UNIVERSITY OF CASSINO AND SOUTHERN LAZIO

DEPARTMENT OF ELECTRICAL AND INFORMATION ENGINEERING "MAURIZIO SCARANO"
INTRODUCTION

The Department of Electrical and Information Engineering "Maurizio Scarano" (DIEI) was founded in 2012 from the fusion of the Department of Automation, Electromagnetism, Information Engineering and Industrial Mathematics and part of the Department of Industrial Engineering. In accordance with the University Statute, DIEI’s main aim is to promote the development, processing and transmission of knowledge in its proper scientific fields. Such an aim is pursued by seeking excellence in research and teaching in the reference sectors helps the goal achievement, activating interdisciplinary synergies, and establishing collaborations with public administrations, other universities, research centers, institutions and companies. In particular, DIEI has the following general objectives:

- to promote scientific research in all its forms and ensure the dissemination of knowledge and technologies;
- to seek national and international research excellence in its scientific fields;
- to provide support, with its skills and facilities to the productive and social fabric of the territory so as to promote development and competitiveness.
- to encourage the research technological transfer towards the territory also by promoting the birth and growth of university start-ups and spin-offs;
- to contribute, through training and research, to a development based on the principles of social cohesion, in a logic of openness, comparison and collaboration with other social actors;
- to promote the creation of qualified employment, in particular for its graduates and employees, also by experimenting new forms of entrepreneurship;
- to ensure the coordination and development of national and international excellence projects;
- to promote the development and enhancement professional skills of its staff;
- to enhance the skills and the needs of research support and qualification in the different scientific and disciplinary fields;
- to promote the internationalization process through the international dimension of research and higher education;
- to continuously improve its research services and enhance the satisfaction of all its stakeholders.
DIDACTICS

Bachelor Degree in Computer and Telecommunications Engineering

Master Degree in Electrical Engineering

Master Degree in Telecommunications Engineering, in English

Master Degree in Computer Engineering

Master Degree in Computer Engineering with Industrial Robotics curriculum, which awards a double degree with the University of Evry Val D’Essonne (France), in English and French

Master Degree in Computer Engineering with MAIA (Medical Imaging and Applications) curriculum which awards a joint degree with the Universitat de Girona (Spain) and the Université de Bourgogne (France), in English

PhD course in Methods, Models and Technologies for Engineering with a curriculum in Information Engineering and a curriculum in Electrical Engineering
THE DIEI’S RESEARCH

The DIEI has a consolidated experience in scientific research and technological development especially regarding Electrical Engineering, Automation, Electronics, Information Technology, Telecommunications and Mathematics.

The DIEI successfully participated to the Quality Research Evaluation (VQR) in the period 2011-2014. Over 70% of supplied products were classified as excellent or high. Moreover, 4 out of 10 Scientific Sectors are ranked in the top 25% in Italy.

The DIEI has been evaluated as Department of Excellence and, since 2018, has been rewarded with additional resources.

The main research lines recently developed are:

