ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

DEPARTMENT
OF ELECTRICAL, ELECTRONIC,
AND INFORMATION
ENGINEERING
"GUGLIELMO MARCONI"

PhD Program

in

Electronics, Telecommunications,

and Information Technologies Engineering (ETIT)

40th Cycle

Academic Year 2024/2025

HEAD AND ADMINISTRATION OFFICE

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1. General information

The PhD program in Electronics, Telecommunications, and Information Technologies Engineering (ETIT) is offered by the Department of Electrical, Electronic, and Information Engineering "G. Marconi" (DEI) of the University of Bologna.

The duration of the program is 3 years, and the overall activities amount to 180 doctoral credits. The official language is English.

The activities of the PhD program are based in the facilities of the DEI department, including the main site located in Bologna, and the organizational unit located in Cesena. The PhD program is also supported by the Advanced Research Center on Electronic Systems "E. De Castro" of the University of Bologna.

The program covers the following scientific-disciplinary sectors:

- ING-INF/01 Electronics
- ING-INF/02 Electromagnetic Fields
- ING-INF/03 Telecommunications
- ING-ING/05 Information Processing Systems

The official website of the PhD program is available at https://phd.unibo.it/etit and the PhD program administration staff can be reached at the following email address dei-phd-etit@unibo.it.

2. The training and research program

The Ph.D. program in Electronic, Telecommunications, and Information Technologies Engineering primarily aims to train experts in the field of scientific research on Information and Communication Technologies (ICT). These experts will be capable of proposing, introducing, and managing technological innovation in their respective operational areas and autonomously managing research and/or technological development projects. In this regard, the educational project of the Ph.D. program includes various levels and types of training activities.

Primarily, candidates will train through scientific research activities related to their assigned research topic, under the guidance of their supervisors and within the multidisciplinary context of the research groups at the Department of Electrical, Electronic, and Information Engineering "G. Marconi," which will provide spaces, advanced laboratories, and opportunities for interaction with its faculty members and researchers. The research activities have advanced objectives, such as publishing scientific papers in high-quality international journals and conferences, developing technological innovation and intellectual property. Doctoral research activities may also be carried out within or in collaboration with national and international competitive research projects, interacting with the respective partners, or in collaboration with industry.

The Ph.D. program also includes attendance to dedicated teaching activities related to the research topics of the Ph.D. and in general to Electronics, Telecommunications, Electromagnetic Fields, and Information Processing Systems. The teaching activities will be specifically organized and delivered for the Ph.D. course by members of the PhD Board or by highly qualified speakers from the university or external institutions. Such educational activities aim to provide advanced knowledge and skills in the ICT field that can contribute to the development of the respective research topics. Additionally, frequent seminar activities are proposed on relevant topics in the

field of ICT by internal speakers or high-profile international experts, along with participation in training activities common to multiple Ph.D. courses aimed at acquiring transversal soft skills, particularly related to the third mission, language skills for scientific research, understanding European research systems and project management, and using bibliographic databases. Ph.D. candidates also have the opportunity, upon motivated request and when relevant to their research topic, to attend specific external Ph.D. courses or master's degree courses. In all cases, the validation of the training activities requires, in addition to attending the activities, passing a knowledge verification test. Participation in extra-curricular training activities specifically aimed at Ph.D. candidates is also encouraged, such as summer/winter schools, international thematic workshops. Each Ph.D. candidate must complete the set of training activities established by the faculty board within the duration of the PhD.

It is also ordinarily expected, in line with the research project undertaken, to conduct research and training activities at highly qualified institutions abroad, such as research institutes, universities, or foreign companies, aimed at acquiring new research methodologies and consolidating scientific results. For specific types of Ph.D. positions, research periods at companies are also planned, aimed at third mission activities and increasing the technological maturity level of the Ph.D. project.

Furthermore, the Ph.D. program aims to train candidates through the implementation of scientific dissemination activities over the three years. Writing scientific articles for international conferences and journals and the related peer review process enhance the quality and awareness of research results by the candidates, as well as their scientific writing skills. Presenting their research results to the relevant scientific community at international conferences provides skills in scientific communication and interaction with peers.

3. Internal organization

The ETIT PhD program is managed by a board of qualified professors appointed by the DEI department. The PhD Board elects a PhD Program Coordinator, who chairs the meetings and supports organizational, educational, and scientific aspects of the PhD program. The DEI department also offers administrative support to the PhD program and PhD students with a PhD Manager and dedicated staff. Moreover, formal careers aspects are managed by the University of Bologna centrally.

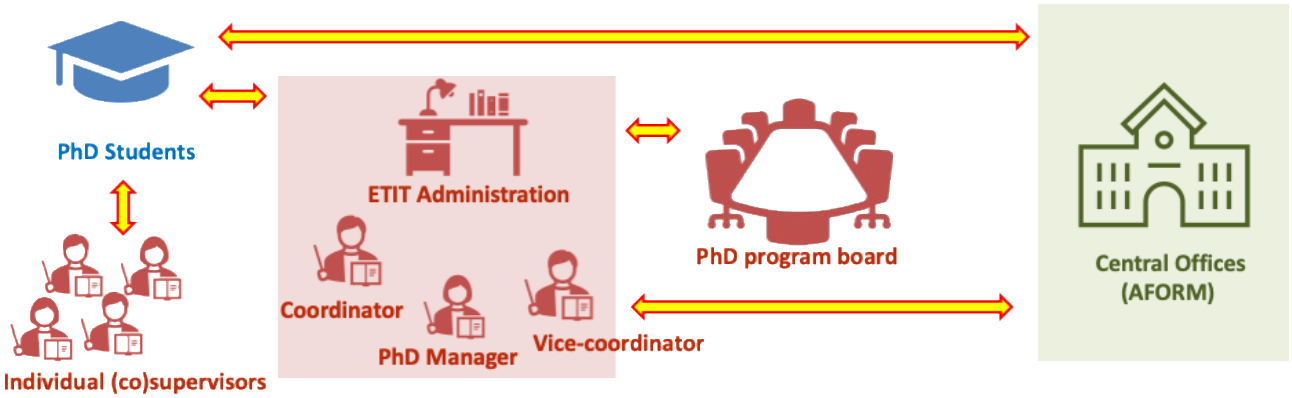

Figure 1. Organizational structure of the ETIT PhD program and interactions between the involved entities

