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I INFORMACIJSKIH TEHNOLOGIJA **OSIJEK**

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FOREWORD

The Faculty of Electrical Engineering, Computer Science and Information Technology Osijek commemorates its 40th anniversary this year. The Faculty of Electrical Engineering, Computer Science and Information Technology Osijek is a modern faculty that has constantly been developing in all areas of its expertise. The educational process consists of three levels with study programmes being continually upgraded and harmonised with recent scientific discoveries and economy needs.

More than 1,900 students are currently enrolled in undergraduate university study programmes in Electrical and Computer Engineering, professional study programmes, graduate university study programmes in Electrical Engineering (five elective modules) and Computer Engineering (four elective modules) and graduate university study programme in Automotive Computing and Communications which has recently been launched. At the postgraduate level, students are educated in postgraduate doctoral study programmes in Electrical Engineering and Computer Science as well as specialist study programmes.

The Faculty's research groups have participated in numerous domestic and European projects as either heads or associates. Cooperation with the economy, encouragement of entrepreneurship and transfer of knowledge and technologies are fundamental indicators of the Faculty's development. The Faculty is the regional leader in the field of electrical engineering, computer science and information and communications technologies, and is strategically aimed at advancing its visibility and competitiveness in science and research, professional projects, students' education, close cooperation with the economy and local community.

Dear students,

you are reading a brochure on the postgraduate doctoral study programme in Electrical Engineering and Computer Science carried out at the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek. This guide will provide you with an abundance of useful and valuable information to make your study and research successful. The postgraduate doctoral study programme will broaden your understandings and knowledge and present you with new challenges. I believe that this brochure will efficiently guide and help you on this journey of postgraduate studies.

Dean

Dr. Drago Žagar, Full Professor

1. INTRODUCTION

1.1. Rationale for initiating the postgraduate doctoral study programme

The Faculty of Electrical Engineering, Computer Science and Information Technology Osijek was founded and developed due to the need of stronger social and economic development of the Slavonia and Baranja region. In the last 39 years, the Faculty has developed into a respectable institution with respect to material and staff resources, which is the foundation for implementing study programmes at the highest level. During that period, the number of classrooms and computer classrooms has been increased and laboratories have been supplied with state-of-the-art teaching and research equipment thus providing research work of high quality to both teachers and students. In order to include all areas scientists conduct research and educate students in, the Faculty of Electrical Engineering in Osijek (ETF) changed its name into the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek (FERIT) in May 2016.

The main rationale for initiating the postgraduate doctoral study programme is as follows:

a) Correlation between research and teaching activities contributes to the development of science in accordance with the needs and requirements of the social community and is of vital importance for the development of economy. The postgraduate doctoral study programme in Electrical Engineering and Computer Science with the modules in Power Engineering, Communications and Informatics and Computer Science provides education of scientific staff in strategic fields important for the development of the country. The optimal usage and management of existing and construction of new power plants with the purpose of more effective energy use on the one hand, and a quick development of computer science as well as information and communication technologies and their implementation into the economic infrastructure on the other hand, require corresponding scientific research. The purpose of the postgraduate doctoral study programme at the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek is to provide support to development projects both for big companies and companies which do not have adequate staff and material resources for conducting demanding research and implementing new technologies. Scientific training of teaching and research assistants is of particular importance for further development of the Faculty for the purpose of teaching quality improvement and the education of a larger number of students at the bachelor and master level programmes in electrical and computer engineering, which is one of the national strategic objectives.

b) The postgraduate doctoral study programme is based on competitive scientific research within the framework of scientific-research projects, technological and development projects which are conducted in cooperation with other scientific-research institutions in the country and abroad, as well as with the economy. Researches in the field of renewable energy sources, advanced power networks, power systems reliability, energy market and efficient utilisation of energy are of great importance. There are intensive researches in the field of communications and informatics connected with radiocommunication systems, communication protocols, multimedia systems, broadband networks as well as design of integrated circuits to be applied in communication. In the field of computer science,

researches are conducted in the fields of intelligent production systems, robot vision, embedded systems, data processing, parallel computer architecture, visualisation of medical data and computer graphics. These scientific researches ensure competences required for the development of the knowledge-based society in important economic fields and society in general, and these are power engineering, communications and informatics and computer science.

c) The goals of the postgraduate doctoral study programme in Electrical Engineering and Computer Science are to develop skills required for successful leading of complex projects applying scientific methods and information technologies with the emphasis on the application in power engineering, communication systems and computer engineering. The study must educate scientists and researchers capable to adjust to constant changes in different fields of electrical engineering, especially communications and information technologies and computer engineering where changes are especially intense. One of important work components of the postgraduate doctoral study programme is to engage doctoral students in research and scientific projects conducted by the Faculty, but also in projects of the Ministry of Science, Education and Sports, Croatian Science Foundation and other state institutions (Croatian Agency for SMEs, Innovations and Investments HAMAG-BICRO, HAKOM – Croatian Regulatory Authority for Network Industries, etc.), European Union, big companies (HEP – Croatian National Grid Company, Siemens, THT – Croatian Telecom) and in development projects conducted by the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek for the purpose of meeting requirements of other economic subjects.

d) This postgraduate scientific study has been developed:

- on the model of other similar study programmes in the country and other worldwide universities;
- on the basis of a years-long experience of the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek in the undergraduate, graduate and postgraduate education;
- on the basis of scientific researches in research projects.

In addition, experience of other related faculties and their study programmes have been used considering modern aspirations in the scientific fields they cover and specific qualities and demands of science in the wider region and Croatia in whole. In terms of study organisation and scientific field, the study can be compared to the doctoral studies in Croatia and following worldwide universities - Vienna University of Technology (Austria), University of Ljubljana (Slovenia), Slovak University of Technology Bratislava (Slovakia), etc. It should also be emphasised that the postgraduate doctoral study programme is harmonised with the recommendations of the National Council for Higher Education and Rectors' Conference. Additionally, this study is in compliance with the Bologna Declaration, Salzburg Declaration and Berlin Declaration as well as recommendations of the Council of Europe related to higher education.

Similarity with other equivalent studies in Europe is manifested in the study duration of 3 years, requirement for a previously completed graduate study programme, a high grade point average earned during the undergraduate and graduate study programme which is one of the admission requirements. Furthermore, as well as on other European postgraduate doctoral study programmes, this study provides students with the possibility to create their own plans of study according to their individual scientific interests but also according to requirements of their institutions and companies. According

to the structure of obligations, most study programmes specify a particular number of courses which have to be attended and completed by students. Consequently, the requirement of 48 ECTS credits obtained upon successful completion of the courses at the postgraduate doctoral study programme at the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek fits into that structure. Like on other foreign study programmes, special attention is given to:

- students' independent scientific-research work;
- well organised, coherent and careful supervisor guidance;
- publishing research results in national and international journals, public presentation of research results at conferences and presentation of seminar papers at and outside the Faculty.

Quality control of a student's scientific work is ensured by tutorial work with a supervisor as well as evaluation carried out by the Doctoral Committee, Dissertation Topic Approval Committee, Doctoral Dissertation Evaluation Committee and Doctoral Dissertation Defence Committee and through a procedure of report verification done by the committees at the Faculty Council.

1.2. Prior experience in implementing postgraduate study programmes

At the beginning of 1997, the Senate of Josip Juraj Strossmayer University of Osijek approved the postgraduate master study programme entitled *Management of Power Engineering and Industrial Plants* at the Faculty of Electrical Engineering in Osijek (today known as the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek). The development of staff and material resources was facilitated by the University Senate decision, adopted on 28 January 2002, which has authorised the Faculty to grant doctoral degrees in the scientific area of Technical Sciences, scientific field of Electrical Engineering. With the purpose of modernising the postgraduate study programmes, the Faculty prepared and the University Senate approved the postgraduate master and doctoral study programmes in Electrical Engineering on 12 March 2004. The postgraduate study programme in Electrical Engineering (branches Power Engineering and Communications and Informatics) was granted by the University Senate in February 2006. The study programme is completely harmonised with the Bologna Declaration and has been carried out since the academic year 2006/2007. At the session held on 28 September 2016, the University Senate adopted the proposed changes to the study programme, which has been carried out since the academic year 2016/2017. The study programme has been adapted and a module of Computer Science has been added thus resulting in changing the programme's name into the Postgraduate doctoral study programme in Electrical Engineering and Computer Science in 2017. The Ministry of Science and Education confirmed the study programme's name change on 10 May 2017.

1.3. Promotion of student mobility

A doctoral student can obtain a specific number of ECTS credits by enrolment and completion of courses at some other related faculties in the country and abroad. Recognition of credits will be regulated through a partnership agreement between the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek and the university/faculty at which the student has

chosen the courses. The supervisor helps the student with the choice of an institution and courses which shall later be approved by the Doctoral Committee. Coordination and agreement of particular arrangements will be conducted by ECTS coordinators of partnership institutions. Both Master degree holders in Electrical Engineering, Computer Science and Master degree holders in other related fields are given the possibility to enrol in the postgraduate doctoral study programme, which makes it evident that the Faculty supports student mobility. Based on a special contract between the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek and an international higher education institution, obtaining a doctoral degree by defending one doctoral dissertation at both institutions and a joint supervision of the doctoral student is possible.

1.4. Possibility of study involvement in the joint programme with foreign universities

The postgraduate doctoral study programme in Electrical Engineering and Computer Science is organised in a way to enable the student to create one's own plan of study under tutorial supervision. The choice of courses to be passed is free and the number of courses is flexible. A study organised in this way enables the involvement in the joint programme with foreign universities either according to the modules (Electrical Engineering, Communications and Informatics and Computer Science) or in the whole.

2. Study description

2.1. Admission requirements

Candidates are admitted to the postgraduate doctoral study programme pursuant to the selection procedure rank and a vacancy announced by the Faculty Council. The vacancy is announced at least six months prior to the beginning of classes and published in media and on the Faculty website.

The vacancy announcement for the admission to the postgraduate doctoral study programme includes the following:

- name of the postgraduate doctoral study programme and the study provider;
- admission requirements;
- admission quota;
- fee;
- list of documents required for the application;
- deadline for submitting applications;
- selection criteria;
- deadlines for the enrolment into the study programme.

Candidates who graduated from the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek with a grade point average (GPA) on an undergraduate and a graduate study level of at least 3.8 are eligible to enrol in the postgraduate doctoral study programme. Such candidates graduated from the Faculty and hold the following degrees:

- Master of Electrical Engineering;
- Master of Computer Engineering;

- Master of Automotive Computing and Communications.

The postgraduate doctoral study programme can also be enrolled by the following students:

- candidates who obtained Master's degrees in Electrical or Computer Engineering at other higher education institutions;
- candidates holding Master's degrees in related technical or natural sciences fields;
- candidates who completed four-year university pre-Bologna study programmes in Electrical or Computer Engineering at one of Croatian higher education institutions prior to 2005;
- candidates who completed graduate university study programmes in Electrical or Computer Engineering at foreign universities after undergoing a process of recognition of academic diplomas;

and possible differential exams from the undergraduate and/or graduate study programmes determined by the Faculty Council upon the proposal made by the Doctoral Committee. A prerequisite to enrol in the postgraduate doctoral study programme is a cumulative undergraduate and graduate or four-year pre-Bologna study level GPA of at least 3.8.

Pursuant to the proposal of the Doctoral Committee, the Faculty Council can make an exception and approve for a candidate, whose GPA is lower than 3.8, but not lower than 3.0, to enrol in the postgraduate doctoral study programme based on published papers and other scientific and professional research results done in the last five years prior to an admission vacancy announcement.

Furthermore, the postgraduate doctoral study programme can be enrolled by

- candidates holding a Master of Science degree with a specialisation in Electrical or Computer Engineering;
- candidates holding a Master of Science degree in related technical or natural sciences fields;

who completed their studies pursuant to the Higher Education Institutions Act (Official Gazette no. 59 adopted on 17 July 1996) or pursuant to acts on Higher Education which were effective in that period as well as candidates holding a Master of Science degree in Electrical or Computer Engineering or a degree in related technical and natural sciences who graduated from foreign universities after undergoing the process of recognition of academic diplomas.

For candidates holding a Master's of Science degree, pursuant to the proposal of the Doctoral Committee, the Faculty Council can list differential exams in case a candidate wants to enrol in a module different from a scientific field he/she obtained a degree in.

A ranking list of candidates is based on a GPA earned at undergraduate and graduate study programmes, four-year university pre-Bologna study programmes or postgraduate university master study programmes, published papers and other scientific and professional research results done in the last five years prior to a postgraduate doctoral study programme admission vacancy announcement. An interview is a mandatory part of the selection procedure.

Candidates who are not satisfied with selection procedure results can file a written elaborative complaint to the Student Administration Office within 15 days of the ranking list results. The

complaint will be considered by the Doctoral Committee who will send a disclosure to a candidate within 15 days of the filing a complaint deadline.

A decision on admitting a candidate to the postgraduate doctoral study programme is made by the Faculty Council, who appoints a study advisor, elected in scientific-educational or scientific titles and employed by the Faculty, to each doctoral student.

2.2. Criteria and selection procedure

The selection of candidates to be admitted to the postgraduate doctoral study programme is based on a cumulative grade point average earned at undergraduate and graduate study programmes and four-year university pre-Bologna study programmes and if there are more candidates than vacant postgraduate doctoral study programme places, published scientific and expert papers, submitted and accepted patents and participation in expert projects will be taken into consideration. Considering all submitted materials (including the recommendation letters by university Professor s), pursuant to the report done by the Doctoral Committee, the Faculty Council makes the final admission decision.

2.3. Competencies students would achieve upon completion of the postgraduate doctoral study programme

Upon completion of the postgraduate doctoral study programme in Electrical Engineering and Computer Science at the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek, students will be able to:

1. demonstrate systematic understanding of the field and a high level of specific knowledge in one's research field;
2. recognise and define research problems and independently conduct research by applying appropriate scientific methods;
3. develop and evaluate new and complex research ideas;
4. broadening knowledge and developing theories, methods, procedures, models and devices, contribute to a total knowledge corpus;
5. present one's research results by publishing scientific papers in national and international publications and publically present research results at internationally recognised conferences;
6. cooperate with peers in one's respective field and interdisciplinary;
7. solve complex social and industry problems as well as propose and lead research projects;
8. transfer knowledge to the academic and a wider social community;
9. apply ethical principles in research and take responsibility for both social usefulness and consequences of research results.

2.4. Module Power Engineering

The postgraduate doctoral study programme in Power Engineering extends knowledge relative to conventional and distributed energy generation and production, advanced power networks and systems, efficient usage and management of electrical energy as well as energy market previously acquired at the graduate study programme in Electrical Engineering. Furthermore, the study

programme is aimed at providing a comprehensive study of physical processes and a theoretical background with respect to the aforementioned issues, as well as scientific methods used for development, construction, management and maintenance planning of the electric power system.

2.5. Module Communications and Informatics

The postgraduate doctoral study programme in Communications and Informatics broadens the prior knowledge of communication network technologies, wireless communication systems, integrated circuits design, analysis and application of modulation processes, advanced methods of image and video processing, software support in television, antenna systems, broadband multimedia services, advanced communication systems and cyber security. Students gain theoretical and scientific knowledge covering the fields of analysis, optimisation, planning and design of communications and information systems, radiocommunications systems, multimedia systems and intelligent and broadband integrated services digital networks.

2.6. Module Computer Science

The postgraduate doctoral study programme in Computer Science extends and deepens knowledge of the algorithmic approach to solving problems, current approaches to software engineering, methods of analysis, synthesis, foundations of computer systems and data analysis systems embedded in all areas of human activity as well as distributed and expert systems, software solution systems and application software support. Students acquire theoretical background and knowledge of scientific methods in the fields of analysis, optimisation, planning and design of current computer systems applicable in the industry and business environments, modern computer architectures and their software support.

Specific skills of gathering scientific information, critical literature review, applying scientific methods, communication skills and team work are acquired by carrying out research activities with one's supervisor, participating in projects, collaborating with teachers on elected courses and the obligatory course of *Methods of scientific research* and seminars for acquiring generic skills. Writing and reporting skills in both Croatian and English are developed by writing and presenting seminar papers, publishing research in journals and presenting research results at conferences as well as attending seminars for acquiring generic skills and within the course of *Research seminar*.

3. ACADEMIC CREDIT SYSTEM AND A COURSE OF STUDY

3.1. Structure and organisation of the study programme

The postgraduate doctoral study programme in Electrical Engineering and Computer Engineering lasts for 6 semesters during which students earn 180 ECTS credits. The programme is available as both a full-time and part-time study mode. Students enrolled in the part-time study mode can fulfil their academic requirements in two academic years instead of two semesters (one academic year).

Pursuant to the proposal of the Doctoral Committee, the Faculty Council appoints a student advisor who helps the doctoral student during one's studies and monitors his/her work and achievements. A student advisor can also be the doctoral student's thesis supervisor.

When enrolling in the postgraduate doctoral study programme, the student opts for one of three modules, namely Power Engineering, Communications and Informatics and Computer Science. Based on the completed graduate study programmes and selected module and pursuant to the proposal of the Doctoral Committee, the Faculty Council can list differential exams to be taken by the doctoral student.

3.2. Structure and organisation of the study programme for different student categories

Four categories of students can enrol in the postgraduate doctoral study programme as follows:

1) candidates who have completed university graduate study programmes and obtained Master's degrees;
2) candidates who have completed four-year university pre-Bologna study programmes (prior to 2005)
3) candidates holding Master's of Science degrees (pursuant to the Higher Education Institutions Act, Official Gazette no. 59 adopted on 17 July 1996);
4) candidates who have completed appropriate study programmes at foreign higher education institutions.

3.2.1. Structure and organisation of the study programme for candidates who have completed university graduate study programmes and obtained Master's degrees

Candidates who have completed university graduate study programmes and obtained Master's degrees are required to earn at least 180 ECTS credits at the postgraduate doctoral study programme as follows:

- **at least 54 ECTS credits by opting for courses, taking exams and participating in seminars as follows**:
  - enrolling in and taking one obligatory and five elective course thus obtaining the following:
    - 5 ECTS credits by taking an obligatory fundamental course;
    - 8 ECTS credits by taking a fundamental course in the first semester;
    - 10 ECTS credits by taking a fundamental module course in the first semester;
    - 24 ECTS credits by taking scientifically-oriented courses in the second semester;
      - Students enrol in at least two scientifically-oriented courses of the elected module and one course of the elected module or other modules offered at the postgraduate doctoral study programme or courses at some other higher education institutions in Croatia or abroad (pursuant to the approving procedure of enrolling in courses at other institutions);
  - 3 ECTS credits by participating in seminars for acquiring generic skills (enrolling in three seminars);

- students who participate in seminars for acquiring generic skills held at institutions other than the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek can earn up to 2 ECTS credits. A decision on acknowledging these ECTS credits will be made by the Doctoral Committee pursuant to the student's written request;
- 4 ECTS credits by participating in a research seminar (four public presentations on scientific research results during three years of studying).

- **<u>at least 70 ECTS credits for publishing research results related to the student's doctoral dissertation:</u>**
  - 5 ECTS credits for publishing a scientific paper in a scientific conference proceedings which are not cited in referral databases (up to two papers from this category are acknowledged);
  - 10 ECTS credits for publishing a scientific paper in a scientific journal cited in referral databases which need not be listed in categories A and B pursuant to the Regulations on requirements for the election to scientific titles, Official Gazette no. 28/2017 (but in other referral databases) or for a scientific paper published in internationally reviewed scientific conference proceedings cited in referral databases listed in categories A and B pursuant to the aforementioned Regulations;
  - 20 ECTS credits for publishing a scientific paper in a scientific journal cited in referral databases (category B pursuant to the Regulations on requirements for the election to scientific titles, Official Gazette no. 28/2017);
  - 40 ECTS credits for publishing a scientific paper in a scientific journal in the fourth quartile (Q4) in the referral databases Current Contents (CC), Science Citation Index (SCI) or Science Citation Index Expanded (SCI-Exp.) (category A pursuant to the Regulations on requirements for the election to scientific titles, Official Gazette no. 28/2017);
  - 50 ECTS credits for publishing a scientific paper in a scientific journal in the third quartile (Q3) in the referral databases Current Contents (CC), Science Citation Index (SCI) or Science Citation Index Expanded (SCI-Exp.) (category A pursuant to the Regulations on requirements for the election to scientific titles, Official Gazette no. 28/2017);
  - 60 ECTS credits for publishing a scientific paper in a scientific journal in the second quartile (Q2) in the referral databases Current Contents (CC), Science Citation Index (SCI) or Science Citation Index Expanded (SCI-Exp.) (category A pursuant to the Regulations on requirements for the election to scientific titles, Official Gazette no. 28/2017);
  - 70 ECTS credits for publishing a scientific paper in a scientific journal in the first quartile (Q1) in the referral databases Current Contents (CC), Science Citation Index (SCI) or Science Citation Index Expanded (SCI-Exp.) (category A pursuant to the Regulations on requirements for the election to scientific titles, Official Gazette no. 84 adopted on 11 July 2005).

  Students obtain a maximal number of ECTS credits for a published paper with 1-4 co-authors; 75% of ECTS credits for a published paper with 5 co-authors; 50% of ECTS credits for a published paper with 6 co-authors, 25% of ECTS credits for a published paper with 7 co-authors and 100/n % of ECTS credits for a published paper with n=8 or more co-authors. ECTS credits will be acknowledged for papers accepted for publication pursuant to an appropriate confirmation (certificate).

- *<u>10 ECTS credits are awarded to the student pursuant to a passed qualifying doctoral exam in the second and third semester</u>*
  - a prerequisite for taking a qualifying doctoral exam is to earn 20 ECTS credits;
  - when initiating a qualifying doctoral exam, the student needs to submit a review paper in the field of his/her doctoral dissertation;
  - a qualifying doctoral exam is a public event. Doctoral students are examined by a three-member committee of scientists elected in scientific-educational or corresponding

scientific titles. At least one member needs to be elected in the scientific-educational title of an associate or a full Professor or the corresponding scientific titles. Committee members are appointed by the Faculty Council pursuant to a proposition of the Doctoral Committee.

- *30 ECTS credits are awarded to the student pursuant to a defended topic of his/her doctoral dissertation*

- additional 10 ECTS credits can be earned by working on a research project (active participation of the student in a research project is confirmed by the project manager in a written report);
- additional (up to) 18 ECTS can be earned by conducting research on a foreign scientific institution. For every 30 mobility days, the student earns 6 ECTS credits (credits can be earned on multiple mobility programmes; however, one mobility programme needs to last for at least 14 consecutive days while others need to last for at least 5 working days). ECTS credits are awarded by the Doctoral Committee pursuant to a host institution confirmation and a report on research results during a mobility programme certified by a student advisor or supervisor.

The student opts for courses upon consultation with a student advisor. Elected courses are approved by the Doctoral Committee. Seminars for acquiring generic skills are enrolled in pursuant to the student's election in the first, second, third, fourth, fifth and sixth semester. The student enters elected courses in the first and second semester in a student's record book while scientific and research work is carried out in the third, fourth, fifth and sixth semester.

Semester enrolment criteria

For enrolling in the second semester, there are no special requirements.

For enrolling in the third semester, the student needs to earn at least 20 ECTS credits and meet the following criteria:

- pass the exam in the Methods of scientific research (5 ECTS credits);
- pass the exam in the fundamental module course (10 ECTS credits);
- other credits need to be earned by taking exams, publishing scientific papers, attending seminars for acquiring generic skills, research seminar and/or mobility programmes.

For enrolling in the fourth semester, the student needs to earn at least 40 ECTS credits and meet the following criteria:

- meet the criteria for the enrolment in the third semester
  - pass the exam in the Methods of scientific research (5 ECTS credits);
  - pass the exam in the fundamental module course (10 ECTS credits);
- pass a qualifying doctoral exam (10 ECTS credits);
- other credits need to be earned by taking exams, publishing scientific papers, attending seminars for acquiring generic skills and/or mobility programmes.

For enrolling in the fifth semester, the student needs to earn at least 66 ECTS credits and meet the following criteria:

- meet the criteria for the enrolment in the fourth semester
  - pass the exam in the Methods of scientific research (5 ECTS credits);
  - pass the exam in the fundamental module course (10 ECTS credits);
  - pass a qualifying doctoral exam (10 ECTS credits);
- pass at least two fundamental or scientifically-oriented module exams (16 ECTS credits);

- give at least one presentation on research results at a research seminar;
- earn at least 10 ECTS credits by publishing scientific papers;
- other credits need to be earned by taking exams, publishing scientific papers, attending seminars for acquiring generic skills and/or mobility programmes.

The doctoral student needs to initiate the procedure of his/her doctoral topic approval no later than in the fifth semester. In order to initiate the topic approval procedure, the student needs to have earned at least 80 ECTS credits and meet the following requirements:

- pass all exams (47 ECTS credits);
- pass the qualifying doctoral exam (10 ECTS credits);
- give at least two presentations of research results at the research seminar;
- publish at least one scientific paper (or have at least one scientific paper accepted for publication), in the field of one's doctoral dissertation, in a journal ranked in category A or B. The student needs to be a lead author (a minimum of 20 ECTS credits). This paper has to be published up to five years prior to initiating the topic approval procedure with a possibility to accept a paper published prior to the student's enrolment in the postgraduate doctoral study programme (considered by the Doctoral Committee);
- other credits need to be earned by publishing scientific papers, attending seminars for acquiring generic skills and/or mobility programmes.

For enrolling in the sixth semester, the student needs to earn at least 110 ECTS credits and meet the following criteria:

- meet the criteria for approval of a doctoral dissertation topic (80 ECTS credits);
- approved topic of one's doctoral dissertation (30 ECTS credits).

3.2.2. Structure and organisation of the study programme for candidates who have completed four-year university pre-Bologna study programmes (prior to 2005)

Candidates who have completed four-year university pre-Bologna study programmes in Electrical or Computer Engineering prior to 2005 are eligible to enrol in the postgraduate doctoral study programme. Candidates are required to earn 180 ECTS credits at the postgraduate doctoral study programme in the same way as candidates who have completed university graduate study programmes and obtained Master's degrees.

3.2.3. Structure and organisation of the study programme for candidates holding Master's of Science degrees pursuant to the Higher Education Institutions Act (Official Gazette no. 59 adopted on 17 July 1996) or other acts effective in that period

Master of Science degree holders can be acknowledged up to 90 ECTS credits when enrolling in the postgraduate doctoral study programme. 50 ECTS credits are acknowledged for passing exams at the postgraduate university (master) study programme and defending a master thesis. Upon the student's request, a maximum of 40 ECTS credits can be acknowledged for scientific papers, in the field of the student's doctoral dissertation, published prior to the enrolment in the postgraduate doctoral study programme pursuant to a proposition of an expert committee appointed by the Doctoral Committee.

At the postgraduate doctoral study programme, a Master of Science degree holder is required to earn additional 90 ECTS credits as follows:

- at least 8 ECTS credits for passing a scientifically-oriented module course;
- at least 40 ECTS credits for publishing scientific papers in the field of one's doctoral dissertation;
- a maximum of 18 ECTS credits for conducting research on a foreign scientific institution (the student needs to submit a host institution's confirmation/certificate and a research report certified by a student advisor or supervisor). For every 30 mobility days, the student earns 6 ECTS credits (credits can be earned on multiple mobility programmes; however, one mobility programme needs to last for at least 14 consecutive days while others need to last for at least 5 working days);
- 10 ECTS credits for working on a research project (active participation of the student in a research project is confirmed by the project manager in a written report);
- 30 ECTS credits for defending a topic of one's doctoral dissertation;
- other ECTS credits are to be earned by publishing scientific papers, attending seminars for acquiring generic skills (up to 2 ECTS credits) or participating in mobility programmes.

For publishing scientific papers, students earn ECTS credits in the same way as students who have completed university graduate study programmes and obtained Master's degrees.

Master of Science degree holders enter elected courses in the fourth semester in a student's record book while scientific and research work is carried out in the fifth and sixth semester.

Semester enrolment criteria for Master of Science degree holders

For enrolling in the fifth semester, Master of Science degree holders do not have to meet any requirements. In the fifth semester (at the latest), the student needs to initiate the procedure for approval of a doctoral dissertation topic. For initiating the procedure, the student needs to have earned at least 80 ECTS credits (including credits acknowledged from the postgraduate university master study programme) and meet the following requirements:

- pass all exams (a minimum of 8 ECTS credits);
- publish at least one scientific paper (or have at least one scientific paper accepted for publication), in the field of one's doctoral dissertation, in a journal ranked in category A or B. The student needs to be a lead author (a minimum of 20 ECTS credits). This paper has to be published up to five years prior to initiating the topic approval procedure with a possibility to accept a paper published prior to the student's enrolment in the postgraduate doctoral study programme (considered by the Doctoral Committee). The student can earn up to 40 ECTS credits for publishing such paper.

For enrolling in the sixth semester, the student needs to earn at least 110 ECTS credits and meet the following criteria:

- meet the criteria for approval of a doctoral dissertation topic (80 ECTS credits);
- approved topic of one's doctoral dissertation (30 ECTS credits).

3.2.4.Structure and organisation of the study programme for candidates who have completed appropriate study programmes at foreign higher education institutions

Candidates who have completed appropriate study programmes at foreign higher education institutions can enrol in the postgraduate doctoral study programme in Electrical Engineering or Computer Science pursuant to a certificate on the recognition of academic diplomas issued by Josip Juraj Strossmayer University of Osijek. For such candidates, the Doctoral Committee proposes and the Faculty Council appoints an expert committee who will determine differential exams. Upon passing differential exams, the structure and organisation of the study programme is the same as for candidates who have completed university graduate study programmes and obtained Master's degrees. If necessary, all classes can be taught in the English language. In the case of a low number of foreign students, classes will be taught in the English language during Professor s' office hours.

3.2.5. Following year enrolment criteria

To enrol in the second year, the student needs to acquire at least 20 ECTS credits and meet the following requirements:

- pass the exam in the Methods of scientific research (5 ECTS credits);
- pass the exam in the fundamental module course (10 ECTS credits);
- other credits need to be earned by taking exams, publishing scientific papers, attending seminars for acquiring generic skills and/or mobility programmes.

To enrol in the third year, the student needs to acquire at least 110 ECTS credits and meet the following requirements:

- meet the requirements for doctoral dissertation topic approval;
- have the doctoral dissertational topic approved (30 ECTS credits).

3.3. The advisory and guidance scheme in the postgraduate doctoral study programme

The student is guided and advised by a supervisor, the head of postgraduate doctoral study programme and the Doctoral Committee. The Doctoral Committee takes care of the general study conditions and individual progress of students.

Student advisor

Upon completion of the postgraduate doctoral study programme vacancy call, the Faculty Council appoints an advisor elected in scientific-educational titles to every student. The student advisor helps the student with his/her research and takes care of publishing research papers.

Supervisor

In the procedure for approval of the doctoral dissertation topic, either the appointed advisor is confirmed for a supervisor or other scholar whose research falls into the scope of the dissertation topic is appointed a supervisor. If necessary, a co-supervisor may also be for the purpose of meeting the best conditions possible for dissertation guidance. The Faculty Council appoints a supervisor and a co-supervisor who must be Professor s employed at the Faculty and elected in scientific-educational titles. Exceptionally, scholars elected in scientific-educational or scientific titles in the scientific field of the postgraduate doctoral study programme and involved in the execution of the postgraduate doctoral study programme can be appointed supervisors.

3.4. Courses a doctoral student can take from other postgraduate doctoral study programmes

Instead of one scientifically-oriented course of the elected module, students can take a course offered by other higher education institutions in Croatia or abroad. Such courses are approved by the Faculty Council upon a proposal of the Doctoral Committee. A course enrolment, students' obligations and rights are regulated by mutual agreements between the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek and the faculty the selected course is taught at. ECTS credits obtained in this way are added to a sum of 180 ECTS credits students need to acquire to complete their studies.

There is no list of possible courses to be taken at other higher education institutions. Pursuant to the student's request, the appropriateness of the elected course and higher education institution it is to be taught at (course content, teacher's qualifications, institution's status, cooperation agreement, organisation of the student's mobility, etc.) are taken into consideration.

3.4.1. Criteria and conditions for transferring ECTS credits

The postgraduate doctoral study programme in Electrical Engineering and Computer Science provides students with the opportunity to take a course taught at other postgraduate doctoral study programmes at higher education institutions in Croatia or abroad instead of one scientifically-oriented course of the elected module. The Doctoral Committee determines the appropriateness of the host institution, elected course and ECTS credits to be attributed to the student upon him/her successfully passing the exam. Attending classes at the host institution and other students' rights and obligations are regulated by mutual agreements between the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek and the host institution.

The student can earn up to 18 ECTS by conducting research on a foreign scientific institution (the student needs to submit a host institution confirmation and a research report). For every 30 mobility days, the student earns 6 ECTS credits (credits can be earned on multiple mobility programmes; however, one mobility programme needs to last for at least 14 consecutive days while others need to last for at least 5 working days). ECTS credits are awarded by the Doctoral Committee pursuant to a host institution confirmation and a report on research results during a mobility programme certified by a student advisor or supervisor.

In case the student transfers from another postgraduate doctoral study programme, upon the proposal of the Expert Committee, the Doctoral Committee determines the number of ECTS credits to be accredited to the student as well as his/her obligations to be carried out at the postgraduate doctoral study programme at the Faculty.

3.5. Classes held in a foreign language

With an exception of the courses entitled *Probability and Statistics – Application* and *Energy Efficiency in Technical Systems*, all courses can be taught in the English language. The courses entitled *Complete Measurement Result and Decision Making* and *Non-linear Electrical Networks and Deterministic Chaos* can also be taught in the German language.

3.6. Resuming interrupted doctoral studies

The requirements to resume interrupted or permanently discontinued studies are regulated by Josip Juraj Strossmayer University of Osijek Regulations on postgraduate study programmes.

The student who has enrolled in the postgraduate doctoral study programme in a full-time mode loses a student status if he/she does not defend his/her doctoral dissertation within a five-year timeframe. The student who has enrolled in the postgraduate doctoral study programme in a part-time mode loses a student status if he/she does not defend his/her doctoral dissertation within a ten-year timeframe.

Pursuant to the University Statute, the student loses his/her doctoral student status if the Faculty Council reaches a decision on suspending the procedure for acquiring the title of the doctor of science.

The student who has lost his/her status of a doctoral student due to a break in study may choose to resume his/her studies provided that no more than three years have passed since the break in studying occurred and that the study programme has not been extensively altered (no more than 20%). A request to resume studies is submitted to the Doctoral Committee.

A decision on resuming interrupted studies is made by the Doctoral Committee. The decision includes the approval to resume interrupted studies, recognition of exams and acquired ECTS credits, the amount of the studying fee which is the same as the fee amount for the generation the student continues to study with.

