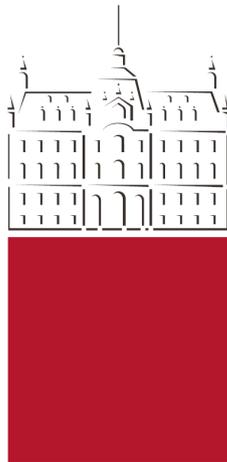


University *of Ljubljana*  
Faculty *of Electrical Engineering*



**DOCTORAL PROGRAMME**  
**ELECTRICAL ENGINEERING**

Ljubljana, 2018



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# INFORMATION BOOKLET DOCTORAL PROGRAMME **ELECTRICAL ENGINEERING** ON FACULTY OF ELECTRICAL ENGINEERING UNIVERSITY OF LJUBLJANA

## 1. General information

Title/name of the study programme:	<b>Electrical Engineering</b>
Type of study programme:	<b>postgraduate doctoral study programme</b>
Level of the study programme:	<b>Level III</b>
Duration of the study programme:	<b>3 years (6 semesters)</b>
Number of ECTS credits:	<b>180</b>
Research discipline:	<b>engineering and technology</b>
Academic degree:	<b>doktor / doktorica znanosti</b>
Abbreviation of the title:	<b>dr.</b> in front of the name

The duration of the postgraduate doctoral study programme of Electrical Engineering is three years, it comprises 180 ECTS credits and is, according to the Bologna scheme, a programme of the 3rd level of higher education. Study obligations are evaluated by the European Credit Transfer System (ECTS), which provides the basis for international exchange of students in countries using the same or a comparable credit system.

The study programme of Electrical Engineering inseparably connects the studies with scientific research and development work. The programme mainly focuses on independent creative research work of students, who are guided by their mentors.

The programme gives priority to optional choice over obligatory forms of studies. In order to adequately cover the increasingly ramified field of modern electrical engineering, the choice of study contents is wide and versatile. The possibility of choosing gives students the opportunity to plan their research careers and follow the needs of future employers as soon as possible. Furthermore, through obligatory seminars and integration of elective generic contents (transferable skills), we offer an appropriate breadth of education. The programme enables mobility in the framework of both organised forms of study and individual research work.

During the studies students are expected to actively participate at Slovenian and international scientific and specialist workshops and conferences. In this way students can develop the skills of scientific communication, critical assessment of the achievements of others and of the results of their own research work. The key obligations of students include the proposal and preparation of the doctoral dissertation. In the doctoral work, in addition to demonstrating their capacity for thinking in a scientific manner and their aptitude for research work, the candidates also give proof of original



contributions to science, which are usually published in international scientific publications indexed by SCIE.



## 2. Aims of the programme and competences acquired

The main aim of the doctoral study programme of Electrical Engineering is to educate independent researchers with broad specialist skills and in-depth basic methodological knowledge.

### General aims of the programme

- To inseparably link the studies with scientific research and development work.
- To develop a scientific approach and to master scientific thinking.
- To encourage comprehensive understanding of electrical engineering and its role in the broader scientific context.
- To encourage students to follow and master of state-of-the-art methods and technologies.
- To develop communication skills, skills of reporting on scientific research achievements and skills of transferring knowledge.
- To develop an objective and critical evaluation of achievements of others and of one's own results.
- To prepare doctoral degree holders for creative scientific research and development work in the field of electrical engineering and broader.

### General competences acquired through the programme

- Competence for individual creative scientific research and development work in the field of electrical engineering and broader.
- Competence for following and accurately evaluating the latest achievements in the broader field of electrical engineering.
- Critical evaluation of the results of one's own research and development work.
- Competence for active professional written and oral communication.
- Competence for team work with experts from various fields.
- Professional, environmental and social responsibility.

### Subject-specific competences acquired through the programme

- Deepening of fundamental knowledge in electrical engineering.
- To conduct independent creative scientific research and technology development, specifically in:
  - electric energy, photovoltaic,
  - electronics, microelectronics, optoelectronics, micro electromechanical systems, and nanostructures,
  - mechatronics, embedded systems, intelligent, control systems, and robotics,
  - metrology, and quality engineering,
  - biomedical engineering and informatics,
  - information, communication, and multimedia technologies.
- Supplementing the existing knowledge with knowledge from complementary fields and with general skills.