PhD students are enrolled with a public selection following the publications of a Call for Applications on the institutional channels of the University of Bologna. The selected students are enrolled by the central PhD offices of the University of Bologna. At the beginning of the PhD academic year, the PhD Board assigns to every PhD student a research topic and at least one supervisor and one co-supervisor, with the purpose of guiding, supporting and providing training. For all internal organizational aspects, like authorizations for periods abroad, credit recognition, external activities, teaching activities, the PhD students interact with the ETIT Administration staff, composed of Coordinator, Vice-Coordinator, and PhD Manager. The PhD board monitors the activities of the PhD students and take decisions related to their requests, admissions to the next year, exclusions, and maintains contacts with the central PhD offices of the university.

4. The PhD Board

The PhD Board is appointed by the DEI Department to qualified professors of the department. The PhD board of the ETIT PhD program 40th cycle is repoted in Appendix A. CVs and additional information are available on their institutional websites.

5. Professional opportunities and job market

The connection between the ETIT doctoral program and the industrial world is extremely strong due to the engineering nature of the subject areas and the departmental research context in which the ETIT doctorate operates. These research areas are characterized by rapid technological development, supported by both basic and applied research, and are at the core of digital transformation.

At both the national and international levels, industry, service companies, research institutions, and public administrations have shown a high level of appreciation for PhD graduates from the ETIT doctoral program, and they constitute a natural professional opportunity for the ETIT PhD degree. Recent surveys show that all ETIT PhD graduates are engaged in intellectual, scientific, and highly specialized professions within one year of obtaining their degree. More specifically, ETIT PhD graduates have excellent employment opportunities in high-tech industries, both internationally and nationally, as well as in all types of academic, industrial, and mixed research institutes.

It is important to emphasize that the skills developed during the doctoral program in areas such as Electronics, Electromagnetic Fields, Telecommunications, and Information Processing Systems are not limited to companies that develop products in the field of Information Engineering. More generally, they extend to all companies that use Information Technology to pursue their goals or aim for digital transition.

Recent surveys on the employment status of ETIT PhD graduates show full absorption into the labor market in very short timeframes (I average 2-3 months from graduation to finding their first job, according to the 2023 survey on ETIT PhD graduates 1, 3, and 5 years after graduation) and across various intellectual, scientific, and highly specialized professions (87.5% at 5 years from graduation, and 100% at 3 and 1 year after graduation, according to the 2023 survey on ETIT PhD graduates). Additionally, most ETIT PhD graduates use the skills acquired during their doctorate to a significant extent in their work and consider these skills very effective from a professional standpoint (87.5%, 66.7%, 83.3%, respectively 5, 3, and 1 years after graduation, 2023 survey on ETIT PhD graduates).

6. Objectives of the PhD program

The primary objective of the Ph.D. program is to acquire skills to autonomously conduct and organize scientific and industrial research activities in the field of information technologies. Achieving this objective requires knowledge of advanced topics related to the disciplines of Electronics, Telecommunications, Electromagnetic Fields, and Information Processing Systems, as well as individual specialization in one or more research areas covered by the Ph.D. program. These areas include, but are not limited to: Analysis and simulation of semiconductor devices – Applications of information technologies: smart cities, smart grids, precision agriculture, monitoring systems, etc. – Architectures, systems, and networks for telecommunications: wireless, cellular, mobile, terrestrial, satellite, connected, and optical – Analog circuits, digital systems, and electronic systems – Statistical signal processing and its applications – High-frequency electronics – Power electronics, power converters, and semiconductor power devices – Energy harvesting – Photonics and microwaves, microwave circuits and systems, millimeter-wave systems – Internet of Things and applications – Micro- and nano-electronics – Networks and their control and management, software-defined networks – Intelligent sensors – Cyber-physical systems – Embedded systems – Reconfigurable intelligent surfaces – Technologies for quantum computing – Information theory and its applications – Telecommunications theory and its applications – Electromagnetic theory and techniques, antennas, antenna systems, beam forming, electromagnetic characterization of materials, propagation models –Wireless transmission of energy and information.

Additionally, the program includes specific training, typically common to multiple Ph.D. courses and provided at university level, aimed at acquiring transversal skills with particular reference to the third mission, refining language skills for scientific research, understanding European research systems, project management, and using bibliographic databases.

In this context, the Ph.D. program sets the goal for each Ph.D. candidate to produce original and significant research results, through the development of high-quality scientific publications and/or the demonstration of innovative technical prototypes and applications, and/or the generation of intellectual property related to the research. In this regard, the Ph.D. project includes specific scientific dissemination activities at international and local conferences.

Finally, as a result of the educational path, the Ph.D. program aims to provide skills related to the introduction and management of innovation in the professional fields where the Ph.D. holder will operate, as well as the ability to participate in and/or manage complex research and development projects.

7. Enrollment

Enrollment of PhD student is done by means of a public selection following the publication of a Call for Applications on the institutional website and channels of the University of Bologna. Applicants are required to hold a Master degree equivalent. Both Italian and international candidates can apply.

The formal requirements, and the details of the application procedures are published on the official website of the PhD programs of the University of Bologna. More specifically, in the section dedicated to the ETIT PhD program, candidates may check the Call for Applications, and the PhD Programme Table, which contain all the necessary information related to the selection. Available positions may be associated to a specific research topic.

As a rule, the admission committee will assess the relevance of previous studies and experiences, the attitude to research, and will verify the possession of adequate technical and scientific knowledge in relation to the themes of the doctorate and the research project.

