UNIVERSITY OF LJUBLJANA | FE Faculty of Electrical Engineering

DOCTORAL PROGRAMME

ELECTRICAL ENGINEERING

Ljubljana, 2024

HANDBOOK OF THE DOCTORAL STUDY PROGRAMME IN ELECTRICAL ENGINEERING AT THE FACULTY OF ELECTRICAL ENGINEERING OF THE UNIVERSITY OF LJUBLJANA

1. General data

Name of programme:	**Electrical Engineering**
Type of programme:	**doctoral programme**
Cycle of study:	**third cycle**
Duration of programme:	**4 years (8 semesters)**
Number of ECTS credits:	**240**
Academic discipline:	**engineering and technology**
Academic title:	**doktor/doktorica znanosti**
Abbreviation:	**Dr** (preceding the name)

The doctoral study programme in Electrical Engineering has a duration of four years, consists of 240 credits and is a third-cycle programme under the Bologna scheme. Course units are allocated credits under the European Credit Transfer and Accumulation System (ECTS), which provides a basis for international student exchanges in countries that use the same or a comparable system of credits.

Within the Electrical Engineering programme, academic study is inextricably linked to research and development work. The principal focus of the programme is on autonomous creative research by the student, directed by a supervisor.

The programme gives priority to elective courses over compulsory courses. In order to cover the whole of the constantly expanding field of modern electrical engineering, the range of content offered by the programme is broad and varied. The elective element gives the student the opportunity to plan their own research career from an early stage and to keep abreast of the needs of prospective employers. At the same time, via compulsory seminars and the inclusion of elective generic content (transferrable skills), we ensure an adequate breadth of education. Mobility is possible within the programme both in the context of taught elements and as part of individual research.

Students are expected to participate actively in domestic and international academic and specialist workshops and conferences during their studies. This gives the student the opportunity to develop skills such as scientific communication and critical assessment of the achievements of others and of the results of their own research. The essential obligations of the doctoral candidate include the proposal and writing of a doctoral dissertation. The doctoral dissertation is an opportunity for the candidate to demonstrate, in addition to their capacity for scientific thinking and their ability to

undertake research, original contributions to scholarship, which they must publish in at least one paper in a scholarly journal with a listed impact factor.

2. Programme aims and competences

The main aim of the doctoral study programme in Electrical Engineering is to produce autonomous researchers with broad professional horizons and in-depth methodological skills and knowledge.

Core programme objectives

- To link academic study inextricably with research and development work.
- To develop a scientific approach and proficiency in scientific thinking.
- To encourage in-depth understanding of electrical engineering and its position in the broader scientific context.
- To encourage students to keep abreast of and master state-of-the-art procedures and technologies.
- To develop communication skills, the ability to report on research achievements, and the transfer of knowledge.
- To develop a correct and critical attitude in evaluating the achievements of others and the results of own work.
- To produce doctoral graduates capable of creative research and development work in the field of electrical engineering and more widely.

General competences acquired through the programme

- The ability to undertake autonomous creative research and development work in the field of electrical engineering and beyond.
- The ability to keep abreast of and correctly evaluate the latest achievements in the wider field of electrical engineering.
- A critical attitude to the results of own research and development work.
- The ability to engage in active technical communication in written and oral form.
- The ability to work in a team with experts from various fields.
- Professional, environmental and social responsibility.

Subject-specific competences acquired through the programme

- Enhancement of basic electrical engineering knowledge.
- The ability to undertake autonomous creative research and development work in the fields of:
    - electricity, photovoltaics,
    - electronics, microelectronics, optoelectronics, microsensor technology and nanostructures,
    - mechatronics, embedded systems, intelligent systems, automation and robotics,
    - metrology and quality assurance,
    - biomedical engineering and informatics,
    - information, communication and multimedia technologies.

– Supplementation of knowledge with knowledge of complementary fields and general skills, particularly communication skills in research and development and more broadly, on the basis of the elective principle and mobility.

