MASTER IN ELECTRICAL AND ELECTRONIC ENGINEERING

Main Language of Instruction:
French ☑ English ○ Arabic ○

Campus Where The Program Is Offered: CST

OBJECTIVES

The Master in Electrical and Electronic Engineering aims to train:
- Teachers and researchers
- High-level specialists in various relevant administrations and consultancy offices
- Foreign researchers: due to the importance of the issues addressed, opening up to foreign students from the Mediterranean basin can lead to a synergy favorable to a better common use of resources.

PROGRAM LEARNING OUTCOMES (COMPETENCIES)

- Acquire and apply advanced knowledge appropriate to the discipline.
- Solve critical issues and demonstrate expertise in key areas in the field of study.
- Analyze and think innovatively to develop novel solutions for real-world problems.
- Apply new and diversified theoretical and experimental methods as appropriate to the discipline.
- Integrate ethics and moral responsibility in engineering solutions in the field.
- Conduct independent, original research and contribute to the advancement of knowledge in the field.
- Communicate, at an advanced level, in oral and written form.
- Recognize the importance of standards of professional integrity.

ADMISSION REQUIREMENTS

Candidates are selected based on their application file.
- Admission to the first semester of the Master's (M1) for candidates holding a Bachelor's degree in physics, electricity, electronics, electrical engineering, electromechanics, or an equivalent degree.
- Admission to the third semester of the Master's (M3) for electrical engineering graduates, holders of a "Maîtrise" or Master's degree in physics, electricity, electronics, electrical engineering, electromechanics.
- Admission to the third semester of the Master's (M3) for third-year electrical engineering students at ESIB (fifth year of higher education).

Candidates are selected by an admissions committee, subject to the program's enrollment capacity.

COURSES/CREDITS GRANTED BY EQUIVALENCE

Graduated engineers in electrical engineering, holders of a "Maîtrise" degree or a Master's degree in physics, electricity, electronics, electrical engineering, electromechanics, students in the fifth year of Electrical Engineering at ESIB, and holders of a recognized equivalent diploma can validate by equivalence a maximum of 60 credits of the program. Based on the proposal of the Director of the Department of PhD Studies, the admission jury will determine for each student admitted directly to M3 the courses and modules validated according to their curriculum and prior results, and will define their journey to the Master in the concentration concerned, possibly including additional prerequisites. The proposal for the validation of previous training is subject to the approval of the USJ Equivalence Commission.

PROGRAM REQUIREMENTS

Required Courses (120 Cr.)
Linear Control (4 Cr.). DC-DC Power Conversion (4 Cr.). Sensors and Instrumentation (4 Cr.). Mini Project 1 (6 Cr.). Electric Machines 2 (4 Cr.). Microprocessor Systems (4 Cr.). Digital Systems and Control (4 Cr.). English (4 Cr.). Power Systems Analysis (4 Cr.). DC-AC Power Conversion (4 Cr.). Modern Control (4 Cr.). Variable Speed Drives (6 Cr.). Mini Project 2 (8 Cr.). Digital Systems Architecture (4 Cr.). Case Study of Electrical Machines Advanced Control (2 Cr.). Case Study of Advanced Power Electronics (2 Cr.). Advanced Control of Electrical Machines (4 Cr.). Advanced Power Electronics (4 Cr.). Modeling and Control of Static Converters (4 Cr.). Electric Networks with Distributed Sources (4 Cr.). Energy Storage (4 Cr.). Case Study of Advanced Control Techniques (2 Cr.). Research Project with Thesis (30 Cr.).

