# Research Infrastructures - Laboratories and Equipment at the University of Cyprus

**Department of Electrical and Computer Engineering (ECE)**

The Department of Electrical and Computer Engineering (ECE) has several dedicated laboratories that support the Department’s study programs. The list of laboratories along with a short description of each laboratory, along with the main equipment facilities is provided below.

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|  | **Lab name** |
| 1 | The Embedded and Application-specific System on Chip Laboratory |
| 2 | The Sensors and Robotics Laboratory |
| 3 | The Microwave Photonics Laboratory |
| 4 | The Communications & Networking Laboratory |
| 5 | The Electronic Design, Test and Reliability Laboratory |
| 6 | The Biomedical Imaging and Applied Optics Laboratory |
| 7 | The Power Systems and Power Electronics Laboratory |
| 8 | The Power Systems Pilot Site |
| 9 | The Power Systems Modelling Laboratory |
| 10 | The Photovoltaic Technology Laboratory |
| 11 | The Multicore Computer Architecture Laboratory (multiCAL) |
| 12 | The Microwaves & Antennas Laboratory (MA-Lab) |
| 13 | The Holistic Electronics Laboratory |
| 14 | Distributed Control Systems and Networks Laboratory |
| 15 | Electromagnetics and Novel Applications Laboratory |
| 16 | Mobile Communications & Networking (MCN) Laboratory |

1. **Embedded and Application-specific System on Chip Laboratory**

**The Embedded and Application-specific System on Chip Laboratory** focuses towards the design, development, implementation and verification of low-power, high-performance and highly reliable systems on chip, suitable for embedded and mobile environments. Equipment includes:

* Multi-GPU supercomputers used for machine learning and computer vision applications
* State-of-the-art low-end and high-end FPGA boards for acceleration of compute intensive applications (computer vision, image processing, machine learning).
* Multi-SOC FPGA-Based BeeCube Platform for large-scale hardware emulation
* Embedded Computing Systems (Raspberry Pi, Gumstix Boards, Odroid Platforms)
* Bumblebee Stereoscopic Camera for stereo vision applications
* Smart Camera Nodes based on the Raspberry Pi Computers
* NVIDIA Jetson TK1 embedded GPU platform for accelerated edge computing
* Logic Analyzers/Oscilloscopes/Function Generators for circuit design
* Hybrid Multi-FPGA/Multi-GPU Platform for large scale circuit and system emulation.

## The Sensors and Robotics Laboratory

**The Sensors and Robotics Laboratory** investigates the design and implementation of embedded, multi-sensor systems for monitoring different environments such as critical infrastructures, buildings etc. These sensors can be on fixed or mobile (robotic) platforms. Key equipment includes:

* + Developmental Matrice-100 drones
  + Miscellaneous terrestrial robotic platforms
  + Drone attachable thermal camera with radiometry (30Hz)

## The Microwave Photonics Laboratory

**The Microwave Photonics Laboratory** conducts research in fiber-optic systems and networks and microwave photonics, including research work on radio-over-fiber (RoF), WDM-based PON access networks, as well as converged optical-wireless access networks. The laboratory is equipped with several testing instruments and optical devices for experimentation and testing including:

* + 12.5 Gb/s Bit Error Rate tester, composed of a 12.5 GHz frequency synthesizer, a pulse pattern generator and the Error Detector unit (Anritsu)
  + 40 GHz electrical spectrum analyzer (Anritsu)
  + 40 GHz vector network analyzer (Agilent)
  + 1 GHz 4 GSa/s scope (Agilent)
  + up to 22 GHz frequency synthesizer (Rohde & Schwarz)
  + 3 GHz vector signal generator
  + Optical spectrum analyzer (Anritsu, 0.07 nm resolution)
  + Optical power meter (ILX)
  + Distributed Feedback (DFB) laser diodes
  + 45-75 GHz Photodiodes
  + Electro-optic Mach-Zehnder Modulators (MZM)
  + Optical switches, couplers, isolators, circulators
  + Tunable optical Filters and Bandpass Attenuators
  + Multiplexers/Demultiplexers
  + Erbium Fiber Optical Amplifiers (EDFAs)