3. Content structure of the programme

Programme structure

The doctoral study programme in Electrical Engineering has a duration of four years, consists of 240 credits and is a third-cycle programme under the Bologna scheme. The programme consists of taught elements (lectures, seminars) and individual research. Credits are allocated to all elements of the programme. The structure of the programme is shown in Table I.

In the first year the emphasis is on the taught elements of the programme (lectures, seminars), while the second, third and fourth years are entirely dedicated to research and the preparation and writing of the doctoral dissertation. Each individual year carries 60 credits and the overall doctoral programme carries 240 credits.

The study programme includes taught elements worth 60 credits. The remaining 180 credits are allocated to individual research for the preparation of the doctoral dissertation.

A single credit corresponds to 25 notional hours of student workload. This means that the total student workload is 750 hours per semester or 1,500 hours per year and the study programme as a whole requires 6,000 hours of work from students.

Table I

1st year: organised forms of studies 30 ECTS credits			
Course unit	ECTS	Course unit	ECTS
Subject A	5	Subject C	5
Subject B	5	Subject D	5
Research work 1*	15	Research work 2*	15
Seminar (Report on research work)	5	Seminar (Report on preparation for the topic of the doctoral dissertation)	5
Total			60

2nd year: organised forms of studies 10 ECTS credits			
Research work 3	30	Research work 4	20
		Preparation of the disposition of doctoral dissertation	10
Total			60

3rd year			
Research work 5	30	Research work 6	30
Total			60

4th year: organised forms of studies 20 ECTS credits			
Research work 7	30	Research work 8	10
		Presentation of the doctoral dissertation before the public defence	10
		Defence of doctoral dissertation	20
Total			60

*Students who have earned at least 20 ECTS by passing the courses in the areas of electrical engineering, mathematics or physics during their completed undergraduate or masters studies are eligible to enrol on this course. Students who do not meet these criteria should have compensated for the missing ECTS by completing additional study requirements in the courses of the First Cycle Academic Study Programme in Electrical Engineering at UL FE before enrolling on this course.

Mode of study

Before enrolment, the student selects a supervisor to advise them on their choice of courses and direct their studies. Together with the supervisor, each student chooses four courses. The two seminars are compulsory and common to all Electrical Engineering doctoral students. The principal element of the programme is, however, independent research for the doctoral dissertation.

Specialist courses

All courses are elective. Students choose two to four courses from the list of specialist courses (Table II), worth a total of 10 to 20 credits (1st and 2nd semesters). Specialist courses are chosen with regard to the research field covered by the doctoral dissertation. All courses carry the same number of credits (5).

Mobility

By agreement with their supervisor, students can choose up to 10 credits worth of course contents from other doctoral programmes at the University of Ljubljana and comparable programmes at other universities (1st and 2nd semesters).

Candidates enrolling in the Electrical Engineering doctoral programme from non-engineering faculties must complete at least 15 credits worth of elective courses from the Electrical Engineering doctoral programme at the University of Ljubljana's Faculty of Electrical Engineering (UL FE) (as per Research Committee decision of 1 October 2020).

Seminars

The two seminars (1st and 2nd semesters) are compulsory for all Electrical Engineering doctoral students and are each worth 5 credits. The seminars are led by supervisors. Each student presents the results of their work in written and oral form. As part of the seminar, students are expected to be present at the presentations of other students and to participate in discussions. This guarantees an expansion of their programme of study beyond the narrow field of their own doctoral dissertation and provides an opportunity for interaction among doctoral students.

During the first semester, each student prepares an overview of the narrow field of their research. In the second semester, each doctoral candidate reports on the preliminary preparation of the

outline of their doctoral dissertation. This ensures an additional control point and an early start to planning the dissertation proposal.