8. The training and research program

8.1. Doctoral credits

Doctoral Credits (CD) measure the workload required of the PhD student in research, training, and teaching activities for the completion of the degree. Each CD is worth 25 hours of work, and the PhD student must earn 60 CDs per year. The ETIT PhD program divides the total number of CDs between research, training, and teaching activities, ensuring an appropriate balance between them, as stated in Table A.

Table A. Distribution of DCs between research and training for the ETIT PhD program, 40th cycle.

Type of activity	Total number of DCs	%
Research activity	144	80%
Training activities	36	20%
Total	180	100%

Table B. Requirements for DC distribution between training activities

Type of activity	Mininum number of CDs	Maximum number of CDs
Disciplinary and multidisciplinary training	12	-
- disciplinary and multidisciplinary doctoral courses	12	-
- seminars	-	-
- other types of university courses	-	-
Soft skills	1	-
Extra-curricular training	1	-
Dissemination	1	-
Supplementary teaching and tutoring	-	-

Among educational/training activities, the ETIT PhD program has set the minimum, maximum, and recommended number of CDs to be obtained for each of the following training activities:

- disciplinary and multidisciplinary training, which includes doctoral courses, seminars, and other types of university courses
- training related to the acquisition of transversal skills,
- extracurricular training for the growth of PhD students as members of a scientific community, including, but not limited to, summer/winter schools, thematic workshops, PhD symposia, etc.,
- dissemination of research results, through the presentation of scientific works at scientific conferences, etc.

- teaching activities, including tutorships for university courses, support to the preparation of bachelor and master theses, etc.

The ETIT PhD program organizes specific disciplinary and multidisciplinary doctoral courses. Each course involves attendance to specialistic lectures and additional individual work, with a final evaluation. The overall work required for every 5 hours of frontal lectures corresponds to 1 CD. PhD students can select doctoral courses delivered by the ETIT PhD program and by the other PhD programs of the DEI department, and other courses delivered by other departments or universities deemed as relevant for the individual PhD career. In the latter case, evidence of attended hours and of a final evaluation is required for credit recognition. The list of available courses for the ETIT PhD program and for other PhD programs of the DEI department is published on the website of the PhD program, and updated during the academic year with additional opportunities.

The acquisition of transversal/soft skill can take advantage of the specific intiatives set by the University of Bologna, including the plan for PhD soft skills and the CLA Academics courses offered by the University Language Center (CLA). All details and plans of teaching activities are available online on the institutional website.

The ETIT PhD program also strongly encourages the participation to extra-curricular training activities, such as attending PhD Schools at national and international level, thematic workshops, and specific advanced training activities. PhD students can select relevant training activites, and take advantage of the networking opportunities to improve their skills and for introductions to the reference scientific communities.

Moreover, as member of the scientific communities, PhD students are expected to produce relevant research and present their findings and results at scientific conferences. This represent a unique opportunity of getting in contact with the state of the art of scientific research in the respective disciplines, to have discussions with peers, and to build a network of scientific contacts. The ETIT PhD program recognizes the value of this type of activities for the training of PhD students, and grants credits proportionally to the attendance hours.

The training value of teaching activities is recognized, although not explicitly requested. This type of activities include tutorships for university courses, support activities to the preparation of bachelor and master theses, etc. The limits stated by the university and national regulations for this type of activities hold.

The ETIT PhD program recommends to distribute training activities in the three years of the PhD program, by considering that the last year typically requires to focus on the consolidation of results and on the final dissertation. The PhD board has set the required and recommended CDs to achieve for every year of course, according to the following table. The PhD board will verify yearly the achievement of the minimum required number of CDs. Achieving at least the minimum number of CDs for every year of course is a requirement for the admission to the next year or to the final exam.

Table C. Training DCs to be acquired at the end of each course year

Training DCs to be acquired	Recommended	Minimum (compulsory)
At the end of first year	15	3
At the end of second year	27	12
At the end of third year	36	36

For every type of training activity, the ETIT PhD program has assessed the distribution between number of hours of lectures and individual work, as reported in the following table. In case of different activities not include in the table, the PhD board is in charge of assessing the corresponding credits.

Table D. Correspondence between workload hours and acquired DCs.

Type of activity	Teaching Hours	Hours of individual work	Total hours	CD
Courses (disciplinary and multidisciplinary teaching) *	5	20	25	1
Other disciplinary and multidisciplinary university courses (1st and 2nd level) *	10	15	25	1
Soft skills (attendance only)	25	0	25	1
Soft skills (with additional individual work) *	10	15	25	1
Soft skills (CLA Academics/AcES/LEA) *	13	12	25	1
Seminars that require self-study	10	15	25	1
Seminars that do not require self-study	25	0	25	1
Supplementary teaching and tutoring	8	17	25	1
Teaching activities (cosupervision of bachelor/master theses, per single thesis, to be split among cosupervisors)	0	10	10	0,4
Teaching activities (other forms of documented activity)	0	25	25	1
Extra-curricular training (hours) *	25	0	25	1
Extra-curricular training (days) *	1 day			0,5
Extra-curricular training (additional individual work done) #	0	25	25	1
Dissemination (hours)	25	0	25	1
Dissemination (days)	1 day			0,5

** unless otherwise indicated by the issuing institution*

 # in case documented additional work is done after the end of the training initiative, and the issuing institution does not provide a measure of the corresponding effort, a number of hours equal to the attendance hours is considered

Overall, PhD students, in agreement with their supervisors and co-supervisors, define their specific training and research paths flexibly, choosing the activities to be undertaken, both in type and amount, while respecting the constraints set by the ETIT PhD Program for each activity and year of study. The acquisition of CDs is verified during the yearly progress review, with rules and procedures established by the program.

For the 40th cycle, the ETIT PhD program will activate the following doctoral courses:

Table E. Doctoral course activated for the ETIT 40th cycle.