## The Communications & Networking Laboratory

**The Communications & Networking Laboratory** examines the modelling, simulation, emulation and design of architectures, protocols, algorithms and technologies for next- generation communication systems (e.g. machine-to-machine, 5G systems, optical/wireless telecommunication networks), with a focus on communication theory, wireless communications and networking. Equipment includes:

* + Commercial/Custom-made simulation software for optical/wireless telecommunication networks
  + Equipment for testing optical/wireless networks (routes, optical/electrical switches, traffic generators, transmitters, receivers, amplifiers, etc).

## The Electronic Design, Test and Reliability Laboratory

**The Electronic Design, Test and Reliability Laboratory** focuses on computer aided design, testing and reliability of modern VLSI circuits and embedded systems, with expertise in CAD algorithms for automatic testing, diagnosis, verification, and resilient design, applicable to different hardware platforms (VLSI, SoCs, NoCs, on-chip multiprocessors). Equipment includes:

* + high-end servers/workstations and logic analysers
  + state-of the-art CAD tools (Synopsys, Cadence, and Mentor Graphic) for development and simulation purposes
  + several FPGA-based prototyping systems

## Optical Diagnostics (ODx) Laboratory

The objective of the **Optical Diagnostics Laboratory** is to bridge the gap between science and medicine and explore the development of new optical and other imaging technologies and their applications in clinical situations. Optical techniques, such as Optical Coherence Tomography and Raman Spectroscopy, have shown great promise over the years. They are, however, still in their infancy and require further development and integration with current medical practice. This area has the potential to significantly improve the diagnostic options of mern health care systems and directly impact patient prognosis and outcome. The ODx Lab strives to integrate the identification of diagnostic challenges, development of new diagnostic technologies, clinical validation and human studies and transfer to industry. Current interests include the implementation of diagnostic technologies for the early detection of pre-malignant and cancerous lesions of the skin and the gynecological and gastrointestinal tracts which are characterized by either high or rising incidence at Cyprus. Expertise in engineering, science and medicine as well as strong ties to the local and international scientific and medical community play an integral role in reinforcing and augmenting the scientific potential of the group. The laboratory also aims to foster an educational environment that promotes independent and creative thinking in a multi- disciplinary environment for both undergraduate and graduate student and to prepare them for a successful career in science or medicine with more relevance to real life problems.

## The Power Systems and Power Electronics Laboratory

Advanced laboratory that enables real-time investigations of power systems in a Hardware- In-the-Loop (HIL) framework. The laboratory has the unique capability of performing advanced and realistic studies of real power systems (including generation plants, transmission and distribution grids, wind and PV power plants, consumers and prosumers, and power electronics based converters) in real-time. Furthermore, the laboratory can be used for research and development purposes in order to test and validate monitoring and control methodologies for the power system in a real-time HIL framework. The main architecture of the laboratory consists of three main layers: the Real-Time Digital Simulator (RTDS), the Control Hardware-In-the-Loop (Control-HIL), and the Power Hardware-In-the- Loop (Power-HIL).

The RTDS layer is an advanced software and hardware equipment with significant computational processing power that is used for implementing a large scale energy network including systems using the multi-domain physics approach. This Real-Time simulator can capture the electrical system from the transmission level (TSO) down to low voltage distribution grids (DSO). The system is able to simulate in real-time up to 150 three-phase buses in EMT domain and large electrical networks in RMS domain (up to 1000 buses). Furthermore, residential PV systems and large solar and wind power systems can also be emulated within the RTDS in real-time and their interaction with the main grid can be investigated.

The control-HIL framework allows the real-time interaction of a controller with the power system emulated in the RTDS. Simultaneously, the power-HIL framework allows the real- time interaction between the emulated power system in the RTDS and a physical equipment (i.e., grid tied PV inverter, electrical loads, generators, etc.). This allows the testing of electrical devices and power converters in a realistic environment for various scenarios.