Research for the doctoral dissertation

Research is subordinated to the preparation and writing of the doctoral dissertation. It carries 180 credits. This is individual research directed by a supervisor. As part of their research, students are expected to participate actively in domestic and international academic and specialist meetings. A series of workshops on the theme of research are held at the faculty in the first and third year of the doctoral programme. These workshops cover a broad spectrum of the knowledge and skills required by researchers in their work.

Doctoral dissertation proposal

By the end of the 3rd semester, students must prepare a draft outline of their doctoral dissertation, breaking it down appropriately and locating it within a specific field of their research; they must also present their expected contributions to scholarship, providing technical and methodological justifications for them and supporting them with initial results. The draft outline must also be presented publicly. The preparation and presentation of the outline carry 10 credits.

Doctoral dissertation

During the final phase of research work and when it is already possible to draw conclusions in accordance with established hypotheses and research questions, the doctoral candidates submit a draft of the doctoral dissertation to the members of the Doctoral Studies Committee, the supervisor and the co-supervisor, and present the results of their research, with an emphasis on the main findings and the contribution to scholarship. The presentation carries 10 credits. When the Senate of the member faculty approves a dissertation, the doctoral candidate shall submit to the member faculty the required number of bound copies of the dissertation and submit an electronic copy of the dissertation in the member faculty's study information system.

Doctoral candidates must submit their doctoral dissertation in electronic and printed form, together with the consent of the supervisor and co-supervisor, within one year at the latest of completion of the final semester of the study programme or in accordance with a decision extending their status on justified grounds.

A public defence is an academic discussion between the members of the committee and the doctoral candidate. The main purpose of the public defence is the presentation of the doctoral dissertation.

The doctoral dissertation is an opportunity for the candidate to demonstrate, in addition to their capacity for scientific thinking and their ability to undertake research, original contributions to scholarship, which they must publish in at least one paper, of which they are the lead author, in a journal with an impact factor included in the Science Citation Index Expanded (SCIE), in accordance with the provisions of Chapter 9 of the Instructions on the Provision of Doctoral Programmes at UL FE.

A doctoral dissertation is an original contribution to scholarship which must be prepared in accordance with the provisions of the Statutes of the University of Ljubljana, the Rules on Doctoral

Programmes at the University of Ljubljana and the Instructions on the Provision of Doctoral Programmes at UL FE.

Supervision

Students choose a supervisor before enrolment and submit the supervisor's written consent to act as supervisor by no later than the date of enrolment.

The supervisor or co-supervisor of a doctoral dissertation shall be a person who holds the academic rank of assistant professor, associate professor or full professor or a research position (research associate, senior research associate, research fellow) and has proof of research activity with a relevant scholarly bibliography in the field covered by the dissertation outline. The minimum condition for supervisors to demonstrate their research activity shall be, in the case of basic research with bibliography, earning 150 Z SICRIS points in the past five years and achieving more than 0 points in the A1/2 important achievements indicator.

The task of the supervisor is to direct the student in their studies and provide conditions for work. Co-supervision is recommended in the case of interdisciplinary or multi-institutional research.

An expert with a title that is comparable to academic ranks or academic titles in Slovenia may also act as supervisor or co-supervisor.

A list of potential supervisors is published on the programme website https://fe.uni-lj.si/en/studij/doktorski-studij/elektrotehnika/dokoncanje-studija/

List of specialist courses

Table II

Year 1, Izbirni predmeti (predmet A, B, C, D)

