hours	ECTS	hours	ECTS	hours	ECTS		
	A. Content group of general education	**168**	**11.5**	**64**	**72**	**16**		**16**	**138**	**8.5**	**30**	**3.0**				
1	occupational health and safety	4		4					4 +						ZHiBP	
2	entrepreneursing and management	30	2.0	16	14				30 +	2					WLO	
3	teamwork tools	30	2.0	8		16		6	30 +	2					WEL / ISŁ	
4	law issues in electronics and telecommunication	44	2.5	20	14			10	44 +	2.5					WEL / ISŁ	
5	foreign language	30	2.0		30				30 +	2					SJO	
6	team leadership	30	3.0	16	14						30 +	3			WLO	
	B. Content group of basic education	**194**	**12.5**	**80**	**64**	**40**		**10**	**90**	**5.5**	**104**	**7.0**				
1	numerical and optimization methods	60	3.5	24	24	12			60 +	3.5					WEL / IRE	
2	theory of electromagnetic field	30	2.0	12	16			2	30 +	2					WEL / IRE	
3	databases	30	2.0	14		8		8			30 +	2			WEL / ISE	
4	stochastic processes	30	2.0	16	8	6					30 +	2			WEL / ISŁ	
5	neural networks	44	3.0	14	16	14					44 X	3			WEL / ISE	
	C. Content group of field-related education	**224**	**17.0**	**86**	**24**	**96**	**2**	**16**	**104**	**9.0**	**90**	**6.0**	**30**	**2**		
1	computer analysis of electronic circuits	30	3.0	12	6	12			30 X	3					WEL / ISE	
2	programmable logic devices	44	4.0	18		24		2	44 X	4					WEL / ISŁ	
3	sensor technique	30	2.0	16	8			6	30 +	2					WEL / IRE	
4	propagation of electromagnetic waves	30	2.0	10	10	8		2			30 +	2			WEL / ISŁ	
5	virtualization in networks and systems	30	2.0	12		16		2			30 +	2			WEL / ISŁ	
6	radio equipment programming	30	2.0	6		24					30 +	2			WEL / ISŁ	
7	basics of cybersecurity	30	2.0	12		12	2	4					30 +	2	WEL/ISŁ	
	D. Content group of elective subjects	**194**	**14.0**	**94**	**28**	**68**		**4**	**74**	**6.0**	**120**	**8.0**				
1	modulation and demodulation	44	3.0	20	8	16			44 X	3					WEL / ISŁ	
2	teletransmission signal encoding	30	3.0	14		12		4	30 +	3					WEL / ISŁ	
3	radiocommunication systems	30	2.0	14	8	8					30 X	2			WEL / ISŁ	
4	satellite systems and networks	30	2.0	16	6	8					30 +	2			WEL / ISŁ	
5	wireless local area networks	30	2.0	16	6	8					30 +	2			WEL / ISŁ	
6	IP networking protocols and technologies	30	2.0	14		16					30 +	2			WEL / ISŁ	
	2 items selected from a group of 5	**60**	**4.0**	**30**	**6**	**20**		**4**			**60**	**4.0**				
1	software defined radio	30	2.0	14	8	8					30 +	2			WEL / ISŁ	
2	data hiding fundamentals	30	2.0	16	6	8					30 +	2			WEL / ISŁ	
3	LTE network applications	30	2.0	14		16					30 +	2			WEL / ISŁ	
4	optical transport systems	30	2.0	12		12		6			30 +	2			WEL / ISŁ	
5	broadcasting systems	30	2.0	14		12		4			30 +	2			WEL / ISŁ	
	2 items selected from a group of 4	**60**	**6.0**	**28**		**32**							**60**	**6.0**		
1	deep learning in applications	30	3.0	14		16							30 +	3	WEL / ISŁ	
2	5G network aplications	30	3.0	14		16							30 +	3	WEL / ISŁ	
3	modern antennas and antenna systems	30	3.0	20	2	8							30 +	3	WEL / ISŁ	
4	metrology of electromagnetic fields	30	3.0	20	2	8							30 +	3	WEL / ISŁ	
	E. Diploma thesis	**24**	**23.0**					**24**	**4**	**1.0**			**20**	**22.0**		
1	pre-graduate seminars	4	1.0					4	4 +	1					WEL	
2	diploma seminars	20	2.0					20					20 +	2	WEL	
3	diploma thesis		20.0										X	20	WEL	
	F. Apprenticeship	**weeks**	**2.0**	**lead time**								**2**				
1	apprenticeship	≥ 2	2.0	in the period of July-September - after the Ist semester							+	2				
	hours / ECTS credits totally	**924.0**	**90.0**	**382**	**194**	**272**	**2**	**74**	**410**	**30.0**	**404**	**30.0**	**110**	**30.0**		
	permissible deficit of ECTS credits								**14**		**0**					
	additional notes															
	types and number of assessments in semester							**number of exams X**	**3**		**2**		**1**		**6**	
								number of graded credits +	**10**		**12**		**4**		**26**	

