



POLITECNICO
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PhD School - Politecnico di Milano
Regulations of the PhD Programme in:

Electrical Engineering

Cycle XXXVII

1. General Information

PhD School - Politecnico di Milano

PhD Programme: Electrical Engineering

Course start: November 2021

Location of the PhD Programme: Milano Bovisa

Promoter Department: Department of Energy

Scientific Disciplinary Sectors

- ING-IND/31 + Electrical engineering
- ING-IND/32 + Power electronic converters, electrical machines and drives
- ING-IND/33 + Electrical power system
- ING-INF/07 + Electric and electronic measurements

PhD School Website: <http://www.polimi.it/phd>

PhD Programme Website: <http://www.dottorato.polimi.it/en/phd-programmes/active-phd-programmes/electrical-engineering/>

2. General presentation

The PhD Programme in Electrical Engineering is based on both courses and research in any field of the Electrical Engineering: from electric power systems to electrical machines, drives and automation, from basic electromagnetics to electric measurements and signal processing. Research is carried out according to the guidance provided by the research groups at both the Department of Energy (DENG) and the Department of Electronics, Information and Bioengineering (DEIB), where the PhD student will be hosted. Courses are delivered at either the Bovisa or the Leonardo Campuses.

The Programme includes advanced training and research in the following fields:

A) Circuits and Electromagnetics: *This field is meant to provide basic knowledge of methods in electrical engineering for power applications. Students are specifically trained to develop critical ability and innovative approaches. The training method encourages the development of discussion and debating skills in a team environment.*

The main research and training subjects are: nonlinear networks and periodic time-variant networks; analysis methods for three-phase and multiphase systems; switching circuits; electromagnetic field equations and numerical analysis; electromagnetic compatibility.

B) Power Systems: *A PhD in the field of Power Systems deals with the following subjects: electrical energy production (e.g., frequency and voltage control, protections, renewable energy sources,*

Dispersed Generation, Microgrids); electrical energy transmission (e.g., power system analysis, real and reactive power optimization, security and stability, integration of renewables); electricity markets (e.g., models, ancillary services, regulations); power quality and Smart Grids (e.g., harmonic distortion, active filters, UPS, interruptions and voltage dips, DC distribution), electric transportations.

C) Electric machines and drives: *This research field is strictly related to the rising demand for improved machine and converter performance, in terms of low price, efficiency, robustness, dynamic response and drive control. This need leads to device optimization and improved design and testing criteria. Moreover, a system approach is required for accurate integration of technical and economic aspects.*

The main subjects in this field are: new materials; novel magnetic structures; methodologies of model development for design and operating analysis; optimization procedures; finite elements code, simulation programs and environments for device study; control system definition.

D) Measurements: *This research field concentrates on the fundamentals of metrology, particularly with respect to characterization of modern measurement systems based on complex digital signal processing structures. Some of the main subjects of study are: measurement methodology as it relates to power systems, including medium and high voltage systems and components, as well as both digital and analog signal processing. Methodologies and measurement systems associated with industrial automation and, in particular, microelectronic sensor applications, distributed structures and advanced methods and algorithms for maintenance-oriented diagnosis of complex systems are investigated in detail.*

The PhD course is run by a Coordinator and a Faculty Board.

The Coordinator chairs the Faculty Board, coordinates the preparation of the annual Educational Programme and organises the general educational activities of the PhD course (see Attachment A1).

The Faculty Board is responsible for the Educational programme and for teaching and administrative activities related to the PhD course (see Attachment A2).

3. Objectives

The main objective of the PhD Programme is to allow a direct, immediate and suitable integration of PhDs in any research body such as an R&D department of a production or service company. A PhD in Electrical Engineering has a solid basic knowledge of mathematics and physics. This is essential, particularly for handling and understanding advanced tools and methods as well as for proper modelling, analysis and design of electrical engineering applications, with particular regard to power applications. A PhD in Electrical Engineering is well acquainted with circuits and electromagnetic fields as well as with methods and applications in the main disciplines of Basic Electrical Engineering, Power Systems, Electrical and Electronic Measurements, Converters, Machines and Electrical Drives. A strong link is already in place with the most important industrial companies in the field.