				Contact hours									
	University Course Code	Course title	Lecturers	Lectures	Seminar	Tutorials	Clinical tutorials	Other forms of study	Individual student work	Total hours	ECTS	Semesters	Elective
1.	0046716	Active distribution networks	Igor Papič		30				95	125	5		yes
2.	0163628	Ambient intelligence	Matej Zajc	30					95	125	5		yes
3.	0046718	Medical Image Analysis	Franjo Pernuš	30	15	15			65	125	5		yes
4.	0046719	Electrical properties of plasmas and introduction to controlled fusion	Tomaž Gyergyek	45	25				55	125	5		yes
5.	0046720	Electrical servo drives in mechatronics	Rastko Fišer	20					105	125	5		yes
6.	0046721	Electromagnetics	Marko Meža	30					95	125	5		yes
7.	0046723	Energy Conversions and Environment	Rafael Mihalič	30		15		30	50	125	5		yes
8.	0046724	Photovoltaics	Marko Topič	30	15			5	75	125	5		yes
9.	0046725	Integrated Microsystems SoC and analog-digital integrated circuits	Aleksander Sešek	30	30				65	125	5		yes
10.	0046726	Intelligent buildings	Matej Bernard Kobav		30				95	125	5		yes

11.	0046727	Intelligent mobile transport systems	Roman Kamnik	30	60				35	125	5		yes
12.	0046728	Advanced intelligent control systems	Igor Škrjanc	30					95	125	5		yes
13.	0046729	Human – machine interaction	Jaka Sodnik	30					95	125	5		yes
14.	0046730	Interactivity and user experience in multimedia systems	Matevž Pogačnik	30	30	15			50	125	5		yes
15.	0046731	Selected topics in Mathematics	Gregor Dolinar	30					95	125	5		yes
16.	0046732	Selected Topics of Complex Systems Control Design	Sašo Blažič, Gašper Mušič	30	60				35	125	5		yes
17.	0042464	Control of Electronically Commutated Motors	Mitja Nemec	30					95	125	5		yes
18.	0046734	Measurement dynamics and techniques of electromagnetic compatibility	Dušan Agrež	30	60				35	125	5		yes
19.	0046735	Measurement and processing of biomedical signals	Tomaž Jarm	30	30				65	125	5		yes
20.	0046736	Metrology and Quality Systems	Janko Drnovšek	30	60			10	25	125	5		yes
21.	0046737	Microbioelectromagnetics	Tadej Kotnik	30	15	15			65	125	5		yes
22.	0046738	Modern design of radio communications	Matjaž Vidmar	30	15	30			50	125	5		yes
23.	0046739	Digital electronic systems design	Andrej Žemva	30	20				75	125	5		yes
24.	0046740	Telecommunication system design and management	Iztok Humar	30	30				65	125	5		yes

25.	0046741	Stochastic Processes and Signals	Vitomir Štruc	30	50				45	125	5		yes
26.	0046742	Nanoelectronics	Benjamin Lipovšek, Franc Smole	30	15			5	75	125	5		yes
27.	0046743	Advanced control of avtonomous systems	Gregor Klančar	30	45				50	125	5		yes
28.	0046744	Advanced microelectronics systems: selected topics	Drago Strle	30	30				65	125	5		yes
29.	0046745	Power System Operation in Market Environment	Miloš Pantoš	30				95		125	5		yes
30.	0046746	Operations research	Andrej Košir	30					95	125	5		yes
31.	0046747	Optimization in Electronic Design Automation	Arpad Bürmen		30				95	125	5		yes
32.	0046748	Optoelectronics	Janez Krč	30	15				80	125	5		yes
33.	0046749	Selected topics in robotics	Marko Munih	30					95	125	5		yes
34.	0046751	Power Electronics Converters	David Nedeljković	30					95	125	5		yes
35.	0046755	Computational electromagnetics	Melita Hajdinjak	30					95	125	5		yes
36.	0046759	Pattern recognition	Simon Dobrišek	30	45				50	125	5		yes
37.	0046762	Sensors and Actuators	Matej Možek	45	30				50	125	5		yes
38.	0046763	Systems for processing large amounts of data	Andrej Kos, Urban Sedlar	15	30	30			50	125	5		yes