Curriculum adopted by the Senate of Military University of Technology on the 22nd of June, 2023

Choosing a specialization profiled by ellective subjects in the first semester of studies

Military University of Technology

PLAN OF FULL-TIME AND SECOND CYCLE MASTER STUDIES OF GENERAL ACADEMIC PROFILE

SCIENTIFIC DISCIPLINE (LEADING): automatic control, electronics, electrical engineering and space techno

FIELD OF STUDY: electronics and telecommunications

SPECIALIZATION PROFILED BY ELECTIVE SUBJECTS: **modern electronics engineering**

effective from academic year 2023/2024 (first edition - spring in 2024)

Groups of classes / subjects		hours / ECTS totally		including hours:					hours / assessment / ECTS credits in semester: I			II		III		organizational unit of administration responsible for the subject	notes
		hours	ECTS	lectures	pract. classes	lab.	project	semin.	hours	ECTS	hours	ECTS	hours	ECTS			
A. Content group of general education		**168**	**11.5**	**64**	**72**	**16**		**16**	**138**	**8.5**	**30**	**3.0**					
1	occupational health and safety	4		4					4 +							ZHiBP	
2	entrepreneursing and management	30	2.0	16	14				30 +	2						WLO	
3	teamwork tools	30	2.0	8		16		6	30 +	2						WEL / ISŁ	
4	law issues in electronics and telecommunication	44	2.5	20	14			10	44 +	2.5						WEL / ISŁ	
5	foreign language	30	2.0		30				30 +	2						SJO	
6	team leadership	30	3.0	16	14						30 +	3				WLO	
B. Content group of basic education		**194**	**12.5**	**80**	**64**	**40**		**10**	**90**	**5.5**	**104**	**7.0**					
1	numerical and optimization methods	60	3.5	24	24	12			60 +	3.5						WEL / IRE	
2	theory of electromagnetic field	30	2.0	12	16			2	30 +	2						WEL / IRE	
3	databases	30	2.0	14		8		8			30 +	2				WEL / ISE	
4	stochastic processes	30	2.0	16	8	6					30 +	2				WEL / ISŁ	
5	neural networks	44	3.0	14	16	14					44 X	3				WEL / ISE	
C. Content group of field-related education		**224**	**17.0**	**86**	**24**	**96**	**2**	**16**	**104**	**9.0**	**90**	**6.0**	**30**	**2**			
1	computer analysis of electronic circuits	30	3.0	12	6	12			30 X	3						WEL / ISE	
2	programmable logic devices	44	4.0	18		24		2	44 X	4						WEL / ISŁ	
3	sensor technique	30	2.0	16	8			6	30 +	2						WEL / IRE	
4	propagation of electromagnetic waves	30	2.0	10	10	8		2			30 +	2				WEL / ISŁ	
5	radio equipment programming	30	2.0	6		24					30 +	2				WEL / ISŁ	
6	virtualization in networks and systems	30	2.0	12		16		2			30 +	2				WEL / ISŁ	
7	basics of cybersecurity	30	2.0	12		12	2	4					30 +	2		WEL/ISŁ	
D. Content group of elective subjects		**180**	**14.0**	**86**	**14**	**68**	**8**	**4**	**60**	**6.0**	**120**	**8.0**					
1	embedded energy sources and power electronics	30	3.0	14		16			30 +	3						WEL / ISE	
2	signal analysis	30	3.0	14		8	8		30 X	3						WEL / ISŁ	
3	ASIC design	30	2.0	14		16					30 X	2				WEL / ISŁ	
4	signal processing in remote sensing	30	2.0	14		12		4			30 +	2				WEL / IRE	
5	fundamentals of modulation and demodulation	30	2.0	16	6	8					30 +	2				WEL / IRE	
6	software defined radio	30	2.0	14	8	8					30 +	2				WEL / ISŁ	
2 items selected from a group of 5		**60**	**4.0**	**32**	**5**	**20**		**3**			**60**	**4.0**					
1	satellite systems and networks	30	2.0	16	6	8					30 +	2				WEL / ISŁ	
2	data hiding fundamentals	30	2.0	16	6	8					30 +	2				WEL / ISŁ	
3	planar antennas	30	2.0	16		10		4			30 +	2				WEL / IRE	
4	optical transport systems	30	2.0	12		12		6			30 +	2				WEL / ISŁ	
5	broadcasting systems	30	2.0	14		12		4			30 +	2				WEL / ISŁ	
2 items selected from a group of 4		**60**	**6.0**	**28**		**32**							**60**	**6.0**			
1	deep learning in applications	30	3.0	14		16							30 +	3		WEL / ISŁ	
2	finite element method	30	3.0	14		16							30 +	3		WEL / ISE	
3	optimal filtration	30	3.0	18	6	6							30 +	3		WEL / IRE	
4	metrology of electromagnetic fields	30	3.0	20	2	8							30 +	3		WEL / ISŁ	
E. Diploma thesis		**24**	**23.0**					**24**	**4**	**1.0**			**20**	**22.0**			
1	pre-graduate seminars	4	1.0					4	4 +	1						WEL	
2	diploma seminars	20	2.0					20					20 +	2		WEL	
3	diploma thesis		20.0										X	20		WEL	
F. Apprenticeship		**weeks**	**2.0**	**lead time**								**2**					
1	apprenticeship	≥ 2	2.0	in the period of July-September - after the Ist semester							+	2					
hours / ECTS credits totally		**910.0**	**90.0**	**376**	**179**	**272**	**10**	**73**	**396**	**30.0**	**404**	**30.0**	**110**	**30.0**			
permissible deficit of ECTS credits									**14**		**O**						
additional notes																	
types and number of assessments in semester									**number of exams X**		**3**		**2**		**1**	**6**	
									number of graded credits +		**10**		**12**		**4**	**26**	

