Control and Power Engineering
ENSEA - AEI 3rd Year Academic Track

AEI_1 Energy (5 ECTS)

AEI_3105 Renewable Energy (Lectures: 10h / Tutorial classes: 8h / Lab: 4h)
The aim of this academic module is to present the economic and technological challenges related to the development of these energy sources use as well as their impact in a "sustainable development" approach.
The main points to be explored will be :
- the different forms of RE and their exploitation
- the technological structures used
- links to the existing electricity network
- environmental and economic impact

AEI_3110 Inverters and power quality (Lectures: 18h / Tutorial classes: 12h / Lab: 12h)
The objective of this course is to introduce the fundamental notions for understanding the functioning of an inverter and its reaction depending on its load and of its power supply network. This training allows to deepen students' understanding of the power components used in energy conversion systems through the particular study of some of them.
- Recap on the operation of alternating current motor – Couple and Speed characteristics. Principles of speed variation.
- Power components, MOS transistor.
- Single-phase and three-phase inverters: principles of MLI and full-wave operation.
- Harmonic study of the output of the inverter.
- Reversibility of the inverter. Application to PWM rectifiers with sinusoidal current absorption.
- Multi-level converters. HVDC link.

AEI_2 Automation and Diagnosis (5 ECTS)

AEI_3104 Non-linear Automation (Lectures: 12h / Tutorial classes: 10h / Lab: -h)
This course is an introduction to control and observation of non-linear systems. It is introduced by a few basic theoretical concepts (controllability, observability, linearity, stability...). Then, control laws and observers are introduced. In order to illustrate the interest off the presented concepts and solutions, a practical application will be proposed with the example of an asynchronous machine control.
- Geometrical approach: change of reference frame, linearization, decoupling, zero dynamics.
- Stability and stabilization: Lyapunov, LaSalle.
- Singular disturbances: invariant variety, reduction model.
- Sliding mode controls and observers.
- Typical examples: electrical engineering, aeronautics, ...

AEI_3151 Diagnosis (Lectures: 8h / Tutorial classes: 8h / Lab: -h)

Diagnosis consists in detecting, locating and, mor generally, determining the characteristics of anomalies occurring in a system. The objective of this course is to present the principles of diagnosis based on the models and the main approaches in order to generate indicators of defects (residuals) and build a decision. The focus will be on conditions for the use of various tools in order to come up with a global diagnosis strategy.
- Structural analysis of a system: causal analysis, sensor placement.
- Generation of residues: observers.
- Inversion to the left.
- Decision for diagnosis: tests, logic and diagnosis, classification.
- Overall diagnostic strategy: functioning/malfunctioning oriented approaches and active control authorizing errors.

AEI_3154 Advanced Automation Lab (Lectures: -h / Tutorial classes: -h / Lab: 16h)
This module aims at putting into practice the main notions of automation explored through different courses of the general study track: identification and parametric estimation, space status, interference rejection, optimal control, error detection and localization, control and non-linear observers, etc....

AEI_3 Identification and Control (4 ECTS)

AEI_3150 Advanced Identification and Control (Lectures: 12h / Tutorial classes: 8h / Lab: -h)
The aim of this course is to show how the optimization techniques have an application in automation, in particular through the identification of models (estimation of parameters) and commands based on the optimization of criteria.
- Non-parametric and parametric identification methods.
- Graphic or deterministic methods: methods of Strejc and Broida, open and closed loop system, non-scalable and scalable systems, oscillatory response system.
- Statistical methods: gradient criterion, least squares, recursive least squares, Kalman filter.
- Optimum control: optimization without and with constraints on the status and control with fixed limits, and variables: methods of variation, principle of minimum.
- General problem of the prosecution and the optimal regulator.

AEI_3153 Multivariable linear control (Lectures: 10h / Tutorial classes: 6h / Lab: 4h)
This course introduces the main concepts in order to study the control of multivariable systems (several actuators, several sensors), based on a representation-type modelling of state. This course extends the notions of state space as seen in the first-year multivariate cases course, and raises and explains the notions of rejection of disturbances and robustness.
- Continuous and sampled linear state representation,
- Relative degrees and Brunowsky's form,
- Multivariable pole placement algorithm,
- Application to control by status feedback with observer,
- Notions of disturbance rejection and robustness.