39.	0046764	Imaging Technologies	Boštjan Likar	30					95	125	5		yes
40.	0046765	Modern electric machines	Damijan Miljavec	30					95	125	5		yes
41.	0046766	Machine vision	Janez Perš	25	12				88	125	5		yes
42.	0046768	Multimodal interactive 3D technologies	Matjaž Mihelj	30					95	125	5		yes
43.	0046769	Virtual measurement systems	Jovan Bojkovski	30	60			10	25	125	5		yes
44.	0046770	Reliability in electrical power engineering	Marko Čepin	30	95					125	5		yes
		Total		1230	982	120	0	155	3013	5500	220		

4. Admission requirements and selection criteria in the case of limited enrolment

Admission requirements

Enrolment in the doctoral study programme in Electrical Engineering is open to candidates who have completed:

- a second-cycle study programme;
- a study programme leading to professions regulated by EU directives or another integrated master's degree programme carrying 300 credits;
- a programme leading to an academic higher education qualification adopted before 11 June 2004;
- a study programme leading to a master of science degree; course units consisting of 60 credits are recognised for candidates;
- a study programme leading to a specialisation and a previously completed academic higher education programme as adopted before 11 June 2004; course units consisting of 60 credits are recognised for candidates;
- a study programme leading to a specialisation and a previously completed professional higher education programme as adopted before 11 June 2004, provided the candidate has completed additional course units consisting of 36 credits as determined for candidates by the competent committee of the Faculty of Electrical Engineering from first-year second-cycle courses in Electrical Engineering: four compulsory specialist courses, depending on the specific programme, and two elective specialist courses;
- an equivalent programme provided by another university. The equivalence of prior learning in another country is established by means of the procedure for the recognition of foreign qualifications for the purposes of continuing education in accordance with Article 121 of the Statutes of the University of Ljubljana.

Selection criteria for limited enrolment

The process of candidate selection will take into account success in a second-cycle programme in the following manner:

Average grade in second-cycle studies, excluding the grade for the master's thesis and defence thereof, or average grade in an academic higher education programme adopted before 11 June 2004, excluding the grade for the bachelor's thesis and defence thereof.	Grade x 7
Grade for master's thesis and defence, or grade for bachelor's thesis and defence for an academic higher education programme adopted before 11 June 2004.	Grade x 3

In the event of restricted enrolment, candidates with a higher score will be selected.

Tuition fees

Tuition fees are paid for each academic year separately, or for each year in which the student enrols, and are specified in the UL price list for the individual academic year. The price list, which is adopted by the UL Governing Board, is published on the website https://www.uni-

lj.si/study/information/tuition/. Enrolment fees, tuition fees and other contributions are regulated by the Rules on Fees and Cost Assessment at the University of Ljubljana. Payment of tuition fees is defined in more detail by the education agreement.

Scholarships

For more information on scholarships see http://www.uni-lj.si/studij/doktorski/financiranje/; http://www.uni-lj.si/studij/koristne_informacije/vrste_stipendij/ and http://www.sklad-kadri.si/.

5. Criteria for recognising knowledge and skills acquired prior to enrolment

Knowledge and skills acquired through formal, non-formal or experiential learning prior to enrolment in the programme will be recognised during the selection process in the case of limited enrolment, in accordance with the rules. The decision on the recognition of knowledge and skills acquired by the candidate before enrolling in the programme will be made by the Research Committee.

The followingg are taken into account when recognising knowledge and skills of this kind: professional specialisation, other diploma from a higher education institution, research completed to date, scholarly publications, professional training.

6. Methods of assessment

Article 120 of the Statutes of the University of Ljubljana stipulates that examinations are graded from 5 to 10, with grades from 6 to 10 being passing grades. Further details on examinations are set out in the Rules on Examinations of the Faculty of Electrical Engineering.

Examinations will be written and oral. The preparation and oral presentation of a seminar will also be assessed. Methods of assessment are described in more detail in individual course syllabuses.

Candidates are awarded the full number of ECTS credits envisaged for a course (course unit) if they pass the examination for that course (course unit).

7. Requirements for progression through the programme

In order to progress from the first year to the second year of the doctoral programme, doctoral candidates must have completed course units consisting of at least 45 credits.