### 3. International projects

In 2014, the Faculty participated in 34 EU projects: 13 projects of the Seventh Framework Programme (FP7), 6 projects of the COST programme, 4 projects of the Metrology Research Programme (EMRP), 3 projects of the TEMPUS programme, 2 projects of the SEE programme and 1 project of each of the following programmes: AAL, ALPINE SPACE, CIP, INTERREG and IPA. The funding received for the implementation of these projects at the Faculty was **EUR 1.62 million**. The Faculty also participated in 3 bilateral projects with research institutions from USA and France.

### 4. Research programmes

Research work at the Faculty is conducted by the Faculty laboratories, as well as by programme and research groups. In 9 departments, there are 33 research laboratories. The laboratories perform their research within programmes and projects funded by the ministries and agencies of the Republic of Slovenia, collaborate with Slovenian industry and take part in projects within framework programmes and other programmes of the European Community.

In 2014, the Faculty was involved in 14 research programmes of the Slovenian Research Agency (ARRS) with total programme funding of EUR 1.72 million or 30.03 FTE (in 2013, EUR 1.59 million or 27.43 FTE). The Faculty coordinates or autonomously conducts 12 research programmes and participates in 3 research programmes coordinated by the Jožef Stefan Institute. The Faculty also runs the infrastructural centre of the Laboratory of Biocybernetics (1 FTE) as part of the infrastructure programme Network of Research Infrastructure Centres at the University of Ljubljana (MRIC UL). In 2014, six research programmes came to a close; however, based on the public call to submit research programmes for the next funding period and reports on the results of the research programmes, all of these programmes have been reselected for funding over the next 4–6 years.

In 2014, a total of 41 research projects of the Slovenian Research Agency (ARRS) were active: 25 basic and 16 applied projects. The volume of project funding by the Slovenian Research Agency in 2014 amounted to EUR 850 thousand or 12.09 FTE, whereby the continued and marked trend of reduced funding for the research projects of the Slovenian Research Agency reverted, but the funding remains far below the former levels (EUR 784 thousand in 2013, EUR 930 thousand in 2012, EUR 1.1 million in 2011).

### 5. Structure of the programme and study guidelines

#### Structure of the programme

The duration of the doctoral study programme of Electrical Engineering is three years, it comprises 180 ECTS credits and is, according to the Bologna scheme, a programme of the 3<sup>rd</sup> level of higher education. The programme consists of organised forms of study and individual research work, both of which are evaluated with ECTS credits. The structure of the study programme is presented in Table I.

The first year focuses on organised studies in the form of lectures and seminars, the second and the third year of the programme are entirely devoted to research work and the preparation and presentation of the doctoral dissertation. One semester comprises 30 ECTS credits, one year 60 ECTS credits and the entire doctoral study programme 180 ECTS credits. Organised study comprises 60 ECTS credits; the other 120 ECTS credits are awarded to research work and the doctoral dissertation. An ECTS



credit is evaluated with 25 hours of students' work. The total number of all study obligations thus equals 750 hours per semester, 1500 hours per year and the entire study programme amounts to 4500 hours of study obligations.

**Table I**

1 <sup>st</sup> year: organised forms of studies 30 ECTS credits					
1 <sup>st</sup> semester: organised studies 15 ECTS credits			2 <sup>nd</sup> semester: organised studies 15 ECTS credits		
Course unit	Type	CR	Course unit	Type	CR
Subject A	E, S	5	Subject C	E, S,	5
Subject B	E, G, S, M	5	Subject D	E, S, M	5
Research work		15	Research work		15
Seminar (Report on research work)	S, O	5	Seminar (Report on preparation for the topic of the doctoral dissertation)	S, O	5
Total		30	Total		30

E: elective; S: specialist; G: generic; O: obligatory; M: mobility

2 <sup>nd</sup> year: organised forms of studies 10 ECTS credits				
3 <sup>rd</sup> semester		CR	4 <sup>th</sup> semester: organised studies 10 ECTS credits	CR
Research work		30	Research work	20
			Subject of the doctoral dissertation	10
Total		30	Total	30