Course Title	Type	Year	Academic year	CDs	Hours of lectures	Period
Communications for smart environments	Multidisciplinary training	1	2024/25	2	10	Jan – Jul 2025
Research trends in microelectronics	Disciplinary training	1	2024/25	2	10	Jan – Jul 2025
Secure architectures and programming	Multidisciplinary training	1	2024/25	2	10	Jan – Jul 2025

Remote communication and sensing	Multidisciplinary training	1	2024/25	2	10	Jan – Jul 2025
Energy Harvesting and Micro-power Management	Multidisciplinary training	1	2024/25	2	10	Jan – Jul 2025
Advanced Cyber-Physical Systems	Multidisciplinary training	2	2025/26	2	10	Jan – Jul 2026
ICT for Energy Efficiency	Multidisciplinary training	2	2025/26	2	10	Jan – Jul 2026
Advanced Topics in Telecommunications	Ddisciplinary training	2	2025/26	2	10	Jan – Jul 2026
High-performance Emerging Computing Paradigms	Multidisciplinary training	2	2025/26	2	10	Jan – Jul 2026
Innovation in IoT	Multidisciplinary training	3	2026/27	2	10	Jan – Jul 2027
Advanced Topics in Signal Processing	Multidisciplinary training	3	2026/27	2	10	Jan – Jul 2027
Electronic and electromagnetic sensing techniqies	Multidisciplinary training	3	2026/27	2	10	Jan – Jul 2027
Advances in Power and RF Electronics	Multidisciplinary training	3	2026/27	2	10	Jan – Jul 2027

The active courses are also offered to all active PhD cycles. Details on ETIT courses are reported in Appendix B. The educational offering is further expanded by the doctoral courses offered by the IBES and EIT4SEMM PhD Programs. The course catalog is made available on the respective websites. Starting from the 40th cycle, the offering of doctoral courses will be expanded, a list of course for the next academic years is reported on Appendix C.

9. Organization of PhD careers, authorizations, period abroads, and credit recognitions

Starting from the 40th cycle, the PhD students will be required to submit with the support of their supervisors, at the beginning of the academic year a study plan, reporting a proposed plan to achieve the required number of doctoral credits. The plan must report the number and type of planned teaching/training activities as listed in Table D. The plan is intended to be flexible, and can be changed during the academic years by sending a communication to the PhD board.

For every achieved training activity, PhD students shall submit a request of credit recognition according to the instructions that will be published on the ETIT website.

According to the university PhD regulations, any external work activity must be previously authorized by the PhD board. Similarly, for any planned research period abroad, an authorization request shall be sent to the PhD board. The respective specific instructions will be reported on the ETIT website.

10. Travels

Travels play an important role during the PhD course, and allow to attend scientific conferences, visit research partners, spend periods in institutions abroad and nationally. According to regulations, PhD students can accees the research funds associated to their scholarship. For more details it is possible to contact the ETIT PhD Administration at dei-phd-etit@unibo.it.

For all research period abroads, PhD student shall submit in advance an authorization request to the PhD board, typically stating the period, the destination, the external tutor, and a letter of invitation. Additional funding in the measure of the 50% of the ETIT scholarship are granted to support research period abroad. Instructions are reported on the ETIT website and on the Intranet of the University of Bologna in the section related to PhD students.

Most importantly, according to the regulations of the University of Bologna, all external activities have to be previously authorized also at department level, by issuing in advance the respective requests of authorization on the specific web portal.

11. Yearly evaluation

All PhD students will undergo a yearly evaluation procedure, aimed at assessing the advancements, the scientific quality of work, and the capabilities to effectively present the research done. Evaluations will consists of productions of reports and the delivery of presentations to the PhD Board or to a specifically appointed committee of professors. Based on this evaluation and on the supervisor yearly assessment, the PhD board will decide about the admission of every PhD student to the next year or to the final exam.

12. Libraries, laboratories, and research facilities

At the premises of the DEI department and of the supporting inter-department center ARCES, there are numerous research laboratories, as detailed at the above linked institutional web pages, where PhD students carry out their activities, making use of workspaces and cutting-edge specialized scientific equipment. More spefically, for the research areas covered by the ETIT PhD program, 11 specialized laboratories are available at DEI, in addition to the 4 laboratories available at ARCES.

Software licenses for operating systems, servers, and Microsoft development tools for ICT, Matlab and Simulink with related toolboxes, LabView, and CAD EDA tools are available for PhD students. Lists are available on the Department's website in the sections related to teaching laboratories. Additionally, individual research groups provide specialized software for different research areas, such as advanced simulators and CAD, for example subscriptions to the Europractice service.

Each PhD student is provided with hardware and software to carry out their research activities, as well as workstations and access to laboratories for experimental activities. Additionally, through the laboratories of the DEI department and the ARCES center, advanced computing and development systems are available in the various research areas of the PhD program, such as measurement benches, computing platforms, servers for Internet-of-Things applications, etc. Each PhD student has access to a workstation, internet connection, printing services, scanner, photocopying, and bibliographic services and databases. Technical support is provided to PhD

students by the staff of the DEI department and of the ARCES center. Dedicated administrative support is provided to PhD students by the DEI Department through a dedicated office for PhD program management lead by a qualified PhD Manager.

Concerning libraries, the resources of the "G. P. Dore" Library of Engineering and Architecture and the "L. B. Alberti" Central Library of the Cesena) are fully available to PhD students, with sections dedicated to information technologies, the resources of the University Library System, and the electronic resources of the AlmaRE catalog (e-books, journals, databases, etc.). Moreover, the University of Bologna manages the Italian Periodicals Catalogue (ACNP) in collaboratio with the National Research Council, allowing the identification of around 210,000 titles and over 1,100,000 collections of periodicals, both in print and electronic formats, across all disciplinary fields. The coverage of the topics of the PhD program is comprehensive, through the availability of resources in print and/or electronic formats from the University Library System, including, for example, the IEEE, Elsevier, ACM, Springer, CRCNet, and Emerald catalogs. The University subscribes to numerous multidisciplinary databases and those related to various disciplinary areas through the coordination of CARE-CRUI. Additional resources are also accessible due to ongoing trials. In most cases, access is available for an unlimited number of simultaneous users. The complete list is available at the institutional website.