The most significant part of the PhD Programme is the development of the research.

4. Professional opportunities and job market

Currently, several high-level opportunities are provided to electrical engineers worldwide. The employment rate for MSc graduate in Electrical Engineering at Politecnico di Milano is very high: 90.2% in less than 6 months (data from Politecnico di Milano Career Service). As far as PhDs in Electrical Engineering are concerned, they are typically employed at

- Major research centres, including University and Academic institutions;
- R&D departments in public and private industry (e.g. manufacturers);
- Power generation, transmission and distribution departments;
- Engineering consultancy firms;
- Metrology reference institutes and certification laboratories;
- Process and transport automation areas;
- Public bodies such as Regulatory or Government agencies.

The PhD students' employment rate at Politecnico di Milano is 92.3% in 1-2 years.

5. Enrolment

5.1 Admission requirements

Italian and International citizens can apply. They are requested to have graduated in accordance with the pre-existing laws D.M. 3.11.1999 n. 509, or to have a Master of Science degree in accordance with D.M. 3.11.1999 n. 509, or a Master of Science in accordance with D.M. 22.10.2004 n. 270, or similar academic title obtained abroad, equivalent for duration and content to the Italian title, with an overall duration of university studies of at least five years.

The certified knowledge of the English language is a requirement for admission. Please refer to the PhD School website for details.

The admission to the programmes will be established according to the evaluation of the candidates' curricula, motivation letters, and an illustrative report about the development of a possible PhD research, which candidates will send contextually with their application to the admission announcement.

Typically, in order to apply for the PhD Programme in Electrical Engineering, a MSc either in Engineering or in a Scientific field is request. Given the research topics investigated during the programme, the MSc in the following engineering fields are preferred: electrical, industrial, energy, computer, electronic. PhD students are required to work full time for their PhD.

5.2 Admission deadlines and number of vacancies

The number of positions is indicated in the Call for admission to the 37th PhD cycle Programmes:

<http://www.polimi.it/phd>

Scholarships both on general and on specific themes are available, in accordance with what is specified in the call for admission.

Usually, a number of generic scholarships are available. However, depending on the requests from industry, scholarships on specific issues could be offered. They will be specified in the admission call. A number of agreements with many important technical universities in Europe and outside Europe is

also in place for student exchanges during the PhD: some students may get access to the PhD Programme at Politecnico di Milano by applying for such agreements.

6. Contents

6.1 Requirements for the PhD title achievement

The achievement of the PhD title in Electrical Engineering requires a study and research activity of at least three years equivalent of full time study, research and development of PhD thesis.

PhD candidates in Electrical Engineering must earn a minimum of 30 course credits (see paragraph 6.3 below), and to continuously conduct studies and research.

At the beginning of the course, the Faculty Board assigns a tutor to each PhD candidate to supervise and assist him/her in the overall training programme. The tutor shall be a professor belonging to the Faculty Board. The tutors assist the candidates in the choice of courses to be included in the study plan, which is eventually submitted for approval to the Coordinator of the PhD Programme (see also section 6.4 below).

The Faculty Board may assign extra course credits to one or more candidates, in case they need to complete their preparation in specific topics, relevant for their research projects.

6.2 Research development

The main aim of all Politecnico di Milano PhD programmes is the development in the candidates of a research-oriented mind-set, with expertise and skills in a specific research topic. To this end, candidates develop a problem-solving capability in complex contexts, including the capacity of performing deep problem analysis, identifying original solutions, and evaluating their applicability in practical contexts.

These skills provide the PhD candidates with major opportunities of development in their research both in the academic field, and in public and private organisations.

PhD candidates are requested to develop an original research contribution. The PhD thesis must thus contribute to increase the knowledge in the candidate's research field. Besides, it has to be coherent with the research topics developed in the Department where the PhD Programme is carried out.

The original research results are collected in the PhD thesis, where the candidate's contribution is put in perspective with respect to the research state of the art in the specific research field.