- Design and testing of control strategies in the framework of industrial, underwater, aerial, mobile and assistive robotics, multi robot systems;
- Techniques for analysis and synthesis of microwave equipment;
- 5G and Beyond-5G wireless systems: signal processing and resource allocation algorithms;
- Cryptographic algorithms also for cybersecurity;
- Artificial intelligence and machine learning applied to sensor fields, manuscript analysis, healthcare and cultural heritage;
- Machine and Deep Learning for biomedical image processing systems for diagnostic purposes;
- Analysis in normal and abnormal conditions in power systems, even in the presence of distributed generation;
- Analysis, management and control of smart grids, with particular reference to the integration of distributed generation from renewables and of demand response;
- Sensors and sensor networks;
- Measures on networks and telecommunications equipment;
- Microwave disinfestation;
- Nanotechnology for electrical and electromagnetic applications;
- Computational Electromagnetism;
- Non destructive testing and evaluation;
- Electromagnetic Compatibility;
- Electric and hybrid vehicles;
- Measurements for electrical networks and Power Quality.
- Measurement methods and tools
- Numerical modeling of components, devices and systems for electrical, electronic and controlled thermonuclear fusion applications;
- Power quality and energy savings in electrical power systems;
- Non-destructive tests, electromagnetic imaging, inverse problems;
- Modeling and EMC characterization tests of electrical and electronic components, devices and systems;
- Characterization of modern electric, electronic and telecommunication equipments;
- Design of electric drives for industrial automation and of electrical machines for electricity production;
- Energy storage systems and BMS (battery management systems) for automotive applications;
- Traction dc/ac converters and EV chargers;
- Design and optimization of components and systems for electric traction and sustainable mobility;
- DC / AC power converters with zero-voltage commutation of the switches;
- Study of the cosmic ray effects on power semiconductor devices;
- Instabilities of power semiconductor devices operated in short circuit or at the edges of their Safe Operating Area;
- Massive MIMO systems and millimeter-wave beamforming algorithms for future generation wireless networks;
- Detection and localization algorithms and adaptive scanning for radar systems;
- Co-existence of radar and wireless communication systems: waveform design and resource allocation;
- Dual-function radar and communication systems and opportunitic sensing through wireless signals;
- Energy efficiency in electrical power systems;
- Highly reliable classification systems based on statistical learning and Bayesian Networks;
- Asymptotic analysis of variational problems, in particular modeling of problems in thin structures and homogenization of problems in strongly oscillating borders domains;
- Nanofluidic modeling for nano-filtration and reverse osmosis applications;
- Mathematical modelling of environmental and industrial problems through nonlinear dynamical systems and reaction-diffusion models; pattern formation; bifurcation and chaos.
LABORATORIES

EMCLAB – LABORATORY OF ELECTROMAGNETIC COMPATIBILITY

The Electromagnetic Compatibility (EMC) Laboratory is fully equipped for EMC testing according to the international standards for ICT, automotive and aerospace applications. Research and teaching activities are related to the design and verification of EMC-aware electrical and electronic devices. The Laboratory is also a competence center for companies and organizations, providing all necessary support for the EMC testing of their products and systems, (for instance, those requested for the CE marking or for the Automotive regulations of the Italian Ministry of Transport). The support to companies and institutions is not limited to the testing phase, but also to the design and pre-compliance ones. The Laboratory is also equipped for outdoor measurements of electromagnetic pollution.

LAN - LABORATORY OF NUMERICAL ANALYSIS

Numerical simulation activities are developed and the team also studies the progress of algorithms applied to cryptography problems. Since the laboratory members are distributed in three different scientific sectors, the laboratory’s activities span across different fields. The main skills are listed below:

- numerical simulations related to liquid flow problems through membranes;
- numerical simulations related to composite materials;
- development of quadrature formulas for singular measures;
- mathematical modelling through nonlinear dynamical systems, models’ validation and numerical simulations in Matlab environment;
- simulations related to dynamic systems;
- development of software algorithms for operations in modular arithmetic in a Java environment;
- development of public key cryptography algorithms;
- generation of random numbers.
LAI – INDUSTRIAL AUTOMATION LABORATORY

ELECTRIC VEHICLES AND RENEWABLE ENERGY SECTION

The LAI Drives, Electric Vehicles and Renewable Sources section has been operating for more than 20 years on research and development in the field of industrial applications and transportation electrification. The research activities focuses on advanced technologies for high efficiency and high performance electrical and electronic equipments, with particular reference to electric propulsion systems, both low voltage and high voltage, power electronics for energy management, renewable generation and energy storage systems.

Most of these activities are oriented towards technology transfer to national and international companies in energy and transport sector, with which the LAI has specific collaboration agreements. The Electric Vehicles and Renewable Sources section of the LAI also hosts national and international projects in the field of motorsport, in collaboration international associations and institutes and it involves students and young researchers from undergraduate and postgraduate courses in Electrical and Mechanical Engineering. Recently, a new start-up company has been created inside the LAI, with the mission of developing and producing high technology level equipments for electric and hybrid vehicles.