The University Library System offers collections of books, journals, exam texts, and databases in both print and electronic formats; it provides advanced bibliographic services to support teaching and research; and it manages the ACNP (Italian Periodicals Catalogue) and the SBN catalogue of the Bologna branch. The system is made up of 24 libraries, with 47 service points and 4,870 reading seats. The collection consists of approximately 4,500,000 printed volumes, 5,180 subscriptions to print journals and 72,000 to online journals, 799,000 eBooks, 380 databases, and over 35,000 doctoral and graduate theses. Available services include: online catalogues, consultation, local and interlibrary loan, document delivery, assistance with bibliographic research through tutorials and online services, digital library platforms for the archiving and preservation of publications produced at the University, as well as assistance and consulting for faculty and researchers (e.g., bibliometric services and support for Open Access).

Appendix A – PhD Board and Coordinator

The ETIT PhD Board for the 40th cycle includes the following members, in alphabetical order. All members meet the national qualifications requirements for the participation to PhD governing boards. The respective CVs are available at the links below.

Name	Scientific-Disciplinary Sector	Affiliation
Prof. Andrea ACQUAVIVA	ING-INF/05 Information Processing Systems	DEI, University of Bologna
Prof.ssa Chiara BURATTI	ING-INF/03 Telecommunications	DEI, University of Bologna
Prof. Walter CERRONI	ING-INF/03 Telecommunications	DEI, University of Bologna
Prof. Marco CHIANI	ING-INF/03 Telecommunications	DEI, University of Bologna
Prof.ssa Alessandra COSTANZO	ING-INF/02 Electromagnetic Fields	DEI, University of Bologna
Prof. Davide DARDARI	ING-INF/03 Telecommunications	DEI, University of Bologna
Prof Claudio FIEGNA	ING-INF/01 Electronics	DEI, University of Bologna
Prof. Corrado FLORIAN	ING-INF/01 Electronics	DEI, University of Bologna
Prof. Diego MASOTTI	ING-INF/02 Electromagnetic Fields	DEI, University of Bologna
Prof. Enrico PAOLINI	ING-INF/03 Telecommunications	DEI, University of Bologna
Prof. Gianni PASOLINI	ING-INF/03 Telecommunications	DEI, University of Bologna
Prof.ssa Carla RAFFAELLI	ING-INF/03 Telecommunications	DEI, University of Bologna
Prof.ssa Susanna REGGIANI	ING-INF/01 Electronics	DEI, University of Bologna
Prof. Aldo ROMANI	ING-INF/01 Electronics	DEI, University of Bologna
Prof. Riccardo ROVATTI	ING-INF/01 Electronics	DEI, University of Bologna
Prof. Enrico SANGIORGI	ING-INF/01 Electronics	DEI, University of Bologna
Prof. Alberto SANTARELLI	ING-INF/01 Electronics	DEI, University of Bologna
Prof. Giovanni TARTARINI	ING-INF/02 Electromagnetic Fields	DEI, University of Bologna
Prof. Alessandro VANELLI-CORALLI	ING-INF/03 Telecommunications	DEI, University of Bologna
Prof Enrico Maria VITUCCI	ING-INF/02 Electromagnetic Fields	DEI, University of Bologna

The elected Coordinator for the 40th cycle is prof. Davide Dardari, who will begin his mandate on November 1st 2024, at the beginning of the PhD academic year.

Coordinator CV

Davide Dardari received his **Laurea degree in Electronic Engineering** (summa cum laude) and his **Ph.D**. in Electronic Engineering and Computer Science from the University of Bologna, Italy, in 1993 and 1998, respectively.
From 1998 to 2000 he was under contract with the Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT), Italy, working on both the experimentation of multimedia services through heterogeneous satellite networks and the design of DSP-based CDMA satellite modems within projects funded by ASI (Italian Space Agency).

From 2000 to 2005, he was a lecturer and a **Research Associate** at the Dipartimento di Elettronica, Informatica e Sistemistica (DEIS), University of Bologna.

During winter-spring 2005 he was a **Visiting Researcher** at Massachusetts Institute of Technology (MIT), Cambridge (USA), working in the field of ultra-wide bandwidth (UWB) technology for communication and localization.

Since 2005, he has been a **Research Affiliate** at Massachusetts Institute of Technology (MIT), Cambridge, USA.

From 2005 to 2021, he was an **Associate Professor** at the University of Bologna, Cesena Campus, where he has participated with Dipartimento di Elettronica Informatica e Sistemistica (DEIS), now Dipartimento di Ingegneria dell'Energia Elettrica e dell'Informazione "Guglielmo Marconi" (DEI).

Now he is **Full Professor** at the same Department.

He is also Research Affiliate at the CNIT National Wireless Communications Laboratory (WiLAB).

He published more than 250 technical papers and he has collaborated in many National and European Projects in some of which he taken the role of **principal investigator, research unit leader** or work package responsible. In particular the following projects are mentioned: ESA Project "LOST", H2020 European projects 6G-SHINE, TIMES, PRIMELOC (Attract), "XCYCLE", FP7 European projects SELECT, DORII, EUWB, PHOENIX, PROMETHEUS, and European Networks of Excellence "NEWCOM-NEWCOM++"; MIUR "WWLAN" project for wideband high speed wireless LAN; several CNIT/ASI joint projects (for example "WAVE" project); MIUR FIRB and PRIN projects, respectively, "VICOM" (Virtual Immersive Communications), CRIMSON and GRETA; in addition, he is the principal investigator of the Project Smart Radio Environments (RESTART -PNRR).