SUGGESTED STUDY PLAN

Semester 1

Code	Course Name	Credits
020AULMM1	Linear Control	4
020CCCMM1	DC-DC Power Conversion	4
020CEIMM1	Sensors and Instrumentation	4
020GE1MM1	Mini Project 1	6
020ME2MM1	Electric Machines 2	4
020SCNMM1	Digital Systems and Control	4
020SMPMM1	Microprocessor Systems	4
	Total	**30**

Semester 2

Code	Course Name	Credits
020ANGMM2	English	4
020ANRMM2	Power Systems Analysis	4
020CCAMM2	DC-AC Power Conversion	4
020CTMMM2	Modern Control	4
020EVVMM2	Variable Speed Drives	6
020GE2MM2	Mini Project 2	8
	Total	**30**

Semester 3

Code	Course Name	Credits
020ASNMM3	Digital Systems Architecture	4
020BCMMM3	Case Study of Electrical Machines Advanced Control	2
020BEPMM3	Case Study of Advanced Power Electronics	2
020CAEMM3	Advanced Control of Electrical Machines	4
020EPAMM3	Advanced Power Electronics	4
020MCCMM3	Modeling and Control of Static Converters	4
020RSDMM3	Electric Networks with Distributed Sources	4
020STEMM3	Energy Storage	4
020BCAMM3	Case Study of Advanced Control Techniques	2
	Total	**30**

Semester 4

Code	Course Name	Credits
020MGEMM4	Research Internship with Thesis	30
	Total	**30**

COURSE DESCRIPTION

Semester M1

020AULMM1 Linear Control 4 Cr.

This course introduces important basic concepts in the analysis and design of control systems. It is divided into two parts. The first covers transient and steady-state response analysis of 1st and 2nd order linear systems, as well as frequency-response analysis using Bode, Nyquist and Nichols diagrams. It is followed by an introduction to closed-loop versus open-loop control systems leading to a stability analysis. The second part covers the analysis and design of linear control systems using different types of controllers. The design of such controllers is presented using frequency-response methods, analytical calculations, and experimental techniques. The whole is validated with exercises and workshops using MATLAB/Simulink, as well as a set of lab experiments leading to the design and test of a linear control system.

020CCCMM1 DC-DC Power Conversion 4 Cr.

This course presents different topologies of DC-DC switch-mode power converters. It studies two categories of converters: the choppers for DC-motor drives and the DC power supplies. A detailed analysis starting from the possible configurations, then finding the mathematical equations, the waveforms and the input-output features, and the selection of the semiconductor devices and all other components is elaborated for each topology. Rating criteria based on the evaluation of the voltage and current stresses are elaborated.

020CEIMM1 Sensors and Instrumentation 4 Cr.

This course introduces sensors, systems that convert non-electrical signals – such as temperature, luminous flux, velocity, position, displacement, force, weight, or torque – into electrical signals for easy processing. It begins with a review of sensor characteristics, including sensitivity, time response delay, and measurement errors. The course then covers various types of sensors in detail, including optical, temperature, tachometric, position and displacement, and force, weight, and torque sensors.

020GE1MM1 Mini Project 1 6 Cr.

This course involves a mini project within one of the semester M1 courses.

020ME2MM1 Electric Machines 2 4 Cr.

This course aims to extend the concepts of electrical engineering according to four axes: I) Transformers: Special transformers – Transformers in unbalanced mode – Transformers in transient mode – Parallel operation of transformers. II) DC machines: DC machines in transient mode - Application in unsaturated transient conditions. III) Induction Machines (IM): Generator and brake operation of a three-phase IM - Special types of IM: Deep-Bar Squirrel-Cage, Double-Cage rotors and Single-Phase IM – Modeling of the induction machine in transient mode and applications. IV) Synchronous machines: Rotating fields theory – Transient modeling of synchronous machines: with smooth poles, with salient poles, with or without damper bars – Applications.

020SMPMM1 Microprocessor Systems 4 Cr.

This course covers the following: Difference between microprocessors, microcontrollers and DSP, microprocessor architecture; realization of a basic board – Microcontroller architecture (PIC 18F2520) – Implementation of ROM, RAM and DATA EEPROM memory – special registers – addressing modes – inputs/outputs – interrupts – timers – analog to digital converter – asynchronous serial port – read from program memory – comparators – watchdog – sleep mode – low voltage detect – oscillator – configuration words – Design, simulation and realization of microprocessor systems.

