

University *of Ljubljana*
Faculty *of Electrical Engineering*



DOCTORAL PROGRAMME
ELECTRICAL ENGINEERING

Ljubljana, 2023



**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 (transferable 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

4 th 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

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/education/3rd_cycle_doctoral_study_programme/electrical_engineering_\(phd\)/presentation/](https://fe.uni-lj.si/en/education/3rd_cycle_doctoral_study_programme/electrical_engineering_(phd)/presentation/)

List of specialist courses

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	prof. ddr. Tomaž Gyergyek	64802	Electrical properties of plasmas and introduction to controlled fusion	5
03	Meža Marko	izr. prof. . dr. Marko Meža izr. prof. ddr. Iztok Humar	64804	Electromagnetics	5
04	Hajdinjak Melita	doc. ddr. Melita Hajdinjak prof. ddr. Tomaž Gyergyek	64805	Computational electromagnetics	5

K 2. Department of Power Systems and Devices

	Course coordinator	Lecturers	Course unit code	Course Title	ECTS
05	Bizjak Grega	doc. dr. Matej Kobav	64877	Intelligent buildings	5
06	Mihalič Rafael	prof. dr. Rafael Mihalič	64807	Energy Conversions and Environment	5
07	Pantoš Miloš	prof. dr. Miloš Pantoš	64808	Power System Operation in Market Environment	5
08	Papič Igor	prof. dr. Igor Papič	64809	Active distribution networks	5
09	Čepin Marko	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
10	Možek Matej	Izr. prof. dr. Matej Možek	64811	Sensors and Actuators	5



11	Topič Marko	prof. dr. Marko Topič prof. dr. ir. Miro Zeman	64812	Photovoltaics	5
12	Smole Franc	prof. dr. Franc Smole izr. prof. dr. Benjamin Lipovšek	64813	Nanoelectronics	5
13	Krč Janez	prof. dr. Janez Krč	64814	Optoelectronics	5
14	Arpad Bürmen	prof. dr. Arpad Bürmen	64815	Optimisation in Electronic Design Automation	5
15	Žemva Andrej	prof. dr. Andrej Žemva doc. dr. Andrej Trost	64816	Digital electronic systems design	5

K 4. Department of Measurement Systems

	Course coordinator	Lecturers	Course unit code	Course Title	ECTS
16	Agrež Dušan	prof. dr. Dušan Agrež	64870	Measurement dynamics and techniques of electromagnetic compatibility	5
17	Bojkovski Jovan	prof. dr. Jovan Bojkovski	64818	Virtual measurement systems	5
18	Drnovšek Janko	prof. dr. Janko Drnovšek izr. prof. dr. Gaber Begeš izr. prof. dr. Igor Pušnik prof. dr. Gregor Geršak	64820	Metrology and Quality Systems	5
19	Kamnik Roman	prof. dr. Roman Kamnik	64823	Intelligent mobile transport systems	5
20	Mihelj Matjaž	prof. dr. Matjaž Mihelj prof. dr. Robert Riener	64824	Multimodal interactive 3D technologies	5
21	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
22	Sešek Aleksander	Doc. dr. Aleksander Sešek	64827	Integrated Microsystems SoC and analogue-digital integrated circuits	5
23	Strle Drago	prof. dr. Drago Strle	64828	Advanced Microelectronic systems: selected topics	5

K 6. Department of Mechatronics

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

K 7. Department of Systems, Control and Cybernetics

	Course coordinator	Lecturers	Course unit code	Course Title	ECTS
28	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
29	Perš Janez	izr. prof. dr. Janez Perš izr. prof. dr. Matej Kristan	64835	Machine vision	5



30	Klančar Gregor	izr. prof. dr. Gregor Klančar prof. dr. Sašo Blažič	64836	Advanced control of autonomous systems	5
31	Štruc Vitomir	prof. dr. Vitomir Štruc	64837	Stochastic Processes and Signals	5
32	Dobrišek Simon	izr. prof. dr. Simon Dobrišek	64839	Pattern recognition	5
33	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
34	Humar Iztok	prof. ddr. Iztok Humar doc. dr. Urban Sedlar	64871	Telecommunication system design and management	5
35	Kos Andrej	prof. dr. Andrej Kos doc. dr. Urban Sedlar	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	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	prof. dr. Matej Zajc	64876	Ambient intelligence	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 doc. dr. Alenka Maček Lebar	64881	Measurement and processing of biomedical signals	5
44	Kotnik Tadej	prof. dr. Tadej Kotnik	64880	MicroBio electromagnetics	5
45	Pernuš Franjo	prof. dr. Franjo Pernuš	64882	Medical Image Analysis	5

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 enrolls, 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 following 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/education/3rd_cycle_doctoral_study_programme/electrical_engineering_\(phd\)/curriculum/](https://fe.uni-lj.si/en/education/3rd_cycle_doctoral_study_programme/electrical_engineering_(phd)/curriculum/)