His interests are on wireless communications, localization techniques, smart radio environments, and distributed signal processing.

He is **co-author** of the books "Wireless Sensor and Actuator Networks: enabling technologies, information processing and protocol design", Elsevier, 2008 and "Satellite and Terrestrial Radio Positioning Techniques - A signal processing perspective", Elsevier 2011.

He received the **IEEE Aerospace and Electronic Systems Society's M. Barry Carlton Award** (2011), the **IEEE Communications Society Fred W. Ellersick Prize (2012)** and other Best Paper Awards.

Prof. Dardari is **Senior Member** of the IEEE where he was the **Chair for the Radio Communications Committee** of the IEEE Communication Society. He has been **Distinguished Lecturer** of the IEEE Communication Society (2018-2019).

He was **co-General Chair** of the 2011 IEEE International Conference on Ultra-Wideband and co-organizer of the IEEE International Workshop on Advances in Network Localization and Navigation (ANLN) - ICC 2013-2016 editions. He was also **TPC Chair** of IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC 2018), TPC co-Chair of the Wireless Communications Symposium of the 2007/2017 IEEE International Conference on Communications, and TPC co-Chair of the 2006 IEEE International Conference on Ultra-Wideband.

Currently, he is **Senior Member** of the Editorial Board of the IEEE Signal Processing Magazine. He served as **Lead Guest Editor** for the EURASIP Journal on Advances in Signal Processing (Special Issues on Cooperative Localization in Wireless Ad Hoc and Sensor Networks, and on Network Localization), Guest Editor for Proceedings of IEEE (Special Issue on UWB Technology & Emerging Applications), for the Physical Communication Journal (ELSEVIER) (Special Issue on Advances in UWB Wireless Communications) and for IEEE Trans. on Vehicular Technology (Special Session on indoor localization, tracking, and mapping with heterogeneous technologies). He served as an **Associate Editor** for IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS from 2006 to 2012.

Appendix B – Course descriptions

Course	**Communications for smart environments**
Type	Multidisciplinary and disciplinary training
PhD course year	1st
Academic year	2024/25
Instructor(s)	Davide Dardari, Enrico Vitucci
Doctoral credits	2
Teaching hours	8 + 2 insights and additional contents
Evaluation	Pass grade
Objectives and contents	The course Communications for Smart Environments proposes the study of topics related to the development of ICT technologies for the creation of smart radio environments. The course may provide knowledge related to the study of next-generation mobile networks with integrated communication and sensing systems, intelligent antennas and radiating systems, smart surfaces and metasurfaces, holographic massive-MIMO radio systems, experimental characterization techniques and RF modeling, fog and edge computing, as well as industrial networks. The course will present a selected set of topics representative of technological innovation in the context."

Course	**Research Trends in Microelectronics**
Type	Multidisciplinary and disciplinary training
PhD course year	1st
Academic year	2024/25
Instructor(s)	Susanna Reggiani, Elena Gnani, Enrico Sangiorgi
Doctoral credits	2
Teaching hours	8 + 2 insights and additional contents
Evaluation	Pass grade
Objectives and contents	The course Research Trends in Microelectronics proposes the study of recent trends and innovations in the field of microelectronics, focusing on devices, integrated circuits, as well as topics related to the microelectronics industry in general and the trends towards open models of integrated design. The course will present a series of selected topics and may also include experts from relevant industrial fields. The objective of the course is to provide updated knowledge in the field of microelectronics research, along with critical skills for understanding and adopting new technologies.

Course	**Secure architectures and programming**
Type	Multidisciplinary and disciplinary training
PhD course year	1st
Academic year	2024/25
Instructor(s)	Walter Cerroni, Franco Fuschini
Doctoral credits	2
Teaching hours	8 + 2 insights and additional contents
Evaluation	Pass grade
Objectives and contents	The course Secure Architecture and Programming addresses the theme of security, closely related to the spread and development of ICT technologies, at various levels. The course aims to provide specialized knowledge regarding hardware and software architectures for supporting and managing security in ICT systems and their programming, as well as techniques and algorithms for cryptography and their implementations, security at the physical level, network services, and infrastructure. The course will present a selected set of research topics that can provide a representation of the current state of the art, along with specialized insights into specific themes.

Course	**Remote communication and sensing**
Type	Multidisciplinary and disciplinary training
PhD course year	1st
Academic year	2024/25
Instructor(s)	Enrico Paolini, Alessandro Vanelli-Coralli
Doctoral credits	2
Teaching hours	8 + 2 insights and additional contents
Evaluation	Pass grade
Objectives and contents	The course Remote Communication and Sensing addresses topics related to telecommunications systems and environmental remote sensing. For example, the course aims to provide specialized knowledge regarding satellite communications, microwave photonics with reference to the detection of radioastronomical signals, radar systems, UWB technologies, electromagnetic remote sensing, environmental monitoring networks, and smart RFID systems. The course will present a selected set of research topics. The objective of the course is to deepen specific themes related to the problem of detection in the telecommunications field.

Course	**Energy Harvesting and Micro-power Management**
Type	Multidisciplinary and disciplinary training
PhD course year	1st
Academic year	2024/25
Instructor(s)	Aldo Romani
Doctoral credits	2
Teaching hours	10
Evaluation	Pass grade
Objectives and contents	The course provides an overview of the main energy harvesting sources, from the basic physical effects to their use in circuit applications. The course also offers knowledge related to the design of circuits for the conversion and management of micropower capable of harnessing environmental sources to power IoT systems, and highlights the concepts of energy budgets and introduces the required design trade-offs.