3 <sup>rd</sup> year: organised forms of studies 20 ECTS credits				
5 <sup>th</sup> semester		CR	6 <sup>th</sup> semester: organised studies 20 ECTS credits	CR
Research work		30	Research work	10
			Doctoral dissertation	20
Total		30	Total	30

### Study plan

Before enrolling in the programme, students choose a mentor, who advises them on the selection of subjects and guides them through the studies. Together with their mentor, students select four subjects. The seminars are obligatory for all students of the doctoral study programme of Electrical Engineering. The main component of the studies is independent research work for the doctoral dissertation.

### Elective subjects

All subjects are elective. Students choose two to four subjects corresponding to 10 to 20 ECTS credits (1<sup>st</sup> and 2<sup>nd</sup> semester) among the offered specialist subjects (see Table II) according to the research field of their doctoral dissertation. All subjects are worth 5 ECTS credits.



### ***Transferable skills***

The Faculty of Electrical Engineering at the University of Ljubljana offers one elective subject of communication skills in a scientific work (marked with an asterisk in Table II), which is also included in the *Generic subjects unit within the Doctoral school of the University of Ljubljana*. Students can choose up to 5 ECTS credits worth of general contents or one general subject (1<sup>st</sup> semester).

### ***Mobility***

Together with their mentor, students can select up to 10 ECTS credits worth of study contents from other doctoral study programmes at the University of Ljubljana and from comparable programmes of other universities (1<sup>st</sup> and 2<sup>nd</sup> semester). Students can attend two semesters at another university (up to 60 ECTS credits), so that they can complete one third of their study obligations elsewhere.

### ***Seminars***

The seminars (1<sup>st</sup> and 2<sup>nd</sup> semester) are compulsory for all doctoral students of Electrical Engineering and are worth 5 ECTS credits each. Seminars are conducted by mentors. Students present the results of their work in written and oral form. Seminars require attendance at presentations by other students and participation in discussions. This ensures the extension of studies beyond the field of the doctoral dissertation as well as interaction between doctoral students.

In the first semester students prepare an overview of the field of their research work. In the second semester, doctoral students report on the pre-preparation of the subject of their dissertation. This ensures an additional time check and a timely approach to dissertation planning.

### ***Research work for the doctoral dissertation***

Research work is devoted to the preparation and completion of the doctoral dissertation. It is evaluated with 120 ECTS credits. This includes individual scientific research work directed by the mentor. Research work requires active participation at Slovenian and international scientific and specialist meetings.

### ***Doctoral dissertation proposal***

By the end of the 4<sup>th</sup> semester, students should prepare the proposal of the subject of their doctoral dissertation, which includes an appropriate breakdown of the subject, its incorporation into the field of the research work, an indication of the expected contribution to science, which should be methodologically supported with initial results. Students present the subject of their dissertation in public. The preparation and presentation of the doctoral dissertation are evaluated with 10 ECTS credits.



### Doctoral dissertation

As a rule, students complete and publicly present their doctoral dissertation – which together comprises 20 ECTS credits – by the end of the 6<sup>th</sup> semester. In the doctoral work, in addition to demonstrating their capacity for thinking in a scientific manner and their aptitude for research work, the candidates also give proof of original contributions to science, which are usually published in international scientific publications indexed by SCIE.

The doctoral dissertation is an original contribution to science, which is prepared in accordance with the provisions of the Statute of the University of Ljubljana and the Rules on doctoral studies.

### Mentorship

The mentor for preparation of the doctoral dissertation is a person with a corresponding academic title (Assistant Professor, Associate Professor, Professor) or a scientific worker with attested research activity and corresponding bibliography from the field of the doctoral dissertation.

Students choose their mentor at their discretion before or upon enrolment. The responsibility of the mentor is guiding the student through the studies (selection of subjects, seminars, proposal and composition of the doctoral dissertation and ensuring working conditions for the work with research equipment, typically in the mentor's lab.