3.7. Conditions under which the doctoral student is entitled to the right of certifying the completed part of doctoral studies

Upon the doctoral student's request, the Faculty issues a letter certifying courses attended and examinations passed within the framework of the postgraduate doctoral study programme.

3.8. Ways and conditions for doctoral study completion by dissertation defence

The postgraduate doctoral study programme in Electrical Engineering and Computer Science is completed when the doctoral student defends his/her doctoral dissertation. The dissertation defence is preceded by the procedures for the doctoral dissertation topic approval and doctoral dissertation evaluation.

3.8.1. Procedure for approval of the dissertation topic

The procedure for approval of the dissertation topic may be initiated by the doctoral student after he/she has achieved a minimum of 80 ECTS credits and at the latest in the fifth semester. The student needs to have published at least one scientific paper (or have at least one scientific paper accepted for publication), in the field of one's doctoral dissertation, in a journal ranked in category A or B with the student being the lead author. The student initiates the procedure for approval of the doctoral dissertation topic by submitting an application to the Faculty Council. The application needs to include the following:

- a suggested dissertation title both in Croatian and English;
- a detailed explanation of the topic;
- a clearly defined research objective and plan;
- research methodology;
- information on the proposed supervisor and his/her competencies;
- an overview of thus far research;
- student record book;
- a list and copies of published papers;
- a short biography with a description of the student's scientific and professional activities;
- a statement that the procedure has not been initiated at any other institution.

The Doctoral Committee establishes whether the conditions for initiating the procedure for approval of the dissertation topic have been met.

If the Doctoral Committee determines that the application does not contain necessary documentation, the doctoral student will be given a deadline, not longer than 30 days, to supplement his/her application.

Pursuant to the proposal of the Doctoral Committee, the Faculty Council appoints the Dissertation Topic Approval Committee consisting of three members (if necessary, five members) and a deputy member. Members of the Dissertation Topic Approval Committee need to be elected in scientific-educational or scientific titles. At least two members need to be elected in the scientific-educational titles of an associate or a full Professor (or the corresponding scientific titles) one of whom needs to be elected in the scientific-educational title of a full Professor (or the corresponding scientific title). One of the two members is a President of the Dissertation Topic Approval Committee. One of the Dissertation Topic Approval Committee members is a scientist not affiliated to the Faculty (usually

not affiliated to Josip Juraj Strossmayer University of Osijek) and not engaged in the postgraduate doctoral study programme. A supervisor and co-supervisor cannot be members of the Dissertation Topic Approval Committee.

All doctoral students who meet the requirements for initiating the procedure for approval of the dissertation topic will be asked to elaborate on their expected scientific contributions during a public interview where each of the presented scientific contributions will be evaluated in terms of its feasibility. The public interview and dissertation proposal defence must take place within 90 days of submitting the application for approval of the dissertation topic. The period from 16 July to 31 August is not included in the outlined deadline.

The Dissertation Topic Approval Committee will give consideration to the student's request to write and defend his/her doctoral dissertation in the English language. The Committee will elaborate on their proposal which will be included in the record for the doctoral dissertation topic defence. A final decision on writing and defending one's dissertation in the English language is made by the Faculty Council during the approval of the dissertation topic.

A supervisor informs the Dissertation Topic Approval Committee, Faculty departments and Doctoral Committee on a public interview date and venue and proposed doctoral dissertation topic at the latest 7 days prior to the public interview. The public interview date and venue is advertised on the notice board and the Faculty website.

The Dissertation Topic Approval Committee provides the Student Administration Office and the Doctoral Committee with the record of the public interview and dissertation topic defence. The record should include a written and signed proposal to accept or decline the doctoral dissertation topic and be sent at the latest 21 days following the public interview. The record of the public interview and dissertation topic defence needs to include the following:

- a suggested dissertation title both in Croatian and English;
- a list of expected scientific contributions;
- a proposal of a supervisor and co-supervisor (if necessary).

Pursuant to the elaborated report and the proposal submitted by the Dissertation Topic Approval Committee, the Faculty Council makes a final decision on accepting or declining a doctoral dissertation topic, informs the student who proposed the doctoral dissertation topic and appoints a supervisor to guide the student.

The proposed supervisor elaborates on the proposed doctoral dissertation topic and expected scientific contributions to the Faculty Council.

According to the proposal of the Dissertation Topic Approval Committee, the Faculty Council can appoint a co-supervisor during the process of approving the doctoral dissertation topic.

3.8.2. Submission and evaluation of the doctoral dissertation

The student may submit his/her doctoral dissertation for evaluation if he/she has acquired a minimum of 180 ECTS credits. The student needs to have published at least one scientific paper (or have at least

one scientific paper accepted for publication), in the field of one's doctoral dissertation, in a journal ranked in category A or B with the student being the lead author (a requirement for initiating the procedure for approval of the doctoral dissertation topic) and have published at least one scientific paper (or have at least one scientific paper accepted for publication), in the field of one's doctoral dissertation, in a journal ranked in category A with the student being the lead author.

The student whose doctoral dissertation topic has been approved initiates the procedure for evaluation of the doctoral dissertation by submitting a written request. In addition to the request, the student needs to submit the following documents to the Student Administration Office:

- completed doctoral dissertation in the Croatian language in four (4) unbound copies;
- a list and copies of published papers;
- a more detailed summary of the doctoral dissertation in the English language;
- an originality statement.

The supervisor submits a report on the student's progress. The report should include an overview of the student's work and achieved original scientific contributions, a review of applied methods and an explicit statement of achieved original scientific contributions. The supervisor proposes members for the Doctoral Dissertation Evaluation Committee.

Pursuant to Josip Juraj Strossmayer University of Osijek Regulations on Postgraduate Studies, a doctoral dissertation can be a scientific work in the form of a monography or a scientific work based on published articles. A doctoral dissertation is to be written in the Croatian language and can be written in the English language if approved by the Faculty Council.

Doctoral dissertation

A doctoral dissertation is structured as follows:

1. The first page should read:

   Josip Juraj Strossmayer University of Osijek

   Faculty of Electrical Engineering, Computer Science and Information Technology Osijek

   (Name and surname)

   (Title of the doctoral dissertation)

   Doctoral dissertation

   Osijek, (year)

2. The second page should read:

   The doctoral dissertation was prepared in (department, i.e. name of the institution)

   Supervisor: ...

   The doctoral dissertation contains ... pages

   Doctoral dissertation number:

3. The doctoral dissertation should also include the following:

   - an essay-form biography written in the first person singular (at least 20 lines);
   - a summary of the doctoral dissertation in the Croatian language;
   - a title and summary of the doctoral dissertation in the English language;

- key words (up to 10) in the Croatian and English language.

Pursuant to the proposal of the Doctoral Committee, the Faculty Council appoints the Doctoral Dissertation Evaluation Committee consisting of three members (if necessary, five members). Members of the Doctoral Dissertation Evaluation Committee need to be elected in scientific-educational or scientific titles. At least two members need to be elected in the scientific-educational titles of an associate or a full Professor (or the corresponding scientific titles) one of whom needs to be elected in the scientific-educational title of a full Professor (or the corresponding scientific title). One of the two members is a President of the Doctoral Dissertation Evaluation Committee. One of the Doctoral Dissertation Evaluation Committee members is a scientist not affiliated to the Faculty (usually not affiliated to Josip Juraj Strossmayer University of Osijek) and not engaged in the postgraduate doctoral study programme. A supervisor and co-supervisor cannot be members of the Doctoral Dissertation Evaluation Committee.

During the process of dissertation evaluation and defence and prior to the submission of bound copies, one unbound copy of the doctoral dissertation is publically available at the Student Administration Office.

The Doctoral Dissertation Evaluation Committee members must submit their report within 90 days upon receipt of the dissertation. The period between 16 July and 31 August is not taken into account when defining the report submission deadline. If the Doctoral Dissertation Evaluation Committee does not submit the report upon a given deadline, the Faculty Council can appoint new members of the Doctoral Dissertation Evaluation Committee.

A report of the Doctoral Dissertation Evaluation Committee should include a detailed overview of the student's work and evidence on achieved original scientific contributions, a review and evaluation of the student's work and applied methods and evaluation. The final evaluation should include an explicit statement on achieved original scientific contributions and a scientific field.

In their report, the Doctoral Dissertation Evaluation Committee may recommend:

- to accept the doctoral dissertation and allow its oral defence;
- to revise the doctoral dissertation and re-evaluate it;
- to reject the doctoral dissertation.

In all three cases, the Committee has to substantiate its decision.

At the Faculty Council meeting, the President of the Doctoral Dissertation Evaluation Committee gives a report on doctoral dissertation assessment explicitly focusing on achieved original scientific contributions.

If the Faculty Council concludes that the report submitted by the Doctoral Dissertation Evaluation Committee does not give grounds for evaluating the doctoral dissertation, it can request that the Doctoral Committee appoints additional members to the Doctoral Dissertation Evaluation Committee and require that they submit separate reports, or to appoint a new Doctoral Dissertation Evaluation Committee that should reconsider and reassess the dissertation in question, as well as submit their report to the Faculty Council.

In case the Doctoral Dissertation Evaluation Committee gives a negative recommendation and the Faculty Council does not reach a decision on appointing additional members to the Doctoral Dissertation Evaluation Committee or new members of the Doctoral Dissertation Evaluation Committee who would reconsider and reassess the doctoral dissertation, the Faculty Council will reach a decision to suspend the doctoral procedure and inform the doctoral student within eight (8) days. In such cases, the doctoral student cannot initiate the doctoral procedure with the same doctoral dissertation topic at the University of Osijek.

3.8.3. Doctoral dissertation defence

If the Faculty Council accepts the positive evaluation of the doctoral dissertation, as a rule, in the same meeting and following the proposal of the Doctoral Committee, it shall appoint the Doctoral Dissertation Defence Committee consisting of three (3) members and one (1) deputy member. If necessary, the Doctoral Dissertation Defence Committee can consist of five (5) members.

Doctoral Dissertation Evaluation Committee members can also be members of the Doctoral Dissertation Defence Committee.

At least two members need to be elected in the scientific-educational titles of an associate or a full Professor (or the corresponding scientific titles) one of whom needs to be elected in the scientific-educational title of a full Professor (or the corresponding scientific title). One of the two members is a President of the Doctoral Dissertation Defence Committee. One of the Doctoral Dissertation Defence Committee members is a scientist not affiliated to the Faculty (usually not affiliated to Josip Juraj Strossmayer University of Osijek) and not engaged in the postgraduate doctoral study programme.

A supervisor can participate at the doctoral dissertation defence. Neither the supervisor not the co-supervisor can be members of the Doctoral Dissertation Defence Committee.

The doctoral dissertation defence is open to public. The date of the public defence is scheduled by the Faculty Council and advertised on the Faculty noticeboard and website at least seven (7) days prior to the defence date.

The Student Administration Office notifies the student about the defence date and venue at least seven (7) days prior to the defence date.

The student defends his/her doctoral dissertation in front of the Doctoral Dissertation Defence Committee. A record of the defence protocol is kept and signed by the Committee members and a secretary. The record includes a decision made by the Doctoral Dissertation Defence Committee.

The Doctoral Dissertation Defence Committee can make the following decisions on the doctoral dissertation:

* defended by an unanimous decision of the Committee members;
* defended by a majority vote of the Committee members;

* was not defended.

The doctoral dissertation is defended only once.

Upon a successful defence, the student adds an additional sheet to his/her dissertation containing the names of the Doctoral Dissertation Evaluation Committee and Doctoral Dissertation Defence Committee members and the defence date. Within one month of the defence, the student has to submit nine (9) bound copies and an electronic version of the doctoral dissertation to the Faculty Secretariat.

If the Faculty Council allowed the student to write his/her doctoral dissertation in the English language, within one month of the defence, the student has to submit nine (9) bound copies, an electronic version and a proofreader's certificate on the linguistic accuracy co-signed by the supervisor to the Faculty Secretariat.

The Student Administration Office delivers one copy of the doctoral dissertation to the National and University Library in Zagreb, City and University Library in Osijek, Josip Juraj Strossmayer University of Osijek, supervisor, Faculty department or the institution at which the doctoral dissertation has been done, Faculty Archive and Faculty library.

The doctoral dissertation is permanently published in the public online database of doctoral dissertations of the National and University Library in Zagreb and on the Faculty website.

Upon doctoral dissertation defence, the Dean of the Faculty submits a report on the doctoral dissertation defence, decision made by the Doctoral Dissertation Defence Committee and one copy of the doctoral dissertation to the Rector of Josip Juraj Strossmayer University of Osijek.

Based on a positive decision of the Doctoral Dissertation Defence Committee, Josip Juraj Strossmayer University of Osijek issues a diploma awarding the student with the academic title of Doctor of Science.

Upon successful doctoral dissertation defence, the student is issued a diploma awarding the student with the academic title of Doctor of Science and a certificate on the completed postgraduate doctoral study programme.

The student who completes the postgraduate doctoral study programme in Power Engineering is awarded the following title:

Doctor of Science, scientific area of Technical Sciences, scientific field of Electrical Engineering.

The student who completes the postgraduate doctoral study programme in Communications and Informatics is awarded the following title:

Doctor of Science, scientific area of Technical Sciences, scientific field of Electrical Engineering.

The student who completes the postgraduate doctoral study programme in Computer Science is awarded the following title:

Doctor of Science, scientific area of Technical Sciences, scientific field of Computer Science.

The diploma is awarded by the Rector at the graduation ceremony.

3.9. Maximum study duration from enrolment to its completion

A full-time postgraduate doctoral study programme lasts for three years, which, in case of justified circumstances, can be extended to five years based on the decision made by the Doctoral Committee.

A part-time postgraduate doctoral study programme lasts for five years maximum, which, in case of justified circumstances, can be extended to seven years based on the decision made by the Doctoral Committee.

4. CONDITIONS FOR CARRYING OUT THE STUDY PROGRAMME

4.1. Venue where the postgraduate doctoral study programme is carried out

The Faculty has a total surface area of 8,500 m^2 and carries out its educational and research activities in three locations as follows:

- Kneza Trpimira 2b: total surface area is 5,100 m^2;
- Cara Hadrijana 10b: total surface area is 3,260 m^2;
- Cara Hadrijana bb, building no. 14: total surface area is 265 m^2.

4.2. Premises, equipment and research resources

The Faculty of Electrical Engineering, Computer Science and Information Technology Osijek has a total surface area of 8,500 m^2, 13 classrooms, 2 amphitheatre lecturing halls, a video conference classroom, 2 computer general purpose classrooms and 22 educational, research and professional laboratories.

The laboratories are equipped with state-of-the-art equipment, installations, computer and communication infrastructure and have continually been upgraded. The equipment of the computer classrooms and laboratories is purchased by the Faculty and partly funded by research and technology projects.

4.3. Faculty Departments, Chairs and Laboratories

The Faculty consists of six departments, 12 chairs and 3 laboratories.

Department of Core Courses

- *Chair of Mathematics, Physics and Mechanical Engineering*
- *Chair of Social Sciences and Humanities*

Department of Software Engineering

- *Chair of Programming Languages and Systems*
- *Chair of Visual Computing*

Department of Computer Engineering and Automation

- *Chair of Computer Engineering*
- *Chair of Automation and Robotics*

Department of Electromechanical Engineering

- *Chair of Fundamentals of Electrical Engineering and Measurements*
- *Chair of Electric Machines and Power Electronics*
- *Electric Machines and Hybrid Electric Drives Laboratory*

Department of Power Engineering

- *Chair of Power Systems and Substations*
- *Chair of Power Plants and Energy Processes*
- *Electromagnetic Compatibility Laboratory*

Department of Communications

- ***Chair of Electronics and Microelectronics***
- ***Chair of Radiocommunications and Telecommunications***
- ***Laboratory for High Frequency Measurements***
- ***Chair of Multimedia Systems and Digital Television***

4.3. Human resources

The Faculty of Electrical Engineering, Computer Science and Information Technology Osijek employs 48 teachers elected in scientific-educational titles 33 of whom participates in the postgraduate doctoral study programme in Electrical Engineering and Computer Science. Thus, the Faculty has high quality human resources to carry out the postgraduate doctoral study programme and mentor students. Table 4.1 provides a list of the Faculty teachers, elected in scientific-educational titles, who are engaged in the postgraduate doctoral study programme.

Table 4.1 List of the employees elected in scientific-educational titles at the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek

Full Professor s
1. Dr. Zoran Baus, Full Professor
2. Dr. Ivica Crnković, Full Professor
3. Dr. Robert Cupec, Full Professor
4. Dr. Željko Hederić, Full Professor
5. Dr. Željko Hocenski, Full Professor
6. Dr. Goran Martinović, Full Professor
7. Dr. Kruno Miličević, Full Professor
8. Dr. Srete Nikolovski, Full Professor
9. Dr. Snježana Rimac-Drlje, Full ›rofessor
10. Dr. Damir Šljivac, Full Professor
11. Dr. Drago Žagar, Full Professor
Associate Professor s
1. Dr. Marinko Barukčić, Associate Professor
2. Dr. Irena Galić, Associate Professor
3. Dr. Hrvoje Glavaš, Associate Professor
4. Dr. Krešimir Grgić, Associate Professor
5. Dr. Marijan Herceg, Associate Professor
6. Dr. Josip Job, Associate Professor
7. Dr. Zvonimir Klaić, Associate Professor
8. Dr. Predrag Marić, Associate Professor
9. Dr. Tomislav Matić, Associate Professor
10. Dr. Krešimir Nenadić, Associate Professor
11. Dr. Slavko Rupčić, Associate Professor
12. Dr. Davor Vinko, Associate Professor
13. Dr. Mario Vranješ, Associate Professor
Assistant Professor s
1. Dr. Ivan Aleksi, Assistant Professor
2. Dr. Krešimir Fekete, Assistant Professor
3. Dr. Ratko Grbić, Assistant Professor
4. Dr. Goran Knežević, Assistant Professor
5. Dr. Zdravko Krpić, Assistant Professor
6. Dr. Tomislav Matić, Assistant Professor
7. Dr. Emmanuel Karlo Nyarko, Assistant Professor
8. Dr. Tomislav Rudec, Assistant Professor
9. Dr. Danijel Topić, Assistant Professor
10. Ivanka Ferčec, MA

11. Yvonne Liermann-Zeljak, MA
12. Dr. Dragana Božić Lenard, Postdoctoral Research Fellow

Adjunct national and international Professor s participate in the postgraduate doctoral study programme in carrying out highly specialised courses of interest to the study programme thus pointing to an additional quality enhancement. Table 4.2 provides a list of the adjunct Professor s participating in the postgraduate doctoral study programme.

Table 4.2 List of the adjunct Professor s participating in the postgraduate doctoral study programme

Josip Juraj Strossmayer University of Osijek	
1.	Darija Krstić, MSc
Faculty alumni	
1.	Dr. Radoslav Galić, Full Professor , Professor Emeritus
2.	Dr. Tihomir Hunjak, Full Professor , Professor Emeritus
Department of Mathematics	
1.	Dr. Mirta Benšić, Full Professor
2.	Dr. Rudolf Scitovski, Full Professor
Faculty of Mechanical Engineering Slavonski Brod	
1.	Dr. Marinko Stojkov, Full Professor
University of Maribor, Slovenia	
Faculty of Electrical Engineering and Computer Science	
1.	Dr. Matjaž Colnarič, Full Professor
2.	Dr. Jože Pihler, Full Professor
3.	Dr. Igor Tičar, Full Professor
University of Maribor, Slovenia	
Faculty of Energy Technology	
1.	Dr. Miralem Hadžiselimović, Full Professor
2.	Dr. Sebastian Seme, Associate Professor
3.	Dr. Bojan Štumberger, Full Professor
4.	Dr. Zdravko Praunseis, Associate Professor

University of Mostar, Bosnia and Herzegovina **Faculty of Mechanical Engineering and Computing**	
1.	Dr. Vlado Majstorović, Full Professor
Faculty of Technical Sciences University of Novi Sad	
Institute Rt-Rk Novi Sad	
1.	Dr. Nikola Teslić, Full Professor
Bremen University of Applied Sciences **Institute of Water-Acoustics, Sonar Engineering and Signal Theory**	
1.	Dr. Dieter Kraus, Full Professor
Energy Institute Hrvoje Požar	
1.	Dr. Mladen Zeljko, Associate Professor
2.	Dr. Ivan Štefanić, Full Professor
Ericsson Nikola Tesla d.d. (Plc)	
1.	Dr. Darko Huljenić, Associate Professor
EC JRC - Directorate G, Petten, the Netherlands	
1.	Dr. Zdenko Šimić, Associate Professor

4.4. Research and development projects

Research activities at the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek are carried out through competitive research projects financed by the Ministry of Science and Education, Croatian Science Foundation, state institutions (Croatian Agency for SMEs, Innovations and Investments HAMAG-BICRO, HAKOM – Croatian Regulatory Authority for Network Industries, etc.), European Union and industry funds.

In the period from 2007 until 2013, the Faculty was a lead beneficiary at ten projects financed by the Ministry of Science and Education as follows:

- *Holographic Logic Analyser* carried out by the project leaders Dr. Franjo Jović, Associate Professor and Dr. Ninoslav Slavek, Associate Professor ;
- *Distributed Computer Control in Transport and Industrial Plants* carried out by the project leader Dr. Željko Hocenski, Full Professor ;
- *Scheduling in Autonomic Distributed Computer Systems* carried out by the project leader Dr. Goran Martinović, Full Professor ;
- *Adaptive Video Transmission over Wireless Networks in Heterogeneous Environment* carried out by the project leader Dr. Snježana Rimac-Drlje, Full Professor ;
- *On-line Monitoring, Testing and Diagnosing Transformers* carried out by the project leaders Dr. Zdenko Godec, Full Professor and Dr. Kruno Miličević, Full Professor ;
- *Quality and Reliability of Croatian Power System on Regional Electricity Market* carried out by the project leader Dr. Srete Nikolovski, Full Professor ;

- *Advanced Indoor Wireless Access Systems and Their Environmental Interaction* carried out by the project leader Dr. Tomislav Švedek, Full Professor ;
- *Broadband Internet Access and Internet Services in Rural Area* carried out by the project leader Dr. Drago Žagar, Full Professor ;
- *Joint program of education and research in the area of renewable energy sources (RES) in Pannonian parts of Serbia and Croatia* carried out by the project leader Dr. Damir Šljivac, Full Professor .

In the period from 2015 until 2018, nine projects were approved to be financed by the Croatian Science Foundation as follows:

- Research project entitled *Advanced 3D Perception for Mobile Robot Manipulators* carried out by the project leader Dr. Robert Cupec, Full Professor (project duration: 1 January 2016 – 31 December 2018);
- Installation research project entitled *Energy Efficient Asynchronous Wireless Transmission* carried out by the project leader Dr. Tomislav Matić, Associate Professor (project duration: 1 September 2015 – 31 August 2018);
- Installation research project entitled *Medical Image Interpretation Methods for a Detailed Heart Health Analysis* carried out by the project leader Dr. Irena Galić, Associate Professor (project duration: 1 March 2018 – 28 February 2023);
- Installation research project entitled *Efficient Wireless Power Supply* carried out by the project leader Dr. Davor Vinko, Associate Professor (project duration: 1 March 2018 – 28 February 2023);
- Installation research project entitled *Co-Simulation Procedures Development for Soft Computing Application in Power Engineering* (UIP-05-2017, principal investigator Dr Marinko Stojkov, Full Professor) carried out by the project leader Dr. Marinko Barukčić, Associate Professor (project duration: 25 May 2018 – 24 May 2023);
- *Young Researchers' Career Development Project – Training of Doctoral Students* carried out by the project leader Dr. Tomislav Matić, Associate Professor (project duration: 15 September, 2016 – 14 September, 2020);
- *Young Researchers' Career Development Project – Training of Doctoral Students* carried out by the project leader Dr. Robert Cupec, Full Professor (project duration: 15 September, 2016 – 14 September, 2020);
- *Young Researchers' Career Development Project – Training of Doctoral Students* carried out by the project leader Dr. Irena Galić, Associate Professor (project duration: September, 2018 – September, 2022).
- Energy Efficient Asynchronous Wireless Transmission (project duration: 01 September 2015 – 31 August 2018)

The Environmental Protection and Energy Efficiency Fund funded the following projects:

- *Research and Development of a Solar-powered Electric Car* carried out by the project leaders Dr. Ljubomir Majdandžić, Full Professor and Dr. Dražen Slišković, Full Professor (project duration: 1 January 2014 – 31 December 2017);
- *Procurement of a Prototype of a Commercial Sun-Test Electric Car* carried out by the project leader Dr. Ljubomir Majdandžić, Full Professor (project duration: 1 September, 2015 – 31 December 2015).

The project funded by the Croatian Institute of Technology within the TEST programme is

- *The System of Locating and Charging with Respect to Activity Duration* carried out by the project leader Dr. Slavko Rupčić, Associate Professor (project duration: 1 December 2009 – 28 February 2012).

The projects funded by the Croatian Agency for SMEs, Innovations and Investments BICRO (PoC Public – Proof of Concepts) are as follows:

- *Application of Chaos Theory in Encryption – CryptoChaos* carried out by the project leader Dr. Kruno Miličević, Full Professor (project duration: 1 December 2012 – 1 December 2013);
- *Energy Efficient System for Wireless Measurement of Biological Signals* carried out by the project leader Dr. Tomislav Matić, Associate Professor (project duration: 1 January 2013 – 1 November 2013);
- *Capacitive Passive Identification System – CapsID* carried out by the project leader Dr. Davor Vinko, Associate Professor (project duration: 1 January 2014 – 31 December 2014);
- *Multifunctional Wireless Access Control System – mWAC* carried out by the project leader Dr. Drago Žagar, Full Professor (project duration: 1 January 2014 – 31 December 2014);
- *Chaotic PLC Modem* carried out by the project leader Dr. Marijan Herceg, Associate Professor (project duration: 1 January 2014 – 31 December 2014);
- *Wireless sensor network for measuring analogue signal* carried out by the project leader Dr. Tomislav Matić, Associate Professor (project duration: 16 November 2015 – 16 August 2017);
- *Wireless Charging Technology for Mobile Devices – PowerSurface* carried out by the project leader Dr. Davor Vinko, Associate Professor (project duration: 15 July 2016 – 14 July 2017).

The Faculty is a lead beneficiary of numerous projects financed by the European Union funds as follows:

- *Collaborative Internationalisation of Software Engineers in Croatia – TEMPUS KISEK*; the project was co-financed by the European Union within TEMPUS programme, project leader Dr. Željko Hocenski, Full Professor ;
- *Electricity Market Simulation and Analysis Curricula for Engineering Education – TEMPUS EMSA*; the project was co-financed by the European Union within TEMPUS programme, project leader Dr. Srete Nikolovski, Full Professor ;
- *Electricity Market Simulation and Analysis Curricula for Engineering Education*; the project was co-financed by the European Union within Leonardo Power Quality Initiative programme, project leader Dr. Srete Nikolovski, Full Professor ;
- *European sensor network architecture – ESNA*; the project was co-financed by the European Union within ITEA 05023 ESNA-BE programme, project leader Dr. Srete Nikolovski, Full Professor ;
- *Joint program of education and research in the area of renewable energy sources (RES) aiming to further develop Pannonian parts of Serbia and Croatia*; the project was co-financed by the European Union within IPA cross-border cooperation programme Croatia-Serbia, project leader Dr. Damir Šljivac, Full Professor ;
- *Photovoltaic Systems as Actuators of Regional Development*; the project was co-financed by the European Union within IPA cross-border cooperation programme Hungary-Croatia, project leader Dr. Denis Pelin, Associate Professor ;
- *Strengthening Women Position in the Labour Market*; the project was co-financed by the European Union within IPA IV, project leader Dr. Snježana Rimac-Drlje, Full Professor ;
- *In Pace with Global Trends to Support Active Labour Market Policy*; the project was co-financed by the European Union within IPA IV, project leader Dr. Goran Martinović, Full Professor ;
- *SeNs Wetlands-Active SEnsor Monitoring Network and Environmental Evaluation for Protection and Wise Use of WETLANDS and Other Surface Waters*; the project was co-

financed by the European Union within the Interreg IPA cross-border cooperation programme Croatia-Serbia, project leader Dr. Tomislav Keser, Assistant Professor ;

- *DRIVE - Modernizing Laboratories for Innovative Technologies*; the project was co-financed by the European Union within the Interreg IPA cross-border cooperation programme Croatia-Serbia, project leader Dr. Mario Vranješ, Associate Professor ;
- *RuRES - Renewable Energy Sources and Energy Efficiency in a Function of Rural Development*; the project was co-financed by the European Union within the Interreg IPA cross-border cooperation programme Croatia-Hungary, project leader Dr. Danijel Topić, Assistant Professor .

Within TETRACOM (Technology Transfer in Computing Systems) of the European Union FP-7 programme, the following Technology Transfer Project was financed:

- *Computer Vision Station Prototype for Biscuit Tiles Quality Control*, project leader Dr. Željko Hocenski, Full Professor (project duration: 1 January 2016 – 30 June 2016).

Within the Scientific Centre of Excellence in Data Science and Cooperative Systems, the Faculty participates in the project entitled

- *DATACROSS - Advanced Methods and Technologies in Data Science and Cooperative Systems*. The project was co-financed by the European Regional Development Fund and carried out by the project leaders Dr. Robert Cupec, Full Professor and Dr. Goran Martinović, Full Professor (project duration: 1 November 2017 – 31 October 2022).

Within the permanently open call for project proposals and allocation of non-refundable funds for the *Increase of the Development for New Products and Services which Supervene from Research and Development Activities* by the Croatian Agency for SMEs, Innovations and Investments HAMAG-BICRO, the Faculty participates in three following projects as a project partner:

- *Research in Spačva Inc. for the Purpose of Developing Innovative Massive Slavonian Oak Doors*; the project was financed by the European Union within the European Regional Development Fund and carried out by the project leader Dr. Dražen Slišković, Full Professor (project duration: 16 July 2018 – 16 July 2022);
- *Research of Beacon for the Purpose of Building a Walking Network - Development of an Urban Mobility Platform*; the project was financed by the European Union within the European Regional Development Fund and carried out by the project leader Dr. Goran Martinović, Full Professor (project duration: 1 June 2018 – 31 May 2020);
- *Development of an Integrative Platform for Smart Grids – SEGIP*; the project was financed by the European Union within the European Regional Development Fund and carried out by the project leader Dr. Denis Vranješ (project duration: 1 October 2018 – 30 September 2021).

The Faculty participates in the implementation of three international projects financed within Erasmus+ programme, Key activity 2: *Cooperation for Innovation and the Exchange of Good Practices* (Capacity Building in the Field of Higher Education) for the purpose of networking and mobility:

- *Boosting the Telecommunications Engineer Profile to Meet Modern Society and Industry Needs* (BENEFIT); project leader Dr. Drago Žagar, Full Professor (project duration: 15 October 2017 – 14 October 2020);
- *Innovative Lifelong e-Learning for Professional Engineers* (e-ProfEng); project leader Dr. Snježana Rimac-Drlje, Full Professor (project duration: 15 October 2017 – 14 October 2020);

- *Mastering Technical Competencies, Management Skills, and Societal Responsibilities* (TEAMSOC21); project leader Dr. Goran Martinović, Full Professor (project duration: 1 September 2017 – 31 August 2019).

In the period from 2013 until now, Josip Juraj Strossmayer University of Osijek has financed the following projects:

- *Establisment of Interdisciplinary Research Group in Field of Renewable Energy Sources and Their Integration to Future Smart Energy Systems*; project leader Dr. Damir Šljivac, Full Professor (project duration: 19 November 2018 – 19 May 2020);
- *Integration of Electric Vehicle Charging Stations into the Micro Grid Through System of Public Lighting Grid*; project leader Dr. Danijel Topić, Assistant Professor (project duration: 19 November 2018 – 19 May 2020);
- *Establishment of a Test Environment for Testing the Electric Vehicle Drive* Subsystems; project leader Dr. Željko Hederić, Full Professor (project duration: 19 November 2018 – 19 May 2020);
- *Optimization and Scheduling in a Dynamic System with Multiple Users and Service Providers*; project leader Dr. Ivica Lukić, Assistant Professor (project duration: 19 November 2018 – 19 May 2020);
- *Improving the Reliability of Autonomous Vehicle Driving by Using a Vehicle Camera System*; project leader Dr. Mario Vranješ, Associate Professor (project duration: 19 November 2018 – 19 May 2020);
- *Provision of Services Based on Digital Video Signals in Rural and Less Populated Areas*; project leader Dr. Mario Vranješ, Associate Professor (project duration: 7 April 2017 – 6 April 2018);
- *Appliance of HF Frequency Band for Wireless Sensor Power up to 100 Meters*; project leader Dr. Davor Vinko, Associate Professor (project duration: 7 April 2017 – 7 April 2018);
- *Wireless Power Transfer for Underground and Underwater Sensors*; project leader Dr. Davor Vinko, Associate Professor (project duration: 1 January 2015 – 31 December 2015);
- *3D Reconstruction and Segmentation of Wound Surface Using RGB-D Sensor*; project leader Dr. Damir Filko, Assistant Professor (project duration: 1 January 2015 – 31 December 2015);
- *Applying Optimization Methods for Demand Side Load Management in Distribution Networks with Photovoltaic Power Plants*; project leader Dr. Krešimir Fekete, Assistant Professor (project duration: 1 January 2015 – 31 December 2015);
- *IPV6 Protocol Implementation into Wireless Sensor Networks*; project leader Dr. Krešimir Grgić, Associate Professor (project duration: 24 September 2013 – 25 September 2014);
- *Application of the Soft Computing Methods for Electric Power Systems and Sets*; project leader Dr. Marinko Barukčić, Associate Professor (project duration: 24 September 2013 – 25 September 2014);
- *Development of the Methods for Ceramic Tiles Accelerated Parallel Image Processing Based on Amd Graphical Processing System*; project leader Dr. Tomislav Keser, Assistant Professor (project duration: 24 September 2013 – 25 September 2014);
- *A Wireless Passive Sensor Network for Environmental Parameters Monitoring*; project leader Dr. Davor Vinko, Associate Professor (project duration: 24 September 2013 – 25 September 2014);
- *The Efficient Video Delivery in Different Transmission Conditions*; project leader Dr. Mario Vranješ, Associate Professor (project duration: 24 September 2013 – 25 September 2014);
- *Consumption Management in the Electricity Distribution System with a Photovoltaic Power Plant Using Smart Solutions Measurements*; project leader Dr. Zvonimir Klaić, Associate Professor (project duration: 24 September 2013 – 25 September 2014);

- *Three-dimensional Heart Model Visualisation Based on Medical Imaging*; project leader Dr. Irena Galić, Associate Professor (project duration: 24 September 2013 – 25 September 2014).
- *Seismic Behavior of Reinforced Concrete Shear Wall Dominant Buildings,* project leader Dr. Damir Filko, (project duration: 1 October 2013 – 1 October 2014).