AEI_3102 Artificial Intelligence for System Control (Lectures: 8h / Tutorial classes: 8h / Lab: 8h)

This course presents the application of Artificial Intelligence techniques to control systems. It is structured in two main parts and a complement:
- Fuzzy control: Fuzzy logic (sets, operators, terminology), fuzzy controller (fuzzyfication, inference, defuzzyfication), Sugeno and Mandani structures, industrial applications, hardware and software aspects.
- Neuronal networks: biological neurons, formal model, multi-layered perceptron, deep architectures, introduction to statistical learning.
- Identification of processes by neural models, regulator copying, neural models for adaptive control and dynamic control.

AEI_4 Actuators (5 ECTS)

AEI_3111 Electrical actuators (Lectures: 16h / Tutorial classes: 12h / Lab: 8h)
The objective of this course is to formalize the design of transducers of mechanical energy, and more specifically as observed in direct and alternating current electrical machines, associated with their static converter.
- Electromechanical energy conversion.
- Permanent magnets.
- General equations of electrical machines.
- Direct current machines: servo-motors, transient state.
- Synchronous and asynchronous alternating current machines.
- Stepper motors, variable reluctance motors.
- Scalar and vector control algorithms.
- Control devices: association with the static converter.

AEI_3121 Direct digital control of devices (Lectures: 8h / Tutorial classes: 8h / Lab: 32h)
This training focuses on the design of microcontroller-based systems, both hardware and software. The application in control-related areas is naturally put in evidence. The Lab is presented in the form of a mini project, where a complete system will be designed.
- Microcontroller-based systems: design, development, choices, languages (C, assembler);
- Presentation of the different kinds of microcontrollers;
- Presentation of a signal processing processor;
- Study of a direct numerical control of an electric actuator by DSP;
- Principle of determination of digital correctors.

AEI_5 Project (6 ECTS)

AEI_3139 Project (Lectures: -h / Tutorial classes: -h / Lab: 56h)
Students must design, study and then carry out completely a control process, control in general or any other aspect related to the teachings of the AEI track. They are supervised and advised by several teachers sometimes in collaboration with companies.

AEI_3152 Electromagnetic Compatibility (Lectures: 4h / Tutorial classes: 4h / Lab: -h)
The objective is to make the students aware of the practical aspects involved in complying with EMC standards in the design of power electronic devices and in their control. This module therefore aims to complete the second-year module, with a focus on the areas specific to the AEI track.

AEI_3140 Conferences (Lectures: 10h / Tutorial classes: -h / Lab: -h)
The lectures are delivered by professionals of the field. Topics covered may vary from one year to the other, the following topics are only a sample of possible subjects. Vector control of asynchronous machines, electric traction, robust control, adaptive control (Kalman filtering).

SH_3EME Humanities (5 ECTS)

DSH_3000 Human Resources Management and International Management (Lectures: 16h / Tutorial classes: 6h / Lab: -h)
This transversal training offers:
- an awareness of labor law specifically for the engineer: employment contract, expatriation, working environment in the company
- managerial aspects dealt within a multicultural context such as team management, corporate culture, professional projects…
- accounting aspects: employee cost versus human capital.

DSH_3060 English (Lectures: -h / Tutorial classes: 24h / Lab: -h)
The objective of the third-year courses is to make the students able to work in English and have a good command of the language.
The goal is achieving a professional use and to reach, at least, a B2 level requested do obtain the degree.
Two third-year options are grouped together for English courses. Level groups can be formed. The students will be able to work on different aspects of life professional (communication in different settings, in the office, abroad, in seminars, through writing, orally, case studies...), by carrying out work groups and putting in practice the knowledge they have acquired throughout their training.

DSH_3061 FLE (French for foreigners) (Lectures: -h / Tutorial classes: 24h / Lab: -h)
The main goal of this class is training the foreign students through communication fundamentals for everyday life, proposing them an introduction to French culture and civilization and more advanced knowledge in order to work in a French company during the final internship period.