In order to progress to the third year, students must have completed the requirements of the taught elements of the programme, with the exception of the presentation of research results and the doctoral dissertation defence, and obtain a confirmed positive assessment of the outline of their doctoral dissertation from the Doctoral Studies Committee at the member faculty's Senate.

In order to enrol in the fourth year, students must have completed all the requirements of the first three years (180 credits) and the UL Senate must approve the outline of their doctoral dissertation.

Repeating a year

Students may repeat the first year provided they have accumulated at least 10 credits from elective courses and 20 credits from seminars and research.

Students may repeat the second year provided they have completed all first-year course units and accumulated 30 credits from second-year research.

Students may repeat the third year provided they have completed all first- and second-year course units and accumulated 30 credits from third-year research.

8. Provisions on transfers between programmes

Under the applicable Criteria for Transfers Between Programmes, the discontinuation of studies in the programme in which a student originally enrolled and the continuation of studies in the third-cycle doctoral programme in Electrical Engineering is considered a transfer between programmes. Programme transfers are possible in accordance with the applicable Criteria for Transfers Between Programmes.

Requests to transfer to the third-cycle doctoral programme in Electrical Engineering will be considered individually by the Senate of the Faculty of Electrical Engineering, on the basis of a reasoned proposal from the Research Committee of the Faculty of Electrical Engineering, which will address students' applications individually and in accordance with Articles 181–189 of the Statutes of the University of Ljubljana.

9. Mode of provision of programme

The third-cycle doctoral study programme in Electrical Engineering is provided as a part-time course.

10. Requirements for completing studies

In order to complete the programme and obtain the academic title of *doktor/doktorica znanosti*, candidates must successfully complete all course units defined by the programme and successfully defend a doctoral dissertation, for a total of 240 credits. Doctoral candidates must also publish, as lead author, at least one scholarly paper on a topic covered by their doctorate in a journal with an impact factor included in the Science Citation Index Expanded (SCIE). The paper must be published or adopted for publication by no later than the date on which the doctoral dissertation is submitted for assessment.

Chapter 9 of the Instructions on the Provision of Doctoral Programmes at UL FE stipulates that doctoral candidates must meet one of the following conditions:

- publication or acceptance for publication of at least one original scholarly paper of which they are the lead author on a topic covered by their doctorate in a journal with an impact factor included in the SCIE, where the journal is classified among the top three quarters of journals by impact factor within its field;
- publication or acceptance for publication of at least two original scholarly papers of which they are the lead author on a topic covered by their doctorate in a journal with an impact factor included in the SCIE;

- publication or acceptance for publication of at least one original scholarly paper of which they are the lead author on a topic covered by their doctorate in a journal with an impact factor included in the SCIE and at least one patent relating to the subject of their doctorate of which they are the lead author, granted by an office which has conducted a full examination of the patent application.

Under certain conditions, Article 46 of the Rules of the University of Ljubljana permits the submission of a special form of doctoral dissertation, where the doctoral dissertation consists of original scholarly papers by the doctoral candidate. In order to ensure the higher quality of dissertations of this type, Chapter 8 of the Instructions on the Provision of Doctoral Programmes at UL FE sets out additional requirements and guidance.

A journal with an impact factor included in the Science Citation Index Expanded (SCIE) is a journal that has an impact factor greater than zero in the JCR database. Classification of the journal by impact factor is verified with reference to the date of publication of the paper or the date of submission of the paper for review.

There is no option of completion of individual parts of the programme.

11. Classification in qualifications frameworks

- Slovenian Qualifications Framework (SQF) 10;
- European Qualifications Framework (EQF) 8;
- Qualifications Framework for the European Higher Education Area (QF-EHEA): third cycle

12. Course syllabuses and list of potential supervisors

Course syllabuses and a list of potential supervisors are published online at https://fe.uni-lj.si/en/studij/doktorski-studij/elektrotehnika/dokoncanje-studija/