5. LIST OF COURSES

5.1. Joint Fundamental Courses

Year of Study: 1.							
Semester : I.							
Code	**Course**	**Lecturer**	**L**	**LP**	**S**	**ECTS**	**Status[1]**
ZT101	Methods of Scientific Research	Professor S. Rimac-Drlje	15	0+0+0	5	5	M
ZT102	Probability and Statistics - Application	Professor R. Galić	20	0+0+0	10	8	E
ZT103	Signal and System Analysis	Assistant Professor I. Galić	20	0+0+0	10	8	E
ZT104	Decision making Theory	Professor T. Hunjak	20	0+0+0	10	8	E
ZT105	Evolutionary Algorithms and Application	Professor R. Scitovski	20	0+0+0	10	8	E
ZT106	Complete measurement result and decision making	Assistant Professor K. Miličević	20	0+0+0	10	8	E
ZT107	Optimization techniques	Assistant Professor .M. Barukčić, Assistant Professor K.E. Nyarko, Assistant Professor T. Rudec	20	0+0+0	10	8	E

L = lectures, LP = laboratory practice, S= seminar paper, Status= mandatory course is marked with M, elective course is marked with E

5.2. Module: Power Engineering

5.2.1. Fundamental Courses of the module Power Engineering

Year of Study: 1.							
Semester: I.							
Code	**Course**	**Lecturer**	**L**	**LP**	**S**	**ECTS**	**Status**
TMEE101	Advanced methods of power system	Professor S. Nikolovski, Assistant	20	0+10+0	0	10	E

	analysis	Professor K. Fekete					
TMEE102	Advance Power Electronics for Applications in Renewable Energy Sources	Professor D. Šljivac	20	0+0+0	10	10	E
TMEE103	Automated electric drives	Assistant Professor . Ž. Hederić, Prof. dr.s.c. B. Štumberger	20	0+0+5	5	10	E

L = lectures, LP = laboratory practice, S= seminar paper, Status= mandatory course is marked with M, elective course is marked with E

5.2.2. Scientific specialisation courses of the module Power Engineering

Year of Study: 1.							
Semester: II.							
Code	**Course**	**Lecturer**	**L**	**LP**	**S**	**ECTS**	**Status**
ZUMEE101	Protection of high voltage network with FACTS devices	Professor S. Nikolovski	20	0+10+0	0	8	E
ZUMEE102	Power System Stability	Assistant Professor P. Marić	20	0+0+0	10	8	E
ZUMEE103	Power system operation planning in open market conditions	Assistant Professor G. Knežević	20	0+0+5	5	8	E
ZUMEE104	Energy efficiency in technical systems	Assistant Professor H. Glavaš	20	0+0+0	10	8	E
ZUMEE105	Distributed Electricity Generation from Renewable Energy Sources Modelying and SImulation	Assistant Professor D. Topić, Assistant Professor . S. Seme	20	0+0+0	10	8	E
ZUMEE106	Detecting causes of electric machine failures	Assistant Professor Ž. Hederić, Assistant Professor Z. Praunseis	20	0+0+5	5	8	E
ZUMEE107	Nonlinear Electrical Networks and Deterministic Chaos	Assistant Professor K. Miličević	20	0+0+0	10	8	E
ZUMEE108	Optimization and estimations in industrial and distribution networks using soft computing methods	Assistant Professor M. Barukčić, Professor. M. Hadžiselimoivić	20	0+5+0	5	8	E
ZUMEE109	Smart Power Grids	Assistant Professor Z. Klaić, Professor D. Šljivac	20	0+0+0	10	8	E

ZUMEE110	EES reliability and availability	Professor S. Nikolovski	20	0+10+0	0	8	E
ZUMEE111	Monitoring and Power Quality	Assistant Professor Z. Klaić	20	0+0+0	10	8	E
ZUMEE112	Switchgear and High Voltage Engineering	Professor J. Pihler	20	0+0+0	10	8	E
ZUMEE113	Advanced methods of electricity market analysis	Assistant Professor K.Fekete, M. Zeljko	20	0+10+0	0	8	E
ZUMEE114	Transients in Electrical Networks	Professor M. Stojkov	20	0+0+0	10	8	E
ZUMEE115	Theoretical electrotechnics – selected chapters	I. Tičar	20	0+0+0	10	8	E
ZUMEE116	Technological risk assessment	Z. Šimić	20	0+0+0	10	8	E
ZUMEE117	Highly Integrated High Voltage Facilities	Professor Z. Baus	20	0+0+0	10	8	E

L = lectures, LP = laboratory practice, S= seminar paper, Status= mandatory course is marked with M, elective course is marked with E

5.3. Module: Communications and Informatics

5.3.1. Fundamental Courses of the module Communications and Informatics

Year of Study: 1.							
Semester: I.							
Code	**Course**	**Lecturer**	**L**	**LP**	**S**	**ECTS**	**Status**
TMKI101	Communication network technologies	Professor D. Žagar	20	0+0+0	10	10	E
TMKI102	Wireless Communication Systems	Assistant Professor, .S. Rupčić	20	0+0+0	10	10	E
TMKI103	Integrated Circuits Design	Assistant Professor T. Matić, Izv. prof. dr.sc .D. Vinko	20	0+0+5	5	10	E

L = lectures, LP = laboratory practice, S= seminar paper, Status= mandatory course is marked with M, elective course is marked with E

5.3.2. Scientific specialisation courses of the module Communications and Informatics

Year of Study: 1.							
Semester: II.							
Code	**Course**	**Lecturer**	**L**	**LP**	**S**	**ECTS**	**Status**
ZUMKI101	Quality of service in Internet	D. Žagar	20	0+0+0	10	8	E
ZUMKI102	Advanced video processing methods	S. Rimac-Drlje	20	0+0+0	10	8	E
ZUMKI103	Smart antennas and systems	S. Rupčić	20	0+0+0	10	8	E
ZUMKI104	Wideband Networks for Multimedia Services	M. Vranješ	20	0+0+0	10	8	E
ZUMKI105	Cybersecurity	K. Grgić	20	0+10+0	0	8	E
ZUMKI106	Modern architectures of radiocommunication systems	M. Herceg	20	0+0+0	10	8	E
ZUMKI107	Open networks communication systems	D. Huljenić	20	0+0+0	10	8	E
ZUMKI108	Software in Television	N. Teslić	20	0+10+0	0	8	E

L = lectures, LP = laboratory practice, S= seminar paper, Status= mandatory course is marked with M, elective course is marked with E

5.4. Module: Computer Science

5.4.1. Fundamental Courses of the module Computer Science

Year of the Study: 1.							
Semester: I.							
Code	**Course**	**Lecturer**	**L**	**LP**	**S**	**ECTS**	**Status**
TMR101	Resource and Performance Management in Computer Sysetems	Professor G. Martinović	20	0+0+0	10	10	E
TMR102	Parallel and Multicore Architectures	Professor Ž. Hocenski	20	0+0+0	10	10	E
TMR103	Component-based Software Systems	Professor I. Crnković	20	0+0+0	10	10	E

L = lectures, LP = laboratory practice, S= seminar paper, Status= mandatory course is marked with M, elective course is marked with E

5.4.2. Scientific specialisation courses of the module Computer Science

Year of the Study: 1.							
Semester : II.							
Code	**Course**	**Lecturer**	**L**	**LP**	**S**	**ECTS**	**Status**
ZUMR101	Computer Systems and Methods for Data Analysis	G. Martinović	20	0+0+0	10	8	E
ZUMR102	Software Reliability	Ž. Hocenski, T. Matić	20	0+0+0	10	8	E
ZUMR103	3D Computer Graphics and Geometric Modelling	Assistant Professor Irena Galić	20	0+0+0	10	8	E
ZUMR104	Design of FPGA systems	Ž. Hocenski	20	0+0+0	10	8	E
ZUMR105	Intelligent Robotic Systems	R. Cupec	20	0+0+0	10	8	E
ZUMR106	Data science	R. Grbić, J. Job	20	0+0+0	10	8	E
ZUMR107	Deep learning	R. Grbić, K.E. Nyarko	20	0+0+0	10	8	E
ZUMR108	Real-time signal, image and video	Ž. Hocenski, D. Kraus, I. Aleksi	20	0+0+0	10	8	E

	processing						
ZUMR109	High performance and scientific computing	Z. Krpić, I. Crnković	20	0+0+0	10	8	E
ZUMR110	Algorithms for NP-hard and online problems	T. Rudec	20	0+0+0	10	8	E
ZUMR111	Data Clustering Algorithms	R. Scitovski	20	0+0+0	10	8	E
ZUMR112	Computer Systems Real-Time Management	M. Colnarič	20	0+0+0	10	8	I
ZUMR113	Intelligent Manufacturing Processes	K. Nenadić	20	0+0+0	10	8	I

L = lectures, LP = laboratory practice, S= seminar paper, Status= mandatory course is marked with M, elective course is marked with E

Seminars for the acquisition of generic skills

Year of Study: 1., 2., 3.							
Semestar: I., II., III., IV., V., VI.							
Code	**Seminars**	**Lecturer**	**L**	LP (AV+LV+ KV)	**S**	**ECTS**	**Status**
S101	Academic writing	I. Ferčec D. Božić Lenard Y. Lierman Zeljak	6	6+0+0	0	1	E
S102	Application of open source text editors for writing scientific paper	I. Galić	3	0+9+0	0	1	E
S103	The Scientific Research Projects Application and Implementation	Štefanić I., D. Krstić	3	3+0+0	6	1	E
S104	Statistical Practicum	M. Benšić	6	0+0+0	6	1	E
S105	Simulation tools for EES analysis	S. Nikolovski	2	0+10+0	0	1	E
S106	New Approaches for Project Management	V. Majstorović	6	0+0+0	6	1	E
S107	Research Seminar	Voditelj poslijediplomskog sveučilišnog studija	0	0+0+0	4	4	M

L = lectures, LP = laboratory practice, S= seminar paper, Status= mandatory course is marked with M, elective course is marked with E

6. List of the Courses with Description and Main Informations

6.1. Joint Fundamental Courses

General information		
Lecturer(s)	**Professor Snježana Rimac-Drlje**	
Course title	**Methods of Scientific Research**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Joint fundamental course	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	15L+0+5S

1. COURSE DESCRIPTION

1.1. Course objectives

Empowering postgraduate students to independently plan and conduct advanced scientific research with the aim of creating new knowledge in the chosen scientific field while writing and publishing scientific work.

1.2. Course enrolment requirements

There are no special requirenments.

1.3. Expected learning outcomes

After passing the course, students will be able to:

1. using bibliographic and quotation bases, choosing the appropriate literature for the research
2. critically evaluate and select appropriate research methods and techniques
3. conduct research according to the research plan
4. choose a suitable journal or conference to publish research results and write a scientific paper in accordance with that choice
5. presenting scientific work

1.4. Course content

Classification of science. Categories of scientific research: fundamental, applied, developmental; examples. Research task and scientific hypothesis, preparation of research plan. Methods of research. Bibliographic and citation databases; efficient search bases. Procedures for finding journals and articles in a particular scientific area. Concept and choice of article topic, basic elements of a scientific article and the process of its submission, reviews and publications in the journal. Presentation of work on scientific conferences. Ethics in carrying out scientific-research work. Copyright protection.

1.5. Types of classes	X lectures X seminars and	X individual work ☐ multimedia

	workshops ☐ auditory excersises ☐ distance learning ☐ fieldwork	☐ laboratory excersises ☐ design exercises X work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Attending lectures, studying literature, writing seminar work (reviewing the field of research), preparing Power point presentations and presenting seminar work.

1.8. Monitoring and assessment of student work

Attendance	0,5	Participation in classes		Seminar paper	3	Experimental work	
Midterm exams (written) exam)		Oral exam		Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio				Project proposal preparation		Presentation	1,5

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max
Lecture (s) Attendance	0,5	1,2,3,4,5	Lecture	Evidence of attendance The minimum required for signature is: 0%	0	10
Research and preparation of oral exam	3	1,4	Oral exam	Evaluation of the applied research competence levels and the rules of writing the scientific work	40	60
Prpearation of the			Public	Evaluation of		

presenataion and the report	1,5	5	presentation	the presentation	20	30

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. D.V. Thiel: Research Methods for Engineers, Cambridge University Press, 2014.

1.11. *Recommended additional literature (at the time of submitting a study programme proposal)*

1. M. Žugaj: Metodologija znanstveno-istraživačkog rada. Fakultet organizacije i informatike, Varaždin, 1997.

2. R. Zelenika: Metodologija i tehnologija izrade znanstvenog i stručnog djela. Ekonomski fakultet, Rijeka, 2000.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Research Methods for Engineers	1	10

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information		
Lecturer(s)	Professor Radoslav Galić	
Course title	**Probability and Statistics - Application**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Joint fundamental course	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

2. COURSE DESCRIPTION

1.1. Course objectives

Introduction to statistical terminology and laws, and construction of statistical models and application of statistical methods in: engineering, process control, quality control and other problems. Preparation for lifelong learning process and use of mathematical tools in application.

1.2. Course enrolment requirements

1.3. Expected learning outcomes

1. Model specific examples using basic probability properties
2. Construct sets of values of a random variable on examples of discrete and continuous one-dimensional and two-dimensional probability distribution
3. Analyze the use of correlation in research
4. Construct statistical models and interpret statistical inference on a set of research results

5. Analyze regression analysis, statistical analysis of time series and trend models on a set of research results
6. Analyse the selected set of statistical data by using appropriate statistical methods and ready-made statistical software packages

1.4. Course content

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

1.8. Monitoring and assessment of student work

Attendance	1.5	Participation in classes		Seminar paper	4.5	Experimental work	
Midterm exams (written) exam)		Oral exam	2	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance	1.5	3, 5	Lectures	Attendance register.	0	10
Oral exam	2	1, 2, 4, 6	Oral exam	Assessment of student's answers	0	10
Seminar paper	4.5	2, 3, 4, 5, 6		Evaluation of the seminar paper	0	80

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. R. Galić, Vjerojatnost i statistika, ETFOS, Osijek, 2013.
2. Ž. Pauše, Uvod u matematičku statistiku, Školska knjiga, Zagreb, 1995.
3. D.C. Montgomery, Applied Statistics and Probability for engineers. USA: Wiley, 2014.
4. G. M. Clarke, D. Cooke, A Basic Course in Statistics, Arnold, London, 1992.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Pavlić, Statistička teorija i primjena, Tehnička knjiga, Zagreb, 2000.
2. Ž. Pauše, Vjerojatnost i stohastički procesi, Školska knjiga, Zagreb, 2004
3. R. Galić, Vjerojatnost , ETFOS, Osijek, 2004
4. R. Galić, Statistika, ETF, Osijek, 2004.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
R. Galić, Vjerojatnost i statistika, ETFOS, Osijek, 2013.		
Ž. Pauše, Uvod u matematičku statistiku, Školska knjiga, Zagreb, 1995		
D.C. Montgomery, Applied Statistics and Probability for engineers. USA: Wiley, 2014.	1	

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information		
Lecturer(s)	Assistant Professor Irena Galić	
Course title	**Signal and System Analysis**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Joint fundamental course	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

3. COURSE DESCRIPTION

1.1. Course objectives

Concepts and tools for continuous- and discrete-time signal and system analysis with applications in electro engineering, communications, and computer science.

1.2. Course enrolment requirements

Requirements met for enrolling in the study programme.

1.3. Expected learning outcomes

1. Analyse models of time continuous (TC) and discrete (TD) signals.
2. Interpret and calculate the convolution, and analyse the result.
3. Use Fourier Transform (TCFS, TCFT, TDFS, TDFT) and their properties.
4. Measure and explain errors when transmitting a digital signal.
5. Interpret Wavelet Transform.
6. Analyse and process a signal.
7. Interpret variational methods.
8. Formulate a mathematical model that has application in the field of electrical engineering or communication or computer science, and explain the result.

1.4.Course content

Models of continuous and discrete signals. Classification. Linear operators. Mapping. Properties, duration, bandwidth, and signal dimensionality. Convolution. Stochastic signal. White and coloured noise. Spectral analysis. Detection of signal. Digital signal transmission errors. Time-frequency processing. Wavelet transformation. Multi-resolution analysis. Variation methods.

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Defined by the FERIT Student Assessment Framework.

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes		Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	Yes	Essay		Research	
Project	Yes	Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT	ECTS	LEARNING	TEACHING	METHOD OF	CREDITS

ACTIVITY	CREDITS	OUTCOME	METHOD	ASSESSMENT	min.	max.
Attendance lectures.	1	1, 2, 5, 7	Lectures	Attendance recording. The minimum required for signature is: 50%.	5	10
Solving a project assignment.	3	1-8	Project	Verification of the resolved project and scoring the accuracy of the solution, the appropriateness and complexity of the approach.	20	40
Writing and preparation of seminar paper.	2	1-8	Seminar paper	Checking the seminar work, scoring the problem description and presentation mode.	12	25
Preparation for oral exam and answering given questions.	2	1-8	Oral exam	Verification of given answers.	13	25

1.10.Obligatory literature (at the time of submitting a study programme proposal)

1. R. L. Allen, D. W. Mills: Signal Analysis: Time, Frequency scale, and Structure, Whiley-IEEE Press, 2004.
2. F. De Coulon: Signal Theory and Processing, Artech House, Dedham, 1986.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. G. Bachman, L. Narici, E. Beckenstein: Fourier and Wavelet Analysis, Springer-Verlag, New York, 2000.
2. G. Cariolaro: Unified Signal Theory, Springer, 2011.
3. I. Daubechies: Ten Lectures on Wavelets, SIAM, 1992.
4. P. Nickolas: Wavelets: A Student Guide, Cambridge University Press, 2017.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*

R. L. Allen, D. W. Mills: Signal Analysis: Time, Frequency scale, and Structure	0	
F. De Coulon: Signal Theory and Processing	0	

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Conducting university questionnaires on teachers (student-teacher relationship, transparency of assessment criteria, motivation for teaching, teaching clarity, etc.). Conducting Faculty surveys on courses (upon passing the exam, student self-assessment of the adopted learning outcomes and student workload in relation to the number of ECTS credits allocated to activities and courses as a whole).

General information		
Lecturer(s)	**Full Professor Tihomir Hunjak**	
Course title	**Decision making Theory**	
Study programme	Postgraduate Doctoral Study Programme Electrical Engineering and Computer Science, Joint fundamental course	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credit	8
	Number of classes (lectures + exercises + seminars)	20L + 10E

1. COURSE DESCRIPTION

1.1. Course objectives

Knowledge about and application of decision-making theory, the use and development of information decision systems.

1.2. Course enrolment requirements

There are no special skills required.

1.3. Expected learning outcomes

1. Developing different approaches to the decision problem solving which is depending on its characteristics.
2. Identify and apply methods for multi-criteria decision-making in solving decision-making problems. Using the methods of group decision making.
3. Using information decision support systems.
4. Analyze risks using simpler methods such as sensitivity analysis and more complex methods using the Monte Carlo simulation (on financial models).
5.Resource priorities in risk management.
6. Forming a projects portfolio.
7. Create models for solving multi-stakeholder decision-making problems.

1.4. Course content

Introduction; decision making, decision making elements, methods for decision making. Multi-criteria decision making. Vector Optimization. Basic theoretical results and characterization of. Multi-criteria decision-making issues, criteria, criteria complexity. Value theory; postulates, functions. Usefulness theory. Analytic Hierarchy Process (AHP method) and Analytic Network Process (ANP method). Method of values for determining alternative priorities and criteria based on

their pairwise comparison. Hierarchical decision making and AHP method. Criteria interaction; reflexive relationship and structure. ANP method. Method of determining alternative criteria based on their pairwise comparison and complex relations. Preference relations. Criterion and pseudo criterion. ELECTRA and PROMETHEE methods. Decision-making methods under uncertainty and risks. making theory, decision-making tree, Bayes formula, information values. Risk and risk analysis based on Monte Carlo simulation. Risk analysis in project management. Modeling of uncertainty numbers and logic. The fuzzy variant of selected methods for multicriteria decision making.

1.5. Types of classes	X lectures ☐ seminars and workshops ☐ auditory excersises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory excersises ☐ design excersises X work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Attending classes, preparing seminar work, passing an oral exam

1.8. Monitoring and assessment of student work

Attendance	1,5	Participation in classes		Seminar paper	5	Experimental work	
Midterm exams (written) exam)		Oral exam	1,5	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max
Attendance	1,5	1,2,4,5,6	Lectures	Evidence of presence	0	0
Seminar paper	5	1-7	Studying literature, conducting research, developing seminar	Evaluation quality of the research and presentation of results	50	70

Oral exam	1,5		Oral exam	Evaluation of given answers	10	30

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. Čaklović, L.: Teorija vrednovanja, Naklada Slap, Jastrebarsko, 2014.
2. Figueira, J., Greco, S., Ehrgott, M., (eds): Multiple Criteria Decision Analysis: State of the Art Surveys, Springer Science + Business Media, Inc., New York, 2005
3. French, S. (1986): Decision Theory, Ellis Harwood, Chichester.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Robert T. Clemen (1997), Making Hard Decisions: An Introduction to Decision Analysis, Duxbury Press; 2 edition
2. Saaty, T.L., Multicriteria Decision Making: The Analytic Hierarchy Process, RWS Publications, 4922 Ellsworth Ave., Pittsburgh, PA 15213.
3. Goodpasture, J.C., Quantitative Methods in Project Management, J. Ross Publishing, 2004.
4. Schuyler, J., Risk and Decision Analysis in Projects, Project Management Institute, 2001.
5. Sikavica, P., Hunjak, T., Begičević-Ređep, N., Hernaus, T.: Poslovno odlučivanje, Školska knjiga, Zagreb, 2014
6. Saaty, T.L., Vargas, L.G., Decision Making with the Analytic Network Process, Springer Science + Business Media, LLC, New York, 2006.

1.12.Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Teorija vrednovanja	0	3
Criteria Decision Analysis: State of the Art Surveys	0	3
Decision Theory	0	3

1.1.3.Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information		
Lecturer(s)	**Professor R. Scitovski**	
Course title	**Evolutionary Algorithms and Application**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Joint fundamental course	
Course status	Elective fundamental course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20LE +10S

1. COURSE DESCRIPTION

1.1. Course objectives

Knowledge of basic global optimization algorithms and their application in some areas of research. Implementation of those algorithams with Mathematica and Matlab.

1.2. Course enrolment requirements

Achieved rights for 3rd semester entry.

1.3. Expected learning outcomes

After passing the course, students will be able to:
1. to integrate the developments of scientific research in the field
2. create a recent review of several important applications in the field
4. formulate complex numerical algorithms.
5. create applications using Mathematica or Matlab software systems.
6. write scientific papers on the requirements of top scientific journals.

1.4. Course content

Illustrative examples. Convex and quasi-convex function. Downward Methods for Convex Functions (Coordinate Relaxation, Gradient Method, Newton's and Quasi-Newt's Minimization Methods). One-dimensional minimization of strict quasi-quantization functions (Enclosure Method, Method of Caption, Gold Cut Method). One-dimensional global optimization (Lipschitz-Continuous Functions, Pious-Method of Broken Duties, Shubert's Method, DIRECT Algorithm). Multidimensional global optimization (DIRECT optimization algorithm for multi variable function, DIRECT optimization algorithm for symmetric function). Evolutionary algorithms. Nelder-Mead method.

1.5. Types of classes	X lectures ☐ seminars and workshops ☐ auditory excersises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory excersises ☐ design excersises X work with a dissertation supervisor ☐ other _____
1.6. Comments		

1.7. Student obligations

Attendance of lectures / consultations, writing papers for publication in a journal or presentation at a conference.

1.8. Monitoring and assessment of student work

Attendance	1,5	Participation in classes		Seminar paper		Experimental work	
Midterm exams (written) exam)		Oral exam		Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio						Making a paper for a journal or a conference	6,5

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max
Attendance	1,5	1-4	Lectures	Attendance monitoring. The minimum required for signature is 0%	0	10
Scientific research and writing paper for a journal or conference	6,5	1-6	Consultations	Evaluation of applied research competences in the preparation of scientific paper.	40	90

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1.R.Scitovski, K.Sabo, D.Grahovac, Globalna optimizacija, Odjel za matematiku, *Sveučilište u Osijeku,* 2016 – rukopis

2. E.M.T.Hendrix, B.G.Tóth, P.M.Pardalos, D.Z.Du *(Eds.),* Introduciton to Nonlinear and Global Optimization *Springer,* 2010

1.11. 1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. R.Grbić, E.K. Nyarko, R. Scitovski, A modification of the DIRECT method for Lipschitz global optimization for a symmetric function, *Journal of Global Optimization, 57(*2013*),* 1193-1212

2. R.Paulavičius, J.Žilinskas, Simplicial Global Optimization, *Springer,* 2014

3. J.D.Pintér, Global Optimization in Action (Continuous and Lipschitz Optimization: Algorithms, Implementations and Applications), *Kluwer Academic Publishers, Dordrecht,* 1996

4. J.Pintér,*(Ed.)* Global Optimization: Scientific and Engineering Case Studies, *Springer,* 2006

5. Gablonsky, J. M.: Direct version 2.0, Technical report, Center for Research in Scientific Computation. North Carolina State University (2001)

6. R.Scitovski, N.Truhar, Z.Tomljanović, Metode optimizacije, *Odjel za matematiku, Sveučilište u Osijeku,* 2014

7. Y.D.Sergeyev, D.E.Kvasov, J.Cochran *(Ed.),* Lipschitz global optimization, *Wiley Encyclopedia of Operations Research*

8. C.M.Bishop, M.Jordan, J.Kleinberg, B.Scho¨lkopf *(Eds.),* Pattern Recognition and Machine Learning, *Springer,* 2006

9.N.Truhar, Numerička linearna algebra, *Odjel za matematiku, Sveučilište u Osijeku,* 2010

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Globalna optimizacija	0	3
Introduciton to Nonlinear and Global Optimization	0	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information		
Lecturer(s)	**Professor Kruno Milicevic PhD**	
Course title	**Complete measurement result and decision making**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Joint fundamental course	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION		
1.1. Course objectives		
To present to students all aspects of measurement relevant to metrology for obtaining and interpreting a complete measurement result for decision making based on the same.		
1.2. Course enrolment requirements		
Enrolled corresponding academic year / semester.		
1.3. Expected learning outcomes		
1. Express the high-level measurement result correctly 2. Apply metrology standards in testing 3. Evaluate compliance 4. Interpret the measurement results and decide on the basis of a complete measurement result		
1.4. Course content		
Measurement uncertainty. Proper expression and interpretation of the measurement results. Propagation of uncertainty measurement by indirect measurements. Frequentist and Bayesian approach. Monte Carlo and the adaptive Monte Carlo method for estimation of measuring uncertainty. Conformity assessment. Deciding on the basis of a complete measurement result.		
1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English and German	
1.7. Student obligations		

Seminar work, solving practical problems during lectures, oral exam.

1.8. Monitoring and assessment of student work

Attendance	0,2	Participation in classes	0,2	Seminar paper	3,6	Experimental work	
Midterm exams (written) exam)		Oral exam	4	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attending classes	0,2	1,2,3,4	Lectures and exercises	Registering the presence	0	0
Solve group tasks	0,2	1,2,3	Lectures and exercises	Correcting solved tasks	0	20
Writing seminar work	3,6	1,2,3	Seminar paper	Checking and evaluating seminar work	0	35
Answering questions	4	1,2,3,4	Oral exam	Evaluating the answers given	0	45

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. Smith, R.C. Uncertainty Quantification. SIAM 2014
2. Guide to the expression of uncertainty in measurement, Joint Committee for Guides in Metrology, 2008.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Devinderjit Sivia, Data Analysis: A Bayesian Tutorial, Oxford University Press; 2 edition, 2006

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*

Smith, R.C. Uncertainty Quantification. SIAM 2014	10	10
Guide to the expression of uncertainty in measurement	Available online	10

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information		
Lecturer(s)	**Assistant Professor Marinko Barukčić, Assistant Professor Emmanuel Karlo Nyarko, Assistant Professor Tomislav Rudec**	
Course title	**Optimization techniques**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Joint fundamental course	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course objectives

Inform students about methods for local and global optimization. Train students to create and use an optimization problem model. Train students to apply the appropriate optimization computing tools.

1.2. Course enrolment requirements

1.3. Expected learning outcomes

1. Based on the given problem instance the student will create a linear, integer or 0-1 version of the model of the problem.
2. The student will create given programming instance in the form required for computer-based solution and after analyzing the solution obtained on the computer, analyze the obtained evaluation schedule.
3. Students will create a multi objective optimization problem and will evaluate solutions obtained by simulation on a computer
4. The student will propose a solution to the specific problem by using the appropriate methods of optimization.
5. Students will evaluate different metaheuristic methods of optimization.

1.4. Course content

Linear programming. Integer and 0 -1 programming. Writing a linear program in the Winqsb software package. Interpretation of the solution. Evolutionary algorithms. Criteria functions. Multi-purpose optimization. Pareto definitions. Hybrid optimization methods.

1.5. Types of classes	☒ lectures ☒	☒ individual work

	seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ multimedia ☒ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments		

1.7. Student obligations

Class attendance, project assignment preparation, seminar paper preparation, attending consultations, oral exam

1.8. Monitoring and assessment of student work

Attendance	10 %	Participation in classes		Seminar paper	80 %	Experimental work	
Midterm exams (written) exam)		Oral exam	10 %	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance	1	1, 2	Lectures	Attendance register.	5	10
Oral exam	6	5	Oral exam	Assessment of student's answers	50	80
Seminar paper	1	1, 2, 3, 4		Evaluation of the seminar paper	5	10

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. C. A. Coello Coello, A Short Tutorial on Evolutionary Multiobjective Optimization.
Available online: http://ftp.bstu.by/ai/To-dom/My_research/Papers-0/For-lecture/Moga/tutorial-slides-coello.pdf
2. Sean Luke, Essentials of Metaheuristics, 2nd Edition, 2013.
Available online: https://cs.gmu.edu/~sean/book/metaheuristics/Essentials.pdf
3. Thomas S. Ferguson, LINEAR PROGRAMMING A Concise Introduction
Available online: https://www.math.ucla.edu/~tom/LP.pdf

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. C. Coello Coello, G. B. Lamont, D. A. van Veldhuizen, Evolutionary Algorithms for Solving Multi-Objective Problems, 2007, Springer US (http://www.springer.com/gp/book/9780387332543)
1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences
The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

6.2. Module: Power Engineering

6.2.1. Fundamental Courses of the module Power Engineering

General information		
Lecturer(s)	**Srete Nikolovski, Full Professor , Krešimir Fekete, Assistant profesor**	
Course title	**Advanced methods of power system analysis**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering	
Course status	Basic course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	10
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION
1.1. Course objectives
In this course students are prepared to independently apply and develop advanced methods for power system analysis, including: single phase power flows in power networks with unbalanced load, harmonic analysis and frequency scan in power networks with harmonic distortion and optimization calculations in power system (optimal power flow, economic dispatch and state estimation).
1.2. Course enrolment requirements
-
1.3. Expected learning outcomes
1. Formulate mathematical models of power system elements required for advanced power system analysis. 2. Connect the problem of traditional power flow with the problem of unbalanced power flows due to unbalanced loads. 3. Formulate a harmonic analysis calculations and obtain a frequency response for a power network. 4. Classify the optimization problems applied to the power system analysis. 5. Design own example of a general optimization problem and perform a mathematical process of finding optimum. 6. Create own optimal optimization model of optimum power flows. 7. Develop a state estimation model for small power system.

1.4. Course content

An overview of the mathematical models of power system elements needed for advanced power system analysis. Harmonic analysis and frequency response of the network with harmonic distorted loads. Mathematical definition of optimization problem and solution of general optimization model - sufficient and necessary optimum condition, KKT conditions. The application of optimization in advanced power system analysis: the optimal power flows, state estimation when the number of unknowns in power system is greater than the measured values etc.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☒ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Students are required to attend at least 75% of the lectures, to work through all laboratory exercises, to create the individual project and pass the oral exam.

1.8. Monitoring and assessment of student work

Attendance	1	Participation in classes		Seminar paper		Experimental work	
Midterm exams (written) exam)		Oral exam	2	Essay		Research	
Project	3	Report		Laboratory exercises	2	Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance	1	1.,2.,3.,4.,5.,6. and 7.	Lectures and laboratory excercises	Recording attendance	0	0
Preparing for laboratory exercises, analysis of results, and	2	2., 3.,5., 6. i 7.	laboratory exercises	Checking preparation, monitoring and control in the laboatory and	10	20

writing reports				checking written reports		
Project making	3	2., 3., 6. i 7.	Individual work	Reviewing and evaluating the project	20	40
Preparation for oral exam and oral examination	2	1., 2., 3. i 4.	Oral exam	Checking given answers	20	40

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. I. Pavić, Trofazni proračun tokova snaga, Sveučilišna skripta, FER 2011 (in Croatian)
2. Jose Arrillaga, Neville R. Watson, Power system harmonic, John Wiley & Sons, 2003
3. A.J. Momoh, Electric Power System Applications of Optimization, CRC Press, Taylor & Francis Group, Boca Raton, Florida, 2009.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. K. Fraendorfen, H. Glavitsch and R. Bacher, Optimization in Planning and Operation of Electric Power Systems: Lecture Notes of the SVOR/ASRO Tutorial Thun, Switzerland, October 14–16, 1992

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
I. Pavić, Trofazni proračun tokova snaga, Skripta FER 2011	1	5
Jose Arrillaga, Neville R. Watson, Power system harmonic, John Wiley & Sons, 2003	1	5
A.J. Momoh, Electric Power System Applications of Optimization, CRC Press, Taylor & Francis Group, Boca Raton, Florida, 2009	1	5

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information	
Lecturer(s)	**Associate Professor Damir Šljivac**
Course title	**Advance Power Electronics for Applications in Renewable Energy Sources**
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering

Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	10
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course objectives

Students should be familiar with advance topologies of the Power Electronic Converter (PEC) for integration Renewable Energy Sources in the utility grid or/and for connection loads with different characteristics. Introduce modulation techniques for control PEC to students regarding to optimisation harmonic content chosen currents or/and voltages as well as procedures for mitigation influences of PES on utility grid.

1.2. Course enrolment requirements

Accomplish criterion for entry on study.

1.3. Expected learning outcomes

1. Classify advance topologies PEC for integration RES in the utility grid
2. Classify modulation techniques for control switching components of PEC.
3. Formulate procedures for mitigation influences of PES on utility grid.
4. Recommend the way of control PEC with purpose of optimisation harmonic content chosen currents or/and voltages.