020SCNMM1	**Digital Systems and Control**	**4 Cr.**

This course is divided into three main parts. The first part discusses discrete system modeling, z-transform, discrete transfer functions and discrete systems stability. The second part develops the design of digital controllers (discretized classic controllers, dead-beat control). The final part presents the implementation of digital controllers using embedded systems and real time simulations of a system in closed loop.

Semester M2

020ANGMM2	**English**	**4 Cr.**

This course is designed to develop critical thinking, reading, writing, and oral communication skills. It focuses on synthesizing sources, producing a research paper and defending it in front of an audience. Emphasis is on the analytical reading of different text types required in the courses as well as on synthesis from a variety of sources to produce a written text and present it orally.

020ANRMM2	**Power Systems Analysis**	**4 Cr.**

This course introduces students to the physical aspects of the electric transmission lines. It explains how to determine their equivalent mathematical model and calculate their structural parameters. Based on such model, a performance study is elaborated in both permanent and transient regimes (power losses, voltage regulation, power factor, transient overvoltage). Compensation techniques to improve the power factor are presented. Numerical methods and algorithms for calculating the power flow are also explained and applied. Short-circuit analysis is detailed, and power system stability following short-circuit disturbance is discussed. In addition, methods for the selection of isolators and protection devices are exposed. Finally, the benefits of DC transmission systems and their technical aspects are presented.

020CCAMM2	**DC-AC Power Conversion**	**4 Cr.**

This course presents different topologies of DC-AC switch-mode power converters: single and three-phase inverters, two and multilevel structures. A detailed analysis starting from the possible configurations, then the establishment of the mathematical equations, the waveforms and the input-output features, and the selection of the semiconductor devices and all other components is elaborated for each topology. Rating criteria based on the evaluation of the voltage and current stresses are elaborated. In addition, this course introduces and studies different Pulse-Width-Modulation (PWM) control strategies: carrier-based PWM, space-vector modulation, pre-calculated modulation, sigma-delta and delta modulations. Numerical simulations are performed to verify the theoretical concepts.

020CTMMM2	**Modern Control**	**4 Cr.**

This course covers the following: Modeling, interpretation, and linearization of a multi-variable system. Response and matrix transfer. Realization of controllability, observability, and Jordan forms. Controllability, and its properties, partial controllability. Observability and its criteria. Minimum implementation, stabilization, and detection. Directions of the poles and zeros, simplification. Pole placement control, error integration, and observers. Optimal quadratic control (LQG): introduction, Riccati equation, Kalman filter, validity conditions. Guided mini project: modeling, design, and simulation.

020EVVMM2	**Variable Speed Drives**	**6 Cr.**

This course aims to introduce the multiple control possibilities offered by variable speed drives for the three main types of motors in the electrical engineering field. I) Variable speed DC machine: Four-quadrant operation, Four-quadrant three-phase rectifier with no circulating current, Speed control using cascaded loops, Current loop and speed loop. II) Variable speed induction machine: Steady-state equivalent circuit at high frequencies, Torque harmonics, Scalar control of a squirrel-cage induction machine, Vector control of a squirrel-cage induction machine, introduction to DTC control of an induction machine. III) Variable speed synchronous drives: introduction to the scalar control and the vector control of synchronous drives. All three case studies are simulated and validated using MATLAB/Simulink software.

020GE2MM2	Mini Project 2	8 Cr.

This course involves a mini project within one of the semester M2 courses.

Semester M3

020ASNMM3	Digital Systems Architecture	4 Cr.

This course covers the following: Introduction to FPGAs and synthesizable VHDL. State machines. Applications. Algorithm-Architecture Adequation Method.

020BCMMM3	Case Study of Electrical Machines Advanced Control	2 Cr.