ROBOTIC DIVISION

The mission of the robotic division of the LAI laboratory is the development and experimental validation of control techniques for industrial and service robotic systems. The members of the laboratory have over 20 years of experience in the field of robotics, with particular reference to kinematics, dynamics and control of industrial manipulators, control of multi-robot mobile systems, marine and aerial robotics, human-robot interaction and assistive robotics.

In order to experimentally validate the developed methodologies, the laboratory is equipped with collaborative manipulators, mobile manipulators, mobile robots, brain-computer interfaces, and autonomous aerial vehicles.

Over the past 10 years the robotic division of the LAI laboratory has participated in 9 competitive research projects funded by the European Commission within the FP7 and H2020 programs, as well as in national projects funded by the MIUR (Ministry of Education, University and Research) and the MISE (Ministry of Economic Development), and to several technology transfer activities.

The LAI Robotics Group is part of the PRISMA Consortium and the ISME Interuniversity Center, and has several scientific collaborations with academic and corporate partners, both national and international.
LAMI – LABORATORY OF INDUSTRIAL MEASUREMENTS

The Laboratory of Industrial Measurements (LAMI) works on Electrical and Electronic Measurements in research, teaching and third mission activities for public institutions, companies and privates. The research focuses on: measurement methods, the creation and experimental characterization of innovative measurement instruments, system design for electrical, electronic and telecommunication measurements. They work on the realization and metrological characterization of advanced sensors in the IoT, WSN field and Industry 4.0, and of instruments and systems for non-destructive tests, they also take care of the realization and metrological characterization of instrumentation for wired and wireless telecommunication networks, realizing and customizing systems for electricity monitoring and Power Quality. The researches in the LAMI are both financed with public (MIUR, CNR, European Community, MISE, etc.) and private funds (local and national organizations, consortia and companies). Regarding metrological services, LAMI is a metrological laboratory accredited by ACCREDIA with LAT N° 105 issued in accordance with the decrees of the law n. 273/1991 in which the National Calibration System (SNT) is established. The laboratory offers calibration services for speed, pressure, time and frequency and volumes. In these areas the laboratory deals with calibrations of speed gauges, pressure gauges, pressure calibrators, and volume meters and tachometers used specifically in fiscal areas. The LAMI was the first academic laboratory (together with the Politecnico di Milano) to achieve the accreditation to IEC / ISO 17025 as a Calibration Center. Consequently the laboratory adopts the aforementioned reference standard for its management and technical organization and for all the test activities (also the not accredited ones). In this context, the LAMI carries out tests related to tachograph checks, electrical and electronic measuring instruments, fiscal instruments, etc. All the experimental activities related to the CE certification of electrical and electronic devices are considered important. The LAMI offers services for operating tests, electrical safety, normal and accelerated thermal cycles, thermal shock, aging tests, etc. Currently, in collaboration with the Science and Technology Park of Southern Lazio (PALMER), the LAMI offers MID certification services for Utility Meters (electricity meters, water, thermal energy and gas).
LIT – LABORATORY OF INFORMATICS AND TELECOMMUNICATIONS

LIT is a multidisciplinary laboratory in the information and communication technologies area. Its associated faculty have expertise in topics such as signal processing, telecommunications, radar, informatics, artificial intelligence, machine learning, networks and remote sensing.

In particular, research activities are focused on these areas:- 5G and Beyond-5G Wireless Networks, massive MIMO systems, millimeter wave communications:

- Deep Learning and Machine Learning for Wireless Communications;
- Detection and localization algorithms and adaptive scanning for radar systems;
- Co-existence of radar and wireless communication systems;
- Dual-function radar and communication systems and opportunistic sensing through wireless signals;
- Statistical classification based on evolutionary algorithms;
- Machine Learning and Deep Learning for Computer-Aided Detection and Diagnosis (CAD) systems and healthcare applications;
- Algorithms for the automatic analysis of biomedical images and manuscripts;
- Research and technology transfer on embedded systems, IoT, Big Data algorithms and methods for automatic analysis of satellite images.