1.4. Course content

Specifications of systems for electrical energy production from renewable energy sources(REC) and their distribution. Advance topologies of power electronic converter (PEC) for integration RES in utility grid or/and for connection of loads of different characteristics.PEC for energy efficient production of electrical energy by using hybrid systems. Modulation techniques for control PEC in the manner to optimise harmonic content of currents or/and voltages of utility grid. Influences of PEC on utility grid. The procedures for mitigation influences of PEC on utility grid. AC filters. Active filters

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☒ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Defined by evaluation criterion for students FERIT and entry 1.9

1.8. Monitoring and assessment of student work

Attendance	Ye	Participation in		Seminar paper	Yes	Experimental work	

	s	classes					
Midterm exams (written) exam)		Oral exam	Yes	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance	1,5	1,2,3	Lectures	Evidence of attendance	0	10
Seminar paper	2,5	3,4	Individual work with student	Checkout of written seminar paper	0	60
Prepare for oral exam and oral exam	2	1,2,3	Oral exam	Checkout of given answers	0	30

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. S.Sumathi, L.A.Kumar,P.Surekha: Solar PV and Wind Energy Conversion Systems; Springer, Switzerland, 2015.
2. I.Flegar: Elektronički energetski pretvarači , Kigen, Zagreb, 2010.
3. R.Teodoresu, M. Liserre, P. Rodrigez: Grid Converters for Potovoltaic and Wind Power Systems, John Wiley & Sons (United Kingdom), 2011.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Rashid, M. H. Power electronics, Pearson Prentice Hall, 2004.
2. Chan-Ki Kim, Vijay K. Sood, Gil-Soo Jang, Seong-Joo Lim and Seok-Jin Lee: HVDC Transmission Power Conversion Application in Power Systems, John Wiley & Sons (Asia), 2009.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
I. Flegar: Elektronički energetski pretvarači, Kigen, Zagreb, 2010	10	

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Committee for postgraduate doctoral overlooks regularity and quality of maintained teaching as well as consultations and exams as appropriate the students evaluation questionnaire should be done.

General information		
Lecturer(s)	**Professor Željko Hederić, Professor B. Štumberger**	
Course title	**Automated electric drives**	
Study programme	**Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering**	
Course status	Scientific directing courses	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	10
	Number of classes (lectures + exercises + seminars)	20L+5E+5S

1. COURSE DESCRIPTION

1.1. Course objectives

Introduce students with advanced computer modelling techniques using soft computing software's. To enable students to conduct an analysis of electric drives, identification parameters for automated management with regard to the requirements of industrial processes. To enable students to develop Scada interface for diagnostics and monitoring using LabVIEW software package. To introduce students to the specific requirements of managing the facility for positioning and hybrid electric drives in vehicles. Present students advanced techniques of optimization in order to intelligent control plants.

1.2. Course enrolment requirements

Enrolled corresponding academic year / semester.

1.3. Expected learning outcomes

1. Differentiate the technique of modelling electrical machines using concentrated and distributed parameters
2. Apply systems for scalar, predictive and vector control of the electric machine
3. Analyse the stationary and dynamic states of the electric motors with respect to the requirements of the industrial process
4. Design the design of automatic control systems for electrical installations
5. Identify and implement state-of-the-art diagnostic procedures and monitoring the operation of electrical machines in the drives
6. Analyse the hybrid electric motor control system

1.4. Course content

Advanced techniques for modelling electrical machines using concentrated metrics (MATLAB) and distributed parameters (Ansys-Maxwell) in order to obtain control parameters. Scalar, predictive and vector control of the electric machine. Analysis of electromotor drives, stationary and dynamic states, quadratic drives. The architecture of the automated control system of electric plants. Automation of electric drives with respect to industrial process requirements. Development of interface for diagnostics and monitoring: mechanical, electrical and control aspects of design. Automated Diagnostic Systems for Monitoring the Condition of an Electric Machine in Operating Conditions. Control of positioning plants. Hybrid electric drives in plants and in transport. Intelligent automated control systems.

1.5. Types of classes	☒ lectures ☒ seminars and workshops	☒ individual work ☐ multimedia ☐ laboratory exercises ☒ design exercises

	☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ work with a dissertation supervisor ☐ other _____ _
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Seminar work, solving practical problems during lectures, oral exam.

1.8. Monitoring and assessment of student work

Attendance	0,5	Participation in classes		Seminar paper	2,5	Experimental work	
Midterm exams (written) exam)		Oral exam	3	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	2
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attending classes	0,5	1,3,4,6	Lectures and exercises	Registering the presence	0	0
Construction exercises	2,0	2,4,5	Lectures and exercises	Correcting solved tasks	15	30
Writing seminar work	2,0	3-6	Seminar paper	Checking and evaluating seminar work	20	40
Answering questions	3	1,3,4,6	Oral exam	Evaluating the answers given	15	30

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. 1. T.M. Bartelt, Industrial Automated Systems: Instrumentation and Motion Control, Cengage Learning, Delmar, 2011.
2. D. Sumina: Električna pogonska tehnika, Graphis, Zagreb, 2013
3. Ž. Ban, J. Matuško: Primjena programskog sustava MATLAB za rješavanje tehničkih problema, Sveučilište Zagreb, 2010

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Riefenstahl, U.: Elektrische Antriebstechnik, Teubner Verlag, Stuttgart Leipzig, 2000.
2. Vasilios N. Katsikis: MATLAB - A Fundamental Tool for Scientific Computing and Engineering Applications, INTECH open access book, 2012
3. Avinash Konkani: Advances in Systems, Control and Automation, Springer, 2017

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

6.2.2. Scientific specialisation courses of the module Power Engineering

General information		
Lecturer**(s)**	**Professor Srete Nikolovski**	
Course title	**Protection of high voltage network with FACTS devices**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course objectives

Training students for sellection of distance protection of HV networks. Detail introduce in FACTS devices and their influence on distance zone protection parameters of HV networks. Modeling HV network with FACTS devices and parametrize protection for all type of faults in simulation software DIgSILENT i DIGSI.

1.2. Course enrolment requirements

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1.3. Expected learning outcomes

1. Define the functions and characteristics of distance protection for HV networks
2. Analyse all types of FACTS devices in HV networks
3. Analyse the influence of FACTS devices on distance protection in HV networks
4. Overcome the settings of distance protection in HV networks with FACTS devices using PCM 600 ili DIGSI software
5. Modeling HV network and all types of distance protections and FACTS devices in DIgSILENT programe package

6. Simulirati VN mrežu, parametrirati distantne releje i FACT sustave za sve tipove kratkih spojeva u VN mreži

1.4. Course content

Advanced method and algorithms of distance protection of HV networks. Impedance diagram and protection zones, as well blocking zone of distence relays. Time –impedance steps of distance relays. Communication of distance relays. FACTS devices in HV networks. Serijal and shunti FACTS devices. STATCOM, SVC, SSG, BEM, UFPC, IPFC devices and their characteristics. The influence of FACTS devices on the protection problems of HV networks. Modeling of HV networks elements with FACTS devices. Simulation od short circuits and setting of distance protection and system protection in HV networks for lost of synhronous in network. The influence of FACTS devices on power flow and increasing the stability of EPS. Simulation and setting of sample cases of HV networks with FACTS devices in DIgSILENT, PCM 600 or DIGSI program packages

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☒ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Students are required to attend at least 75% of the lectures, to work through all laboratory exercises, to create the individual project and pass the oral exam.

1.8. Monitoring and assessment of student work

Attendance	1	Participation in classes		Seminar paper		Experimental work	
Midterm exams (written) exam)		Oral exam	2	Essay		Research	
Project	3	Report		Laboratory exercises	2	Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance	1	1., 2., 3., 4., 5., i 6.	Lectures and laboratory excercises	Recording attendance	0	0
Preparing for laboratory	2	2., 3.,5., 6.	laboratory	Checking preparation,	10	20

exercises, analysis of results, and writing reports			exercises	monitoring and control in the laboatory and checking written reports		
Project making	3	3., 4 .,5., i 6.	Individual work	Reviewing and evaluating the project	20	40
Preparation for oral exam and oral examination	2	1., 2., 3., 4., 5., i 6.	Oral exam	Checking given answers	20	40

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. S. Nikolovski „ Zaštita u EES-u.“ ETF Osijek 2007.
2. G. Ziegler, Numerical Distance Protection: Principles and Applications, 4th Edition, SIEMENS, 2011
3. K.R. Padiyar **“** FACTS Controllers in Power Transmission and Distribution“ New age international publisher 2016**.**

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. M. Zellagui, A. Chagni „Distance Protection for electrical transmission lines“ Lambhert, 2012.
2. N. G. Hingorani **,** L. Gyugyi „Understanding FACTS: Concepts and Technology of Flexible AC Transmission System“ IEEE Pres 1999.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
S. Nikolovski „ Zaštita u EES-u.“ ETF Osijek 2007	1	5
G. Ziegler, Numerical Distance Protection: Principles and Applications, 4th Edition, SIEMENS, 2011	1	5
K.R. Padiyar, FACTS Controllers in Power Transmission and Distribution	1	5

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information	
Lecturer(s)	**Associate Professor Predrag Marić**
Course title	**Power System Stability**

Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION

1.1. Course objectives

Mastering a complex methodology of stability analysis of multimachine power systems.

1.2. Course enrolment requirements

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1.3. Expected learning outcomes

1. To classify controllability, observability and power system stability
2. To make dynamic model of single machine infinite bus system in parameter space
3. Analysis of electromechanical motion of synchronous generator rotor
4. Analysis of oscillatory stability, rotors motion coherence and participation factors
5. Synthesis of power system linearized model in parameter space
6. Synthesis of power system stabilizers

1.4. Course content

Mathematical system foundation in general. Controllability, observability and power system stability. Dynamic models of single machine infinite bus system and multimachine power systems in parameter space. Electromechanical rotor motion of synchronous generators during and after large disturbances, power system transient stability. Linearized models of power system in parameter space and oscillatory stability (small signal stability). Rotors motion coherence of synchronous generators and participation factors in power systems. Devices for enhancement of power system stability and damping in power systems. Power system stabilizers.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Class attendance, project assignment preparation, seminar paper preparation, attending consultations, oral exam

1.8. Monitoring and assessment of student work

Attendance	Y	Participat		Seminar	Ye	Experimenta	

	es	ion in classes		paper	s	l work	
Midterm exams (written) exam)		Oral exam	Yes	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance Lectures	1	To classify controllability, observability and power system stability To make dynamic model of single machine infinite bus system in parameter space	Lectures	Attendance register. Mandatory attendance percentage is: **0%**	0	5
Oral exam	0		Oral exam	Assessment of student's answers	0	0
Project assignment	7	Analysis of electromechanical motion of synchronous generator rotor Analysis of oscillatory stability, rotors motion coherence and participation factors Synthesis of power system linearized model in parameter space Synthesis of power system stabilizers	Seminar paper	Evaluation of the applied methods	0	95

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. M.J. Gibbard, P. Pourbeik and D.J. Vowles," Small-signal stability, control and dynamic performance of power systems", University of Adelaide Press, 2015.
2. Jan Machowski, Janusz Bialek, Dr Jim Bumby, "Power System Dynamics: Stability and Control", 2nd Edition, Wiley, 2008
3. Paul M. Anderson, A.A. Fouad, "Power System Control and Stability'', IEEE Press, New York 1994.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Prabha Kundur, " Power System Stability and Control", McGraw Hill, Inc, New York, 1994.
2. J. A. Momoh, M. E. El-Hawary, "Electric Systems, Dynamics and Stability with Artificial Intelligence Applications, Marcel Dekker Inc. New York Basel 2000

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Jan Machowski, Janusz Bialek, Dr Jim Bumby, "Power System Dynamics: Stability and Control", 2nd Edition, Wiley, 2008	1	

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information		
Lecturer(s)	**Assistant Professor Goran Knežević**	
Course title	**Power system operation planning in open market conditions**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+5E+5S

1. COURSE DESCRIPTION

1.1. Course objectives

Explain to the students the methods and models of electrical power system planning. Students are enabled to determine the work plan of the power system in open market conditions, taking into account the risk of doing business with regard to certain risk factors.

1.2. Course enrolment requirements

Requirements met for enrolling in the study programme

1.3. Expected learning outcomes

1. Classify basic mathematical methods for power system operation planning and techno-economic analysis.

2. Formulate changes and limitations in the planning and upgrading of the transmission and distribution network in open market conditions with an emphasis on regulatory requirements for ensuring the safety and reliability of power supply.
3. Integrate the environmental conditions and constraints and the technical-economic cost-effectiveness analysis in planning work and construction of new production facilities.
4. In the framework of the seminar, propose a model for the production plan of the observed production plant, taking into account the conditions of the open electricity market.
5. Develop a model for operation planning of the observed production plant using software programing tool

1.4. Course content

Basic principles of power system planning. Planning time horizons. Assessment of a potential market. Modelling the operation of different types of power plants (forecasting the load curve and the load duration curve, conventional thermal power plants, hydroelectric and storage hydroelectric power plants, unconventional power plants). Planning models and techniques (simulation, optimisation). The logic of engaging power plants in market conditions. Electric energy generation costs for different types of power plants (constant and variable costs, marginal costs). Generation restrictions considering ecology demands (emmision). Treatment of generation of new renewable sources (RES). Incentive systems for RES of electrical energy and possible deviations of the real open market (feed-in-tariff). Minimum cost vs. maximum profit principle. Analysis of risk factors and risk hedging. Operational planning of power plants (hourly, daily, weekly, yearly).

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☒ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Class attendance, project assignment preparation, seminar paper preparation, attending consultations, oral exam

1.8. Monitoring and assessment of student work

Attendance	2	Participation in classes		Seminar paper	2.5	Experimental work	
Midterm exams (written) exam)		Oral exam	2	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	1.5
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance Lectures, Design exercises	2	1,2,3,5	Lectures, Design exercises	Attendance register. Mandatory attendance percentage is: 70%	0	0
Solve a problem with given in Design excercises	1.5	2,5	Design exercises	Evaluation of the solution	5	10
Oral exam	2	1,2,3	Oral exam	Assessment of student's answers	25	50
Create a project assignment	2.5	4,5	Seminar paper (project)	Evaluation of the solution for the given project assignment	20	40

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. D.S. Kirschen, G. Strbac, Fundamentals of Power System Economics, John Wiley & Sons, Inc., New York, 2004
2. B. Udovičić : Elektroenergetika, Kigen, Zagreb, 2005

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. S. Stoft : Power System Economics, IEEE/Wiley, 2002.
2. A.J. Momoh, Electric Power System Applications of Optimization, CRC Press, Taylor & Francis Group, Boca Raton, Florida, 2009.
3. A.J. Wood, B.F. Wollenberg, Power Generation Operation and Control, John Wiley & Sons, Inc., New York, 1996
4. M. Shahidehpour, H. Yaminand Z. Li, Market Operationsin Electric Power System – Forecasting, Scheduling and Risk Management, John Wiley & Sons, Inc., New York, 2002

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Conducting university questionnaires on teachers (student-teacher relationship, transparency of assessment criteria, motivation for teaching, teaching clarity, etc.). Conducting Faculty surveys on courses (upon passing the exam, student self-assessment of the adopted learning outcomes and student workload in relation to the number of ECTS credits allocated to activities and courses as a whole).

General information		
Lecturer(s)	**Assistant Professor Hrvoje Glavaš**	
Course title	**Energy efficiency in technical systems**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course objectives

The aim of the course is to provide participants with the knowledge of energy balance and distribution in the sectors of consumption. Explain the existence of a legislative framework set up to carry out energy policy. Analyzing the emergence of energy efficiency through time prism, develop the logic applied to solve technical challenges. Introduce students with the development of the energy performance building directive (EPBD I and EPBD II) and certification in the building industry as the most important sector of consumption of the Republic of Croatia. Industrial needs are presented through PINCH analysis and the need for a mechanical part of the system as the backbone of energy audits of large enterprises. The multidisciplinary approach brings the TELOS analysis through a particularly emphasized aspect of energy efficiency indicators, taking into account the capital expenditure of the investment cycle in the implementation of the proposed energy efficiency measures. The ability of OIE integration into technical systems as one of the goals represents an important subset of efficient finding of energy policy solutions with the aim of providing ZEB. Finally, getting to know the ESCO model concept is an option in situations where other solutions can not be found due to the impossibility of finding a responsible person for the practical implementation of EnU projects

1.2. Course enrolment requirements

Knowing the basics of energy

1.3. Expected learning outcomes

1. Participants will be able to analyze the energy balance
2. Students will be able to conduct TELOS analysis
3. They will be able to devise an optimal energy efficiency measure

1.4. Course content

The energy efficiency in the technical systems provides an overview of energy balances, classifying consumption in the sectors. The analysis of the legislative framework is carried out by taking into account the historical techno-economic factors that led to its Renaissance in the second millennium. The development of the energy performance building directive (EPBD I and EPBD II) resulted in certification in the building industry, which is particularly pronounced in the Republic of Croatia because of its share in total energy consumption. Particular attention is given to the PINCH analysis and the mechanical part of the system as they represent the backbone of energy audits of large companies. The implementation of TELOS analysis is particularly emphasized from the aspect of energy efficiency indicators, taking into account the capital expenditure of the investment cycle in the implementation of the proposed energy efficiency measures. OIE's integration into technical systems is an important subset of an efficient finding of energy policy solutions with the aim of securing ZEB. Ultimately, the ESCO model is presented in situations where it is not possible to find other solutions due to the impossibility of finding a responsible person for the practical implementation of the EnU

projects		
1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Teaching can not be performed in a foreign language	

1.7. Student obligations

The student's obligation is an independent research in the area of energy flow analysis and economic analysis of energy efficiency measures

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes		Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	Yes	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Energy balance analysis	2	Independent performance of said activity	Frontal teaching	examination	1	10
EBPD analysis, building certification and energy audits	2	Independent performance of said activity	Frontal teaching	examination	1	10
TELOS analysis	2	Independent performance of said activity	Frontal teaching	examination	1	10

ESCO model analysis	2	Independent performance of said activity	Frontal teaching	examination	1	10

1.10. Obligatory literature (at the time of submitting a study programme proposal)

Energija u Hrvatskoj, Ministarstvo zaštite okoliša, prostornog uređenja i graditeljstva, metodologija provođenja energetskog pregleda zgrada, Zagreb, 2009.
Priručnik za energetsko certificiranje zgrada 1
Priručnik za energetsko certificiranje zgrada 2
Energy Management Handbook, seventh edition, CRC press, 2009.
A. Thumann, Handbook of energy audits,7th ed., by The Fairmont Press, 2008
Udovičić, B.: Energetika, Školska knjiga Zagreb, 1993.
Subhes C. Bhattacharyya, Energy Economics, Springer-Verlag London Limited 2011.
I. Dincer and M. A. Rosen, Exergy, Elsevier, London 2007.
M.Pehnt, M.Cames,C.Fischer, B.Praetorius,L.Schneider, K.Schumacher,J.P.Voß, Micro Cogeneration, Springer-Verlag Berlin Heidelberg 2006.
K.Sankaranarayanan, H.Kooi, J. Arons, EFFICIENCY and SUSTAINABILITY in the ENERGY and CHEMICAL INDUSTRIES, Taylor and Francis Group, LLC, 2010.
Barney L. Capehart, Wayne C. Turner, William J. Kennedy, Guide to Energy Management, The Fairmont Press, 2006.
Handbook of energy efficiency and renewable energy, edited by F. Kreith and D.Y.Goswami, CRC Press, Taylor and Francis Group, LLC, 2006.
G.Schaub, T.Turek, Energy Flows, Material Cycles and Global Development, Springer-Verlag Berlin Heidelberg 2011.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

N. W. H. CHEETHAM, Introducing Biological Energetics, Oxford University Press Inc., New York 2010.
Požar, H.: Osnove energetike 1, 2 i 3, Školska knjiga-Zagreb, 1976.
Jozsa, L.: Energetski procesi i elektrane, udžbenik, ETF Osijek, 2004.
Šljivac, D., Šimić, Z.: Obnov. izvori energije s osvrtom na gospodarenje, ETF – HKAIG, 2008.
Zakonu o energiji (NN 68/01, 177/04, 76/07)
Zakonom o Fondu za zaštitu okoliša i energetsku učinkovitost (NN107/03)
Zakon o prostornom uređenju i gradnji (NN 76/07)
Tehničkim propisom o uštedi toplinske energije i toplinskoj zaštiti u zgradama (NN 79/05)
UNDP, Priručnik za energetske savjetnike, Zagreb, 2008.
Directive 2006/32/Ec Of The European Parliament And Of The Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC
Directive 2002/91/Ec Of The European Parliament And Of The Council of 16 December 2002 on the energy performance of buildings

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Electrical Energy Efficiency: Technologies and Applications	0	3
Energy Management Handbook, seventh edition	0	3
Handbook of energy audits	0	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information		
Lecturer(s)	**Assistant Professor Danijel Topić, Assistant Professor, Sebastian Seme**	
Course title	**Modelling and simulation of the renewable energy distributed generation**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, modul Power Engineering	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course objectives

1. Introduce of renewable energy distributed generation to students.
2. Present mathematical and computing models of renewable energy distributed generation to students.
3. Demonstrate the application of the modelling and simulation of renewable energy distributed generation in power systems to students.

1.2. Course enrolment requirements

Achieved requirements for enrolment of second year of study.

1.3. Expected learning outcomes

1. Classified the renewable energy distributed generation.
2. Formulate mathematical models of the renewable energy distributed generation.
3. Select mathematical models of the renewable energy distributed generation for simulation applications.

1.4. Course content

Basic characteristics of renewable energy distributed generation. Modelling of wind power plants. Modelling of photovoltaic power plants. Modelling of small hydro power plants. Modelling of geothermal power plants and biomass power plants. Modelling of the electricity storage systems. Modelling and simulation of renewable energy distributed generation in the power system.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor

	learning ☐ fieldwork	☐ other _____ ___
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Class attendance, project assignment preparation, seminar paper preparation, attending consultations, oral exam

1.8. Monitoring and assessment of student work

Attendance	2	Participation in classes		Seminar paper	2	Experimental work	
Midterm exams (written) exam)		Oral exam	2	Essay		Research	2
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance	2	1, 2 and 3			7	10
Research	2	1, 2 and 3			15	30
Seminar Paper	2	2 i 3			15	30
	2		Oral exam		15	30

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. Modeling and Control of Sustainable Power Systems, Wang, Lingfeng, Springer 2012.
2. Dynamic Modeling, Simulation and Control of Energy Generation, Vepa, Ranjan, Springer 2013.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Wind Energy Generation:Modelling and Control, Olimpo Anaya-Lara, Nick Jenkins, Janaka Ekanayake, Phill Cartwright, Mike Hughes, Wiley 2009.

2. Design of Smart Power Grid Renewable Energy Systems, Ali Keyhani, Wiley, 2011

3. Renewable energy integration: Practical management of variability, uncertainity and flexibility in power grids, L.E. Jones, Academic Press, 2014

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of*	*Number of students*

	copies	

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information		
Lecturer(s)	**Professor Željko Hederić, Assistant Professor Zdravko Praunseis**	
Course title	**Detecting causes of electric machine failures**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering	
Course status	Scientific directing courses	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+5E+5S

1. COURSE DESCRIPTION

1.1. Course objectives

To familiarize students with the application of advanced techniques in the field of diagnostics of electrical machines. Explain contribution to diagnostics and monitoring machines to reduce damage and increase efficiency in motor drives. Explain the basic types of failures of electrical machines considering the location and operating modes. To introduce students to the basic tests given the life expectancy of electrical machines in the manufacturing process, the initial start-up, regular maintenance and monitoring, laboratory after repairs. To enable students to use basic diagnostic tools: instrumentation for data collection and software for data collection and processing. Explain the procedures for modeling and simulation of failure conditions. Present students as from the analysis of failure conditions to carry out the necessary requirements for improving the electrical machines and drives in which they are located.

1.2. Course enrolment requirements

Enrolled corresponding academic year / semester.

1.3. Expected learning outcomes

1. Distinguish the state of failure of electrical machines
2. Identify and implement state-of-the-art diagnostic procedures and monitoring the operation of electrical machines in the drives
3. Assess the level and type of failure and appropriate diagnostic methods
4. Analyze the results of various diagnostic methods with the aim of more reliable determination of the actual causes of the failure.
5. Identify the influence of the power supply of asynchronous machines from the inverter to the surge arrester and to the axle and bearing currents.
6. Identify the influence of eccentric rotor position in the stator and the determination of characteristic frequencies in stators, axial bursts, oscillation currents and vibrations

1.4. Course content

Advanced techniques in the field of electrical machinery diagnostics.

Impact of diagnostics and monitoring of machines to reduce damage and increase efficiency in electric motors.
Allocation of types of electrical machinery failures with regard to the location and operating mode.
Classification of fundamental tests with respect to the lifespan of electrical machines: in the production process, initial start-up, regular maintenance and monitoring, in the after-repair laboratory.
Diagnostic tools: Data acquisition instrumentation and software for data collection and processing.
Modeling and simulating bad states by using soft computing methods.
Analyzes of defective states for defining the parameters from which follows the improvement of design of the electrical machines and the drive in which they are located. The eccentric position of the rotor in the stator and the determination of the characteristic frequencies in the stator current, axial burst flow, oscillation current and vibration. Impact of power supply of asynchronous machines from inverter to surge arrester and to axle and bearing current.

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☒ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Seminar work, solving practical problems during lectures, oral exam.

1.8. Monitoring and assessment of student work

Attendance	0,5	Participation in classes		Seminar paper	2,5	Experimental work	
Midterm exams (written) exam)		Oral exam	3	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	2
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attending classes	0,5	1-6	Lectures and exercises	Registering the presence	0	0
Construction exercises	2,0	2,4,5,6	Lectures and exercises	Correcting solved tasks	15	30

Writing seminar work	2,0	2,4,5,6	Seminar paper	Checking and evaluating seminar work	20	40
Answering questions	3	1,3,4	Oral exam	Evaluating the answers given	15	30

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. H. A . Toliyat , S. Nandi, S. Choi,H. Meshgin-Kelk, Electric Machines: Modeling, Condition Monitoring, and Fault Diagnosis, CRC Press, 2013.
2. Peter Tavner, Li Ran, Jim Penman and Howard Sedding: Condition Monitoring of Rotating Electrical Machines, 2nd Edition, IET Digital Library, 2008,

Rolf Isermann: Fault-Diagnosis Applications: Model-Based Condition Monitoring, Springer , 2011

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. P. Vas (1993.), Parametar Estimation Condition Monitoring and Diagnosis of Electrical Machines, Clarendon Press
2. Srb:Magnetski monitoring električnih rotacijskih strojeva, Graphis, 2004

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Modeling, Condition Monitoring, and Fault Diagnosis	0	3
Condition Monitoring of Rotating Electrical Machines	0	3
Fault-Diagnosis Applications: Model-Based Condition Monitoring	0	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information		
Lecturer(s)	**Professor Kruno Milicevic PhD**	
Course title	**Nonlinear Electrical Networks and Deterministic Chaos**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course objectives

Introduce students to the complex behavior of relatively simple nonlinear electrical networks. Present ways of analyzing such networks and examples in practice.		
1.2. Course enrolment requirements		
Enrolled corresponding academic year / semester.		
1.3. Expected learning outcomes		
1. Model and formulate equations of nonlinear electrical networks 2. Select the appropriate metering and analytical solution method 3. Determine the response of the nonlinear circuit using experimental, analytical and numerical methods 4. Understand the complexity of the behavior of nonlinear electric circuits and nonlinear systems in general		
1.4. Course content		
The course covers the analysis and measurement of the behavior of nonlinear electrical networks by applying to real examples of electrical networks such as nonlinear circuits, nonlinear parts of the power grid, etc. The topics include: modeling of nonlinear electrical networks, methods of measuring parameters and impact of nonlinear electrical networks, local and the global behavior of nonlinear electrical networks, the impact of initial values, types of steady-states, the deterministic chaos, and usage of chaos in communication.		
1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English and German	
1.7. Student obligations		
Seminar work, solving practical problems during lectures, oral exam.		
1.8. Monitoring and assessment of student work		

Attendance	0,2	Participation in classes	0,2	Seminar paper	3,6	Experimental work	
Midterm exams (written) exam)		Oral exam	4	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT	ECTS	LEARNING	TEACHING	METHOD OF	CREDITS

ACTIVITY	CREDITS	OUTCOME	METHOD	ASSESSMENT	min.	max.
Attending classes	0,2	1,2,3,4	Lectures and exercises	Registering the presence	0	0
Solve group tasks	0,2	1,2,3	Lectures and exercises	Correcting solved tasks	0	20
Writing seminar work	3,6	1,2,3	Seminar paper	Checking and evaluating seminar work	0	35
Answering questions	4	1,2,3,4	Oral exam	Evaluating the answers given	0	45

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. Kapitaniak, Tomasz. Chaos for Engineers: Theory, Applications, and Control. New York, Springer Verlag, 2000. ISBN: 9783540665748

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Strogatz, Steven H. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering. New York, NY: Perseus Books, 2001. ISBN: 9780738204536

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Kapitaniak, Tomasz. Chaos for Engineers: Theory, Applications, and Control. New York, Springer Verlag, 2000. ISBN: 9783540665748	0	10

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information		
Lecturer(s)	**Assistant Professor Marinko Barukčić, Assistant Professor Miralem Hadžiselimović**	
Course title	**Optimization and estimations in industrial and distribution networks using soft computing methods**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+5E+5S

1. COURSE DESCRIPTION							
1.1. Course objectives							
Introduce students with application of the soft computing methods to solve the complex optimization and estimation problems in electrical distribution and industrial networks. Introduce students with existing software packages of the soft computing techniques in Python programming environment. Train students for solving the complex optimization problems in the distribution and industrial networks by using the soft computing methods. Train students to solve the complex problems using co–simulation of software tools for the soft computing techniques and the tools for simulation of the electrical systems.							
1.2. Course enrolment requirements							
Electrical power substations, Electrical machines or Electric drives or Transmission and distribution of electrical energy							
1.3. Expected learning outcomes							
1. classify the optimization problems in power engineering and suitable soft computing methods to solve the problems 2. formulate optimization and estimation problems in power engineering 3. recommend suitable soft computing method for optimizations and estimations in power engineering 4. relate software tools for electrical system analysis and soft computing tools to solve the optimization problems in the power engineering 5. create solving procedure for the optimization problem in power engineering including formulation of the problem and solving the problem by co–simulation of the software tools							
1.4. Course content							
Overview of the soft computing techniques: evolutionary algorithms, fuzzy inference systems and artificial neural networks. Mathematical notation of the single objective optimization problems. Mathematical notation of the multi objective optimization problems. The Pareto definitions for multi objective optimization. Examples of the complex optimization and estimation problems: optimal allocation of devices (volt-var control devices, distributed generation, filters…), voltage profile estimation, parameter estimations of the equivalent circuits (transformer, machine, line …). Solving the complex optimization and estimation problems by using the robust optimization methods of the evolutionary optimizations: genetic algorithm, differential evolution, evolutionary strategy, ant colony optimization, NAGA, SPEA, multi objective ACO… Estimation of parameters and variables by using fuzzy inference system and artificial neural networks.							
1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☒ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____					
1.6. Comments	Classes can be taught in English						
1.7. Student obligations							
Class attendance, Consultations with lecturer, Making seminar paper, Presentation of the seminar paper on the oral exam							
1.8. Monitoring and assessment of student work							
Attendance	1	Participati		Seminar	2	Experiment	

		on in classes		paper		al work	
Midterm exams (written) exam)		Oral exam	2	Essay		Research	
Project		Report		Laboratory exercises	1	Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance	1	1-5	Lectures	Attendance list	0	0
Laboratory exercises: preparation, preforming and analysis	1	4 and 5	Laboratory exercises	Checking of the preparation, control of the performing, Checking of the analysis	15	30
Writing and presentation of the seminar paper	2	3-5	Seminar paper	Checking the seminar paper	20	40
Preparation for the oram exam and oral exam	2	1-5	Oral exam	Checking of the given answers	15	30

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. D. K. Chaturvedi, *Soft Computing Techniques and its Applications in Electrical Engineering*, 2008, Springer Berlin Heidelberg (http://www.springer.com/gp/book/9783540774808)
2. G. Chicco ; A. Mazza ; A. Russo, *Optimization and decision-making in electrical distribution networks*, 2012 International Conference and Exposition on Electrical and Power Engineering, 25-27 Oct. 2012, Iasi, Romania, (http://ieeexplore.ieee.org/document/6463608/)
3. S. Tan ; J.X. Xu ; S.K. Panda, *Optimization of Distribution Network Incorporating Distributed Generators: An Integrated Approach*, IEEE Transactions on Power Systems ,Volume: 28, Issue: 3, Aug. 2013 (http://ieeexplore.ieee.org/document/6497085/)

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1.C. Coello Coello, G. B. Lamont, D. A. van Veldhuizen, *Evolutionary Algorithms for Solving Multi-Objective Problems*, 2007, Springer US (http://www.springer.com/gp/book/9780387332543)
2.K. Chakraborty, A. Chakrabarti, *Soft Computing Techniques in Voltage Security Analysis*, 2015, Springer India (https://link.springer.com/book/10.1007/978-81-322-2307-8)
3.Y. Wang, S. Mao, R. M. Nelms, *Online Algorithms for Optimal Energy Distribution in Microgrids*, 2015, Springer International Publishing (https://link.springer.com/book/10.1007/978-3-319-17133-3)
4. R. Kruse, C. Borgelt, F. Klawonn, C. Moewes, M. Steinbrecher, P. Held, Computational

Intelligence
A Methodological Introduction, 2013, Springer London (https://link.springer.com/book/10.1007/978-1-4471-5013-8
)
5. C. A. Coello Coello, *A Short Tutorial on Evolutionary Multiobjective Optimization,* On-line: http://ftp.bstu.by/ai/To-dom/My_research/Papers-0/For-lecture/Moga/tutorial-slides-coello.pdf , (26.06.2017.)

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Soft Computing Techniques and its Applications in Electrical Engineering	0	3
Optimization and decision-making in electrical distribution network	0	3
Optimization of Distribution Network Incorporating Distributed Generators: An Integrated Approach	0	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The committee for postgraduate studies controls regularity and quality of the classes, consultations and exams. Also, the questionnaire evaluation by students can be done if it is needed.

General information

Lecturer(s)	**Assistant Professor Zvonimir Klaić, Professor Damir Šljivac**	
Course title	**Smart Power Grids**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION

1.1. Course objectives

Introduce students to concepts and the application of smart grids, and to the balancing ability of supply and demand in real time with regard to the influence of distributed generation from the RES on power system. Introduce students with concepts of microgrids and virtual power plants and the concept of a smart home.