Curriculum adopted by the Senate of Military University of Technology on the 22nd of June, 2023

Choosing a specialization profiled by ellective subjects in the first semester of studies

Wojskowa Akademia Techniczna

Wydział Elektroniki

Opinia
Wydziałowej Rady ds. Kształcenia
Wydziału Elektroniki Wojskowej Akademii Technicznej
im. Jarosława Dąbrowskiego

Nr 79/RDK/WEL/2023 z dnia 15 czerwca 2023 r.

o programie stacjonarnych studiów II stopnia
na kierunku „elektronika i telekomunikacja" w jez. angielskim
dla naborów rozpoczynających się od r.a. 2023/2024

Na podstawie § 92 ust. 1 pkt 1 Statutu WAT, stanowiącego załącznik do uchwały Senatu WAT nr 16/WAT/2019 z dnia 25 kwietnia 2019 r. w sprawie uchwalenia Statutu WAT (tj. obwieszczenie Rektora WAT nr 1/WAT/2021 z dnia 21 października 2021 r.), wyraża się następującą opinię:

Wydziałowa Rada ds. Kształcenia Wydziału Elektroniki Wojskowej Akademii Technicznej im. Jarosława Dąbrowskiego wyraża pozytywną opinię o programie stacjonarnych studiów II stopnia na kierunku „elektronika i telekomunikacja" w jęz. angielskim dla naborów rozpoczynających się od r.a. 2023/2024, stanowiącym Załącznik do niniejszej opinii.

Przewodniczący Rady ds. Kształcenia

Jacek Jakubowski

dr hab. inż. Jacek JAKUBOWSKI, prof. WAT

Sporządził Robert Berczyński – Sekretarz Rady ds. Kształcenia

ARKUSZ UZGODNIEŃ
do projektu programu studiów

Jednostka organizacyjna: **Wydział Elektroniki**

Kierunek studiów: **elektronika i telekomunikacja**

Poziom studiów: **studia II stopnia**

Forma studiów: **stacjonarne**

Profil studiów: **ogólnoakademicki**

Studia w języku: **angielskim**

Rok akademicki rozpoczęcia kształcenia: **2023/2024**

Nazwa komórki (jednostki) organizacyjnej, z którą projekt był uzgadniany	Stanowisko instytucji opiniującej (*uzgodniono /nie uzgodniono*) *Uwagi*	Stopień, imię, nazwisko i podpis osoby opiniującej
Rada Studentów WEL WAT	uzgodniono	Z upoważnienia przewodniczącego RS WEL Szymon Rojewski