Course	**Advanced Cyber Physical Systems**
Type	Multidisciplinary and disciplinary training
PhD course year	2nd
Academic year	2025/26
Instructor(s)	-
Doctoral credits	2
Teaching hours	8 + 2 insights and additional contents
Evaluation	Pass grade
Objectives and contents	The course Advanced Cyber Physical Systems will cover advanced topics related to sensor technology, computational systems, connectivity systems, and energy management based on the state of the art in scientific research and their integration. These topics will be discussed with particular reference to electronic technologies and energetically autonomous wireless systems. The objective is to introduce and propose new technologies suitable for the development of intelligent systems and to stimulate the generation of new ideas and applications related to the individual doctoral project.

Course	**ICT for Energy Efficiency**
Type	Multidisciplinary and disciplinary training
PhD course year	2nd
Academic year	2025/26
Instructor(s)	-
Doctoral credits	2
Teaching hours	8 + 2 insights and additional contents
Evaluation	Pass grade
Objectives and contents	The course ICT for Energy Efficiency aims to present a selection of topics related to information technologies aimed at achieving energy efficiency objectives in systems, such as innovative nanoelectronic devices for computation and energy management, policies and algorithms for energy management in electronic systems and consumption reduction, monitoring systems for consumption, and techniques and methods for energy-efficient communication, including methodologies for the experimental characterization of components and circuits.

Course	**Advanced Topics in Telecommunications**
Type	Multidisciplinary and disciplinary training
PhD course year	2nd
Academic year	2025/26
Instructor(s)	-
Doctoral credits	2
Teaching hours	8 + 2 insights and additional contents
Evaluation	Pass grade
Objectives and contents	The course Advanced Topics in Telecommunications will provide specialized knowledge derived from recent scientific research related to a selected set of advanced topics in the field of telecommunications, such as terrestrial and satellite wireless communications, new 5G/6G mobile networks, networking, wireless propagation at mm-wave and Terahertz frequencies, multiple antenna systems and smart beamforming, physical layer security, and machine learning applied to wireless communications. The objective is to provide updated knowledge related to advanced aspects of the evolution of telecommunications systems and networks.

Course	**High-performance Emerging Computing Paradigms**
Type	Multidisciplinary and disciplinary training
PhD course year	2nd
Academic year	2025/26
Instructor(s)	-
Doctoral credits	2
Teaching hours	8 + 2 insights and additional contents
Evaluation	Pass grade
Objectives and contents	The course High Performance Emerging Computing Paradigms will address topics related to the management of computation in the development of ICT components and systems, such as advanced microprocessor architectures at the embedded/edge and HPC levels, new computational paradigms like neuromorphic computing and quantum information computing. The educational objective is to provide the necessary knowledge to critically evaluate and select the most suitable state-of-the-art technologies for managing computation based on the context and project specifications.

Course	**Innovation in IoT**
Type	Multidisciplinary and disciplinary training
PhD course year	3rd

Academic year	2026/27
Instructor(s)	-
Doctoral credits	2
Teaching hours	8 + 2 insights and additional contents
Evaluation	Pass grade
Objectives and contents	The course Innovation in IoT aims to provide specialized knowledge, including practical applications, related to a selected set of emerging new technologies or case studies for Internet-of-Things applications, such as wireless sensor networks, sensors and electronic interfaces, energy harvesting, simultaneous transmission of information and power, smart RFID, communication protocols and cloud services for IoT, and architectures for security management. The objective is to study these recent developments in the IoT field from an application perspective, also by exploring solutions presented in the scientific domain.

Course	**Advanced Topics in Signal Processing**
Type	Multidisciplinary and disciplinary training
PhD course year	3rd
Academic year	2026/27
Instructor(s)	-
Doctoral credits	2
Teaching hours	8 + 2 insights and additional contents
Evaluation	Pass grade
Objectives and contents	L'insegnamento Advanced Topics in Signal Processing propone l'approfondimento di tematiche legate all'elaborazione dei segnali inerenti ai temi di ricerca del corso di dottorato. L'insegnamento potrà fornire conoscenze riguardo ai temi dell'elaborazione statistica del segnale per telecomunicazioni, sensing e sistemi di localizzazione, applicazioni del machine learning al signal processing, gestione ed applicazioni di segnali UWB, compressed sensing. L'insegnamento prevede la presentazione di un insieme selezionato di argomenti di ricerca negli ambiti sopra citati. L'obiettivo è fornire conoscenze specialistiche applicabili ai temi di ricerca individuali del corso di dottorato.

Course	**Electronic and electromagnetic sesning techniques**
Type	Multidisciplinary and disciplinary training
PhD course year	3rd
Academic year	2026/27
Instructor(s)	-
Doctoral credits	2
Teaching hours	8 + 2 insights and additional contents
Evaluation	Pass grade
Objectives and contents	The course Electronic and Electromagnetic Sensing Techniques proposes the study of techniques for detecting physical quantities and managing sensors based on electronic architectures and/or wireless electromagnetic techniques. The course may provide knowledge in the area of sensor systems, electronic interfaces for signal conditioning, MEMS systems, and the use of electromagnetic fields for sensing applications. The objective is to present a selected set of research topics characterized by high originality, even at a limited TRL (Technology Readiness Level), capable of stimulating ideas and connections with individual doctoral projects.

Course	**Advances in Power and RF Electronics**
Type	Multidisciplinary and disciplinary training
PhD course year	3rd

Academic year	2026/27
Instructor(s)	-
Doctoral credits	2
Teaching hours	8 + 2 insights and additional contents
Evaluation	Pass grade
Objectives and contents	The course Advances in Power and RF Electronics proposes the study of research topics related to recent developments in power electronics and applications in radio frequency. The course may provide knowledge in the area of power electronic devices, regarding new types of power converters based on innovative electronic devices, the themes of wireless power transfers, management of micropowers, and techniques for characterization and modeling of RF devices and circuits. The objective of the course is to present a selected set of research topics and provide students with a representation of the current state of the art in technology, while stimulating new ideas for the development of individual research themes.