Case study: Energy conversion chain design for a variable speed drive.
This case study focuses on designing an energy conversion chain, which includes a variable speed drive for a mechanical load. The requirements involve selecting the appropriate motor, associated converter(s), and the most suitable control method for the application. The complete sizing of the chain is validated through simulations to ensure the system operates correctly. The study also explores the application of predictive control to a permanent magnet synchronous drive, followed by a performance comparison with a conventional control method based on PI regulators.

020BEPMM3	Case Study of Advanced Power Electronics	2 Cr.

Case study: Design, control, simulation and performance analysis of a high-power quality converter.

020CAEMM3	Advanced Control of Electrical Machines	4 Cr.

This course covers the following: Vector control of asynchronous actuators. Direct Torque Control (DTC). Sensorless control. Estimation and observation of unmeasurable variables. Design of controllers and observers. Self-control and vector control of synchronous actuators. Digital implementation: ADC, sensors, delays, filters, etc. Control of speed and position.

020EPAMM3	Advanced Power Electronics	4 Cr.

This course covers the following: Harmonic distortion in electric grids. Active compensation. Modeling and control of switch-mode power converters. Power factor correction circuits. Case of a Boost, a SEPIC and a Sheppard-Taylor converter. High power factor three-phase rectifiers. Six-switch rectifier. Vienna rectifier. Current injection rectifiers. Active and hybrid power filters.

020MCCMM3	Modeling and Control of Static Converters	4 Cr.

This course covers the following: Instant modeling and average values, sampled models. PWM and amplitude control of static converters, case of three -phase tension inverters. Comparisons of different modulation laws. Control laws for single -phase and three-phase PWM recovery in sinusoidal absorption (3 axes, 2 axes, DPC, etc.). Control of active parallel filters (control of the reactive power and harmonics). Predictive control laws for converters: Application to DC-DC and AC-DC converters.
Case study: Control of a PFC as part of a cascade structure using MATLAB/Simulink.

020RSDMM3	Electric Networks with Distributed Sources	4 Cr.

This course covers the following: Distributed generation: definition, benefits, smart grids, role of power electronics, energy storage. Static converters in distributed networks: families of converters, applications, power semiconductors. Grid-connectivity of photovoltaic sources. Grid-connectivity of wind generation systems. Control and modulation techniques. Power quality and filters. Static compensators and FACTS. Numerical methods for power flow analysis. Transient stability.

020STEMM3	Energy Storage	4 Cr.

This course covers the following: Energy storage issues, electrical energy as a vector. Electricity: Easy transport but problematic storage. Values range (mass and volume powers) - Application contexts (stationary and vehicles). Stationary storage (cases, interest, challenges) - Available technologies. Primary sources (batteries). Accumulators

(electrochemical, electromagnetic, mechanical): performance, technological considerations, and management. Case study I: Production/consumption adequacy in a home (islanding). Production fluctuations (wind, solar). Consumption fluctuations. Hourly production/consumption and storage inadequacy.
Case study II: Optimization of an airplane network (power supply to a landing gear). Structure of a plane edge network. Some values range (powers involved, voltages, currents, size, etc.). Optimization of on-board weight (local storage vs cables section). Power structure around an electric actuator landing gear. System control.
Case study III: The battery pack in a vehicle (BMS, load balancing, etc.). Batteries for electric vehicles (advantages and disadvantages). Energy gauge: a necessity and a serious problem according to technology. The battery: a complex component to model. Modeling, characterization and identification in real time - Battery packs, characteristics dispersion and cell balancing. Global structure for managing a battery pack: BMS - The life of a battery and its indicators. Towards the fast load: issues and difficulties.

020BCAMM3 Case Study of Advanced Control Techniques 2 Cr.

This course covers the following: Quadratic controls. Predictive control. Application of predictive control to a 2nd order system.

Semester M4

020MGEMM4 Research Internship with Thesis 30 Cr.

This course serves as an initiation into research techniques. It is the synthesis of four months of research work in a research centre or laboratory.