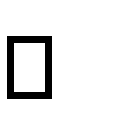
The laboratory is also equipped with a multitude of equipment for implementing advanced and real-life configurations for the interconnection of renewable energy sources to the grid. The Power Electronics part of this laboratory is equipped with several advanced converters (i.e., DC/AC, AC/DC, DC/DC). The laboratory specializes on developing real-time control algorithms for the power electronic converters for advancing the operation and the inter- connection of renewable energy sources (i.e., PV systems, wind turbines, storage solutions for renewables, etc.).

## The Power Systems Pilot Site

This outdoors, grid-connected laboratory boasts state-of-the-art equipment for modeling, simulating, and emulating energy systems, both at the building level and at the grid level. Expertise in developing smart converters for the integration of renewable energy sources to the grid and to the buildings, generation and storage technologies (225 kW wind turbine, 5 kW photovoltaic systems, 6 kW flywheel based kinetic battery, 40 kW fuel cells, 80 kW electrolyzer, and hydrogen storage).

## The Power Systems Modelling Laboratory

The Power Systems Modelling Laboratory is equipped with numerous commercial and customized software as well as hardware equipment for modeling and simulating:

* Electrical Control and Analysis of DC Corrosion.
* Engineering Cost/Benefit Analysis and Risk Management.
* Earthing/ Lightning Protection – Solar Applications and LV systems.
* Loss Evaluation of Power Transformers.
* Earthing Design for Microgrids. Power System Analysis.

Software includes: Commercial software CDEGS (Current Distribution, Electromagnetic Fields, Grounding and Soil Structure Analysis Software), SLIM (Power Transformers Finite Element Electromagnetic Field Analysis Software), DIgSILENT Power Factory (Power System Analysis Tool Software), ATP (Digital Simulation Package for Transient Studies), as well as customized software tools for “Dynamic Stray Current Assessor for DC Mass Transit Systems”, “Net – Metering Evaluator”, and “Loss Evaluation and Total Ownership Calculator (Power and Distribution Transformer)”.

Equipment include: Earth ground testers, Probes & Amplifier AC/DC current meters, and Multi-function installation testers.

## The Photovoltaic Technology Laboratory

The main focus of the PV technology lab is to contact modeling, simulation, and experiments into the area of renewable energy sources with emphasis on solar and PV systems.

The PV Technology Laboratory has developed state-of-the-art outdoor and indoor facilities for the characterisation, evaluation, and monitoring of different PV technologies ranging from crystalline silicon to thin film technologies, concentrators as well as novel technologies such as organic phototovoltaics, flexible photovoltaics and building integrated photovoltaics. Work in the PV lab focuses in particular on the understanding of the loss processes under real and standardised conditions, the development of models for the characterisation of these technologies based on the real outdoor data and the study of degradation, reliability, stability and durability.

The outdoor facilities consist of diagnostics for the measurement and monitoring at a high resolution of all the important environmental and operational parameters for photovoltaic technologies (including the spectrum on an accurate instrumented tracker and at the plane of the array). 25 different grid-connected PV technologies each one having a nominal power of 1kW p are currently being monitored. The technologies involved range from fixed system mono crystalline, poly crystalline silicon to amorphous thin film silicon, cadmium telluride (CdTe), CuInSe2, HIT-cell and other high efficiency solar cell technologies from a range of manufacturers such as BP Solar, Atersa, Sanyo, Solon, Sunpower etc. A tracked system has also been installed as well as the latest concentrator technologies covering the majority of the current and up and coming PV technologies.

The aim of the lab is to set up the infrastructure for continuous monitoring of PV systems (together with weather and irradiation data) and to assess their performance under the exact same field conditions through exhaustive data analysis. Furthermore, work in the lab aims at developing physical and electrical models in order to enhance the understanding of the underlying processes, especially for new technologies, and to optimise the systems for improved performance. Monitoring the concentrator systems, in addition, will also allow a direct comparison and assessment of this technology to be obtained. The effect of temperature, mismatch and optical losses on the performance of the systems is also of significant interest.