1.2. Course enrolment requirements

Expected conditions for enrolment of the second year of study

1.3. Expected learning outcomes

1. Analyse the concept of an smart power grid as a concept for the integration of distributed production
2. Identify and propose concepts and design of smart grids and microgrids, to design microgrids management and operation modes depending on the given components
3. Analyse and suggest potential applications for energy management in smart gridsw
4. Identify and classify methods for optimization in smart grids and microgrids
5. Create a smart grid or microgrid model

1.4. Course content

Advanced measurements and application. Concept and design of advanced and micronetworks. Managing ipogon micronetworks. Consumption management. Integration of RES into advanced networks. Advantages of advanced and micronetworks compared to conventional networks. Optimization methods in advanced networks and micronets. Smart houses

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Defined by the FERIT student assessment framework and Paragraph 1.9

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes	Yes	Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	Yes	Essay		Research	Yes
Project	Yes	Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance: lectures	1.5	1,2,3,4,5	Lectures	Evidence of presence. The minimum		

				required for signature is 25%.		
Preparation for oral exam and answering questions	2.5	1,2,3,4,5	Oral exam	Checking of the given answers		
Creating seminar work	2	2,3,4,5	Individual work	Evaluation of seminar work		

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. Bernd M. Buchholz, Zbigniew Styczynski: Smart Grids – Fundamentals and Technologies in Electricity Networks, Springer 2014.
2. Daphne Mah • Peter Hills, Victor O. K. Li, Richard Balme: Smart Grid Applications and Developments, Springer, 2014.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Microgrids, Arhitectures and Control, Nikos Hadziargyriou, IEEE Press, Wiley, 2014.
2. K. S. K. Weranga, Sisil Kumarawadu, D. P. Chandima: Smart Metering Design and Applications, Springer 2014.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Bernd M. Buchholz, Zbigniew Styczynski: Smart Grids – Fundamentals and Technologies in Electricity Networks, Springer 2014.	1	3
Daphne Mah • Peter Hills, Victor O. K. Li, Richard Balme: Smart Grid Applications and Developments, Springer, 2014.	1	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General Information	
Lecturer(s)	**Full Professor Srete Nikolovski**
Course title	**EES reliability and availability**
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Module Power Engineering
Course status	Elective course
Year of study	First

Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L + 10E

1. COURSE DESCRIPTION

1.1. Course objectives

Train students for independent reliability analysis and application of EES's reliability and availability budgeting programs. Calculation of ESS reliability indicators at hierarchical levels I, II and III using computer programs "NEPLAN" and "DIgSILENT

1.2. Course enrolment requirements

There are no specific requirements.

1.3. Expected learning outcomes

After passing the course, students will be able to:
1. Predict random probability distribution in the EES. Determine all availability and reliability indicators at hierarchical levels of EE systems I, II and III.
2. Analyze stochastic processes in the EES using Markov's model of space space and make Markov's models for these processes. Component states: work, failure, overhaul, breakdown, overlap, multi-state generator model, consumption model
3. Statistical analysis of input data for reliability and availability analysis of EES and associated distributions, and determination of mean values of input indicators
4. Analyze the reliability of the transmission grid or the distribution grid by a state-of-the-art analysis methodology and explain reliability, both systematic and individual.
5. Perform network load sensitivity analysis and individual component components to reliability indicators.
6. Investigate the Monte Carlo simulation model for assessing the adequacy of the production transmission system and determining LOLP indicators. LOEE, EENS. Analyze the availability of production on HL I

1.4. Course content

Reliability theory, definition and reliability concept. Reliability, reliability and availability. Types of failures and their causes. Independent, dependable failures and failures with a common cause. Multiple hardware failures. Malfunction Function Models. Function Availability and Unavailability of Renewable Components. Recovery function. Reliability of serial, parallel and mixed systems. Analytical and simulation methods for calculating system reliability and availability. Mark's model of space space. The minimum path and section method. Frequency and duration method. The redundancy of components. Reliability models of EES components (switches, cables, bus, transformers). Examples of calculations of reliability indicators (frequency of interruption, interruption time, probability of interruption and probably unacceptable el.energy, SAIFI, CAIFI, SAIDI, CAIDI, ASAI, ASUI, ENS, AENS, ASIFI, ASIDI) using computer programs "NEPLAN" DIgSILENT.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory excersises ☐ distance learning ☐	☒ individual work ☐ multimedia ☒ laboratory excersises ☐ design excersises ☐ working with a disseration supervisor ☐ other _____

	fieldwork	
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Attending classes, preparing a project assignment, coming to consultations, oral exam

1.8. Monitoring and assessment of student work

Attendance	1	Participation in classes		Seminar paper		Experimental work	
Midterm exams (written) exam)		Oral exam	3	Essay		Research	
Project	3	Report		Laboratory exercises	2	Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max
Lecture Attendance	1	1., 2., 3., 4., 5., i 6.	Lectures, laboratory excersises	Evidence of Attendance	0	0
Preparation for LE, result analysis, and report writing	2	2., 3.,5., 6.	laboratory excersises	Evaluation of LE preparation, LE monitoring, evaluation of written reports	10	20
Project assignment	3	3., 4 .,5., i 6.	Individual work	Reviewing and evaluating the project task	20	40
Preparation for Oral Exam and Oral Answering Questions	2	1., 2., 3., 4., 5., i 6.	Oral exam	Evaluation of given answers	20	40

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. S. Nikolovski „ Analiza Pouzdanosti EES.“ ETF Osijek 1995.
2. V. Mikuličić, Z . Šimić, Modeli pouzdanosti, raspoloživosti i rizika u elektroenergetskom sustavu 1.dio. 2008.
3. R. Billinton, R. Allan “Reliability Assessment of Large Electric Power Systems“ Springer 2012.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. J. Nahman „Dependability of engineering systems , modeling and evaluataion“ Springer , 2002.

2. R. Bilinton R. W. Li „Reliability Assessment of Electrical Power Systems Using Monte Carlo Methods“ Planum Press 1994.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Analiza Pouzdanosti EES	1	3
Modeli pouzdanosti, raspoloživosti i rizika u elektroenergetskom sustavu 1.dio..	1	3
Reliability Assessment of Large Electric Power Systems	1	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information		
Lecturer(s)	**Assistant Professor Zvonimir Klaić**	
Course title	**Monitoring and Power Quality**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION

1.1. Course objectives

Introduce students with analytical approaches in describing the voltage quality parameters. Defining the causes, consequences, and methods of improving power quality disturbances. Power quality analysis and application in power system. Introduce students with stochastic methods of voltage dips estimation and probability distribution of voltage events in power system. Analysis of the impact of renewable energy sources on power quality in power system, power quality in smart grids.

1.2. Course enrolment requirements

Expected conditions for enrolment of the second year of study

1.3. Expected learning outcomes

1. By the analytical approach, link the causes and consequences of power quality disturbances.
2. By using the stochastic method, predict the number of voltage dips per year at a specific site in the power system.
3. Classify voltage dips with respect to depth and predict the number of dips due to depth
4. Carry out an economic assessment of the power quality disturbance.

5. To predict the impact of renewable sources on the power quality in power system.

1.4. Course content

Voltage quality indicators, causes, consequences and methods for improvement for the following disturbances: voltage fluctuations and oscillations, voltage dips and interruptions, overvoltages and overvoltages, higher harmonics, voltage asymmetry. In-depth and detailed analysis of the results of measuring and monitoring the quality of electricity, linking causes and consequences. Stochastic estimation of voltage dips due to short circuits in the power system. Economic effects of poor electricity quality. Influence of renewable sources on electricity quality. Electricity quality in advanced networks.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Defined by the FERIT student assessment framework and Paragraph 1.9

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes	Yes	Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	Yes	Essay		Research	Yes
Project	Yes	Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance: lectures	1.5	1,2,3,4,5	Lectures	Evidence of presence. The minimum required for		

				signature is 25%.		
Preparation for oral exam and answering questions	3	1,2,3,4,5	Oral exam	Checking of the given answers		
Creating seminar work	1.5	2,4,5	Individual work	Evaluation of seminar work		

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. Presentations from lectures
2. Understanding Power Quality Problems, Math H.J. Bollen, IEEE Press, Wiley, 2000.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Tokić, A; Milardić, V. Kvalitet električne energije. PrintCom Tuzla, 2015.
2. l. Baggini, A. Handbook of Power Quality. John Wiley & Sons Ltd, 2008.
3. Zvonimir Klaić: Stohastička procjena naponskih propada uslijed kratkih spojeva u elektroenergetskom sustavu, doktorska disertacija, Osijek 2011.
4. Zvonimir Klaić: Mjerenje i analiza kvalitete električne energije u distribucijskoj mreži prema EN 50160, magistarski rad, Osijek 2006.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
1. Presentations from lectures		
Understanding Power Quality Problems, Math H.J. Bollen, IEEE Press, Wiley, 2000.	1	

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information		
Lecturer(s)	**Professor Jože Pihler**	
Course title	**Switchgear and High Voltage Engineering**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering	
Course status	Elective subject	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of this course is to acquaint students with basics of design and testing of switchgears and performing of researches and tests
1.2. Course enrolment requirements
1.3. Expected learning outcomes
1. Analyse and select adequate switchgear elements 2. Design of switchgears 3. Tests of electrical devices 4. Analyse and evaluate receive results
1.4. Course content
• Contemporary design of switchgears: the use of existent and development of new program tools for device design, selection of insulating and arcing media, research of switchgear influences to people and environment by normal and fault operation. • Sources and types of high voltages on electrical devices operation. • Sources and types of large currents on electrical devices operation. • Types of high voltages and large currents which are necessary to consider by designing of new electrical apparatus and devices. • Devices for generation and measuring high voltages and large currents. • Verifying of endurance of new electrical devices prototype: cooperation in research of new product, definition and realization of tests.

1.5. Types of classes	X lectures X seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments		

1.7. Student obligations
Oral exam, seminar
1.8. Monitoring and assessment of student work

Attendance	0,5	Participation in classes	0,5	Seminar paper	2	Experimental work	
Midterm exams (written) exam)		Oral exam	3	Essay		Research	
Project		Report		Laboratory exercises	1	Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance	0,5		Lecture	Recording of presence. Minimum to 50%.	0	10
Participation in classes	0,5			Evaluation	0	10
Seminar paper	2		Preparation and presentation of seminar	Evaluation	15	30
Preparation of oral exam	3		Oral exam	Evaluation	20	50

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

- Stewart, Stan**:** *Distribution switchgear Electric switchgear*, Published by The Institution of Engineering and Technology, London, United Kingdom, 2008**,** ISBN 0 85296 107 3.
- Steffen Rebennack, Mario V.F. Pereira, Niko A. Iliadis: *Handbook of Power Systems I*, © Springer-Verlag Berlin Heidelberg 2010, ISBN: 978-3-642-02492-4 e-ISBN: 978-3-642-02493-1.
- Hugh M. Ryan: High Voltage Engineering and Testing, IET,ISBN -13: 978-1849192637, 2013.
- W. Hauschild, E. Lemke: High-Voltage Test and Measuring Techniques, Springer 2014.
- J. Voršič, J. Pihler: *Tehnika visokih napetosti in velikih tokov*, Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko, Maribor, 2005
- J. Pihler: *Stikalne naprave elektroenergetskega sistema*, Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko, Maribor, 2003.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information		
Lecturer(s)	**Krešimir Fekete, Assistant profesor; Mladen Zeljko, Assistant profesor**	
Course title	**Advanced methods of electricity market analysis**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power System	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course objectives

In this course students are prepared to independently apply and develop advanced methods for electricity market analysis, including: electricity price forecasting, load forecasting, forecasting electricity production from intermittent electricity sources (wind power), market rules analysis, modelling of competition on electricity market and analysis of transmission congestion.

1.2. Course enrolment requirements

-

1.3. Expected learning outcomes

1. Connect economic basis of markets with the specifics of electricity markets.
2. Integrate and connect models for load forecasting and electricity price forecasting.
3. Propose model for electricity production forecasting from the intermittent energy sources (wind power plants).
4. Integrate developed forecasting models into tool for decision making in the process of selling/buying electricity on the electricity market.
5. Generalize and classify different market rules that are applied in the practice.
6. Suggest a mathematical model for modelling competition in the imperfect electricity market.
7. Classify different methods for congestion management that are used in the practice of the electricity market.

1.4. Course content

Introduction to electricity market – restructuring electricity sector and introduction of competition, economic basis of markets – types of trading and contracts, different design of electricity market. Planning of buying/selling electricity on the liberalized electricity market – applying advanced tools for different forecasts: electricity load forecast, electricity price forecast and electricity production from intermittent energy sources forecast. Creating and testing different market rules. Modelling competition on the electricity market. Usage of electricity market simulator. Analysing of different congestion management methods.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning	☒ individual work ☐ multimedia ☒ laboratory exercises ☐ design exercises ☐ work with a dissertation

	☐ fieldwork	supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Students are required to attend at least 75% of the lectures, to work through all laboratory exercises, to create the individual project and pass the oral exam.

1.8. Monitoring and assessment of student work

Attendance	1	Participation in classes		Seminar paper		Experimental work	
Midterm exams (written) exam)		Oral exam	2	Essay		Research	
Project	3	Report		Laboratory exercises	2	Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance	1	1.,2.,3.,4.,5.,6. and 7.	Lectures and laboratory excercises	Recording attendance	0	0
Preparing for laboratory exercises, analysis of results, and writing reports	2	2., 6. i 7.	laboratory exercises	Checking preparation, monitoring and control in the laboatory and checking written reports	10	20
Project making	3	2., 3., 4., 6. i 7.	Individual work	Reviewing and evaluating the project	20	40
Preparation for oral exam and oral examination	2	1., 5., 6. i 7.	Oral exam	Checking given answers	20	40

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. M. Shahidehpour, H. Yamin, Z. Li: Market operations in electric power systems: Forecasting, Scheduling, and Risk Management, J. Wiley 2002.
2. L. Yang, M. He, J. Zhang, V. Vittal: Spatio-Temporal Data Analytics forWind Energy Integratio,

Springer, 2014
3. Lecture Notes in Energy: The Interrelationship Between Financial and Energy Markets, Volume 54, editors: S. Ramos, H. Veiga, Springer, 2014

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. S. Stoft: „Power System Economics: Designing Markets for Electricity, J. Wiley 2002.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
M. Shahidehpour, H. Yamin, Z. Li: Market operations in electric power systems: Forecasting, Scheduling, and Risk Management, J. Wiley 2002.	1	3
L. Yang, M. He, J. Zhang, V. Vittal: Spatio-Temporal Data Analytics forWind Energy Integratio, Springer, 2014	1	3
Lecture Notes in Energy: The Interrelationship Between Financial and Energy Markets, Volume 54, editors: S. Ramos, H. Veiga, Springer, 2014	1	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information		
Lecturer(s)	**Professor Marinko Stojkov**	
Course title	**Transients in the Electrical Networks**	
Study programme	Postgraduate Doctoral Study Programme Electrical Engineering and Computer Science	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credit	8
	Number of classes (lectures + exercises + seminars)	20L+ 10 S

1. COURSE DESCRIPTION

1.1. Course objectives

Train students to model electromagnetic transit processes in electrical power system.

1.2. Course enrolment requirements

Completed masters degree in Electrical Engineering, obtained appropriate knowladge in the field of Electrical Engineering and Mathematics.

1.3. Expected learning outcomes

After passing the course, students will be able to:
1. classify the causes of temporary, intermittent and atmospheric overvoltages.
2. design physical models of overvoltage and overvoltage overvoltages.
3. develop a system model analysis of part of the real-time power system and its components and mathematically formulate each component of the plant from the aspect of extending the surge.
4. remove faults and damage to individual components of the power system with possible causes - overvoltage parameters.
5. suggest technical decisions and parameters of modern surge protection methods.
6. to predict the techno-economic justification of investment in over-protection.

1.4. Course content

Temporary overvoltage's due to earth leakage, sudden loss of load and Ferro resonance. Switching overvoltage's at the fitting of lines, in the generation and elimination of failures, and in the termination of capacitive and inductive currents. The rise, spread and harmful effects of atmospheric overvoltage. Calculations arresters. Modelling of elements: overhead line, cable, energy and metering transformers, overvoltage arresters, high-voltage switchgear. Overview of modern protection methods of overvoltage.

1.5. Types of classes	X lectures X seminars and workshops ☐ auditory excersises ☐ distance learning ☐ fieldwork	X individual work ☐ multimedia ☐ laboratory excersises ☐ design excersises X work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Attending classes, seminars and oral exams.

1.8. Monitoring and assessment of student work

Attendance	1,5	Participation in classes		Seminar paper	4	Experimental work	
Midterm exams (written) exam)		Oral exam	2,5	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max
Lecture	1,5	1-4	Lectures	Evidence of	0	5

Attendance				presence		
Seminar paper	4	4-6	Studying literature, conducting research, developing project and seminar paper and technical solution proposal.	Evaluation of the research quality, scoring accuracy of the model and obtained results, appropriateness and complexity access.	35	65
Oral exam	2,5	1-6	Oral exam	Evaluation of given answers	15	30

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. P. CHOWDHURI: Electromagnetic Transients in Power Systems, Research Studies Press, John Wiley & Sons, Ltd, New York, 1996.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. L. van der SLUS, Transients in Power Systems, John Wiley & Sons, Ltd, New York, 2002.
2. N. WATSON, J. ARRILAGA: Power Systems Electromagnetic Transients Simulation, IEE, 2003.
3. Akihiro Ametani, Naoto Nagaoka, Yoshihiro Baba, Teruo Ohno, Power System Transients: Theory and Applications, 2013

1.12.Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Electromagnetic Transients in Power Systems	0	3

1.1.3.Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information

Lecturer(s)	**Professor Igor Tičar**	
Course title	**Theoretical electrotechnics – selected chapters**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering	
Course status	Elective course	
Year of study	First	
Credit value (ECTS)	ECTS credits	8

and teaching methods	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course bjectives

To give postgraduate students deeper knowledge about general electromagnetic field theory and about special areas concerning the concrete problems

1.2. Course enrolment requirements

Bologna 2nd degree

1.3. Expected learning outcomes.

On completion of this course the student will be able to: Solving of complex problems in electromagnetics and electromagnetic wave propagation using numerical methods.

1.4. Course content

Eddy current problems
Skin effect
Neighbourhood proximity problem
Electromagnetic field – wave propagation
Modern approach in solving electromagnetic field problems using numerical methods

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6.Comments	Classes can be taught in English	

1.7. Student obligations

Completed tutorial; oral examination

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes		Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	Yes	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	

Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.

1.10. Obligatory literature (at the time of submitting a study programme proposal)

- Bosanac, Tomo: *Teoretska elektrotehnika* Zagreb : Tehnička knjiga, 1973
- R.S.Elliot: *Electromagnetics*; IEEE Press, New York, 1993.
- A.H.Kovetz: *Electromagnetic Theory*; Oxford Press Inc., 2000.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. O**.** Biro, K Richter: *CAD in Electromagnetism; Advances in Electronics and Electron Physics*, Vol. 82, Academic Press Inc., New York, 1991.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Teoretska elektrotehnika	0	3
Electromagnetics	0	3
Electromagnetic Theory	0	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information		
Lecturer(s)	**Professor Zdenko Šimić**	
Course title	**Technological risk assessment**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Power Engineering	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course objectives

Learning approaches, methods and applications of the technological risk assessment. Explaining specifics of probabilistic approach and connections with conventional deterministic approach.

Defining role of risk assessment within risk management. Exploring integrated approach, risk perception, and safety goals within risk assessment and management.

1.2. Course enrolment requirements

Defined by the FERIT Student Assessment Framework and Paragraph 1.9

1.3. Expected learning outcomes

1. Summarize the parts of probability theory and mathematical statistics essential to understanding the risk estimation methods and risk analysis methods audit.
2. Model with fault tree and event tree methods for risk assessment.
3. Analyze uncertainty and sensitivity assessment (data, assumptions, model, quantification, and final results) as well as application for risk management.
4. Appraise possibilities of integrated risk management, specific scenarios and total consequences, as well as dealing with multiple criteria.
5. Analyze risks in environment caused by technical system life cycle operation

1.4. Course content

Risk assessment modeling and simulations. Describing failure types and hazards. Selected methods: FMEA, fault and event tree, Markov models and Bayesian networks. Human reliability assessment. Statistical data assessment and extreme events. Uncertainty and sensitivity assessment (data, assumptions, model, quantification, and final results). Importance of uncertainty for the risk management. Selected methods applications. Use of risk assessment for the technological systems design and operation (maintenance, reliability, risk). Risk assessment for different configurations and special conditions. Environmental risk assessment for the life cycle operation and functional safety. Risk management fundamentals: safety and other criteria, scenarios and total hazard. Relevance of risk perception for the risk management of different technological risk.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Students are required to attend at least 75% of the lectures, to work through all laboratory exercises, to create the individual project and pass the oral exam.

1.8. Monitoring and assessment of student work

Attendance	1	Participation in classes		Seminar paper	3	Experimental work	
Midterm exams (written) exam)		Oral exam	2	Essay		Research	
Project		Report		Laboratory exercises	2	Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT	ECTS	LEARNING	TEACHING	METHOD OF	CREDITS

ACTIVITY	CREDITS	OUTCOME	METHOD	ASSESSMENT	min.	max.
Attendance	1	1.,2.,3.,4.,5.	Lectures and	Recording attendance	0	0
Seminar making	3	2., 3.	Individual work	Reviewing and evaluating the seminar	40	60
Preparation for oral exam and oral examination	2	1., 2., 3, 4. i 5.	Oral exam	Checking given answers	20	40

1.10.Obligatory literature (at the time of submitting a study programme proposal)

1. Y.Y. Haimes (Ed.), A.P. Sage (Ser. Ed.): Risk Modeling, Assessment, and Management, 4th Ed., Wiley 2015
2. H. Kumamoto: Satisfying safety goals by probabilistic risk assessment, Springer 2007
3. M. Modarres: Risk Analysis in Engineering: Techniques, Tools, and Trends, CRC Press, 2005.

1.11.Recommended additional literature (at the time of submitting a study programme proposal)

1. V. Mikuličić, Z. Šimić: Modeli, pouzdanosti, raspoloživosti i rizika u elektroenergetskom sustavu, 1. dio, Kigen, 2008.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General Information		
Lecturer(s)	**Full Professor Zoran Baus**	
Course title	**Highly Integrated High Voltage Facilities**	
Study Programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Module Power Engineering	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L + 10E

1. COURSE DESCRIPTION

1.1. Course objectives

To enable students for independent implementation and development of advanced methods for analysis of highly integrated high voltage (HV) power facilities (HIS). Particular attention is paid to the construction and constructive properties of compact, VN highly integrated installations due to the dielectric strength and the voltage and current stresses due to the compacting of the plant. Analysis of very fast transient phenomena in VN facilities.

1.2. Course enrolment requirements

-

1.3. Expected learning outcomes

After passing the course, students will be able to:
1. Analyze electrical conditions in highly integrated VN plants from the aspect of electric fields.
2. Develop mathematical models for describing very fast transition phenomena and such VN facilities
3. Select and apply procedures for testing highly integrated VN gas isolated systems.
4. Assess the parameters of individual components of the highly integrated VN plant (switch, current transformers, voltage transformers, disconnectors, earthing switches, bus, air and cable connections, surge arresters, control system and monitoring system
5. To propose new methods of analysis for transition phenomena and testing of highly integrated VN facilities.

1.4. Course content

Ionization processes in isolation of high voltage (VN) plants. Mechanisms of voltage probe at very rapid surge surges in VN plants. Uniform fields in coaxial cylinders. Surface roughness effects. Breakdown in HIS installations .. Basic features of processes in highly integrated installations. Construction and life cycle of its plants: switch, current transformers, voltage transformers, disconnectors, earthing switches, bus, air and cable connections, direct transformer connections, surge arresters, control system, isolation coordination monitoring system. Transitional phenomena in HIS plants and influence on the power system. Earthing and performance methods of its HIS installations with regard to very fast electromagnetic transient phenomena. Techniques of Partial Discharge Diagnosis for HIS. Create and broadcast high frequency VF signals in HIS installations. Application of VF technique for partial discharge detection in HIS plants.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory excersises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☒ laboratory excersises ☐ design excersises ☐ work with a disseration supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Attend lectures, collect all laboratory exercises, solve individual project assignment and pass the oral exam.

1.8. Monitoring and assessment of student work

Attendance	1	Participation in classes		Seminar paper		Experimental work	

Midterm exams (written) exam)		Report	2	Essay		Research	
Project	3	Report		Laboratory exercises	2	Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max
Attendance	1	1., 2., 3., 4., 5.	Lectures (L), laboratory exercises (LE)	Attendance register	0	0
Pisanje priprema za LV, analiza rezultata, te pisanje izvještaja	2	2., 3.,5..	Laboratory excersises (LV)	Assessment of student's answers	15	20
Project	3	2., 3.,	Individual work	Evaluation of the project assessment	30	40
Oral exam	2	1., 2., 3. i 4.	Oral exam	Evaluation of giv3en answers	20	40

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. Akihiro Ametani, Naoto Nagaoka, Yoshihiro Baba, Teruo Ohno: „Power System Transients: Theory and Applications" 2013. CRC Press

2. John D. McDonaland: „Electric Power Substations Engineering, Third Edition" " 2012. CRC Press

3. A. Haddad; D. Warne: „ Advances in High Voltage Engineering",Institution of High Voltage Engineering and Technology, London,2007.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. H. Koch: „GIS-Gas Insulated Substations" John Wiley and Sons Ltd,UK,2014

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Power System Transients: Theory and Applications	1	3
Electric Power Substations Engineering	0	3
Advances in High Voltage Engineering	0	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences
Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

6.3. Module: Communications and Informatics

6.3.1. Fundamental Courses of the module Communications and Informatics

General information		
Lecturer(s)	**Professor Drago Žagar**	
Course title	**Communication network technologies**	
Study programme	**Postgraduate doctoral study programme Electrical Engineering and Computer Science, Module Communications and Informatics**	
Course status	Elective fundamental course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION
1.1. Course objectives
Applied knowledge in advanced communication network technologies, critical research trends in respective scientific field, as well as personal development for autonomous research.
1.2. Course enrolment requirements
-
1.3. Expected learning outcomes
1. Classify and assess the connection solutions in modern communication network technologies. 2. Integrate problematics of flow and error control in communication network. 3. Connect the mechanisms and application of network management protocols. 4. Connect and propose the advanced communication network technological solutions. 5. Research and find the open research problems in related field and propose the plan of research directions
1.4. Course content
Protocol hierarchy and referral models. Advanced mechanisms for flow control and error control. Advanced mechanisms of congestion control. IPv6 protocol. Advanced components of transport protocols. Internet applications. Quality of service in internet. Advanced technologies for media streaming – audio and video streaming. Multimedia services on demand. Mobility and general availability of users and services- transparency. Mobile IP networks – mobile internet. Network management. Network management protocols. Application of mobile network agents. Future of internet and new technologies. Technological challenges of internet. Quality of service realization for different applications and users. The challenges of network transformation and data processing – concept of Cloud computing. IoT technologies and smart systems for interconnection – open questions and challenges: throughput and network capacity, scalability, quality of service etc. regulatory aspects of interconnecting and new network technologies. Regulation challenges in “smart”

environment. Wireless sensor networks (WSN) as a part of IoT concept. Security aspects of network technologies.		
1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Class attendance, project assignment preparation, seminar paper preparation, attending consultations, oral exam

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes		Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	Yes	Essay		Research	Yes
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Lecture attendance	1	- Classify and assess the connection solutions in modern communication network technologies. - Integrate problematics of flow and error control in communication network. - Connect the	Lectures	Official records	5	10

		mechanisms and application of network management protocols. - Connect and propose the advanced communication network technological solutions. - Research and find the open research problems in related field and propose the plan of research directions				
Seminar	3	- Integrate problematics of flow and error control in communication network. - Connect the mechanisms and application of network management protocols. - Connect and propose the advanced communication network technological solutions. Research and find the open research problems in related field and propose the plan of research directions	Standalone research with supervision	Assessment of level of applied research competences in seminar paper and presentation of seminar paper results	20	40
Oral exam	4	- Classify and assess the connection solutions in modern communication network technologies.	Standalone training for exam by research of relevant	Assessment of knowledge adoption and understanding	25	50

		- Integrate problematics of flow and error control in communication network. - Connect the mechanisms and application of network management protocols. - Connect and propose the advanced communication network technological solutions. Research and find the open research problems in related field and propose the plan of research directions	literature			

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. William Stallings, Data and Computer Communications, 10th Edition, 2014 Pearson
2. A. S. Tanenbaum, D. J. Wetherall: „Computer Networks" (5. izdanje), Prentice Hall, Boston, 2013.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. J. F. Kurose, K. W. Ross: „Computer Networking: A Top-Down Approach" (6. izdanje), Addison-Wesley, Boston, 2013.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
William Stallings, Data and Computer Communications, 10th Edition, 2014 Pearson	1	
A. S. Tanenbaum, D. J. Wetherall: „Computer Networks" (5. izdanje), Prentice Hall, Boston, 2013.	1	

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

PhD committee supervises the quality of teaching, consultancies and exams, as well as periodically student evaluations could be conducted.

General Information		
Lecturer(s)	**Assistant Professor Slavko Rupčić**	
Course title	**Wireless Communication Systems**	
Study Programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Communications and Informatics	
Course status	Elective fundamental course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	10
	Number of classes (lectures + exercises + seminars)	20L + 10S

1. **COURSE DESCRIPTION**

1.1. Course objectives

The aim of the course is to familiarize students with the basic principles of advanced wireless communication systems and the methods of analysis and synthesis of these systems, in order to improve the existing and develop new optimal wireless communication systems.

1.2. Course enrolment requirements

There are no specific requirements.

1.3. Expected learning outcomes

After passing the course, students will be able to:
1. Evaluate wireless communication systems according to their applications and parameters.
2. Classify, compare and evaluate advanced multiple access systems and parameters.
3. Suggest and develop new coding procedures in wireless communications.
4. Apply existing and develop new models of communication channels.
5. Suggest and anticipate the development of advanced wireless systems in next generations

1.4. Course content

Studying the principles of work and parameters of advanced wireless communication systems. Classification of wireless transmission channel by parameters, characteristics (broadband and focused) and their modeling. Statistical coverage of advanced wireless systems. Analysis of the fundamental principles of adaptive modulation techniques and coding procedures in wireless communication systems. Structuring advanced wireless communication networks and their mathematical modeling. Transceivers and signal processing in wireless systems - wireless communication link, modulation formats, demodulation, diversification, coding, equalizers. Classification and analysis of advanced multiple access systems according to parameters and applications. Processes of antenna signal processing (multiple antenna systems) and their application.

1.5. Types of classes	X lectures X seminars and workshops ☐ auditory excersises ☐ distance learning ☐ fieldwork	☐ individual worki ☐ multimedia ☐ laboratory excersises ☐ design excersises ☐ work with a dissertation supervisor ☐ other _____

		———
1.6. Comments	Classes can be taught in English	
1.7. Student obligations		
Regular lectures attendance and preparation of seminar work as a prerequisite for oral exam.		
1.8. Monitoring and assessment of student work		

Attendance	1	Participation in classes		Seminar paper	5	Experimental work	
Midterm exams (written) exam)		Oral exam	4	Esej		Research	
Project		Report		Laboratorijske vježbe		Design exercises	
Portfolio							

1.9.Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max
Attendance	1	1,2,3,4,5	Lectures (LE)	Attendance monitoring. The minimum required for signature is 0%.	0	10
Seminar paper	5	3,4,5	Literature study, research work and seminars.	Quality Evaluation of Research and Presentation of Results	30	50
Oral exam preparation	4	1,2,3,4,5	Oral exam	Assessment of student's answers	20	40

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1.A.F.Molish, Wireless Communications, John Wiley & Sons, LTD. Second edition, 2010.
2. S. G. Glisic, Advanced Wireless Communications, John Wiley & Sons, 2005.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1.D.Tse, P.Viswanath, Fundamentals of Wireless Communications, Cambridge Univ. Press, 2005.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Naslov	*Broj primjeraka*	*Broj studenata*

A.F.Molish, Wireless Communications, John Wulwy & Sons, LTD, 2010.	1	3
S. G. Glisic, Advanced Wireless Communications, John Wiley & Sons, 2005.	1	3
D.Tse, P.Viswanath, Fundamentals of Wireless Communications, Cambridge Univ. Press, 2005.	.pdf format (*https:// web.stanford.edu///~dntse/wireless_book.html*)	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information		
Lecturer(s)	**Assistant Professor Tomislav Matić; Assistant Professor Davor Vinko**	
Course title	**Integrated Circuits Design**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Communications and Informatics	
Course status	Fundamental	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	10
	Number of classes (lectures + exercises + seminars)	20P + 5E + 5S

1. COURSE DESCRIPTION

1.1. Course objectives

The aim of the course is to educate students to design CMOS integrated circuits and to familiarize them with modern micro and nanoelectronic technologies.

1.2. Course enrolment requirements

First year of university postgraduate doctoral studies in electrical engineering, module communication and informatics.

1.3. Expected learning outcomes

1. Assess the choice of technology for the manufacture of integrated circuits;
2. Apply adequate design techniques for CMOS integrated circuits (System on a Chip - SoC);
3. Develop basic digital, analogue and digital / analogue integrated circuits (synthesis and simulation results analysis);
4. Analyze the applicability of certain DFT (design for testability) principles for the subject integrated circuit (Relationship of Circuit Addition / Testing Improvement);
5. Synthesis of technology selection, design techniques and DFT for the integrated circuit.

1.4. Course content

Integrated circuit design technologies: planar silicon technology. Technology for standard and application-specific integrated circuits design. Components of bipolar and unipolar integrated circuits. Challenges and foreseeable development of microelectronics development in future generation CMOS

integrated circuits. Techniques of CMOS integrated circuits design. Analog and Analog / Digital CMOS application-specific integrated circuits. Analog bipolar and unipolar integrated circuits: constant current sources; reference voltage sources, DC voltage level translators, basic amplifier stages (common emitter, common source), differential amplifiers, operational amplifier structures. DFT – design for testability methods for integrated circuits.