The PhD research is developed under the guidance of a supervisor, who supports the candidate in the setting-out and in the everyday activities related to the thesis development. The supervisor is not necessarily a member of the Faculty Board, and may also belong to an institution different from Politecnico di Milano. The supervisor can be supported by one or more co-supervisors.

Further activities intended to develop the candidate's personal skills and research expertise are encouraged during the PhD path.

Candidates must acquire the capability to present and discuss their work in their research community. Consequently, both the participation to international conferences and the publication of the research results in peer-reviewed journals are encouraged.

The PhD programme favors the candidates' research interactions with other groups in their research field, preferably abroad. Research visits of at least three months are strongly encouraged, as through them the candidates may acquire further skills to develop their research work and thesis.

The duration of the programme is normally three years.

6.3 Objectives and general framework of the teaching activities

The PhD Programmes and the PhD School activate teaching forms of different kind and credit value, including courses, seminars, project workshops, laboratories. Teaching activities both cover the basic research issues (problems, theories, methods), which represent the founding element of the PhD Programme and identify clearly its cultural position, and deepening in a specialist way some research issues connected with the problems developed in the theses.

Lessons are usually held in English, except when indicated otherwise. The PhD programme includes at least one complete path delivered in English language.

Structured teaching activities allow to earn ECTS credits. Other activities, typically specialised and for which it is difficult to evaluate the learning and its quantification, fall within the scientific activities of which the Faculty Board takes into account in the overall evaluation, but they do not allow to earn ECTS.

The PhD School of Politecnico di Milano proposes a set of courses aiming to train the PhD candidates in soft and transferable skills. The skills and abilities provided by these courses are expected to help candidates across different areas of their careers in order to respond to the rapidly evolving needs of the global economy and society at large. The PhD School courses activated for the 2021-2022 Academic Year are summarized in the following table.

Course name	Professor
Advanced Interaction Skills for Academic Professionals	Michela Arnaboldi
Approaches to Resilience: Social, Economic, Environmental and Technological Challenges of Contemporary Human Settlements. Modeling and Automated Verification of Real-Time Systems	Alessandro Balducci
Communication Strategies That Score in Worldwide Academia	Emanuela Jacchetti
English For Academic Communication	Paolo Biscari
Epistemology of Scientific and Technological Research (Technologies Reshaping Humans)	Simona Chiodo
Ethical Aspects of Research on Dual-Use Technologies	Pierangelo Masarati
Ethics in Research	Andrea Aliverti
European Culture	Lorenzo Cardilli
Introduction to Academic Research	Paolo Gaetano Volontè
Laboratorio di insegnamento a classi numerose	Maurizio Zani
La comunicazione nella scienza	Anna Maria Paganoni
Power of Images and Visual Communication for Research Dissemination	Maria Pompeiana Iarossi
Practicing Research Collaboration / La pratica della collaborazione nella Ricerca	Silvia Luisa Pizzocaro
Professional Communication	Nicoletta Di Blas
Project Management (In Action)	Mauro Mancini
Science, Technology, Society and Wikipedia	Guido Raos
Scientific Reasoning: Philosophy, Logic and Applications	Giovanni Valente
Strengthening Critical Spatial Thinking	Simonetta Armondi
Sulla responsabilità della Tecnica	Paolo Maria Ossi
Sustainability Metrics, Life Cycle Assessment and Environmental Footprint	Monica Lavagna
Teaching Methodologies, Strategies and Styles	Susanna Sancassani
The Copernicus Green Revolution for Sustainable Development	Marco Gianinetto

At least 10 of the 30 course credits that each candidate is required to earn shall be obtained through soft and transferable skills courses organized by the PhD School.

During the first two years, PhD Students must select PhD level courses relevant to their research and pass the corresponding exams, thus acquiring at least 30 ECTS.

PhD level courses can be chosen among the courses offered by

- the PhD Programme in Electrical Engineering;
- the PhD School of Politecnico di Milano;
- other PhD Programmes at Politecnico di Milano;
- other “Summer Schools” or Courses equivalent to the above PhD level, to be a priori evaluated by the Academic Board.

In any case, a final exam is mandatory for the acquisition of the ECTS pertaining to a course.