The lab’s indoor facilities consist of climatic chambers, solar simulators, UV chambers, cell and lens characterisation systems and spectral response measurement equipment.

Additional work includes solar assisted desalination and cooling, grid integration, power quality issues in the presence of large penetration of solar energy, energy management systems, automation and telemetry, development of solutions for remote and accurate monitoring of PV systems and solar thermal technologies.

## The Multicore Computer Architecture Laboratory (multiCAL)

Research within the multi-core Computer Architecture Laboratory (multiCAL) is weaved around two intertwined strands: (1) The primary research strand focuses on the architectural design of multi-/many-core computer systems. The ultimate goal is the creation of efficient and scalable architectures that can enable massively parallel computing on a single chip. Research focuses on emerging architectural trends and challenges in both homogeneous and heterogeneous Chip Multi-Processors (CMP). (2) A secondary research strand within multiCAL delves into the interconnection backbone of next-generation multicore chips. More specifically, the effects and contributions of the on-chip communication fabric on the overall architecture of the microprocessor are analyzed, and techniques that aid the processor’s operation through a re-interpretation of the interconnect structure are investigated. The laboratory employs a state-of-the-art high-end computer cluster for full-system, cycleaccurate simulations and digital system development, and FPGA-based hardware emulation engines for prototyping and validation/verification.

## The Microwaves & Antennas Laboratory (MA-Lab)

Work in the Microwaves & Antennas Laboratory focuses on the design of novel electromagnetic structures, such as antennas and RF/microwave/mm-wave circuits and systems, which exhibit new phenomena and/or demonstrate superior performance characteristics compared to their conventional counterparts. By developing innovative structures that advance the state of the art in the area, valuable contributions are made in the fields of wireless communications, biomedical devices and imaging, radio-frequency identification, space/satellite systems, and wireless power transfer systems.

Activities focus on the design, development and testing of:

Antenna systems and sub-systems

* RF, microwave and mm-wave circuits and devices
* Engineered electromagnetic materials such as negative-refractive-index metamaterials
* Implantable antennas and devices for biomedical applications
* Antenna array systems for biomedical imaging
* Non-radiative wireless power transfer systems
* Electromagnetic energy harvesting systems for wireless sensor networks and RFIDs
* Compact reconfigurable antenna systems for space-born and ground Satellite-OnThe-Move (SOTM) terminals.

The Microwaves & Antennas Laboratory has extensive experience in the design, simulation, fabrication and testing of antennas and RF/microwave/mm-wave circuits and systems. In order to conduct high-calibre research in this area, it is equipped with the requisite software and hardware equipment, such as industry-standard computer-aided design software, highprecision mechanical and wet etching fabrication facilities, and state-of-the-art microwave and antenna testing and characterization facilities, enabling coaxial as well as on-wafer testing of devices.

## The Holistic Electronics Laboratory

The aim of the lab is to conduct leading research into electronic circuits & systems using a holistic approach. Methods combine analogue, mixed-signal and asynchronous digital integrated circuit design with custom sensor design (MEMS and optical) in order to find solutions for bio-related or biomimetic systems. State-of-the-art and upcoming technologies in microelectronics, microsystems and nanosystems are utilized towards this goal.