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☒ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory exercises ☒ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Class attendance, project assignment preparation, seminar paper preparation, attending consultations, oral exam

1.8. Monitoring and assessment of student work

Attendance	1	Participation in classes		Seminar paper	2	Experimental work	
Midterm exams (written) exam)		Oral exam		Essay		Research	
Project		Report		Laboratory exercises		Design exercises	3
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Lectures attendance (PR)	1	1. Assess the choice of technology for the manufacture of integrated circuits; 2. Apply adequate design techniques for CMOS integrated circuits (System on a Chip - SoC); 3. Develop basic digital, analogue and digital / analogue	Lectures (PR)	Evidence of presence. The minimum required for signature is: 70 %	0	0

		integrated circuits (synthesis and simulation results analysis); 4. Analyze the applicability of certain DFT (design for testability) principles for the subject integrated circuit (Relationship of Circuit Addition / Testing Improvement); 5. Synthesis of technology selection, design techniques and DFT for the integrated circuit.				
Design exercises	3	1. Assess the choice of technology for the manufacture of integrated circuits; 2. Apply adequate design techniques for CMOS integrated circuits (System on a Chip - SoC); 3. Develop basic digital, analogue and digital / analogue integrated circuits (synthesis and simulation results analysis); 4. Analyze the applicability of certain DFT (design for testability) principles for the subject integrated circuit (Relationship of Circuit Addition / Testing Improvement); 5. Synthesis of	Solve the default problem and suggest effective solutions.	Accuracy assessment of solutions, applicability and complexity of access	30	60

		technology selection, design techniques and DFT for the integrated circuit.				
Seminar paper	2	1. Assess the choice of technology for the manufacture of integrated circuits; 2. Apply adequate design techniques for CMOS integrated circuits (System on a Chip - SoC); 3. Develop basic digital, analogue and digital / analogue integrated circuits (synthesis and simulation results analysis); 4. Analyze the applicability of certain DFT (design for testability) principles for the subject integrated circuit (Relationship of Circuit Addition / Testing Improvement); 5. Synthesis of technology selection, design techniques and DFT for the integrated circuit.	Processing individual chapters and developing seminar work	Scoring the problem description and presentation mode	20	40

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. Behzad Razavi, Design of Analog CMOS Integrated Circuits 2nd Edition, ©2017
2. T. Švedek, Osnove mikroelektronike, Elektrotehnički fakultet Osijek, 2002.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Buddharaju, Pradeep, Oey, James, ASIC Physical Design A practical guide to ASIC design implementation, Springer, ©2022
2. Tony Chan Carusone, David Johns, Kenneth Martin, Analog Integrated Circuit Design, 2nd Edition International Student Version, Wiley, 2012.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course		
Title	*Number of copies*	*Number of students*
1. Behzad Razavi, Design of Analog CMOS Integrated Circuits 2nd Edition, ©2017	0	
2. T. Švedek, Osnove mikroelektronike, Elektrotehnički fakultet Osijek, 2002.	5	
1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences		
The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.		

6.3.2. Scientific specialisation courses of the module Communications and Informatics

<table>
<tr><td colspan="3">General information</td></tr>
<tr><td>Lecturer(s)</td><td colspan="2">Drago Žagar</td></tr>
<tr><td>Course title</td><td colspan="2">Quality of service in Internet</td></tr>
<tr><td>Study programme</td><td colspan="2">Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Communications and Informatics</td></tr>
<tr><td>Course status</td><td colspan="2">Elective fundamental course</td></tr>
<tr><td>Year of study</td><td colspan="2">First</td></tr>
<tr><td rowspan="2">Credit value (ECTS) and teaching methods</td><td>ECTS credits</td><td>8</td></tr>
<tr><td>Number of classes (lectures + exercises + seminars)</td><td>20L+10E</td></tr>
<tr><td colspan="3">1. COURSE DESCRIPTION</td></tr>
<tr><td colspan="3">1.1. Course objectives</td></tr>
<tr><td colspan="3">Understanding the technologies for assuring necessary quality of service in the internet. By successful subject adoption students will acquire the knowledge necessary for standalone research and solving the problems of quality of service in internet network.</td></tr>
<tr><td colspan="3">1.2. Course enrolment requirements</td></tr>
<tr><td colspan="3">-</td></tr>
<tr><td colspan="3">1.3. Expected learning outcomes</td></tr>
<tr><td colspan="3">1. Classify the quality of service form user, application and network point of view, respectively.
2. Formulate requirements of different applications for quality of service and minimal quality requirements.
3. Propose the mechanisms for quality of service realization in packet networks.
4. Generalize the models for implementation of quality of service in the internet.
5. Apply the technologies assuring necessary quality of service level in the internet.</td></tr>
<tr><td colspan="3">1.4. Course content</td></tr>
<tr><td colspan="3">Basic and advanced parameters for QoS realization. Applications classification and QoS requirements. Multimedia applications classification. Quality of service from user point of view. Quality of service from application point of view. Quality of service from network point of view. Quality of service classes. Applications and services in IP environment. The basic elements for quality of service realization: packet classification, packet scheduling and access control. Quality of service and resource management. Network resource management. End system resource management: adaptive applications and systems, proactive applications and systems. Quality of service negotiation. User and application parameters specification. Application – network parameters mapping. Service level agreement SLA. Performance and quality of service management. Basic models for quality of service implementation. Hybrid models. Flow management and performance optimization. Traffic engineering. Internet quality of service trends and perspectives.</td></tr>
<tr><td>1.5. Types of classes</td><td>☒ lectures
☐ seminars and workshops
☐ auditory exercises
☐</td><td>☒ individual work
☐ multimedia
☐ laboratory exercises
☐ design exercises
☒ work with a dissertation supervisor
☐ other</td></tr>
</table>

	distance learning ☐ fieldwork	_____
1.6. Comments	Classes can be taught in English	
1.7. Student obligations		
Class attendance, project assignment preparation, seminar paper preparation, attending consultations, oral exam		
1.8. Monitoring and assessment of student work		

Attendance	Yes	Participation in classes		Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	Yes	Essay		Research	Yes
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Lecture attendance	1	- Classify the quality of service form user, application and network point of view, respectively. - Formulate requirements of different applications for quality of service and minimal quality requirements. - Propose the mechanisms for quality of service realization in packet networks. - Generalize the models for implementation of quality of service in the internet.	Lectures	Official records	5	10

		- Apply the technologies assuring necessary quality of service level in the internet.				
Seminar	3	- Formulate requirements of different applications for quality of service and minimal quality requirements. - Propose the mechanisms for quality of service realization in packet networks. - Generalize the models for implementation of quality of service in the internet. - Apply the technologies assuring necessary quality of service level in the internet.	Standalone research with supervision	Assessment of level of applied research competences in seminar paper and presentation of seminar paper results	20	40
Oral exam	4	- Classify the quality of service form user, application and network point of view, respectively. - Formulate requirements of different applications for quality of service and minimal quality requirements. - Propose the mechanisms for quality of service realization in packet networks. - Generalize the models for implementation	Standalone training for exam by research of relevant literature	Assessment of knowledge adoption and understanding	25	50

		of quality of service in the internet. - Apply the technologies assuring necessary quality of service level in the internet.				

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. XiPeng Xiao, Technical, Commercial and Regulatory Challenges of QoS: An Internet Service Model Perspective. Morgan Kaufmann 2008.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. John Evans, Clarence Filsfils , Deploying IP and MPLS QoS for Multiservice Networks: Theory and Practice, Morgan Kaufmann, 2007
2. Mario Marchese, QoS Over Heterogeneous Networks, Wiley, 2007.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
XiPeng Xiao, Technical, Commercial and Regulatory Challenges of QoS: An Internet Service Model Perspective. Morgan Kaufmann 2008.	0	

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

PhD committee supervises the quality of teaching, consultancies and exams, as well as periodically student evaluations could be conducted.

General Information		
Lecturer(s)	**Professor Snježana Rimac-Drlje**	
Course title	**Advanced video processing methods**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Communications and Informatics	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION

1.1. Course objectives

To enable postgraduate study students to develop new methods for video signal analysis and processing as well as for the implementation of adaptive and real-time techniques for coding, enhancing and evaluating video signal quality and other video signal processing applications.

1.2.Course enrolment requirements

There are no specific requirements.

1.3.Expected learning outcomes

After passing the course, students will be able to:
1. Classify methods for detecting, evaluating, and replacing movements;
Critically evaluate and select appropriate research methods and techniques for video coding;
3. Classify and apply video segmentation methods;
4. Develop new methods to improve video quality;
5. Develop new methods for increasing spatial and temporal resolution of video signals;
6. Develop new methods for objective video quality evaluation.

1.4.Course content

Time and space properties of video signals. Spectral analysis of video sequences: Fourier transformation, DCT and DWT. Motion Analysis: Motion Detection, 2-D and 3-D Methods of Estimating and Replacing Movements. MPEG and H.26x video compression standards. Scalable video encoding. 3D and multi-view video coding. Spatial, temporal and spatial-time segmentation of the video. Detection and tracking of objects in video sequences. Methods to improve video quality: reduce noise, enhance contrast, focus, remove block effects. Increase spatial and temporal resolution of video signals. Objective and subjective methods for quality assessment of video sequences.

1.5.Types of classes	X lectures ☐ seminars and workshops ☐ auditory excersises ☐ obrazovanje na daljinu ☐ terenska nastava	X individual work zadaci ☐ multimedia ☐ laboratory excersis ☐ design excersises vježbe X work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Regular lectures attendance and preparation of seminar work as a prerequisite for oral exam.

1.8. Monitoring and assessment of student work

Attendance	0,5	Participation in classes		Seminar paper	1,5	Experimental work	
Midterm exams (written) exam)		Oral exam	2	Essay		Research	2
Project	2	Report		Laboratory exercises		Design exercises	
Portfolio				Working on project proposal		Prezentation of the seminar	

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	ISHOD UČENJA	LEARNING OUTCOME	METHOD OF ASSESSMENT	CREDITS	
					min	max
Attendance	0,5	1,2,3,4,5,6	Lecture(s)	Attendance register.	0	10
Project	2	2,3,4,5,6	Individual work	Assessment of student's project	15	30
Research and seminars	3,5	4,5,6	Individual work	Evaluation of applied research competence levels	20	40
Preparation for the oral exam	2	1,2,3,4,5,6	Oral exam	Assessment of student's answers	10	20

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. A. Murat Tekalp, Digital Video Processing, Prentice Hall 2015.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. R.C.G. Gonzalez; R. E Woods, Digital Image Processing. New Jersey: Pearson Education, 2008.
2. Iain E.G. Richardson: H.264 and MPEG-4 Video Compression, Video Coding for Next-generation Multimedia, Wiley, 2003
3. Izabrani radovi iz znanstvenih časopisa

Number of obligatory literature copies in relation to the number of students currently taking the course

Naslov	*Broj primjeraka*	*Broj studenata*
Digital Video Processing	1	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information		
Lecturer(s)	**Assistant Professor . Slavko Rupčić**	
Course title	**Smart antennas and systems**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Communications and Informatics	
Course status	Optional	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20P + 10S

1. COURSE DESCRIPTION

1.1. Course objectives

Adopt knowledge on the principles of the work of smart antenna arrays of different configurations. By successfully mastering this course, students will be able to analyze existing smart antennas and thus enable them to solve a wide range of problems that may arise in these systems, but they would also have knowledge of the creation of these systems.

1.2. Course enrolment requirements

First year of university postgraduate doctoral studies in electrical engineering, module communication and informatics.

1.3. Expected learning outcomes

1. Define smart antenna arrays of different performances and configurations.
2. Create and analyze smart antenna array with beam formatting and predefined parameters.
3. Analyze the work of different smart antenna arrays
4. Understand and interpret the data obtained by calculating and measuring smart antennas.

1.4. Course content

Introduction – Wireless (Mobile) Communications, Antenna Arrays, Diversity Techniques, Smart Systems. Smart Antenna Configurations. Switched-Beam Antennas. Adaptive Antenna Approach. Space Division Multiple Access. Architecture of a Smart Antenna System. Receiver and Transmitter. Benefits and Drawbacks. Mutual Coupling Effects. DOA Estimation. Beamformin. Integration Smart Antennas. Space–Time Processing.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Class attendance, project assignment preparation, seminar paper preparation, attending consultations, oral exam

1.8. Monitoring and assessment of student work

Attendance	1	Participation in classes		Seminar paper		Experimental work	3
Midterm exams (written) exam)	2	Oral exam		Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT	ECTS	LEARNING	TEACHING	METHOD OF	CREDITS

ACTIVITY	CREDITS	OUTCOME	METHOD	ASSESSMENT	min.	max.
Lectures attendance (PR)	1	1,2,3,4	Lectures (PR)	Evidence of presence. The minimum required for signature is: 70 %	5	10
Experimental work	3	2,3,4	Solve the default problem and suggest effective solutions.	Accuracy assessment of solutions, applicability and complexity of access	25	50
Oral exam	2	1,4	Processing individual chapters and developing seminar work	Scoring the problem description and presentation mode	20	40

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1.C. A. Balanis, P. I. Ioannides, Introduction to Smart Antennas , Morgan & Claypool, Arizona State University, 2007.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. J. C.Liberty, T.S.Rappaport: „Smart Antennas for Wireless Communications,Prentice Hall PTR, New Jersey,1999.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
C. A. Balanis, P. I. Ioannides, Introduction to Smart Antennas , Morgan & Claypool, Arizona State University, 2007.	1	3
J. C.Liberty, T.S.Rappaport: „Smart Antennas for Wireless Communications,Prentice Hall PTR, New Jersey,1999.	1	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information	
Lecturer(s)	**Assist. Prof. Mario Vranješ, PhD**
Course title	**Wideband Networks for Multimedia Services**
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Communications and Informatics

Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

2. COURSE DESCRIPTION

1.1. Course objectives

Introduce students with the basics of multimedia services. Explain to the students the components of multimedia system. Introduce students to the types of multimedia networks (ATM networks, IP networks, radiocommunications, mobile and satellite networks). Explain to the students the types of modulations for digital broadcasting television transmitters. Introduce students with the planning of digital broadcasting networks. Introduce students with single frequency broadcasting networks. Explain to the students how videoconferencing and remote learning operate. Introduce students with the usage of multimedia in medicine. Introduce students with the most common distortions of image, video signal and audio signals that may occur in network transmission and explain the reason of their incurrence. Qualify students to develop algorithms for detecting of different distortions of multimedia signals.

1.2. Course enrolment requirements

Expected conditions for enrollment.

1.3. Expected learning outcomes

1. Classify different multimedia services and different components of multimedia systems
2. Analyze the structure of wideband networks and the possibility of their application for the transmission of multimedia signals
3. Evaluate the various modulation procedures of digital broadcasting television transmitters
4. Link the cause of the individual distortion of the multimedia signal with the type of network and its characteristics
5. Perform scientific research in the field of broadband networks for multimedia services and write scientific papers
6. Design and develop the own advanced algorithm for detecting of specific distortion of given multimedia signal

1.4. Course content

Introduction to multimedia services. Components of the multimedia system. Types of multimedia networks: ATM networks, IP networks, radiocommunications, mobile and satellite networks, broadcasting networks. Types of modulations of digital broadcasting television transmitters. Planning of digital broadcasting networks. Single frequency broadband networks. Video conferencing, distance learning, multimedia in medicine. Distortion of image, video, audio signals. Algorithms for detecting of distortion of multimedia signals (image, video, audio).

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance learning ☐	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____

	fieldwork	
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Defined by the FERIT Student Assessment Framework.

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes		Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	Yes	Essay		Research	Yes
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attending classes (lectures, consultations)	1	1,2, 3,4,6	Lectures, mentoring	Identifying the presence	5	10
Performing research in the field of broadband networks for multimedia services	2,5	2, 3, 4, 5, 6	Research	Checking and evaluating of research methods	10	25
Writing seminar and/or scientific paper based on the results of research	2	5, 6	Seminar paper	Checking of the proposed solution and the achieved results	10	25
Preparation for oral exam and oral answering to the questions	2,5	1, 2, 3, 4, 6	Oral exam	Checking of given answers	20	40

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. L.M. Correia: Mobile Broadband Multimedia Networks, Academic Press, 2006.
2. S. Stanković, I. Orlović, E. Sejdić, Multimedia Signals and Systems, Springer, 2016.
3. J. Tang, Y. Cheng, Intrusion Detection for IP-Based Multimedia Communications over Wireless Networks, Springer, 2013

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. J. Ohm, Multimedia Signal Coding and Transmission (Signals and Communications Technology), Berlin, Heidelberg, Springer, 2016.
2. R. Zhang, L. Cai, J. Pan, Resource Management for Multimedia Services in High Data Rate Wireless Networks, Springer, 2017

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Providing university questionnaires on teachers (access to students, transparency of criteria, motivation to perform activities, clarity of presentation, etc.). Performing faculty questionnaires on subjects (after passing the subject self-evaluation of students about the learning outcomes adopted, and about the workload compared to ECTS with activities and subjects as a whole).

General information		
Lecturer(s)	**Dr. Kresimir Grgic, Assistant Professor**	
Course title	**Cybersecurity**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Communications and informatics	
Course status	Elective course	
Year of study	Second	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+5E+5S

1. COURSE DESCRIPTION

1.1. Course objectives

Provide students with knowledge required for understanding cybersecurity aspects in modern ICT systems (recognize threats, detect attacks and analyse risk). Enable students for individual planning and implementation of modern security mechanisms and protocols intended for systems for data transmission and storage.

1.2. Course enrolment requirements

-

1.3. Expected learning outcomes

1. Define and explain different types of modern symmetric and asymmetric cryptosystems
2. Understand and explain existing security threats, attacks and risks in modern ICT systems and apply appropriate countermeasures
3. Plan, design and implement security systems and mechanisms in modern information networks

4. Implement different Internet security protocols and standards into IP networks (wired and wireless)
5. Plan and perform security test of information system, with systematic result analysis and suggestions for security level improvement

1.4. Course content

Basic cybersecurity terms. Cryptography. Substitution and transposition ciphers. Symmetric cryptosystems and their applications. Asymmetric cryptosystems and their applications. Cryptographic hash functions. Digital signature. Security threats, attacks and possible countermeasures. Malware types. Intrusion detection and prevention. Firewalls and virtual private networks. Security protocols. Security in IP networks. E-mail security. Secure authentication protocols. Security in wireless, ad hoc and sensor networks.

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☒ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Student has to attend lectures, solves individual tasks in laboratory (supervised by teacher), and make seminar paper.

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes		Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	Yes	Essay		Research	
Project		Report		Laboratory exercises	Yes	Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance of lectures and laboratory exercises	1	1, 2, 3, 4, 5	Lectures, laboratory exercises	Attendance tracking (required minimum: 75%)	1	5

Writing preparation for laboratory exercises, result analysis and writing reports	1	2, 3, 4, 5	Laboratory exercises	Verification of written preparations, monitoring of the exercises and verification of written reports	9	20
Seminar paper	4	3, 4, 5	Making and presentation of seminar paper	Seminar paper content evaluation and presentation of the results	25	50
Preparation for oral exam and answering the questions	2	1, 2, 3, 4, 5	Oral exam	Evaluation of obtained answers	15	25
					50	100

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. A. Dujella, M. Maretić, Kriptografija, Element, Zagreb, 2007.
2. W. Stallings, Cryptography and Network Security – Principles and Practice, Prentice Hall, New Jersey, 2011.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. W. Stallings, Computer Security – Principles and Practice, Prentice Hall, New Jersey, 2011

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
1	1	3
2	1	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Questionnaire for students.

General information

Lecturer(s)	**Associate prof. Marijan Herceg**	
Course title	**Modern architectures of radiocommunication systems**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Communication and informatics	
Course status	Elective course	
Year of study	Second	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION

1.1. Course objectives

The aim of the course is to introduce students with the structure and work of modern architecture of communication systems. Allow students to propose optimal communication systems in different environments.

1.2. Course enrolment requirements

Realized conditions for enrolment

1.3. Expected learning outcomes

1. Select the optimal multiple access technique for a given application.
2. Suggest an effective communication system depending on the parameters of the communication channel.
3. Classify communication systems with regard to different parameters (transmission speed, spectrum width, complexity of hardware, etc.).
4. Develop new methods for improving the performance of a given communication system.
5. Predict the influence of communication channel parameters on the performance of the communication system.

1.4. Course content

Models of communication channels. Multiple Frequency Division Multiple Access (FDMA) techniques, time division multiple access (TDMA) and code division multiple access (CDMA). Broadband radio-communication systems with direct sequences (DS) and frequency hopping (FH). Orthogonal Frequency Division Multiplexing (OFDM) modulation scheme with increased resistance to multipath propagation, inter-symbol interferences (ISI) and narrowband interference. Encoded OFDM (coded OFDM - COFDM). Ultra-wideband modulation scheme (UWB) and low spectral density. Multiple input-multiple-output systems (MIMOs) with multiple antenna structures on the receiving and transmission side. MIMO channel encoding.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Defined by the FERIT Student Assessment Framework and paragraph 1.9

1.8. Monitoring and assessment of student work

Attendance	1	Participation in classes		Seminar paper	2	Experimental work	
Midterm exams (written) exam)		Oral exam		Essay		Research	
Project	3	Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attending lectures	1	1,2,3,4,5	Lectures	Evidence of presence. The minimum required for signing is 70%.	0	10
Project asignment	2	1,2,3,4,5	Solve a given problem and suggest effective solutions	Accuracy assessment of solutions, applicability and complexity of access	30	50
Seminar work	3	1,2,3,4,5	Processing individual chapters and developing seminar work	Scoring the problem description and presentation mode	20	40

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. John Proakis and Masoud Salehi, Digital Communications, 5th Edition, McGraw-Hill 2008
2. Andreas F. Molisch, Wireless Communications 2nd Edition, John Wiley & Sons Ltd. 2011

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Theodore S. Rappaport, Wireless Communications: Principles and Practice (2nd Edition), Prentice-Hall 2002

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
John Proakis and Masoud Salehi**,** Digital	1	3

Communications		
Andreas F. Molisch**,** Wireless Communications 2nd Edition	1	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information		
Lecturer(s)	**Dr. Darko Huljenić, associate Professor**	
Course title	**Open networks communication systems**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Communications and Informatics	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION

1.1. Course objectives

Familiarising students with basic concepts of architecture in communication systems. Specification the basic quality parameters in architecture of communication system. The communication system openness conditions and principles, and basic principles of networked communication system interactions. The historical overview and today's trends in development of open network communication systems. The basic models for analysis of open network communication systems.

1.2. Course enrolment requirements

No special conditions.

1.3. Expected learning outcomes

1. describe and explain basic items open communication systems
2. analyse standards and concepts of open communication system architecture
3. classification and analysis of functional and non-functional requirements for modelling of communication system
4. analyse and explain trends in open communication system architecture
5. suggest the model and parameters for analysis of open communication system

1.4. Course content

The basic concepts and principles for defining and analysis of software based communication system architecture. Definition and analyse of communication system architecture representation. Examples of communication systems architecture and development trends (new generation networks, cloud computing, virtualization). An architecture and system components modelling possibilities.

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a

	auditory exercises ☒ distance learning ☐ fieldwork	dissertation supervisor ☐ other _____ __
1.6. Comments	Classes can be taught in English	
1.7. Student obligations		
Attendance to the classes, research and preparation of seminar paper for final exam.		
1.8. Monitoring and assessment of student work		

Attendance	Yes	Participation in classes		Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)	30	Oral exam	Yes	Essay	30	Research	120
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance to classes	1	- describe and explain basic items open communication systems - analyse standards and concepts of open communication system architecture - classification and analysis of functional and non-functional requirements for modelling of communication system - analyse and explain trends	Lectures	Attendance register. Minimum attendance percentage: 50%	0	10

		in open communication system architecture - suggest the model and parameters for analysis of open communication system				
Elected topic – seminar paper	1	- describe and explain basic items open communication systems - analyse standards and concepts of open communication system architecture - classification and analysis of functional and non-functional requirements for modelling of communication system - analyse and explain trends in open communication system architecture - suggest the model and parameters for analysis of open communication system	Individual literature study work, conducting research and writing a seminar paper	Evaluating the content and research results.	0	30
Preparing for and taking oral exam	4	- analyse and explain trends in open communication system architecture - suggest the model and parameters for	Studying the literature and taking oral exam	Knowledge assessment	0	60

		analysis of open communication system				

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. R. N. Taylor, N. Medvidović, E. M. Dashofy, Software Architecture: Foundations, Theory, and Practice, Wiley 2010, ISBN-13-978-0470-16774-8
2. S. Becker, G. Brataas, S. Lehrig, Engineering Scalable, Elastic, and Cost-Efficient Cloud Computing Applications, The CloudScale Method Springer, 2017, ISBN 978-3-319-54285-0, DOI: 10.1007/978-3-319-54286-7
3. 3GPP standards
4. Conference papers

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. IEEE Communications Magazine

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
R. N. Taylor, N. Medvidović, E. M. Dashofy, Software Architecture: Foundations, Theory, and Practice, Wiley 2010	1	3
S. Becker, G. Brataas, S. Lehrig, Engineering Scalable, Elastic, and Cost-Efficient Cloud Computing Applications, The CloudScale Method, Springer, 2017	1	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information		
Lecturer(s)	**Professor Nikola Teslić**	
Course title	***Software in Television***	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Module Communications and Informatics	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION

1.1. *Course objectives*		
The goal of the course is to provide in-depth knowledge of modern DTV implementation and deployment practices. Core focus area is to understand actual middleware and DTV application technologies, which provide environment for execution of full scope of interactive applications. Specific topics also include modern aspects of non-linear television, such as IPTV, Internet TV, Social TV and second screen paradigms. Practical work would include software development for actual DVB-T2 set-top box devices, utilizing actual middleware software stacks and modern operating systems (such as Android).		
1.2. *Course enrolment requirements*		
The corresponding academic year / semester.		
1.3. *Expected learning outcomes*		
1. Knowledge of modern DTV implementation and deployment practices 2. Middleware and DTV application technologies, non-linear television, IPTV, Internet TV, Social TV and second screen paradigms. Through practical work students will learn to develop software for actual DVB-T2 set-top box devices, utilizing actual middleware software stacks and Android		
1.4. *Course content*		
Unit 1: DTV Middleware; Middleware overview; Abstracting middleware from hardware platform; Software model of DTV device; Abstract signal routes; Middleware validation; Middleware functions: Channels, Multiplexes, Tables, EPG; Application APIs. Project - Client-side DTV middleware integration; Unit 2: DTV receiver GUI development technologies; Native GUI programming; Declarative GUI; HTML-based GUI; Android-based GUI; GUI integration layers – Browser plugin, JNI; Unit 3: Connected TV, IPTV; Connected TV and convergence; Social TV and second screen; Hybrid TV; IPTV overview; Internet TV and Over-the Top; Protocols in IP-based TV; Cast protocol; Home Gateway; Fast channel change technologies; Standards. Unit 4: Over-the-Top DTV Middleware; OTT middleware introduction; Architecture; OTT client agent; OTT protocols, REST, JSON, XML; Secure communication; DRM; OTT specification and integration aspects; Project – OTT middleware integration. Unit 5: Application execution environments and standards; MHEG and interactive TV; MHEG application and lifecycle; MHEG engine architecture; MHEG file system; Programming MHEG; Integration of MHEG stack to DTV device; HbbTV overview; HbbTV applications and scope; Application lifecycle; HbbTV engine architecture; AIT signaling; HbbTV integration; Programming HbbTV. Unit 7: Complex DTV applications; DTV application taxonomy; DTV application development phases; UX design; UI design; Prototyping; Design patterns; Application elements overview. Project - Modern DTV application development in Android.		
1.5. *Types of classes*	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. *Comments*		
1.7. *Student obligations*		

Seminars, resolving practical problems, final exam.

1.8. *Monitoring and assessment of student work*

Attendance	0.75	Participation in classes		Seminar paper		Experimental work	
Midterm exams (written) exam)		Oral exam	2.75	Essay		Research	
Project	3	Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. *Assessment and evaluation of student work during classes and in the final exam*

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance	0.75	1, 2	Attendance		0	10
Oral exam	2.75	1, 2	Oral exam		0	60
Project	3	1, 2	Project		25	60

1.10. *Obligatory literature (at the time of submitting a study programme proposal)*

1. M. Bjelica, N. Teslic, V. Mihic, „Softver u televiziji i odbradi slike 1“, 2016
2. Fischer, W. "Digital Video and Audio Broadcasting Technology - A Practical Engineering Guide," Springer-Verlag, 2010.
3. Benoit, H. "Digital Television - Satellite, Cable, Terrestrial, IPTV, Mobile TV in the DVB Framework", Focal Press, 2008
4. Richardson, I. E. G. "H.264 and MPEG-4 Video Compression", Wiley, 2004

1.11. *Recommended additional literature (at the time of submitting a study programme proposal)*

1. Fischer, W. Digital Video and Audio Broadcasting Technology -A Practical Engineering Guide, Springer-Verlag, 2010.

1.12. *Number of obligatory literature copies in relation to the number of students currently taking the course*

Title	*Number of copies*	*Number of students*

1.13. *Quality assurance methods ensuring the acquisition of knowledge, skills and competences*
The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

6.4. Module: Computer Science

6.4.1. Fundamental Courses of the module Computer Science

General information		
Lecturer(s)	**Professor Goran Martinović**	
Course title	**Resource and Performance Management in Computer Sysetems**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Computer Science	
Course status	Elective fundamental course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	10
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course objectives

Explain, demonstrate, develop and use models, processes, tools and computing environments for resource planning and management, and determine the performance of the hardware and software part of embedded, distributed, service, mobile, and other computing systems, environments, and related software solutions.

1.2. Course enrolment requirements

-

1.3. Expected learning outcomes

1. Describe the computer environment from the point of view of load, resource management, planning and performance evaluation.
2. Analyze circuit and program capabilities, resource management procedures, planning, and performance evaluation of embedded, distributed, service, mobile and other environments.
3. Define models, methodologies, procedures, developmental and program capabilities for resource and performance management in the specified environments.
4. Apply models, methodologies, algorithms, development and program capabilities for resource management and performance.
5. Examine, measure, modify, optimize, and analyze the performance improvements of embedded, distributed, service, mobile and other environments.

1.4. Course content

Principles of resource management in computer systems. Scheduling problems: types and algorithms complexity, scheduling, deterministic and stochastic approaches. Resource restrictions. Multi-criteria scheduling. resorce management in actual computer environments. The impact of resource management, scalability, virtualization, modeling and software implementation on computer system performance. Real-time and autonomic behavior. Performance evaluation: Basic principles and measurement techniques. Load description. System capacity planning. Performance estimation. Data analysis. Comparison of alternatives. Statistical models, the basics of queing theory, stochastic and

mixed models. Performance prediction: regression, time series and pattern analysis. Programming tools for measuring, evaluating and monitoring performance. Analysis of the actual systems at the level of computer architecture, system and application software for embedded, distributed, service, mobile, and other computing environments.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Attendance, a review of literature, a project research task accompanied by a seminar paper and oral examination.

1.8. Monitoring and assessment of student work

Attendance	1.0	Participation in classes		Seminar paper	1.0	Experimental work	
Midterm exams (written) exam)		Oral exam	1.0	Essay		Research	1.0
Project	2.0	Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attending lectures and consultations	1.0	1, 2, 3, 4	Lectures, consultations	Evidence of attendance at lectures and consultations (minimum 70% in lectures and consultations)	0	0
Research, literature analysis, research survey writing	1.0	1, 2, 3,	Seminar paper	Analysis of seminar work and research field covered by the seminar paper	10	20

Solving programming and analytic assignments, result analysis, documentation	2.0	2, 3, 4, 5	Experimental work (programming assignments in seminar paper)	Checking, analyzing and evaluating of the program code	20	40
Writing a research review report	1.0	2, 3, 4	Research	Checking research report	10	20
Oral exam	1.0		Exam preparation and finalisation	Oral examination	10	20

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. J.-Y. Le Boudec, Performance Evaluation of Computer and Communication Systems (Computer and Communication Sciences), EPFL Press, 1 Ed., 2011.
2. A. Kejariwal, J. Allspaw, The Art of Capacity Planning: Scaling Web Resources in the Cloud, O'Reilly Media, 2nd Ed., 2017.
3. I. Molyneaux, The Art of Application Performance Testing: From Strategy to Tools, O'Reilly Media, 2nd Ed., 2014.
4. J. Blazewicz, K.H. Ecker, Scheduling Computer and Manufacturing Processes, Springer, 2nd Ed., 2013.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. N. Antonopoulos, L. Gillam, Cloud Computing: Principles, Systems and Applications (Computer Communications and Networks), Springer; 2nd Ed., 2017.
2. D. Nicolette, Software Development Metrics, Manning Publications, 1st Ed., 2015.
3. F.C. Delicato, P.F. Pires, T. Batista, Resource Management for Internet of Things, Springer; 1st Ed., 2017.
4. C.X. Mavromoustakis, E. Pallis, G. Mastorakis, Resource Management in Mobile Computing Environments (Modeling and Optimization in Science and Technologies), Springer, 2014.
5. C. Wu, R. Buyya, Cloud Data Centers and Cost Modeling: A Complete Guide To Planning, Designing and Building a Cloud Data Center, Morgan Kaufmann, 1st Ed., 2015.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
1. J.-Y. Le Boudec, Performance Evaluation of Computer and Communication Systems (Computer and Communication Sciences), EPFL Press, 1 Ed., 2011.	1	3
2. D. Nicolette, Software Development Metrics, Manning Publications, 1st Ed., 2015.	1	3
3. I. Molyneaux, The Art of Application Performance Testing: From Strategy to Tools, O'Reilly Media, 2nd Ed., 2014.	1	3
4. J. Blazewicz, K.H. Ecker, Scheduling Computer and Manufacturing Processes, Springer, 2nd Ed., 2013.	1	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences		
The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey is conducted.		

General information		
Lecturer(s)	**Professor Željko Hocenski** **Assistant Professor Tomislav Matić**	
Course title	**Parallel and Multicore Architectures**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Module Computer Science	
Course status	Elective fundamental course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	10
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION		
1.1. Course objectives		
To enable students to research in the field of architecture and communication within multi-processor systems. Getting familiar with parallel troubleshooting and parallel algorithms. Acquire Skills in Designing Parallel Processing Programs and Working with Multiple Processor and Parallel Architecture Operational Systems. To enable students to use CUDA and GPGPU technology.		
1.2. Course enrolment requirements		
Msc in computer engineering or computer science,		
1.3. Expected learning outcomes		
1. Define and explain the functionality of multi-processor and parallel computer systems 2. Differentiate and compare the work of multi-processor and parallel systems 3. Analyze and compare the work of simple and complex multiprocessor and multichannel GPGPU parallel systems 4. Design and model multi-processor and multi-core GPGPU parallel systems 5. Apply and test multiprocessor and multichannel GPGPU parallel computing systems 6. Analyze properties and propose improvements to multi-processor and multichannel GPGPU parallel systems		
1.4. Course content		
Basic forms of multiprocessor system building. Bundles with one or more main computers. Communication in computer systems and communication protocols. Operational systems and multiprocessor program execution. Synchronize Access with Common Resources. System Buildings MISD, SIMD and MIMD. Systemic fields. Data-controlled computers. High-tech computers. Artificial Neural Networks. Teaching methods in artificial neural networks. Model of cerebral cortex. Model for information processing in brain CMAC. Learning Algorithm for CMAC. Multi-processor computers for real-time operation. NVIDIA CUDA platform. ATI STREAM platform. GPGPU programming. Tolerance of failures in multi-processor systems. Some applications of multi-processor and parallel systems.		
1.5. Types of classes	☒ lectures ☒	☒ individual work ☐ multimedia

	seminars and workshops ☐ auditory exercises ☒ distance learning ☐ fieldwork	☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Attending lectures, studying literature, developing seminars, solving tasks and taking exams.