Each course will be suitably advertised in terms of dates, programs, schedule, evaluation, etc. on the website of the PhD Programme.

The tables below summarize the candidate's path (as regards coursework activities). At the same time, the programme foresees that the candidates are devoted to research activity in a continuous way, following the lead of their supervisors, and of the Faculty Board.

First/Second Year

Courses	Possible details or reference to following tables	Number of credits (min-max)	Note
<i>PhD School Courses</i>		<i>10</i>	
<i>Courses characterising the PhD Programme</i>	<i>Table A</i>	<i>10-20</i>	
<i>Other PhD courses</i>	<i>Table C</i>	<i>0-10</i>	<i>Only if a final exam is passed</i>

Third year

In the third year the candidate should be devoted entirely to the research and to the development of the PhD thesis.

PhD Course List

A) The PhD Programme in Electrical Engineering organises the **Characterising Courses** listed in table A.

For the admission to the final exam the acquisition of at least 10 credits in this list is mandatory. Every year the PhD Programme in Electrical Engineering guarantees the availability of courses for at least 20 ECTS.

For the admission to the second year, at least 10 ECTS must be acquired during the first year.

B) The PhD School organises every year general and Interdoctoral courses. The acquisition of **at least 10 credits** is **mandatory** among the courses of B type. The list of PhD courses organized by the PhD School is available at the website <http://www.dottorato.polimi.it/en/during-your-phd/phd-school-courses>

C) Other PhD courses

PhD courses can be taken from other PhD Programmes at Politecnico di Milano or from well-known universities or research/training institutions; according to the PhD Regulations of the Politecnico di Milano, these must be PhD-level Courses. Prior approval of the Supervisor, of the Tutor and of the Coordinator of the Academic Board is mandatory. To obtain such approval, the PhD student must present the detailed course program, the timetable and the list of lecturers. To obtain registration of ECTS, a final exam must be taken at the Institution offering the Course.

An example of such courses are summer schools for PhD students organized by certain research groups in Italy, listed in Table C.

PREPARATORY COURSES (only if foreseen)

If the supervisor and the tutor find it useful or necessary that the candidate attends preparatory courses (chosen among the activated courses at the Politecnico di Milano) the Faculty Board of the PhD programme may assign some extra-credits to be acquired to complete the training path. The credits acquired in this way will be considered as additional, in relation to the mandatory credits to be acquired with the PhD courses.

SPECIALISTIC COURSES, LONG-TRAINING SEMINARS

The attendance of Specialist Courses, Workshops, Schools, Seminars cycles is strongly encouraged and (if these seminars, workshops are certified and evaluated) may permit to acquire credits according the modalities established by the Faculty Board and previous approval of the study plan submitted by the candidate. These courses and workshops can be inserted in the study plan, even if they are not evaluated (and therefore not qualified as credits), as optional “additional teaching”.

The scheduled course planning for the academic year 2021-2022 and 2022-2023 follows. Other courses may be activated during the year. In this case the candidates will be promptly informed, and will be allowed to insert these new courses in their study plan.

Table A: PHD COURSES CHARACTERISING THE PHD PROGRAMME

SSD	Name of the Course	Professor	A.A./Semester	Language	Credits
ING-IND/31	Engineering applications of electric systems simulation	Giambattista Grusso	2022/23	EN	5
ING-IND/31	Electromagnetic Compatibility: Theory and System Optimization	Riccardo Zich	2021/22	EN	5
ING-IND/32	Modelling, Control and Management of integrated electromechanical drives	Francesco Castelli Dezza	2022/23	EN	5
ING-IND/33	Stability and control of Nonlinear Energy Systems	Claudio Cañizares	2021/22	EN	5
ING-IND/33	Smart grid technical and regulatory issues: DG integration and advanced network management	Maurizio Delfanti	2022/23	EN	5
ING-IND/33	Electric mobility: technologies, experiences and future trends	Dario Zaninelli	2022/23	EN	5
ING-INF/07	Advanced architectures and methods for digital signal processing applied to measurements	Alessandro Ferrero	2021/22	EN	5
ING-INF/07	Estimation and forecasting in power systems	Gabriele D'Antona	2021/22	EN	5
ING-INF/07	The validation of the experimental data: tracing measurement results back to the International System of Units	Alessandro Ferrero	2022/23	EN	5