LM – MICROWAVE LABORATORY

The Microwave Laboratory operates with analysis, synthesis, implementation and testing of microwave devices. The activity is currently divided into four strands:

- design, construction and testing of antennas for wireless communication systems and innovative industrial applications;
- synthesis, optimization and diagnostics of large arrays, both for RADAR and satellite applications, for MIMO communication applications, and for the realization of plane wave generators (PWG) used in the characterization of high performance antennas;
- study of electromagnetic scattering using analytical regularization methods;
- non-telecommunication applications (electromagnetic characterization of nanocomposite dielectric materials with non-negligible magnetic response, reflectivity measurement of composite panels, electromagnetic characterization of biological tissues). The laboratory equipment includes spectrum analyzers and networks operating up to 20 Ghz and a near-field scanning system in cylindrical geometry.
LaSE – LABORATORY OF ELECTRICAL SYSTEMS

The LaSE laboratory was established in 1997. Its basic, applied and service research activities concern the study, the use and the enhancement of advanced technological innovations in the area of electrical power systems and smart grids. In particular, the LaSE Lab works on:

- **Generation and Distributed Energy Resources:** estimation of producibility from renewable sources; tecnono-economic analysis and optimization of investments; territorial and environmental analysis of sites; interface of generators with the network; design, development and testing of electronic converters for connection to the grid; impact on distribution grids; flexible and modular control systems for converters on DSP platforms.

- **Power Quality and Safety:** voltage quality monitoring and verification; electrical safety analysis and verification; characterization of emissions and immunities of equipment and components; analysis, design and prototyping of electronic compensators for industrial users (filters, DVR, StatCom).

- **Energy Savings in the Lighting sector:** analysis of the performance of the road infrastructure lighting system; analysis of energy consumption of lighting systems.

- **Management and Control:** analysis and development of supervisory and control structures (SCADA / DCS); participation strategies in electricity markets; automation of industrial electrical systems; rationalization of consumption and energy saving.

The LaSE Lab offers teaching support for electrical and non-electrical majors, and services to companies. During its activity, the LaSE has activated scientific collaboration with prestigious research centers such as Ansaldo Trasporti - Naples, Ansaldo Sistemi Industriali – Milan, Materials Engineering and High Voltage Laboratory - University of Bologna, Department of Electrotechnics - Politecnico di Milano.

Research agreements have been carried out with Semikron - Pomezia, Screen - Ceprano, NLC Sistemi Metallici - Latina, Pa.L.Mer - Ferentino, GETRA - Caserta, Tironi - Modena, Schneider Electric - Italy, TERNIA – Roma, and ANAS - Roma.

Recently, the LaSE has started collaborations with ENEL Global Infrastructure, Networks Technology and Innovation, and with MARES – Naples and the Q8 oil group, together with the LAMI Lab.
LEI – "GIANNI D’ANGELO" INDUSTRIAL ELECTRONICS LABORATORY

The Laboratory hosts the research and teaching activities of the scientific-disciplinary sectors ING-IND / 32 Converters, Electric Machines and Drives and ING-INF / 01 Electronics.

In the first sector electric machines for special applications in very different fields of application are studied and designed. Moreover, with the help of an equipped mechanical workshop, equipped with precision instrumentation and a CNC work center, the team made prototypes to carry out the necessary experimental and testing activities. In the LEI the electronic conversion and digital control systems for the prototypes are also designed and implemented, studying and applying innovative solutions in industrial, energy and electric traction areas.

Research activities include the theoretical and experimental study of modern semiconductor power devices from the point of view of their robustness and reliability even in harsh environments and in the presence of ionizing radiations. The attention is also focused on their behaviour in soft switching applications with the aim of optimizing efficiency, volumes and costs of the conversion systems.