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes	Yes	Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	No	Essay		Research	Yes
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance Lectures (PR)	1 (30h)	1-2	Lectures	Attendance record	5	10
Research	4 (120h)	3-4	For selected software investigate different reliability models and predict software reliability	The evaluation of the applied research competencies in the seminar paper preparation and the presentation of the obtained results	30	60
Preparation of seminar paper	1 (30h)	1-4		The evaluation of material understanding.	15	30

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. M.Dubois, M. Annavaram, P. Stenstrom, Parallel Computer Organization and Design, Cambridge, 2012.
2. Yan Solihin, Fundamentals of Parallel Multicore Architectures, Chapman & Hall,2015.
3. D.P. Agrawal, Advanced Computer Architecture, IEEE Computer Society Press Washington, 1986
4. Cook, Shane; CUDA programming: a developer's guide to parallel computing with GPUs, San Francisco, California, Morgan Kaufmann Publishers Inc., 2013.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. K. Hwang, D. Degroot, (eds.), Parallel Processing for Supercomputers and Artificial intelligence, McGraw-Hill Pub. Company, New York, 1989.
2. S. Ribarić, Arhitektura računala, Školska knjiga, Zagreb, 1990
3. Munshi, Aaftab; Gaster, Benedict; Mattson, Timothy; Fung, James; Ginsburg, Dan; OpenCL Programming Guide, San Francisco, California, Addison-Wesley Professional, 2012.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
1	0	
2	0	
3	1	
4	0	
5	1	

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information		
Lecturer(s)	**Professor Ivica Crnković**	
Course title	**Component-based Software Systems**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Computer Science	
Course status	Elective fundamental course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	10
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course objectives

Understanding principles of design and development of component-based software systems.

1.2. Course enrolment requirements

Master level education in computer science, or electrical engineering, or related fields

1.3. Expected learning outcomes

1. Understanding trends in the development of component-based software systems.
2. Obtaining knowledge of principles of component models based on requirements in different engineering fields.

3. Familiarising with challenges and possible solutions.
4. Writing and reviewing of research papers as well as the presentation of respective papers in the form of a seminar.

1.4. Course content

Basic principles of component-based software systems and their implementation. Specification of software components: interface, functional and non-functional. Component interaction. Software architecture. Composition of components and their features – component modelling and prediction of component features. Component-based development process. Components for embedded systems and real-time systems. Problems and research challanges of the component-based approach.

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Class attendance, project assignment preparation, seminar paper preparation, attending consultations, oral exam

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes		Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	Yes	Essay	Yes	Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance Lectures	2	understand the principles of component-based programming	Lectures, discussions	Discussions	0	10
Seminar	1	Selection of the topic		Report	0	10

Systematic literature review	2	- follow scientific trends and research results in the area of component-based programming - conduct a systematic review of scientific literature		Report, presentation	0	10

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. I. Crnkovic, M. Larsson, Building Reliable Component-Based Software Systems, Artech House Publishers, 2002.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Literature form Software Engineering conferences (ICSE, Euromicro SEAA)

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
1. I. Crnkovic, M. Larsson, Building Reliable Component-Based Software Systems, Artech House Publishers, 2002.	2	

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Presentation of the report, its discussion, preparation of the report as basis for a scientific paper.

6.4.2. Scientific specialisation courses of the module Computer Science

General information		
Lecturer(s)	**Professor Goran Martinović**	
Course title	**Computer Systems and Methods for Data Analysis**	
Study programme	**Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Computer Science**	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course objectives

To explain, present, develop and use distributed and service-oriented computer systems, methods and tools for efficient big data analysis in business, research, industrial and other areas.
1.2. Course enrolment requirements
-
1.3. Expected learning outcomes
1. To describe hardware and software characteristics and capabilities of distributed and service-oriented environments in big data analysis, 2. To analyse hardware and software characteristics and capabilities of distributed and service-oriented environments in big data analysis, 3. To define models, methodologies, algorithms, development and programming solutions for big data analysis in those environments, 4. To apply models, methodologies, algorithms and programming solutions for big data analysis, 5. To test, measure, modify, optimise and analyse solutions developed for big data analysis.
1.4. Course content
Hardware and software hypotheses of distributed and service-oriented computer systems working. Parallel and distributed algorithms. Resource management, tools, users, reliability and security. Platform, infrastructure and visualisation. Development, testing and deployment of service. Use of public cloud services and tools. Big data. Discovery, storage, handling and processing of big data. Supervised, unsupervised, reinforcement and other machine learning approaches. Usage of current analytical and implementation methods, technologies and tools for data analysis. Linking a cloud environment and the Internet of Everything (IoE) as a data source. Applications in business, scientific, medical, industrial and other environments. Monitoring, measurement and evaluation of performance of distributed and service-oriented systems and data analysis.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations
Attendance, a review of literature, a project research task accompanied by a seminar paper and oral examination.
1.8. Monitoring and assessment of student work

Attendance	1.0	Participation in classes		Seminar paper	1.0	Experimental work	1.0
Midterm exams (written) exam)		Oral exam	1.0	Essay		Research	
Project	2.0	Report		Laboratory		Design exercises	

				exercises			
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attending lectures and consultations	1.0	1, 2, 3, 4	Lectures, consultations	Evidence of attendance at lectures and consultations (minimum 70% in lectures and consultations)	0	0
Research, literature analysis, research survey writing	1.0	1, 2, 3,	Seminar paper	Analysis of seminar work and research field covered by the seminar paper	10	20
Solving programming assignments, result analysis, documentation	2.0	2, 3, 4, 5	Experimental work (programming assignments in seminar paper)	Checking, analyzing and evaluating of the program code	20	40
Writing a research review report	1.0	2, 3, 4	Research	Checking research report	10	20
Oral exam	1.0		Exam preparation and finalisation	Oral examination	10	20

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. C.A. Varela, G. Agha, Programming Distributed Computing Systems: A Foundational Approach, MIT Press, 2013.
2. B. Wilkinson, Grid Computing: Techniques and Applications, Chapman and Hall/CRC, 2009.
3. M.J. Kavis, Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, and IaaS), Wiley, 2014.
4. B. Baesens, Analytics in a Big Data World: The Essential Guide to Data Science and its Applications, Wiley, 2014.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. A. Osseyran, M. Giles, Industrial Applications of High-Performance Computing: Best Global Practices, Chapman and Hall/CRC, 2015.

2. I. Foster, C. Kesselman, The Grid 2: Blueprint for a New Computing Infrastructure (2 izdanje), Morgan Kaufmann, 2004.

3. J. Rhoton, R. Haukioja, Cloud Computing Explained: Implementation Handbook for Enterprises (2nd Ed.), Recursive Press, 2009.

4. F. Provost, T. Fawcett, Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking, O'Reilly Media, 2013.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
1. C.A. Varela, G. Agha, Programming Distributed Computing Systems: A Foundational Approach, MIT Press, 2013.	1	
2. B. Wilkinson, Grid Computing: Techniques and Applications, Chapman and Hall/CRC, 2009.	1	
3. M.J. Kavis, Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, and IaaS), Wiley, 2014.	1	
4. F. Provost, T. Fawcett, Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking, O'Reilly Media, 2013.	1	

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey is conducted.

General information		
Lecturer(s)	**Professor Željko Hocenski** **Assistant Professor Tomislav Matić**	
Course title	**Software Reliability**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Module Computer Science, Module Communication and Informatics	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION

1.1. Course objectives

Students are able to independently study the reliability of computer software support. Allow students to classify specific problems in the area of design of reliable software support, organize testing, rejuvenate, incorporate tolerance of software malfunction. Enable students to apply models and tools

for predicting reliability, refinement, and reuse of software.

1.2. Course enrolment requirements

Msc in computer engineering or computer science, Msc of communication and informatics

1.3. Expected learning outcomes

1. Explain terms related to the reliability of software support
2. Classify and analyze different prediction models of software
3. Test the developed program support
4. Select the appropriate model of software reliability estimation and apply the same to the actual problem
5. Install methods for detecting malfunctions and tolerating errors.
6. Realize the rejuvenation and reuse of restored program support.

1.4. Course content

Introduction. Dependability, definitions. Software faults, key challenges. Fault detection and error detection methods. Software reliability prediction models. Software faults, bugs, errors classification. Software fault tolerance methods. Software aging and rejuvenation. Software reuse. Software testing.

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☒ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Attending lectures, studying literature, developing seminars, solving tasks and taking exams.

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes	20	Seminar paper	20	Experimental work	
Midterm exams (written) exam)		Oral exam	No	Essay		Research	60
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT	ECTS	LEARNING	TEACHING	METHOD OF	CREDITS

ACTIVITY	CREDITS	OUTCOME	METHOD	ASSESSMENT	min.	max.
Attendance Lectures (PR)	1 (30h)	1-2	Lectures	Attendance record	5	10
Research	4 (120h)	3-4	For selected software investigate different reliability models and predict software reliability	The evaluation of the applied research competencies in the seminar paper preparation and the presentation of the obtained results	30	60
Preparation of seminar paper	1 (30h)	1-4		The evaluation of material understanding.	15	30

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. J.D.Musa, Software Reliability Engineering, McGraw-Hill, 1998.
2. Laura Pullum, Software Fault Tolerance Techniques and Implementation, Artech House, 2001.
3. Katinka Wolter, Stochastic Models for Fault Tolerance: Restar, Rejuvenation and Checkpointing, Springer, 2010.
4. Stanislaw Jarzabek, Effective Software Maintenance and Evolution: A Reuse-Based Approach, Auerbach Publications, Taylor & Francis Group, 2007.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. M. R. Lyu, Handbook of Software Reliability Engineering, IEEE Computer Society Press, 1996.
2. Shigeru Yamada, Software Reliability Modeling: Fundamentals and Applications, Springer, 2014.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
J.D.Musa, Software Reliability Engineering, McGraw-Hill, 1998.	1	3
Laura Pullum, Software Fault Tolerance Techniques and Implementation	0	3
Katinka Wolter, Stochastic Models for Fault Tolerance: Restar, Rejuvenation and Checkpointing	0	3
Stanislaw Jarzabek, Effective Software Maintenance and Evolution: A Reuse-Based Approach	0	3
Shigeru Yamada, Software Reliability Modeling: Fundamentals and	0	3

Applications		

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information		
Lecturer(s)	**Assistant Professor Irena Galić**	
Course title	**3D Computer Graphics and Geometric Modelling**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Computer Science	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course objectives

Theoretical and practical knowledge of the application of the principles of geometric modelling, 3D graphics and computer animation. Practical computer graphics programming skills.

1.2. Course enrolment requirements

Requirements met for enrolling in the study programme.

1.3. Expected learning outcomes

1. Interpret geometric modelling methods.
2. Interpret 3D computer graphics.
3. Build a 3D object based on the basic principles and procedures of geometric modelling and 3D computer graphics.
4. Build a virtual scene based on the basic principles and procedures of geometric modelling and 3D computer graphics.
5. Apply illumination, transparency, texture and shading patterns.
6. Make animation of virtual scene.

1.4. Course content

Methods of geometric modelling. Curves and surfaces. Sampling and reconstruction in computer graphics. Matrix representation of geometric transformations and projections in 3D. Virtual scene. Coordinate system. Camera model and transformation. Hierarchical structure. Volume rendering. Illumination and shading. Texture. The Human Vision System. Colour.

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance	☐ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____

	learning ☐ fieldwork	—
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Defined by the FERIT Student Assessment Framework.

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes		Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	Yes	Essay		Research	
Project	Yes	Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance lectures.	1	1, 2, 3	Lectures	Attendance recording. The minimum required for signature is: 50%.	5	10
Solving a project assignment.	3	1-6	Project	Verification of the resolved project and scoring the accuracy of the solution, the appropriateness and complexity of the approach.	20	40
Writing and preparation of seminar paper.	2	1-6	Seminar paper	Checking the seminar work, scoring the problem description and presentation mode.	12	25
Preparation for oral exam and	2	1-6	Oral exam	Verification of	13	25

answering given questions.				given answers.		

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. J. D. Foley, J. F. Huges, A. van Dam, M. McGuire, D. F. Sklar, S. K. Feiner, K. Akeley, Computer Graphics: Principles and Practice, Addison-Wesley, Willard, 2013.
2. A. S. Glassner, Principles of Digital Image Synthesis, Morgan Kaufman, San Francisco, 1996.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. A. H. Watt: 3D Computer Graphics, Addison-Wesley, 2000.
2. M. K. Agoston: Computer Graphics and Geometric Modelling: Implementation and Algorithms, Springer, 2005.
3. G. Farin: Curves and Surfaces for Computer Aided Geometric Design (Fifth Edition), Morgan Kaufmann, 2002.
4. Wolfgang Kühnel: Differential Geometry: Curves - Surfaces - Manifolds, American Mathematical Society, 2005.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
J. D. Foley, J. F. Huges, A. van Dam, M. McGuire, D. F. Sklar, S. K. Feiner, K. Akeley, Computer Graphics: Principles and Practice, Addison-Wesley, Willard, 2013.	0	
A. S. Glassner, Principles of Digital Image Synthesis, Morgan Kaufman, San Francisco, 1996.	Free	

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Conducting university questionnaires on teachers (student-teacher relationship, transparency of assessment criteria, motivation for teaching, teaching clarity, etc.).
Conducting Faculty surveys on courses (upon passing the exam, student self-assessment of the adopted learning outcomes and student workload in relation to the number of ECTS credits allocated to activities and courses as a whole).

General information	
Lecturer(s)	**Professor Željko Hocenski, Professor Laszlo Juhasz dr. sc. Ivan Vidović**
Course title	**Design of FPGA systems**
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Module Computer Science, Module Communication and Informatics
Course status	Elective course
Year of study	First

Credit value (ECTS) and teaching methods	ECTS credits	6
	Number of classes (lectures + exercises + seminars)	30L+15S

1. COURSE DESCRIPTION

1.1. Course objectives

Enable students to develop algorithms of FPGA-based embedded systems for real-time operation. Enable students to implement algorithms on FPGA image / video processing, signal processing, financial calculations, biomedicine etc. Develop a prototype using a V-cycle based on the model and simulate the entire system by repairing software and hardware until the required specifications are met.

1.2. Course enrolment requirements

Msc in computer engineering or computer science, Msc of communication and informatics

1.3. Expected learning outcomes

1. Analyze the control of process and data processing problem and research the existing solutions.
2. Select the algorithm to solve the specific signal processing problem.
3. Implement the control and data processing algorithm on a system based on an FPGA platform.
4. Eliminate the deficiencies and enable the required specifications to be achieved using the V cycle.
5. Verify a computer system developed on the FPGA platform.

1.4. Course content

Computer models based on FPGA platforms. Implementing algorithms using the SDSoC development environment. Implement compute-intensive algorithms on FPGA-based systems. Using an OpenCV library on FPGA-based computer systems. Development of hardware to accelerate compute-intensive algorithms. Development of a computer system prototype using the V cycle. Verification of a computer system developed on the FPGA platform.

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Attending lectures, studying literature, work on a individual tasks and writing a seminar paper.

1.8. Monitoring and assessment of student work

Attendance	10	Participation in classes		Seminar paper	50	Experimental work	
Midterm exams (written) exam)		Oral exam		Essay		Research	40
Project		Report		Laboratory		Design exercises	

				exercises			
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance	0.6	1,2,4,5		Attendance register	5	10
Seminar paper	3.0	1-5		Evaluation of research, implemented solution and written seminar work	25	50
Research (individual tasks)	2.4	1-5		Evaluation of individual tasks	20	40

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. Louise H. Crockett, Ross A. Elliot, Martin A. Enderwitz and Robert W. Stewart: The Zynq Book Embedded Processing with the ARM® Cortex®-A9 on the Xilinx Zynq-7000 All Programmable SoC, Strathclyde Academic Media, July 2014.
2. SanjayChuriwala, Designing with Xilinx FPGAs Using Vivado, Springer, 2016.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Louise H. Crockett, Ross A. Elliot, Martin A. Enderwitz and David Northcote: The Zynq Book Tutorials for Zybo and ZedBoard, , Strathclyde Academic Media, August 2015.
2. João M.P. Cardoso and Michael Hübner: Reconfigurable Computing - From FPGAs to Hardware/Software Codesign, Springer, 2011.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
The Zynq Book Embedded Processing with the ARM® Cortex®-A9 on the Xilinx Zynq-7000 All Programmable SoC	0	3
Reconfigurable Computing -From FPGAs to Hardware/Software Codesign	0	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey.

General information

Lecturer(s)	**Professor Robert Cupec**	
Course title	**Intelligent Robotic Systems**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Computer Science	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION

1.1. Course objectives

To train students for research in the field of artificial intelligence, robotics and computer vision. To provide information about advanced approaches and methods researched and applied in the field of artificial intelligence, robotics and computer vision.

1.2. Course enrolment requirements

Msc. in computer engineering or computer science

1.3. Expected learning outcomes

1. To design a robot control system which uses methods from the field of artificial intelligence, robotics and computer vision.
2. To classify technical problems within the field of artificial intelligence, robotics and computer vision.
3. To combine knowledge from the field of artificial intelligence, robotics and computer vision in order to solve technical problems.
4. To select appropriate methods for solving technical problems from the field of artificial intelligence, robotics and computer vision.
5. To develop solutions of technical problems from the field of artificial intelligence, robotics and computer vision in the form of a computer program.

1.4. Course content

Object recognition by computer vision. Segmentation of images and point clouds. Object classification by computer vision. Object and environment models for application in object recognition and classification. Vision based robot manipulation. Mobile robot navigation: path planning, obstacle detection and avoidance using perception sensors. Fusion of sensor data. Robot localization. Environment map building using sensor data. Mobile robot manipulation.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Attending lectures, studying literature and writing a seminar paper.

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes		Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	Yes	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance	0.8	1 – 4		Attendance register	5	10
Seminar paper	5.2	1 - 5		Assessing student's competencies for doing a seminar paper and presenting research results	45	90

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. Roland Siegwart and Illah Nourbakhsh: Introduction to Autonomous Mobile Robots, The MIT Press, A Badford Book, 2004.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. J. C. Latombe, Robot Motion Planning, Norwell, Massachusetts, USA: Kluwer Academic Publishers, 1991.
2. S. Thrun, W. Burgard, D. Fox, Probabilistic Robotics, Cambridge Massachusetts, 2006.
3. S. J. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, Upper Saddle River, New Jersey, 1995.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Introduction to Autonomous Mobile Robots	0	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information		
Lecturer(s)	**Assistant Professor Ratko Grbić, Assistant Professor Josip Job**	
Course title	**Data science**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Computer Science	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION

1.1. *Course objectives*

Introduction to data science which covers introduction to different methods and techniques for data management, data analysis and knowledge extraction from data and the obtained results presentation. Learning appropriate skills with software tools and frameworks which enable data collection, integration and manipulation, data visualization, statistical data analysis, data based modelling and prediction.

1.2. *Course enrolment requirements*

-

1.3. *Expected learning outcomes*

1. Distinguish and explain the basic activities in data analysis.
2. Recommend the most appropriate method for data analysis and knowledge extraction from the data for a given problem.
3. Select and use appropriate techniques for data getting and cleaning.
4. Select and use appropriate techniques of exploratory data analysis.
5. Recommend and explain how data visualization should be performed for a specific problem.
6. Use the software tools, libraries and platforms for data visualization.
7. Recommend and explain selection of method for solving a machine learning problem.
8. Use software tools, libraries and platforms for machine learning algorithms implementation.

1.4. *Course content*

Introduction to data science. Problem definition and translation to the data problem. Data sources. Properties of the data. Data management. Data getting and cleaning. Exploratory data analysis. Data visualization. Statistical methods. Fundamentals of machine learning. Types of machine learning. Methods for data clustering and dimensionality reduction. Development of different predictive models. Big data analytics. Deep learning. Advanced optimization methods. Results interpretation, presentation and reproducibility, decision making. Available software tools and platforms for data visualization and data analytics (R, Python, d3.js, Tableau, Google TensorFlow etc.). Developing data products. Different applications.

1.5. *Types of classes*	☒ lectures ☐ seminars and workshops ☐ auditory exercises	☐ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a

	☐ distance learning ☐ fieldwork	dissertation supervisor ☐ other _____
1.6. *Comments*	Class can be taught in a foreign language (English language)	
1.7. *Student obligations*		
Attending lectures. Seminar paper. Oral exam.		

1.8. *Monitoring and assessment of student work*

Attendance	25%	Participation in classes		Seminar paper	42%	Experimental work	
Midterm exams (written) exam)		Oral exam	33 %	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. *Assessment and evaluation of student work during classes and in the final exam*

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance Lectures (PR)	1,5 (45h)	1-5,7	Lectures (PR)	Attendance record	5	10
Seminar paper	2,5 (75h)	1-8	Preparation of seminar paper	Seminar paper presentation and the evaluation of written part	25	50
Preparation for the oral exam and an oral reply to questions	2 (60h)	1-8	Oral exam	The evaluation of knowledge and material understanding.	20	40

1.10. *Obligatory literature (at the time of submitting a study programme proposal)*

1. J. Grus, Data Science from Scratch: First Principles with Python, O'Reilly Media, 2015.
2. S. Murray, Interactive Data Visualization for the Web, O'Reilly Media, 2013.
3. S. Raschka, Python Machine Learning, Packt Publishing, 2015.

1.11. *Recommended additional literature (at the time of submitting a study programme proposal)*
1. T. Hastie, R. Tibshirani, J. Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer, 2009. 2. C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2007. 3. R. D. Peng, R Programming for Data Science, Leanpub, 2015.

1.12. *Number of obligatory literature copies in relation to the number of students currently taking the course*

Title	*Number of copies*	*Number of students*
Data Science from Scratch: First Principles with Python	0	3
Interactive Data Visualization for the Web	Available online	3
Python Machine Learning	1	3

1.13. *Quality assurance methods ensuring the acquisition of knowledge, skills and competences*
By conducting student surveys

General information		
Lecturer(s)	**Assistant Professor Ratko Grbić, Assistant Professor Emmanuel Karlo Nyarko**	
Course title	**Deep learning**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Computer Science	
Course status	Elective course	
Year of study	Second	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION
1.1. *Course objectives*
Introduction to the principles and methods of machine learning. Introduction to deep learning methods. Introduction to the architecture of deep neural networks, learning algorithms and possible application of deep learning. Learning appropriate skills with software tools and cloud services which enable the development of complex models and deep learning.
1.2. *Course enrolment requirements*
Linear algebra, probability and statistics, programming
1.3. *Expected learning outcomes*
1. Define and explain the concepts of machine learning and deep learning. 2. Explain and analyze the architecture of deep neural networks. 3. Classify, explain and analyze deep learning algorithms. 4. Suggest a solution to the problem by using the appropriate methods and models of deep learning.

5. Build and integrate a solution to a specific problem using the software tools for implementing deep learning methods.

1.4. *Course content*

Basics of machine learning. Types of machine learning. Fundamentals of neural networks: multilayer perceptron, Hopfield network, Boltzmann machine and restricted Boltzmann machine. Deep learning fundamentals. Deep learning architectures and algorithms. Deep neural networks. Deep Boltzmann machine. Deep belief network. Convolutional deep neural networks. Recurrent neural networks. Other deep hybrid networks. The use of deep learning in signal and information processing: speech and sound processing, natural language processing, computer vision and image processing, recommender systems. Work with software tools / cloud services that support deep learning: Python, R, Theano, Google TensorFlow, Caffe, Torch, Amazon Web Services etc.

1.5. *Types of classes*	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☐ work with a dissertation supervisor ☐ other _____
1.6. *Comments*	Class can be taught in a foreign language (English language)	

1.7. *Student obligations*

Attending lectures. Seminar paper. Oral exam.

1.8. *Monitoring and assessment of student work*

Attendance	17%	Participation in classes		Seminar paper	58%	Experimental work	
Midterm exams (written) exam)		Oral exam	25 %	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. *Assessment and evaluation of student work during classes and in the final exam*

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance Lectures (PR)	1 (30h)	1-4	Lectures (PR)	Attendance record	5	10

Seminar paper	3,5 (105h)	1-5	Preparation of seminar paper along with consultation and literature studying	The evaluation of the applied research competencies in the seminar paper preparation and the presentation of the obtained results	30	60
Preparation for the oral exam and an oral reply to questions	1,5 (45h)	1-4	Oral exam	The evaluation of knowledge and material understanding.	15	30

1.10. *Obligatory literature (at the time of submitting a study programme proposal)*

1. I. Goodfellow, Y. Bengio, A Courville, Deep Learning, MIT Press, 2016.
2. S. Raschka, Python Machine Learning, Packt Publishing, 2015.

1.11. *Recommended additional literature (at the time of submitting a study programme proposal)*

1. T. Hastie, R. Tibshirani, J. Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer, 2009.
2. E. Alpaydin, Introduction to Machine Learning, MIT Press, 2014.

1.12. *Number of obligatory literature copies in relation to the number of students currently taking the course*

Title	*Number of copies*	*Number of students*
Deep Learning	Available online	
Python Machine Learning	1	

1.13. *Quality assurance methods ensuring the acquisition of knowledge, skills and competences*

By conducting student surveys

General information		
Lecturer(s)	**Professor Željko Hocenski , Prof. Dr.-Ing. Dieter Kraus , Assistant Professor, Ivan Aleksi Assistant Professor Tomislav Matić**	
Course title	**Real-time signal, image and video processing**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Module Computer Science	
Course status	Elective course	
Year of study	2.	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20P+10S

1. COURSE DESCRIPTION

1.1. Course objectives

Allow students to study real-time video, video, and video processing. Provide information on advanced methods that are used or investigated in the field of image processing, segmentation, filtering, separation and recognition of features and parallel processing algorithms in real time.

1.2. Course enrolment requirements

Msc in computer engineering or computer science, Msc of communication and informatics

1.3. Expected learning outcomes

1. Define and explain the concepts of real-time image processing
2. Explain and analyze different image processing algorithms
3. Classify, explain and analyze different computational platforms for real-time image processing
4. Select and apply appropriate platform for real-time image processing
5. Develop and test appropriate software tools for real-time image processing

1.4. Course content

The basics of signal/image/video (data) processing. Types of data and their acquisition. Real-time systems. Basics of GPU, CPU, DSP and FPGA computing platforms. Applications of specific platforms on practical real-time problems. Analysis of a certain algorithm implementation on different computer architectures. Data processing in real-time: segmentation, filtering, feature extraction and identification, data analysis. Practical examples: identification based on image or video of face, iris, fingerprint, failure detection in quality assurance etc. Implementation of parallel algorithms in several programming languages: C ++, CUDA, VHDL, MATLAB.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☒ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Class can be taught in a foreign language (English language)	

1.7. Student obligations

Attending lectures, studying literature and writing a seminar paper.

1.8. Monitoring and assessment of student work

Attendance	20	Participation in classes		Seminar paper		Experimental work	
Midterm exams (written) exam)		Oral exam	20	Essay		Research	60
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT	ECTS	LEARNING	TEACHING	METHOD OF	CREDITS

ACTIVITY	CREDITS	OUTCOME	METHOD	ASSESSMENT	min.	max.
Attendance Lectures (PR)	1 (30h)	1-4	Lectures	Attendance record	5	10
Research	3,5 (105h)	1-5	Survey of State of the art methods for a particular real-time image processing problem	The evaluation of the applied research competencies in the seminar paper preparation and the presentation of the obtained results	30	60
Preparation for the oral exam and an oral reply to questions	1,5 (45h)	1-4	Oral exam	The evaluation of knowledge and material understanding.	15	30

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. Uvais Qidwai and C.H. Chen: „Digital Image Processing, An Algorithmic Approach With MATLAB," Chapman & Hall, 2010. ISBN13: 978-1-4200-7950-0.
2. Robert Sedgewick, Kevin Wayne: "Algorithms," 4th edition, Addison-Wesley Professional, 2011. ISBN-13: 978-0321573513.
3. Sen M. Kuo, Bob H. Lee, Wenshun Tian: "Real-Time Digital Signal Processing: Fundamentals, Implementations and Applications," 3rd edition, Wiley, 2013. ISBN-13: 978-1118414323.
4. John C. Russ, J. Christian Russ: "Introduction to Image Processing and Analysis," CRC Press, 2007. ISBN-13: 978-0849370731.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Aaftab Munshi, Benedict Gaster, Timothy G. Mattson, James Fung, Dan Ginsburg: "OpenCL Programming Guide," Addison-Wesley Professional, 2011. ISBN-13: 978-0321749642.
2. Mark Nixon: "Feature Extraction & Image Processing for Computer Vision", 3rd edition, Academic Press, 2012. ISBN-13: 978-0123965493.
3. Thaddeus Baynard Welch III, Cameron H.G. Wright, Michael G. Morrow: "Real-Time Digital Signal Processing from MATLAB® to C with the TMS320C6x DSPs," 3rd edition, CRC Press, 2011. ISBN-13: 978-1439883037.
4. James Reinders: "Intel Threading Building Blocks: Outfitting C++ for Multi-core Processor Parallelism," O'Reilly Media, 2007. ISBN-13: 978-0596514808.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Digital Image Processing, An Algorithmic Approach With MATLAB	1	3
Algorithms, 4th edition	1	3

Real-Time Digital Signal Processing: Fundamentals, Implementations and Applications	1	3
OpenCL Programming Guide	1	3
Feature Extraction & Image Processing for Computer Vision	1	3
Introduction to Image Processing and Analysis	1	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information		
Lecturer(s)	**Zdravko Krpić, Ph. D.**	
Course title	**High performance and scientific computing**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Computing	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION

1.1. Course objectives

- The main objective is to teach students to design, analyze and implement scalable software for the high-performance computing systems and to tailor scientific applications to work on state of the art parallel computing systems.
- Provide knowledge to the student on time analysis and profiling the execution of parallel and distributed applications, testing and measuring the performance of the programs running on state of the art computing units of the advanced high performance computing systems and allocating, assigning and mapping of software to parallel computing systems.
- Teach students the strategies and methods of software parallelization, design and analysis of advanced parallel algorithms, task and data parallelism, and work sharing techniques among the program's executable units.
- Teach students how to develop advanced parallel programs using OpenMP, MPI and other advanced programming technologies, tools and environments for creating and evaluating parallel applications.
- Provide knowledge to students to develop applications using advanced numeric and self-tuned programming libraries intended for high performance computer systems.
- Provide students with the knowledge to design their own high performance computer systems of the required scale (small to exascale), and to identify and remove the shortcomings of the existing systems.

1.2. Course enrolment requirements

- Proficiency in programming in a high-level language such as C, C++, or FORTRAN.
- Basic knowledge of computer architecture and algorithms and data structures.

1.3. Expected learning outcomes

On course completion students will be able to:
1. Design and create software for high performance computer systems.

2. Integrate parallel programming techniques into software solutions in science.
3. Classify computer systems according to the degree and form of parallelism, and design and construct software solutions to evaluate them.
4. Isolate key performance indicators on current high performance computer systems and formulate metrics for evaluating it.
5. Measure the performance of parallel programs and high performance computing systems.
6. Automatically split the parallel software into units of execution and allocate them to the available parallel hardware.

1.4. Course content

Introduction to advanced computing architectures, parallel algorithms, programming languages and environments. Performance-oriented computing. Analysis and application of real-world case studies from computational science and engineering application domains. Describing the key characteristics of high-end computing architectures. Development of efficient programs for scientific computing. Parallel algorithms in the context of their assignment to the high-end computer architectures. Designing and implementation of software in the field of computer science and engineering that achieve best performance. Writing, analyzing and optimizing software for the modern high performance computer systems. Evaluating the performance of parallel Programs. Evaluating the performance of multiprocessing units, multi-computers and multiprocessor systems. GRID computing, mass storage, visualization.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

The presence of at least 70% of lectures, submission of seminar work, independent learning and research.

1.8. Monitoring and assessment of student work

Attendance	1	Participation in classes		Seminar paper	3	Experimental work	2
Midterm exams (written) exam)		Oral exam		Essay		Research	2
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.

Attending lectures and consultations	1	1, 2, 3, 4, 6	Lectures, consultation	Evidence of attendance at lectures and consultations (minimum 70% in lectures and consultations)	0	0
Research, analysis, report writing, research survey writing	3	1, 2, 3, 4, 5	Seminar paper	Analysis of seminar work, analysis of the research field covered by the seminar paper	20	40
Solving programming assignments, result analysis, writing documentation	2	1, 2, 3, 6	Experimental work (programming assignments in seminar paper)	Checking, analyzing and evaluating of the program code	15	30
Writing a review report in the field of research	2	2, 3, 4	Research	Checking research report	15	30

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. Rauber, T, Rünger, G., Parallel Programming for Multicore and Cluster Systems, Springer Berlin Heidelberg, 2013.
2. Błażewicz, J., Ecker, K., Plateau, B., Trystram, D., Handbook on Parallel and Distributed Processing, Springer-Verlag Berlin Heidelberg, 2000.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Hager, G., Wellein, G., Introduction to High Performance Computing for Scientists and Engineers, CRC Press, 2010.
2. McCool, M., Reinders, J., Robison, A., Structured Parallel Programming: Patterns for Efficient Computation, Morgan Kaufmann, 2012.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Parallel Programming for Multicore and Cluster Systems	1	3
Handbook on Parallel and Distributed Processing	1	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

The Postgraduate Study Committee monitors the regularity and quality of teaching, consulting and examination, and, if necessary, student evaluation through a survey is conducted.

General information		
Lecturer(s)	**Tomislav Rudec, Assistant Professor**	
Course title	**Algorithms for NP-hard and online problems**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, modul Communications and Informatics	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10E

1. COURSE DESCRIPTION

1.1. Course objectives

1. Introducing students to techniques for analyzing computer algorithms for NP-hard and online problems.
2. Familiarizing students with the most common NP-hard problems.
3. Introducing students to the different heuristic methods for analyzing computer algorithms for NP-hard and online problems

1.2. Course enrolment requirements

1.3. Expected learning outcomes

1. Classifying different harder problems from graph and network theory considering their speed complexity.
2. Creating new heuristic methods and approximation algorithms for graph problems, using already known ones
3. Classifying algorithms for graphs with regard to their speed
4. Creating fast algorithms for different online problems.