Table C OTHER PhD COURSES

SSD	Name of the Course	Semester	Credits
ING-INF/07	PhD Summer School "Italo Gorini"	Summer	5
ING-IND/32ING-IND/33	European PhD School: Power Electronics, Electrical Machines, Energy Control and Power Systems	Spring	5
ING-IND/31	Scuola Nazionale Dottorandi di Elettrotecnica Ferdinando Gasparini	Summer	5

6.4 Presentation of the study plan

PhD candidates must submit a study plan, which may be revised periodically (approximately every three months), in order to adequate them to possible changes in the course list, or to needs motivated by the development of their PhD career. The study plans must be approved by the PhD programme Coordinator, according to the modalities established by the Faculty Board of the PhD Programme itself.

6.5 Yearly evaluations

Candidates present their work to the Faculty Board at least once a year. In particular, the candidates must pass an annual evaluation in order to be admitted to the following PhD year. The third year evaluation establishes the candidate's admission to the final PhD defense.

As a result of each annual evaluation, the candidates who pass the exam receive an evaluation (A/B/C/D) and may proceed with the enrolment at the following year. Candidates who do not pass the exam are qualified either as "Repeating candidate"(Er) or "not able to carry on with the PhD (Ei)". In the former case (Er), the candidates are allowed to repeat the PhD year at most once. The PhD scholarships – if any –are suspended during the repetition year. In the latter case (Ei) the candidates are excluded from the PhD programme and lose their scholarships – if any.

In case the Faculty Board holds appropriate to assign directly an exclusion evaluation (Ei) without a previous repetition year, the request must be properly motivated, and validated by the PhD School.

After the final year, candidates who have achieved sufficient results but need more time to conclude their research work and write their thesis, may obtain the admission to a further year.

6.6 PhD thesis preparation

The main objective of the PhD career is the development of an original research contribute. The PhD thesis is expected to contribute to the advance of the knowledge in the candidate's research field.

The PhD study and research work is carried out, full time, during the three years of the PhD course. Stages or study periods in (Italian or International) companies or external Institutions may complete the candidate's preparation.

The resulting theses need to be coherent with the research issues developed in the Department where the PhD programme is developed.

The candidate must present an original thesis, discuss its contribution to the state of the art in the

research field in the research community.

The PhD research is developed following the lead of a supervisor, who supports the candidate in the setting out and in the everyday activities regarding the thesis development.

At the conclusion of the PhD studies, the Faculty Board evaluates the candidates. Candidates who receive a positive evaluation submit their theses to two external reviewers for refereeing. If the evaluation provided by the reviewers is positive (or after the revisions required by the external reviewers), the candidates defend their thesis in a final exam, in front of a Committee composed of three members (at least two of which must be external experts).

7. Laboratories, PhD Secretary Services

Each PhD Student will carry out his/her research exploiting all available facilities of the research group he/she belongs to and all facilities made available by the Departments.

Each PhD Student will have at his/her disposal an office, a personal desk, computing facilities, access to the Politecnico di Milano libraries and electronic resources and, if necessary, to laboratories, instrumentation and machines.

The Secretariat of the PhD in Electrical Engineering is available at the Department of Energy.

8. Internationalisation and inter-sectoriality

Carrying out study and research activities at external laboratories is strongly recommended.

Politecnico di Milano supports joint PhD paths with International Institutions, as well as Joint and Double PhD programmes. Further information is available on the PhD School website and on the PhD programme website.

More specifically, the PhD programme in Electrical Engineering collaborates with Xi'an Jiaotong University (China), Queensland University of Technology (Australia), Technion – Israel Institute of Technology (Israel), The University of Danang (Vietnam), Communauté Université Grenoble Alpes (France), Doshisha University (Japan), University of Applied Sciences and Arts of Southern Switzerland (SUPSI).