Primary application areas include:

* ultra low power circuits & systems
* electronics for space applications (using radiation hardening by design techniques)
* imagers & vision systems
* smart sensors and MEMS devices
* biomedical devices and neuroprosthetics
* neuromorphic, bio-mimetic & bio-inspired electronics
* brain-computer interfaces (BCI) Equipment Include:
* Semiconductor Characterisation equipment
* Probe Station
* Vector Network Analyser
* Spectrum Analyser
* Vector Signal Generator
* Mixed-signal Oscilloscopes
* Logic analyser
* Temperature chamber Arbitrary Function Generator
* PCB prototyping system for up to 6 layer boards
* Wire bonder
* Motorised Laser Cutting System (532nm & 355nm)
* Single Axis Rate Table with Horizontal Tilt Motion Dynamic TES3T
* Accelerometer Test Rig (Bruel & Kjaer)
* Real-time X-Ray Inspection System
* EEG System
* 3D printer

## Distributed Control Systems and Networks Laboratory

The proliferation of computing and inexpensive network connectivity has led to the emergence of many new paradigms for remotely monitoring, managing, and controlling complex systems. Examples include remote control tasks (e.g., remote surgery or control of unmanned aerial vehicles) as well as more complex networked control systems that need to be managed and controlled in a distributed manner (e.g., electric power distribution systems and transportation systems of various sorts). The laboratory performs research in aspects of these problems, particularly with respect to fault tolerance (e.g., to network delays, packet drops, and component failures) and resiliency to malicious attacks on the network.

## Electromagnetics and Novel Applications Laboratory

The main scope of the laboratory is to create a strong scientific research team in order to play a key role in research and technological development activities in the field of electromagnetic fields (EMF) and electromagneitc compatibility (EMC) within Cyprus and at international level.

The lab aims to provide high quality scientific knowledge and research and development in the areas of RF and Microwave Engineering and Electromagnetic Fields. The laboratory is particularly active in research in the fields:

* + Electromagnetic Field Measurements
  + Electromagnetic Field Shielding
  + RF, Microwave and mm Wave component design and development
  + RF and Microwave subsystem design and development
  + 3D Full-wave EM RF device modelling

Additionally, the laboratory commences to quality and ISO 17025 certified services of EMF measurements of HF in the spectrum range of 75 MHz - 3 GHz.

The laboratory consists of the following equipment and infrastructure:

* + Spectrum analyzers for EMF measurements in the frequency range 75 MHz

- 18 GHz

* + Power meters

Complete system for low frequency EMF measurements (50Hz). EMF isotropic field analyzer in the frequency range of 5 Hz to 32 kHz

* + Antennas and tripods for measuring EMF
  + EMF personal monitors
  + EMF data acquisition hardware for continuous monitoring
  + Software for design and analysis
  + In the process of designing an anechoic chamber for EMC, EMI testing
  + Network analysers
  + Signal generators and synthesizers

## Mobile Communications & Networking (MCN) Laboratory

The main focus of the Mobile Communications & Networking (MCN) Laboratory is to design next-generation wireless network technologies and mobile computing systems. In particular, MCN Laboratory conducts research in the broad area of communication theory, wireless communications and networks, with focus on the physical and MAC layers.

Work in the lab concerns various types of wireless communication networks: Machine- toMachine (M2M) communications, cellular networks, relaying, cognitive radio, heterogeneous networks, 5G wireless communications. We are interested in communication-theoretic/signal processing aspects, but also in designing of practical communication protocols and transmission techniques. Topics of particular interest are:

* Signal processing for Wireless communication systems
* Cognitive radio/dynamic resource allocation
* Radio-frequency energy harvesting/wireless energy transfer
* MIMO and multi-user communication systems
* Physical-layer secrecy/Information theoretic secrecy
* Cooperative networks/Relaying
* Heterogenous networks/ small cells
* Full-duplex radio/Hardware-based modeling and signal processing techniques • Software radio/USRP experimental implementation
* 5G Communication systems/ massive MIMO/millimeter-wave communications
* Large-scale networks/stochastic geometry

Equipment include:

* NI USRP: Software Defined Radio Platform: An affordable, PC-hosted platform used with NI LabVIEW software to build powerful wireless communications systems for research and education.
* Energy Harvesting Development Kit for Wireless Sensors: It is a complete demonstrationand development platform for creating battery-free wireless sensors (passive wireless sensor tags) powered by RF energy (radio waves). It is designed and configured for extremely low power operation, and the firmware is pre-installed for out-of- the-box operation.