1.4. Course content

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Pohađanje nastave, izrada projektnog zadatka, izrada seminarskog rada, dolazak na konzultacije, usmeni ispit

1.8. Monitoring and assessment of student work

Attendance	1	Participation in classes		Seminar paper	4	Experimental work	
Midterm exams		Oral exam	3	Essay		Research	

(written) exam)							
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance	1	1	Teaching	Recording presence . The minimum required for the signature is: 0%	0	5
Midterm exams or seminar paper	4	2, 3, 4	Independent work	Examination of given paper	0	50
Oral exam	3	2, 3, 4	Oral exam	Examination of given answers	0	45

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. Allan Borodin Ran El-Yaniv. Online computation and competitive analysis. Cambridge University press. 2005.
2. D.S. Hochbaum (editor): Approximation Algorithms for NP-Hard Problems. PWS Publishing Company, Boston MA, 1997.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. C.H. Papadimitrou, K. Steiglitz: Combinatorial Optimization - Algorithms and Complexity, Second Edition. Prentice-Hall, Englewood Cliffs NJ, 1998

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Allan Borodin Ran El-Yaniv. Online computation and competitive analysis. Cambridge University press. 2005	0	
D.S. Hochbaum (editor): Approximation Algorithms for NP-Hard Problems. PWS Publishing Company, Boston MA, 1997.	0	

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General Information	
Lecturer(s)	**Professor Rudolf Scitovski**

Course title	**Data Clustering Algorithms**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Computer Science	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L+10S

1. COURSE DESCRIPTION

1.1. Course objectives

The course objective is to familiarize the student with the basic methods of grouping data and applications, especially in identifying the forms. Implementation of Mathematica and Matlab Codes.

1.2. Course enrolment requirements

-

1.3. Expected learning outcomes

After passing the course, students will be able to:
1. Review of the movement of scientific research in the field
2. A recent review of several important applications in the field
4. Writing Complex Numerical Algorithms.
5. Programming and using Mathematica or Matlab programming systems.
6. Writing of scholarly work on the demands of top scientific journals.

1.4. Course content

Representative data. Data grouping: motivation and application. Basic quasi-metric functions. Grouping data in a cluster based on one or more attributes. Search for optimal partitions: k-means algorithm, global optimization mode, agglomeration hierarchy algorithms, adaptive Mahalanobis algorithms, DBSCAN. Select the most appropriate cluster number - index. Fuzzy clustering. Applications (recognizing shapes, especially geometric objects and non-conforming shapes, image and signal analysis). Finished Mathematica and Matlab Codes.

1.5. Types of classes	x lectures ☐ seminars and workshops ☐ auditory excersises ☐ distance learning ☐ tfieldwork	☐ individual worki ☐ multimedia ☐ laboratory excersises ☐ design excersises x work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Regular lectures attendance and preparation of seminar work as a prerequisite for oral exam.

1.8. Monitoring and assessment of student work

Attendance	1,5	Participation in classes		Seminar paper		Experimental work	
Midterm exams		Oral exam		Essay		Research	

(written) exam)							
Project		Report		Laboratory exercises		Design exercises	
Portfolio						Writting paper for journal or presenting on the conference	4,5

1.9. Assessment and evaluation of student work during classes and in the final exam

AKTIVNOST STUDENTA	ECTS	ISHOD UČENJA	NASTAVNA METODA	METODA PROCJENE	BODOVI	
					min	max
Pohađanje nastave predavanja	1,5	1-4	Predavanje	Praćenje prisutnosti Minimum potreban za potpis iznosi: 0%	0	10
Znanstveno istraživački rad i pisanje rada za časopis ili konferenciju	4,5	1-6	Konzultacije	Procjena primijenjenih istraživačkih kompetencija u pripremi znanstvenog rada	40	90

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. R.Scitovski, M.Briš Alić, Grupiranje podataka, Ekonomski fakultet u Osijeku, 2016.,
2. .J.C.Bezdek, J.Keller, R.Krisnapuram, N.R.Pal, D.Dubois, H.Prade *(Eds.)*, Fuzzy models and algorithms for pattern recognition and image processing, *Springer*, 2005

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. P.N.Tan, M.Steinbach, V.Kumar, Introduction to Data Mining, *Wesley*, 2006
2. S.Theodoridis, K.Koutroumbas, K. Pattern Recognition, *Academic Press, Burlington*, 2009
3. A.Morales-Esteban, F.Martínez-Álvarez, R.Scitovski, S.Scitovski, A fast partitioning algorithm using adaptive Mahalanobis clustering with application to seismic zoning, *Computers & Geosciences*, 2014, *73*, 132–141
4. J.Kogan, Introduction to Clustering Large and High-dimensional Dana *Cambridge University Press, New York*, 2007.
5. K.Sabo, R.Scitovski, I.Vazler, One-dimensional center-based l_1-clustering method, *Optimization Letters*, 2013, *7*, 5-22
6. R.Scitovski, T.Marošević, Multiple circle detection based on center-based clustering, *Pattern Recognition Letters*, 2014, *52*, 9-16
7. R.Scitovski, I.Vidović, D.Bajer, A new fast fuzzy partitioning algorithm, *Expert Systems with Applications*, 2016, *51*, 143-150
8. Dheeraj Kumar, James C. Bezdek, Marimuthu Palaniswami, Sutharshan Rajasegarar, Christopher Leckie, Timothy Craig Havens, A hybrid approach to clustering in big data, IEEE Ttransactions on cybernetics, 2015
9. M.Ester, H.Krieogel, J.Sander, A density-based algorithm for discovering clusters in large spatial databases with nosie, *2nd International Conference on Knowledge Discovery and Data Mining(KDD-96)*, 1996, 226-231
10. R.Scitovski, K.Sabo, Analysis of the k-means algorithm in the case of data points occurring on the

border of two or more clusters, Knowledge-Based Systems 57(2014), 1-7
11. R.Scitovski, Numerička matematika, Odjel za matematiku, Sveučilište u Osijeku, Osijek, 2004.

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Grupiranje podataka	0	3
Fuzzy models and algorithms for pattern recognition and image processing	0	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information		
Lecturer(s)	**Professor Matjaž Colnarič**	
Course title	**Computer Systems Real-Time Management**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, module Computer Science	
Course status	E**lective course**	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20L + 10E

1.COURSE DESCRIPTION

1.1. Course objectives

The course aims to acquaint students with the time-critical procedures of the embedded system, with the special features of the circuits, software, and real-time communications, with strategies for scheduling and synchronizing tasks and security requirements for applications.

1.2. Course enrolment requirements

Computer Architecture and Embedded Computing Systems.

1.3. Expected learning outcomes

1. Evaluate the criticality of the time behavior of the embedded system
2. Design a multi-tasking system architecture for real-time operation
3. Analyze and evaluate the existing solution of the embedded system
4. Suggest appropriate scheduling and synchronization strategies
5. Assess the security requirements of the application, and determine the measures for achieving them Use the learned principles to apply a computer-controlled environment.

1.4. Course content

Definitions and types of real time systems; Special features: time, predictability, reliability, resource constraint; Time in embedded computing systems; Tasks, Life Cycle, Multitasking; Synchronization between tasks in the real-time system; Scheduling Tasks. Special features of hardware, software support and communication in real-time systems; Programming languages for the development of embedded computing systems; Fault Toleration - Referrals, Procedures. Advanced elective topics for

seminar work: Distributed computer systems, Intermediate layer of embedded computer system; Coordinator of hardware and software support; Real Time Applications Design - UML-RT; Analysis of Time Requirements and Performance (WCET, Reliability Analysis); Reliability and error processing: recommendations and standards for reliability assurance; Processing exceptions in embedded computing systems; Special applications of embedded computing systems: industry, transportation, intelligent homes, ubiquitous and pervasive applications.

1.5. Types of classes	x lectures x seminars and workshops ☐ auditory excersises ☐ distance learning ☐ fieldwork	x individual work ☐ multimedia ☐ laboratory excersises ☐ design excersises x work with a disseration supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Regular lectures attendance and preparation of seminar work as a prerequisite for oral exam.

1.8. Monitoring and assessment of student work

Attendance	1	Participation in classes		Seminar paper	4	Experimental work	
Midterm exams (written) exam)		Oral exam	3	Essay		Research	x
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max
Attendance	1	1-5	Lectures	Attendance register.	2	5
Seminar paper	4	6	lStudying iterature, conducting research, developing seminar work.	Presentation	25	50
Oral exam	3	1-5	Oral exam	Assessment of student's answers	25	45

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. COLNARIČ, Matjaž, VERBER, Domen, HALANG, Wolfgang A.. Distributed embedded control systems : improving dependability with coherent design, (Advances in industrial control). Berlin; London: Springer, 2008. XVII, 250 str., ilustr. ISBN 978-1-84800-051-3. ISBN 978-1-84800-

052-0
2.A. Burns, A. Wellings, Real-Time Systems and Their Programming Languages, Addison Wesley Longman, April 2009.
3. Storey, Safety Critical Computer Systems. Addison Wesley, 1996.
4. M. Colnarič, Lecture notes (in Slovene), yearly updated.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

5.J. Cooling, Software Engineering for Real-Time Systems, Addison Wesley, 2002.
Materijali s Interneta

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Distributed embedded control systems : improving dependability with coherent design	0	3
Real-Time Systems and Their Programming Languages, Addison Wesley Longman	0	3
Lecture notes	Dostupno online	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General Information		
Lecturer(s)	**Assistant Professor . Krešimir Nenadić**	
Course title	**Intelligent Manufacturing Processes**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, Module Computer Science	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credits	8
	Number of classes (lectures + exercises + seminars)	20P + 10S

1. COURSE DESCRIPTION

1.1. Course objectives

Introducing students with application of artificial intelligence in industrial production processes.

1.2. Course enrolment requirements

There are no specific reqirements.

1.3. Expected learning outcomes

After passing the course, the student will be able to:
1. Create a new method of solving a problem in the production process by applying artificial intelligence

2. Suggest a way of collecting and presenting knowledge
3. Conclude on the basis of probability - Bayesian conclusion, Damster-Shafer theory, ad-hoc or heuristic methods
4. Predict the behavior and results of the proposed methods.
5. Classify and evaluate the proposed procedure based on measured quantities or simulated data
6. Critically compare the proposed method with the existing methods

1.4. Course content

Introduction to Artificial Intelligence. An overview of the field of application of artificial intelligence. Knowledge, general concepts, importance of knowledge, knowledge-based systems. Presentation of knowledge. Organization and management of knowledge. Collecting knowledge. Examples of industrial systems. Presentation of knowledge in industrial systems. Deductive and non-destructive methods of conclusion. Working with contradictory and indefinite systems: a system for maintaining truth. Prerequisite for a closed world. Modal, temporal and diffuse logic. Conclusion from probabilistic: Bayesian conclusion, possible worlds, Damster-Shafer theory, ad-hoc and heuristic methods. Structured knowledge: graphs, frames, ontologies - languages for ontology. Organization and Handling of Knowledge in Industry. Knowledge organization and management: indexing, retrieval techniques, integrating knowledge into the system, knowledge base organization. Theory of usefulness. Applications: maintenance and monitoring of system operation (application in all areas of activity).

1.5. Types of classes	☒ lectures ☒ seminars and workshops ☐ auditory excersises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory excersises ☐ design excersises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Attending lectures, studying literature, writing a project assignment (reviewing the field of research), preparing Power point presentations and presenting a project assignment, consulting, oral exam

1.8. Monitoring and assessment of student work

Attendance	1	Participation in classes		Seminar paper	2	Experimental work	
Midterm exams (written) exam)		Oral exam	2	Essay		Research	
Project	3	Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max

Lectures Attendance	1	1-6	Lecture(s)	Evidence of presence The minimum required for signature is: **0%**	0	10
Research and project	3	1-6	Individual work	Verification of the created project and scoring accuracy of the solution, appropriateness and complexity of access	20	40
Presentation preparation,paper writing	2	1-6	Public presentation od seminar paper	Evaluation of the Rules of Work Presentation	15	30
Priprema za usmeni ispit i odgovaranje na pitanja	2	1-6	Usmeni ispit	Validaiton of given answers.	15	20

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. F. Jović, Expert Systems in Process Control, Chapman and Hall, London, Van Nostrand Reinhold Inc., New York, 1992.
2. M. Flasinski,: Introduction to Artificial Intelligence, Springer International Publishing, Springer International Publishing Switzerland, 2016.
3. E. Alpaydin: Introduction to Machine Learning, Second Edition, MIT Press eBooks, 2009.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. IEEE Trans. on Expert Systems
2. IEEE Trans on Systems, Man and Cybernetics
3. N. Effingham: An Introduction to Ontology, Polity Press, Cambridge UK, 2013

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Expert Systems in Process Control	1	3
Introduction to Artificial Intelligence	0	3
Introduction to Machine Learning	0	3

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

6.5. Seminars for the generic skills acquisition:

<table>
<tr><td colspan="3">General information</td></tr>
<tr><td>Lecturer(s)</td><td colspan="2">Ivanka Ferčec, MA, Yvonne Liermann-Zeljak, MA, Dragana Božić Lenard, PhD</td></tr>
<tr><td>Workshop title</td><td colspan="2">Academic writing</td></tr>
<tr><td>Study programme</td><td colspan="2">Postgraduate doctoral study programme Electrical Engineering and Computer Science, all modules</td></tr>
<tr><td>Status</td><td colspan="2">Workshop</td></tr>
<tr><td>Year of study</td><td colspan="2">All years</td></tr>
<tr><td rowspan="2">Credit value (ECTS) and teaching methods</td><td>ECTS credits</td><td>1</td></tr>
<tr><td>Number of classes (lectures + exercises + seminars)</td><td>6L+6E</td></tr>
<tr><td colspan="3">1. WORKSHOP DESCRIPTION</td></tr>
<tr><td colspan="3">1.1. Workshop objectives</td></tr>
<tr><td colspan="3">The aim of the workshop is to provide doctoral students with formal means of expressing in the English language accentuating linguistics forms used in different parts of a scientific paper. Correcting errors in chosen sections of a scientific paper, the aim is to present doctoral students with prototypical errors and instruct them to correct errors.</td></tr>
<tr><td colspan="3">1.2. Workshop enrolment requirements</td></tr>
<tr><td colspan="3">Doctoral students are required to have passed English language courses during their undergraduate studies (B2 level)</td></tr>
<tr><td colspan="3">1.3. Expected learning outcomes</td></tr>
<tr><td colspan="3">Upon completion of the workshop, doctor students will be able to:
1. Identify and describe the differences between general and technical English language based on the chosen specialised texts and topics;
2. Apply appropriate grammatical structures in writing;
3. Apply linguistic rules and principles in writing;
4. Recognise and correct prototypical errors in writing;
5. Choose appropriate linguistic patterns in each part of a scientific paper.</td></tr>
<tr><td colspan="3">1.4. Workshop content</td></tr>
<tr><td colspan="3">Academic phrasebank (signaling transitions, being critical, classifying and listing, comparing and contrasting, explaining causality, giving examples); appropriate use of tenses; active and passive voice; paraphrasing techniques; describing processes and procedures; interpreting data (verbalizing tables, graphs, mathematical expressions etc., appropriate use of numbers); correcting errors.</td></tr>
<tr><td>1.5. Types of classes</td><td>☐ lectures
☒ seminars and workshops
☐ auditory exercises
☐ distance learning
☐ fieldwork</td><td>☒ individual work
☐ multimedia
☐ laboratory exercises
☐ design exercises
☐ work with a dissertation supervisor
☐ other
_____</td></tr>
</table>

1.6. Comments	Workshop is done in English

1.7. Student obligations

Active participation in the workshop. Individual tasks.

1.8. Monitoring and assessment of student work

Attendance	Yes	Participation in classes	x	Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam	Yes	Essay	x	Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

Doctoral students' work is assessed by their active participation and individual tasks completion during the workshop. Successful task completion is verified by signing their matriculation books. For successful task completion doctoral students are not graded.

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. de Chazal, E. (2014). *English for Academic Purposes*. Oxford: Oxford University Press
2. Howe, S., Henriksson, K. (2007). *PhraseBook for Writing Papers and Research in English.* Cambridge: The Whole World Company
3. Porter, D. (2007). *Check your Vocabulary for Academic English*. London: A & C Black

General information

Lecturer(s)	**Associated Professor Irena Galić**	
Course title	**Application of open source text editors for writing scientific paper**	
Study programme	Postgraduate doctoral study programme Electrical Engineering and Computer Science, all Modules	
Course status	Elective course	
Year of study	All years	
Credit value (ECTS) and teaching methods	ECTS credits	1
	Number of classes (lectures + exercises + seminars)	3L+9E

1. COURSE DESCRIPTION

1.1. Course objectives

Teach students basics of writing seminars and other scientific papers or professional texts using open source text editors.

1.2. Course enrolment requirements

Requirements met for enrolling in the study programme.
1.3. Expected learning outcomes
1. Operatively use the open source text editor for writing the scientific paper. 2. Operatively use the open source text editor for writing mathematical formulas. 3. Operatively use the open source text editor for using and describing images. 4. Operatively use the open text editor for data processing, tables, and graphs. 5. Operatively use the open-source text editor to quote and references in scientific paper. 6. Find information about using open source text editors on their own.
1.4. Course content
Introduction to open source text editors for writing scientific papers. Start writing a seminar work in the open source text editor. Using open source text editor to write mathematical formulas. Use and describe the images in the open source text editor. Use open source text editor to process data, tables, and graphs. Use the open source code editor to write and quote the literature in scientific work.

1.5. Types of classes	☒ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations
Defined by the FERIT Student Assessment Framework.
1.8. Monitoring and assessment of student work

Attendance	x	Participation in classes		Seminar paper	Yes	Experimental work	
Midterm exams (written) exam)		Oral exam		Essay		Research	
Project		Report		Laboratory exercises	Yes	Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min.	max.
Attendance lectures, laboratory		1-5	Lectures	Attendance recording. The minimum required for	5	40

exercises.				signature is: 50%.		
Writing and preparation of seminar paper.	2	1-6	Seminar paper	Checking the seminar work, scoring the problem description and presentation mode.	25	60

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. The not so short introduction to LaTeX (https://tobi.oetiker.ch/lshort/lshort.pdf)
2. G. Grätzer, More Math Into LaTeX, 4th edition, Springer Verlag New York, 2007, ISBN 978-0-387-68852-7

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. A. Samardžić, G. Nenadić, P. Jančić, LaTeX 2e za autore (http://poincare.matf.bg.ac.rs/~janicic/books/latex2e.pdf)

1.12. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Conducting university questionnaires on teachers (student-teacher relationship, transparency of assessment criteria, motivation for teaching, teaching clarity, etc.).
Conducting Faculty surveys on courses (upon passing the exam, student self-assessment of the adopted learning outcomes and student workload in relation to the number of ECTS credits allocated to activities and courses as a whole).

General information		
Lecturer(s)	**Professor Ivan Štefanić, mr.sc. Darija Krstić**	
Course title	**The Scientific Research Projects Application and Implementation**	
Study programme	Postgraduate Doctoral Study Programme Electrical Engineering and Computer Science, all modules	
Course status	Workshop	
Year of study	All years	
Credit value (ECTS) and teaching methods	ECTS credits	1
	Number of classes (lectures + exercises + seminars)	3L+3E+6S

1. WORKSHOP DESCRIPTION

1.1 Workshop objectives
The aim of the course is to strengthen the capacity of participants for independent preparation and implementation of projects, particularly those funded from EU funds and other sources, and to teach the learners how to prepare a project proposal with the design of concepts and project strategies according to PCM methodology.
1.2 Workshop enrolment requirements
There are no special skills required.
1.3 Expected learning outcomes
After passing the course, students will be able to: 1. Understand the methodology of preparation and implementation of projects funded from EU funds and other sources 2. Demonstrate the ability to independently prepare projects funded from EU funds and other sources 3. Apply adopted techniques and tools and strategic thinking when developing, implementing and implementing projects 4. Critically study and apply new literature for project conclusion 5. Present the results of the analysis and the possibility of their application
1.4 Workshop content
The course will cover the following thematic areas: 1. EU institutional framework 2. Introduction to EU policies - a strategic framework 3. Other terms (project, project cycle phases, stakeholders) 4. Elaboration of project ideas - problem analysis, goal analysis, logical matrix 5. Project application - tender documentation

1.5 Types of classes	x lectures x seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	x individual work ☐ multimedija ☐ laboratory exercises ☐ design exercises x work with a dissertation supervisor ☐ other _____
1.6 Comments	Workshop can be done in English	

1.7 Student obligations
Active participation in the workshop. Individual tasks.

1.8 Monitoring and assessment of student work

Attendance	x	Participation in classes		Seminar paper	1	Experimental work	
Midterm exams (written) exam)		Oral exam		Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9 Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max
PCM - development of stakeholder analysis, problem analysis and goal analysis in shaping intervention logic in project ideas	0,5	1.,2.,3., 4., 5.	Lectures and individual assignments (exercises)	Evaluation of the created problem tree, goal tree and stakeholder definition	30	60
PCM – creation of a logical matrix	0,5	1.,2.,3., 4., 5.	Lectures and individual assignments (exercises)	Evaluation of the review of available programs and relevant institutions and the logical matrix of the project idea	20	40

1.10 . Obligatory literature (at the time of submitting a study programme proposal)

1. Brigljević, K.; Brnčić A.; Gotovac I.; Očuršćak M.; Mali leksikon europskih integracija, Zagreb 2010., http://www.mvep.hr/files/file/publikacije/mali_leksikon_europskih_integracija_20101.pdf
2. Europska komisija, Ured za suradnju EuropeAid, Opća uprava za razvoj: Smjernice za upravljanje projektnim ciklusom, 2010. http://www.strukturnifondovi.hr/UserDocsImages/Publikacije/Smjernice_za_.pdf

1.11 Recommended additional literature (at the time of submitting a study programme proposal)

1. Tufekčić, M; Turfekčić, Ž.: EU politike i fondovi 2014-2020', Zagreb, 2013.
2. Grupa autora: Vodič kroz fondove Europske unije: pristup najvećem europskom donatoru, Nacionalna zaklada za razvoj civilnog društva, Zagreb, 2005.
3. Grupa autora: PRIRUČNIK ZA KORISNIKE BESPOVRATNIH SREDSTAVA U OKVIRU PROJEKATA FINANCIRANIH IZ EUROPSKIH STRUKTURNIH I INVESTICIJSKIH FONDOVA, http://www.strukturnifondovi.hr/UserDocsImages/Publikacije/SAFU_-_Prirucnik_za_korisnike.pdf
4. Grupa autora: MOGUĆNOSTI FINANCIRANJA IZ OPERATIVNOG PROGRAMA KONKURENTNOST I KOHE ZIJA 2014. - 2020.,http://www.strukturnifondovi.hr/UserDocsImages/Za%20web/Bro%C5%A1ura%20Mogu%C4%87nosti%20financiranja%20iz%20OPKK.pdf
5. Grupa autora: PROGRAM RURALNOG RAZVOJA REPUBLIKE HRVATSKE ZA RAZDOBLJE 2014. – 2020. POPIS MJERA S OSNOVNIM INFORMACIJAMA, http://www.mps.hr/ipard/UserDocsImages/Postpristupno%20razdoblje%20%20EAFRD/BRO%C5%A0URA%2003_2015/MPS_program%20ruralnog%20razvoja%20RH_200x275_v6%20-%20LQ.pdf
6. Vela, V.: Menadžment ESI fondova - Priručnik o pripremi i provedbi projekata financiranih iz ESI fondova u financijskoj perspektivi 2014. - 2020., Zagreb, 2015.

1.12 Number of obligatory literature copies in relation to the number of students currently taking the course

Naslov	*Broj primjeraka*	*Broj studenata*

Mali leksikon europskih integracija	Dostupno online	5
Smjernice za upravljanje projektnim ciklusom	Dostupno online	5
1.13 Quality assurance methods ensuring the acquisition of knowledge, skills and competences		
Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.		

General information		
Lecturer(s)	**Professor Mirta Benšić**	
Course title	**Statistical Practicum**	
Study programme	Postgraduate Doctoral Study Programme Electrical Engineering and Computer Science	
Course status	Elective course,	
Year of study	First, second or third	
Credit value (ECTS) and teaching methods	ECTS credit	1
	Number of classes (lectures + exercises + seminars)	6L+6S
1. COURSE DESCRIPTION		
1.1. Course objectives		
To provide students with a statistical conclusion based on the understanding of statistical models and methods using statistical software tools.		
1.2. Course enrolment requirements		
There are no specific requirements.		
1.3. Expected learning outcomes		
After passing the course, students will be able to: 1. apply statistical models for statistical locking in their research; 2. use computers and appropriate software packages as tools for data analysis; 3. critically analyze and apply new literature for data analysis; 4. present the conclusions obtained by statistical analysis from their researches layman experts.		
1.4. Course content		
1. Introduction to R 2. Depending on the databases that will be included in the seminars (after consultation students on the direction of their research) areas of multivariate methods. Particular emphasis will be placed on the choice of distribution modelling on linear and nonlinear regression.		
1.5. Types of classes	☐ lectures ☒ seminars and workshops ☐ auditory excersises ☐ distance learning	☐ individual work ☐ multimedia ☐ laboratory excersises ☐ design excersises ☒ work with a dissertation supervisor

	☐ fieldwork	☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Each student independently prepares the seminar paper in writing. Seminar work should be in a form suitable for publishing professional or scientific work. On the verbal part of the exam, we will check the understanding of the statistical procedures used in the preparation of the seminar work.

1.8. Monitoring and assessment of student work

Attendance	x	Participation in classes	x	Seminar paper	0,5	Experimental work	
Midterm exams (written) exam)		Oral exam	0,5	Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max
Attendance		1-4	Lectures	Evidence of presence	0	0
Seminar paper	0,5	1-4	Individual work	Quality evaluation of the presentation. Quality evaluation of the seminar paper.	25	50
Oral exam	0,5	1-4	Individual work. Oral exam	Evaluation of given answers.	25	50

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. W. K. Härdle, L. Simar, Applied Multivariate Statistical Analysis, Springer, 2012.
2. M. Benšić, N. Šuvak, Uvod u vjerojatnost i statistiku, Sveučilište J.J. Strossmayera, Odjel za matematiku, Osijek, 2014.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. D.C. Montgomery, G.C. Runger, Applied Statistics and Probability for Engineers, John Wiley & Sons, Inc., 2010.

2. M. Benšić, N. Šuvak, Primijenjena statistika, Sveučilište J.J. Strossmayera, Odjel za matematiku, Osijek, 2013.
3. D.J. Sheskin, Handbook of parametric and nonparametric statistical procedures, CRC Presss, 2011.
4. P.J. Brockwell, R.A. Davis, Introduction to Time Series and Forecasting, Springer, 2016.

1.12.Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
Applied Multivariate Statistical Analysis	Dostupno online	5
Uvod u vjerojatnost i statistiku	Dostupno online	5

1.1.3.Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information		
Lecturer(s)	**Professor Srete Nikolovski**	
Course title	**Simulation tools for EES analysis**	
Study programme	Postgraduate Doctoral Study Programme Electrical Engineering and Computer Science	
Course status	Elective course	
Year of study	First, second or third	
Credit value (ECTS) and teaching methods	ECTS credit	1
	Number of classes (lectures + exercises + seminars)	2L + 10E

1. COURSE DESCRIPTION

1.1. Course objectives

To enable students to use computer modeling and simulation software independently EES co-ordination coordination that includes: a three-phase and one-phase short-term calculation, time-current coordination of protective devices in parts of EES power plants, distribution networks, and industrial networks.

1.2. Course enrolment requirements

There are no special requirements.

1.3. Expected learning outcomes

After passing the course, students will be able to:
1. Use a computer program for graphics display and entry into the database of EES elements, in particular, the base
digital protection devices.
2. Formulate Time-Current Characteristics (TCCs) for all network and specified protection devices KS places.
3. Create TCC curves and analyze the coordination of protective devices in the system.
4. Develop the bus protection model in EES using fiber optic sensors and associated one's

digital relays

1.4. Course content

Modelling of digital protective devices for the coordination of protection in the EES and its parts. Overcoming the Power Protector Program Coordination Kit. Especially the modelling of differential, overburden and earthing protection in the program and their practical application. Fully mastering workstation power tools Power Protection for Coordinate Protection in EES.

1.5. Types of classes	☐ lectures ☐ seminars and workshops ☐ auditory excersises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☒ laboratory excersises ☒ design excersises ☐ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Attending classes, writing reports.

1.8. Monitoring and assessment of student work

Attendance		Participation in classes		Seminar paper		Experimental work	
Midterm exams (written) exam)		Oral exam		Essay		Research	
Project		Report		Laboratory exercises	1	Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max
LV preparation, results analysis, report writing	1	1,2,3,4	Laboratory exercise	Checking for LV preparation, LV monitoring, checking written reports	50	100

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1.11. Recommended additional literature (at the time of submitting a study programme proposal)		
1.12.Number of obligatory literature copies in relation to the number of students currently taking the course		
Title	*Number of copies*	*Number of students*
	0	3
	0	3
	0	3
1.1.3.Quality assurance methods ensuring the acquisition of knowledge, skills and competences		
Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.		

General information		
Lecturer(s)	**Professor Vlado Majstorović**	
Course title	**New Approaches for Project Management**	
Study programme	Postgraduate Doctoral Study Programme Electrical Engineering and Computer Science	
Course status	Elective course	
Year of study	First	
Credit value (ECTS) and teaching methods	ECTS credit	1
	Number of classes (lectures + exercises + seminars)	6L+6S
1. COURSE DESCRIPTION		
1.1. Course objectives		
Students will obtain knowledge about the nature and context of project management, framework and project management standard, areas of project management knowledge, and new approaches to project management. In addition, students will be introduced to new trends in project management. They will be able to apply the planning methodology in practice while developing project plans in the field with the use of computer support for designing and running projects.		
1.2. Course enrolment requirements		
There are no specific requirements.		
1.3. Expected learning outcomes		
After passing the course, students will be able to: 1. Define, differentiate and explain the nature and context of project management; 2. Differentiate and link basic processes and areas of project management; 3. Differentiate, explain and link different conditions and new trends in management projects; 4. Analyze, select and apply the appropriate project planning tools and techniques; 5. Apply the methodology of project planning in practice and make a project plan;		

6. Differentiate, analyze, compare and apply different project management software.
1.4. Course content
Nature and context of project management. Processes of Creation and Projects. Access management projects. Project management framework. Project management standard. Areas of Knowledge in the project management framework. New approaches to project management. Extreme, adaptive and others approach. Trends in Project Management. Computer support for project management.

1.5. Types of classes	☐ lectures seminars and workshops ☒ auditory excersises ☐ distance learning ☐ fieldwork	☒ individual work ☐ multimedia ☐ laboratory excersises ☐ design excersises ☒ work with a dissertation supervisor ☐ other _____
1.6. Comments	Classes can be taught in English	

1.7. Student obligations

Attending classes, seminar work.

1.8. Monitoring and assessment of student work

Attendance	x	Participation in classes	x	Seminar paper	1	Experimental work	
Midterm exams (written) exam)		Oral exam		Essay		Research	
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.9. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max
Attendance	1,5	1,2,4,5,6	Lectures	Evidence of presence	0	0
Seminar paper	5	1-7	Studying literature, conducting research, developing seminar	Evaluation quality of the research and presentation of results	50	70

Oral exam	1,5		Oral exam	Evaluation of given answers	10	30

1.10. Obligatory literature (at the time of submitting a study programme proposal)

1. A Guide to the Project Management Body of Knowledge, (PMBOK Guide), Project Management Institute (PMI), Pennsylvania, USA, 2010.
2. Majstorović, V., Projektni menadžment, Sveučilište u Mostaru, Mostar, 2010.
3. Wysocki R.K. and McGary, R. Effective Project Management, Third Edition. Indianapolis, IN: John Wiley & Sons, Inc, 2003.

1.11. Recommended additional literature (at the time of submitting a study programme proposal)

1. Kerzner, H. Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Eighth Edition. Hoboken, NJ: JohnWiley & Sons, Inc, 2003.
2. Hauc, A., Projektni menadžment & projektno poslovanje, M.E.P Consult, Zagreb, 2007.
3. Heerkens, G.R. Project Management. New York, NY: McGraw-Hill, 2002.
4. Hughes B. and Cotterell, M. Software Project Management (Second Edition). London: McGraw-Hill, 1999
5. Kerzner, H., Project Management Case Studies, Willey, 2004.
6. Kleim R.L. and Ludin, I.S. Project Management Practitioner's Handbook. AMACOM Books, 1998.

1.12.Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*
A Guide to the Project Management Body of Knowledge	0	5
Projektni menadžment	0	5
Effective Project Management	0	5

1.1.3.Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

General information		
Lecturer(s)	Head of postgraduate study	
Workshop title	Research Seminar	
Study programme	Postgraduate Doctoral Study Programme Electrical Engineering and Computer Science, all modules	
Status	Workshop	
Year of study	All years	
Credit value (ECTS) and	ECTS credits	4

teaching methods	Number of classes (lectures + exercises + seminars)	4S

2. WORKSHOP DESCRIPTION

1.14. Workshop objectives

Improving the skills of expressing the results of own research in the given form and the public presentation of these results.

1.15. Workshop enrolment requirements

Achieved expected conditions for enrollment

1.16. Expected learning outcomes

After passing the course, students will be able to:
1. Prepare the presentation of the research results according to the given form;
1. 2. Publicly present the results of its research at the level of appropriate scientific exposition.

1.17. Workshop content

As part of the Research Seminar, students present the results of their research during their studies. The mentor is assisting the student in preparing the presentation. The research seminar organizes the head of postgraduate study at least once every semester.

1.18. Types of classes	☐ lectures ☐ seminars and workshops ☐ auditory exercises ☐ distance learning ☐ fieldwork	☐ individual work ☐ multimedia ☐ laboratory exercises ☐ design exercises ☒ work with a dissertation supervisor ☒ Presentation of research results
1.19. Comments	The workshop can be done in English	

1.20. Student obligations

Preparation of PowerPoint Presentation and Presentation of Research Results 4 Times During Study

1.21. Assessment and evaluation of student work during classes and in the final exam

Attendance		Participation in classes		Seminar paper		Experimental work	
Midterm exams (written) exam)		Oral exam		Essay		Research	4
Project		Report		Laboratory exercises		Design exercises	
Portfolio							

1.22. Assessment and evaluation of student work during classes and in the final exam

STUDENT ACTIVITY	ECTS CREDITS	LEARNING OUTCOME	TEACHING METHOD	METHOD OF ASSESSMENT	CREDITS	
					min	max
Research and presentation of the	4	1,2	Public presentation	Evaluation of the presentation clarity and the way of presenting the results of the research	50	100

1.23. Obligatory literature (at the time of submitting a study programme proposal)

1.24. Recommended additional literature (at the time of submitting a study programme proposal)

1.25. Number of obligatory literature copies in relation to the number of students currently taking the course

Title	*Number of copies*	*Number of students*

1.26. Quality assurance methods ensuring the acquisition of knowledge, skills and competences

Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.