Interaction with and exposure to non-academic sectors provides significant benefits to doctoral candidates as well as to research and innovation intensive employment sectors. Direct exposure to the challenges and opportunities in non-academic sectors of the economy and society at large is fostered by networking, connectivity, inter-sectoral mobility and wide access to knowledge. In particular, the PhD programme in Electrical Engineering collaborates with the following Industrial partners: ABB (Italy and Switzerland), Fichtner (Germany), Schaffner (Switzerland), Engie-EPS (Italy), Leonardo (Italy), Ricerca sul Sistema Energetico - RSE (Italy).

Attachment A1 – PhD Programme Coordinator

Gabriele D'Antona received the M.Sc. degree in Electrical Engineering and the Ph.D. degree in Electrical Engineering from Politecnico di Milano in 1989 and 1994, respectively.

He was with the Joint European Torus Laboratory, Abingdon, U.K., from 1990 to 1996. From 1996 to 2007, he was with the Department of Electrical Engineering, Politecnico di Milano, where he became an Associate Professor of Electrical and Electronic Measurements in 2002. Since 2008, he has been with the Electrical Engineering Division, Department of Energy, Politecnico di Milano.

His current research interests are principally concerned with design and development of measurement systems for the diagnosis and control of power systems and components. The research activity is documented by more than 150 papers published in national and international journals or presented at national or international conferences.

He has been involved in 28 National and International research programs financed by public bodies, for 21 of them being the scientific coordinator. He has also co-ordinated 13 research projects with private companies.

Attachment A2 – PhD Faculty Board

Description of the composition of the Faculty Board

Name	Affiliation	Scientific Disciplinary Sector
D'Antona Gabriele (coordinator)	Department of Energy	ING-INF/07
Berizzi Alberto	Department of Energy	ING-IND/33
Brenna Morris	Department of Energy	ING-IND/33
Castelli Dezza Francesco	Department of Mechanical Engineering	ING-IND/32
Cristaldi Loredana	Department of Electronics, Information and Bioengineering	ING-INF/07
Di Gerlando Antonino Claudio	Department of Energy	ING-IND/32
Faranda Roberto Sebastiano	Department of Energy	ING-IND/33
Ferrero Alessandro	Department of Electronics, Information and Bioengineering	ING-INF/07
Foiadelli Federica	Department of Energy	ING-IND/33
Grassi Flavia	Department of Electronics, Information and Bioengineering	ING-IND/31
Grillo Samuele	Department of Electronics, Information and Bioengineering	ING-IND/33
Grimaccia Francesco	Department of Energy	ING-IND/31
Gruosso Giambattista	Department of Electronics, Information and Bioengineering	ING-IND/31
Leva Sonia	Department of Energy	ING-IND/31
Merlo Marco	Department of Energy	ING-IND/33
Mussetta Marco	Department of Energy	ING-IND/31
Norgia Michele	Department of Electronics, Information and Bioengineering	ING-INF/07
Perini Roberto	Department of Energy	ING-IND/32
Piegari Luigi	Department of Electronics, Information and Bioengineering	ING-IND/32
Pignari Sergio Amedeo	Department of Electronics, Information and Bioengineering	ING-IND/31
Spadacini Giordano	Department of Electronics, Information and Bioengineering	ING-IND/31
Toscani Sergio	Department of Electronics, Information and Bioengineering	ING-INF/07

Attachment A3 – PhD Advisory Board

Description of the composition of the Advisory Board

Name	Affiliation
Canizares Claudio	University of Waterloo, Waterloo Institute for Sustainable Energy, Canada
Carlini Enrico Maria	Terna Rete Italia SpA
Cherbaucich Claudio	Ricerca sul Sistema Energetico - RSE SpA
Ercoli Sergio	Zeroemissioni Srl
Godio Andrea	Alstom Transport
Lo Schiavo Luca	Autorità di Regolazione per Energia Reti e Ambiente - ARERA
Mansoldo Andrea	DNV GL – Kema Middle East
Monti Antonello	E.ON Energy Research Center - RWTH Aachen University
Ragaini Enrico	ABB SpA
Zannella Sergio	Edison SpA