The LEI covers about 200 square meters and is organized into five thematic areas: study and design of machines, design of conversion systems, testing of electrical machines, rapid electronic prototyping, studying and characterization of power devices. There is also a separate area that hosts the precision mechanical workshop.
LEMNDE – LABORATORY OF ELECTROMAGNETIC CALCULATION AND NON-DESTRUCTIVE ELECTROMAGNETIC DIAGNOSTICS

The mission of LEMNDE is twofold: (I) numerical modeling of electromagnetic fields and (II) electromagnetic non-destructive testing and evaluation of materials.

The first research area concerns the development of original numerical models, methods and codes for the computation of electromagnetic fields for complex problems and/or structures. The main applications are related to electromagnetic imaging and testing of materials, plasmas for fusion applications, electromagnetic compatibility, nanotechnology for electrical and electronic applications, interaction of electromagnetic fields with nanostructures and quantum structures (plasmonics, etc.). Particular care is paid to the development of “fast” numerical methods and algorithms for the simulation of complex structures on HPC computing architectures based on CPU and GPU, available at LEMNDE.

The second research area concerns the development of experimental methods and systems for non-destructive inspection and evaluation of materials. The laboratory is specialized in real-time techniques for imaging and electromagnetic testing of conductive, dielectric, composite and ferromagnetic materials which are of interest for applications in nuclear, aeronautical and industrial fields.

In addition to this, LEMNDE possess a solid know-how and computational tools to analyze numerically existing probes and to design and build new, ad-hoc, probes for specific applications. LEMNDE has been and is involved in numerous international projects, through scientific collaborations with the main players in the international scientific community.
PhD COURSES

The PhD course in Methods, Models and Technologies for Engineering offers high-level scientific training, implemented with the combination of research, technology and innovation. The course aims to train professionals with a high technical-scientific profile on basic and applied research on engineering topics.

Using different training tools (courses and seminars taught at the University and in other schools, research carried out with advanced means of investigation, scholars participating in joint activities with researchers from other universities, and discussions with the Committee members) researchers are able to set and autonomously manage technological innovation processes not rigidly framed in restricted scientific fields.

The PhD course in Methods, Models and Technologies for Engineering offers a high level knowledge in one of the most profitable sectors in Italy and abroad; it is a key element for accessing leading companies and for reaching important positions in large international companies strong in research and development, innovation and design.

Curricula

The training course includes a three-year cultural course with some courses common to all students and others specific. It ends with a PhD thesis on an innovative research topic developed by the candidate.

The course is divided into the following curricula, each one gathers specific scientific competences of the teaching staff:

C1: Civil and Environmental Engineering
C2: Information Engineering
C3: Electrical Engineering
C4: Mechanical and Management Engineering
C5: Environments and technologies for physical activity and health
The vivacity of DIEI in research activities translates itself into the ability to attract funding from competitive calls. Since 2014, 11 projects were funded by the European Community FP7 and Horizon 2020:

2014: EuRoC
2015: AEROARMS, DexROV, ROBUST, WiMUST
2016: NDTonAIR
2017: MICEV
2018: SmartCom, TERASSE, EUMarineRobots
2019: IUCCF

6 national funded projects from MIUR (PRIN, FIRB)
4 regional projects (PON, POR)
1 NATO project

The considerable commitment of DIEI in research activities related to national and international competitive projects is witnessed by the amount of the incomes. In the last 3 years they represented a share between 50% and 70% of the annual budget of the Department, on an average value of approximately 2.5 million euros.
TECHNOLOGY TRANSFER

The DIEI research activities produced numerous international and national patents. The complete list is available on the department site.

DIEI researchers are involved in setting up the following companies and spin-offs:

- Greenergy srl
- LEDA Advanced ElectroDynamic Laboratory srl
- Power on Demand

The DIEI contributes to the innovation and competitiveness of the territory also making fruible the research results and its own skills and knowledges to businesses, public administration and professionals.

LIBRARIES

The Center for Library Services of the Engineering area handles the acquisition, cataloging and use of the book and documentary heritage of the Department of Electrical and Information Engineering, of the Department of Civil and Mechanical Engineering and of the Frosinone headquarter.

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