Students can choose a different mentor by the beginning of the 3<sup>rd</sup> semester. In this case the student should inform their earlier mentor and the Vice Dean for research and development activities in writing about the change, for which the new mentor must give his or her consent. After the beginning of the 3<sup>rd</sup> semester the potential change of mentor is discussed by the Commission for scientific research on the basis of a well-founded request of the student. Co-mentorship is recommended in the case of interdisciplinary or multi-institutional researches. Co-mentorship is deliberated by the Commission for scientific research.

### List of elective subjects

Table II.

#### K1. Department of Fundamentals of Electrical Engineering, Mathematics and Physics

	Course coordinator	Lecturers	Course unit code	Course Title	ECTS
01	Dolinar Gregor	prof. dr. Gregor Dolinar izr. prof. dr. Emil Žagar prof. dr. Gašper Fijavž	64801	Selected topics in Mathematics	5
02	Gyergyek Tomaž	izr. prof. ddr. Tomaž Gyergyek prof. dr. Milan Čerček	64802	Electrical properties of plasmas and introduction to controlled fusion	5
03	Iglič Aleš	prof. ddr. Aleš Iglič prof. dr. Veronika Kralj – Iglič	64803	Electrostatics of Surfaces and Nanostructures	5
04	Križaj Dejan	prof. dr. Dejan Križaj izr. prof. dr. Anton Sinigoj izr. prof. ddr. Iztok Humar	64804	Elektromagnetics	5
05	Slivnik Tomaž	prof. dr. Tomaž Slivnik	64805	Computational elektromagnetics	5

#### K 2. Department of Power Systems and Devices

	Course coordinator	Lecturers	Course unit code	Course Title	ECTS
06	Bizjak Grega	prof. dr. Grega Bizjak	64877	Intelligent buildings	5
07	Mihalič Rafael	prof. dr. Rafael Mihalič	64807	Energy Conversions and Environment	5
08	Pantoš Miloš	prof. dr. Miloš Pantoš	64808	Power System Operation in Market Environment	5
09	Papič Igor	prof. dr. Igor Papič	64809	Active distribution networks	5
10	Čepin Marko	izr. prof. dr. Marko Čepin	64810	Reliability in electrical power engineering	5



### K 3. Department of Electronics

	Course coordinator	Lecturers	Course unit code	Course Title	ECTS
11	Možek Matej	doc. dr. Matej Možek	64811	Sensors and Actuators	5
12	Topič Marko	prof. dr. Marko Topič prof. dr. ir. Miro Zeman	64812	Photovoltaics	5
13	Smole Franc	prof. dr. Franc Smole	64813	Nanoelectronics	5
14	Krč Janez	prof. dr. Janez Krč	64814	Optoelectronics	5
15	Tuma Tadej	prof. dr. Tadej Tuma	64815	Optimization in Electronic Design Automation	5
16	Žemva Andrej	prof. dr. Andrej Žemva izr. prof. dr. Andrej Trost	64816	Digital electronic systems design	5

### K 4. Department of Measurement Systems

	Course coordinator	Lecturers	Course unit code	Course Title	ECTS
17	Agrež Dušan	prof. dr. Dušan Agrež	64870	Measurement dynamics and techniques of electromagnetic compatibility	5
18	Bojkovski Jovan	prof. dr. Jovan Bojkovski	64818	Virtual measurement systems	5
19	Drnovšek Janko	prof. dr. Janko Drnovšek izr. prof. dr. Gaber Begeš izr. prof. dr. Igor Pušnik izr. prof. dr. Gregor Geršak	64820	Metrology and Quality Systems	5
20	Kamnik Roman	prof. dr. Roman Kamnik	64823	Intelligent mobile transport systems	5
21	Mihelj Matjaž	prof. dr. Matjaž Mihelj prof. dr. Robert Riener	64824	Multimodal interactive 3D technologies	5
22	Munih Marko	prof. dr. Marko Munih prof. dr. Jadran Lenarčič	64825	Selected topics in robotics	5