Appendix C – ETIT Course Catalog

For the next academic years, the ETIT PhD program is planning to expand the offering of doctoral courses related to information technologies engineering. A catalog of potential future activations is reported herein along with instructor names and course durations. In the next academic years, this courses will add on top of the program listed in Appendix B, and will progressively reach a configuration of at least 5 doctoral courses delivered per academic year.

Course Title	Instructor(s)	Academic Year	Hours	Contents
Short-range localization and tracking	Davide Dardari	not active in a.y. 2024/25	10	L'insegnamento fornisce le basi teoriche di elaborazione dei segnali per la localizzazione e tracking attivi e passivi mediante segnali radio. L'insegnamento offre inoltre conoscenze relative alle tecnologie abilitanti, applicazioni fornendo spunti su tematiche di ricerca avanzate.
Latest Advances in Microwave Photonics technologies	Giovanni Tartarini, Jacopo Nanni	not active in a.y. 2024/25	10	Microwave Photonics technology efficiently generates, processes, controls, and distributes radio, microwave, millimeter-wave, and THz-frequency signals through interaction with optical waves. This technology covers antenna remoting for wireless signal distribution, optical processing of microwave signals, and optical control of phased array antennas, enhancing performance in areas like wireless communication, radar, sensors, and radio astronomy. Originating in the mid-1980s with military applications, the field is now expanding into societal applications due to advancements in photonic integrated circuits, low-cost packaging, and increased market demand. The course will review basic concepts and explore the latest advancements from devices to system-level applications.
Neuromorphic computing: From Spiking Neural Networks to Neuromorphic Accelerators	Andrea Acquaviva, Francesco Barchi	not active in a.y. 2024/25	15	L'insegnamento fornisce le basi delle reti neurali spiking, che si configurano come alternativa maggiormente ispirata al neurole cerebrale rispetto alle tradizionali reti neurali artificiali. Verranno spiegate le applicazioni di queste reti sono adeguate al processamento di eventi da sensori di tipo neuromorfico (ex DVS camera). Verranno poi descritti i principali sistemi hardware neuromorrfici atti ad eseguite questo tipo di reti con una elevata efficienza energetica, focalizzandosi su acceleratori di tipo digitale.

Digital Signal Processing and Software Defined Radio	Gianni Pasolini	not active in a.y. 2024/25	10	Il corso fornisce le nozioni alla base delle tecniche di elaborazione digitale dei segnali (DSP), quali ad esempio la generazione di segnali con tecniche digitali, il processamento multirate, la rappresentazione della grandezze numeriche in virgola fissa e in virgola mobile. Verranno inoltre introdotti i principi e gli strumenti alla base della software defined radio (SDR), che consentono di implementare e modificare sistemi di comunicazione radio interamente tramite software. Il corso prevede esercitazioni pratiche con ambienti di simulazione e hardware SDR, permettendo agli studenti di applicare i concetti teorici appresi.
Physical modeling of power devices and reliability	Susanna Reggiani	not active in a.y. 2024/25	5	The short course will deal with semiconductor transistors for power applications. A brief introduction to the integrated power MOSFETs in silicon and future monolithically-integrated GaN/AlGaN HEMTs will be given to the purpose of highlighting the most relevant figures of merits in terms of performance and reliability. The technology CAD adopted by the Semiconductor Companies and Research Centers as a specific design tool-kit will be presented along with some relevant investigations carried out on the key physical mechanisms. Wide-bandgap semiconductor devices will be compared to silicon-based ones and their specific reliability issues will be discussed.
Modern coding theory	Enrico Paolini	not active in a.y. 2024/25	10	The course will delve into theory and practice of modern error correcting codes based iterative decoding, including low-density parity-check codes and their generalizations and polar codes. These coding schemes are nowadays employed in all digital communication systems, from wired (100 Gbit Ethernet, Tbit Ethernet, optical) to wireless (terrestrial, satellite, deep-space).
Organic-Semiconductor based electronic and optoelectronic devices	Claudio Fiegna	not active in a.y. 2024/25	10	The course will provide an introduction to organic semiconductors and to their electronic and optoelectronic properties. The principle of operation and the fabrication process of organic transistors, organic solar cells and organic light emitting diodes (OLED) will be described. Examples of applications, such as organic integrated circuits, flexible and semi-transparent solar cells and large area displays based on OLEDs, will be discussed.
Satellite systems per remote communication and sensing	Alessandro Vanelli-Coralli	not active in a.y. 2024/25	10	

A deep dive into RISC-V and Extensions: architectures, chips, applications	D. Rossi, F. Conti	not active in a.y. 2024/25	10	In this course, we will provide an in-depth discussion on RISC-V processors, starting from ISA organization, moving to micro-architecture and finally to design and implementation. We will focus on the distinctive advantages offered by RISC-V openness and extensibility across these abstraction layers. We will use the open RISC-V cores from the PULP platform as concrete case studies, in single and multi-core configurations, and heterogeneous combinations. We will also discuss opportunities and challenges related to the silicon implementation of these RISC-V cores in academic and commercial Systems-on-Chip and share our experience and vision for the future research and development opportunities an challenges on open cores and open (RISC-V) hardware.
Measurement-based modelling of GaN HEMTs for the design of high frequency electronic circuits	A. Santarelli	not active in a.y. 2024/25	10	This course aims to provide knowledge on compact empirical modelling of GaN HEMTs for high-frequency electronic circuit design. Main techniques for the nonlinear characterization of devices both at low- and high-frequencies will also be described. Finally, application examples of FET measurement-based models will be discussed.
Introduction to quantum computing and communications for engineers	M. Chiani	not active in a.y. 2024/25	06-Apr	The course is intended as an introduction to quantum information for PhD students in the areas of electronic and telecommunication engineering, and computer science. It does not require a previous background in quantum mechanics. Content: history and potential applications, basics of quantum mechanics, quantum bits, quantum computation, quantum algorithms, quantum communication, quantum error correction.