### K 5. Department of Microelectronics

	Course coordinator	Lecturers	Course unit code	Course Title	ECTS
23	Pleteršek Anton	izr. prof. dr. Anton Pleteršek	64827	Integrated Microsystems SoC and analog-digital integrated circuits	5
24	Strle Drago	izr. prof. dr. Drago Strle izr. prof. dr. Anton Pleteršek	64828	Advanced Microelectronic systems: selected topics	5

### K 6. Department of Mechatronics

	Course coordinator	Lecturers	Course unit code	Course Title	ECTS
25	Fišer Rastko	izr. prof. dr. Rastko Fišer prof. dr. Vanja Ambrožič	64829	Electrical servo drives in mechatronics	5
26	Miljavec Damijan	prof. dr. Damijan Miljavec	64830	Modern electric machines	5
27	Zajec Peter	izr. prof. dr. Peter Zajec izr. prof. dr. David Nedeljković prof. dr. Danjel Vončina	64831	Power Electronics Converters	5
28	Vončina Danijel	prof. dr. Danijel Vončina izr. prof. dr. Peter Zajec	64832	Control of Electronically Commutated Motors	5

### K 7. Department of Systems, Control and Cybernetics

	Course coordinator	Lecturers	Course unit code	Course Title	ECTS
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29	Atanasijević Kunc-Maja	prof. dr. Maja Atanasijević-Kunc prof. dr. Gašper Mušič prof. dr. Sašo Blažič	64833	Selected Topics of Complex Systems Control Design	5
30	Perš Janez	doc. dr. Janez Perš izr. prof. dr. Matej Kristan	64835	Machine vision	5
31	Klančar Gregor	izr. prof. dr. Gregor Klančar prof. dr. Drago Matko prof. dr. Sašo Blažič	64836	Advanced control of autonomous systems	5
32	Mihelič France	prof. dr. France Mihelič	64837	Stochastic Processes and Signals	5
33	Dobrišek Simon	izr. prof. dr. Simon Dobrišek	64839	Pattern recognition	5
34	Škrjanc Igor	prof. dr. Igor Škrjanc	64840	Advanced intelligent control systems	5

#### K 8. Department of Information and communication Technologies

	Course coordinator	Lecturers	Course unit code	Course Title	ECTS
35	Humar Iztok	izr. prof. ddr. Iztok Humar	64871	Telecommunication system design and management	5
36	Kos Andrej	prof. dr. Andrej Kos	64872	Systems for processing large amounts of data	5
37	Košir Andrej	prof. dr. Andrej Košir	64873	Operations research	5
38	Pogačnik Matevž	izr. prof. dr. Matevž Pogačnik	64874	Interactivity and user experience in multimedia systems	5
39	Sodnik Jaka	izr. prof. dr. Jaka Sodnik	64878	Human – machine interaction	5
40	Vidmar Matjaž	prof. dr. Matjaž Vidmar	64875	Modern design of radio communications	5
41	Zajc Matej	izr. prof. dr. Matej Zajc	64876	Ambient intelligence in multimedia environments	5

#### K 9. Department of Biomedical Engineering

	Course coordinator	Lecturers	Course unit code	Course Title	ECTS
42	Likar Boštjan	prof. dr. Boštjan Likar	64851	Imaging Technologies	5
43	Jarm Tomaž	prof. dr. Tomaž Jarm izr. prof. dr. Alenka Maček Lebar	64881	Measurement and processing of biomedical signals	5
44	Kotnik Tadej	prof. dr. Tadej Kotnik	64880	Microbioelectromagnetics	5
45	Pernuš Franjo	prof. dr. Franjo Pernuš	64882	Medical Image Analysis	5

## 6. Admission requirements and enrolment criteria

### Enrolment criteria

The following candidates can enrol in the postgraduate doctoral studies of Electrical Engineering:

- graduates of postgraduate master study programmes,
- graduates of study programmes providing education for occupations regulated by Directives of the European Union evaluated with at least 300 ECTS credits,
- graduates of university study programmes established before 11. 6. 2004,



- graduates of postgraduate study programmes for obtaining a Master’s degree established prior to the Bologna reform. The fulfilled study obligations of these candidates are recognised to the extent of 90 ECTS credits,
- graduates of specialist study programmes after university programmes, established before 11. 6. 2004. The fulfilled study obligations of these candidates are recognised to the extent of 60 ECTS credits,
- graduates of specialist study programmes after the higher education, established before 11. 6. 2004. Additional study obligations, four compulsory courses and two elective courses of the first year postgraduate study programme in Electrical engineering amounting to 36 ECTS credits, are determined by the commission nominated by the Faculty of Electrical Engineering,
- graduates of equivalent study programmes at other universities. The equivalence of the obtained education abroad is determined in the process of recognition of education abroad for the continuation of education, in accordance with Article 121 of the Statute of the University of Ljubljana.

### Selection criteria when enrolment is restricted

The selection of candidates will be based on the success in postgraduate master studies as follows:

Grade point average in postgraduate master studies, or grade point average of university study programmes established before 11. 6. 2004, excluding thesis and defence assessment.	grade x 7
Master thesis and its defence assessment, or university diploma thesis and its defence assessment established before 11. 6. 2004.	grade x 3

In case of restricted enrolment the candidates with more points will be accepted.

### Tuition fee

The tuition fee is paid individually for each study year or for each year that the student enrolls in.

The tuition fees are published in the price list adopted by the UL Governing Board (<https://www.uni-lj.si/study/information/tuition/>).

### Scholarship opportunities

For information about scholarship opportunities, please visit <https://www.uni-lj.si/study/information/scholarships/> and <http://www.sklad-kadri.si/>.

## 7. Criteria for recognising knowledge and skills acquired before enrolment in the programme

Knowledge and skills acquired by formal, informal or empirical learning will be recognized in case of restricted enrolment in accordance with Article 9 of the Criteria on accreditation of study programmes. The body deciding on recognition of knowledge and skills acquired before enrolment in the programme is the Commission for scientific research.

The factors taken into account when deciding on the recognition of such knowledge and skills are: specialization, another degree at a higher education institution, the existing scientific research work, published scientific works, professional training.



## 8. Methods of assessment

In accordance with Article 132 of the Statute of the University of Ljubljana the performance at examinations is assessed with grades from 1 to 10, positive grades being 6 – 10. Details about the assessment of knowledge are regulated by the Examination rules of the Faculty of Electrical Engineering at the University of Ljubljana.

The programme includes written and oral exams and the assessment of the preparation and presentation of a seminar. Methods of assessment are described in detail under individual course syllabi.

Candidates receive the proposed number of ECTS credits for a course if they perform successfully at the required knowledge assessment for that particular course.

## 9. Requirements for progression through the programme

- Requirements for progression to the 2<sup>nd</sup> year of the doctoral studies are the completed study requirements worth a total of at least 50 ECTS credits.
- For progression to the 3<sup>rd</sup> year of the postgraduate doctoral studies students must have completed all study obligations of organised forms of studies from the first two years of their studies.
- The last, third year is intended for research work and the preparation and defence of the doctoral dissertation.

## 10. Provisions on changing programmes

Termination of the student's education in the study programme in which he/she enrolled and the continuation of the studies in the doctoral study programme of Electrical Engineering is regarded as transfer between programmes. Students' applications for transfer to the doctoral study of Electrical Engineering will be – in accordance with Articles 181-189 of the Statute of the University of Ljubljana – separately dealt with by the Commission scientific research of the Faculty of Electrical Engineering.

## 11. Mode of study

Doctoral Programme of Electrical Engineering is implemented as a part-time study.

## 12. Requirements for completion of the programme

Requirements for completion of the study programme and for acquisition of the academic title of Doctor of Science are: successfully completed all study obligations determined by the programme and the successfully defended doctoral dissertation, which together is worth 180 ECTS credits. Candidates for the doctoral degree should also have at least one published scientific article in a magazine indexed by SCIE, the candidate being the first author. The scientific article should be published or accepted for publication prior to submission of the dissertation for assessment.

Completing individual parts of the programme is not possible.

### Levels of SQF, EQF and EHEQF

Slovenian Qualifications Framework (SQF) 10;

European Qualifications Framework (EQF) 8;

European Higher Education Qualifications Framework (EHEQF) Third cycle