Embedded Systems
ENSEA - ESE 3rd Year Academic Track

ESE_1 Microcontrollers (4 ECTS)

ESE_3720 Microcontroller systems (Lectures: 14h / Tutorial classes: 10h / Lab: 28h)
At the end of this course, students will be able to design a microcontroller or DSP-based system, both hardware and software. The lab consists in developing a complete system, such as the interfacing of a SPI inclinometer on CAN network.
- Processor architecture. CISC, RISC, DSP, pipeline.
- Design of an embedded system based on a microcontroller. Memory plan, address decoding, device controller, device management (waiting loop, interruption and DMA).
- Memories. Memory hierarchy, the different types of memory, volatile and non-volatile memory technology, cache operation, virtual memory (MMU).
- 32-bit microcontrollers. Blackfin architecture, interruptions, SPI bus, DMA, memory management, study of a digital filter for audio.
- ARM processors. Kinds of ARM processors, description of a CortexA9, programming model, calculation unit (NEON), trustzone, presentation of the SABRE Lite board based on the iMX6Q microcontroller from Freescale.
- Operation of multi-core processors.

ESE_2 Sensors and Actuators

ESE_3710 Sensors and conditioning (Lectures: 14h / Tutorial classes: 10h / Lab: -h)
The objective of this course is the design of a measurement chain from the sensor to the analog to digital convertor. The use and parameterization of an integrated sensor are part of this training.
- Measurement chains. The different elements of a measurement chain, characteristics, accuracy of a chain of measurement.
- Instrumentation and isolation amplifiers. Objectives and realization, common mode rejection, guard circuit, technological choices.
- Design of a measurement chain. Calculation of signal-to-noise, filtering, choice of analog to digital converter, effective resolution.
- Sensors for temperature, deformation, force and pressure.
- Accelerometers. Operating principle of acceleration sensors, characteristics, applications.
- Study of an integrated sensor.

ESE_3745 Actuators and applied automation (Lectures: 14h / Tutorial classes: 8h / Lab: 8h)
The objective of this course is to present in a functional way the different types of electric actuators that can be used in industrial embedded applications. Without proposing a detailed and structural study of it, the different families of actuators are presented with their associated command, then some examples will be studied.
- The different types of electrical machines (direct current, alternative, stepper, etc.).
- The main associated sensors: current measurements, speed, position, couple.
- Modelling of electric actuators: assemblies formed of the machine, its feeding device (static energy converter), associated sensors and command.
- The command laws used: direct orders or servo drives, analogue commands or

sampled, performance obtained.
- The practical work will allow to implement some control laws studied on conventional actuators, based on a direct or alternative current motor.

ESE_3760 Sensors and Networks Lab (Lectures: -h / Tutorial classes: -h / Lab: 20h)
This module includes three practical exercises: a first one on the instrumentation amplifier and on the dimensioning of a noise filter in relation to an analogue-to-digital converter, the second on the CAN network and a third, in three sessions, on the programming of a network socket, within the framework of the realization of a connected device under Linux.

ESE_3 Embedded real-time systems (5 ECTS)

ESE_3735 Real-time Kernel (Lectures: 10h / Tutorial classes: 4h / Lab: 20h)
This course presents the principles and implementation of the real-time kernels in an embedded environment. The multitasking concepts (task objects, semaphores, mail boxes, etc.) and the input-output mechanisms (interruptions, drivers) are presented in the context of a real-time operating system (VxWorks), and illustrated through examples and hands-on sessions.
The multiprocessor aspect will be presented and illustrated with manipulations on multi DSP systems. Different technologies are presented and compared (time cores, time kernels, real time UNIX, Linux).
- Multitasking systems. Notion of task, allocation tasks, communication between tasks, synchronization, multitasking kernels, interruptions, I/O.
- Implementation on a Sabre Lite board based on a CortexA9.

ESE_3756 Electronic systems for the automotive industry (Lectures: 12h / Tutorial classes: 4h / Lab: -h)
This course consists in studying some embedded systems in the automobile industry, by considering first the global functional aspect, then by looking at one or more parts of the system to illustrate the lessons learned from this study track.

ESE_3727 Industrial Networks and Buses (Lectures: 8h / Tutorial classes: 4h / Lab: -h)
The objective of this course is to study buses and networks allowing systems to communicate. The main buses and networks are presented: Ethernet, WiFi, CAN, FlexRay, not to mention the software dimension.
- Networks. OSI layered model, function of different layers, comparison with the structure of a TCP/IP stack,
- layers 1 and 2: the main standards (Ethernet, WiFi, PPP), layers 3 and 4: IPv4, associated protocols (TCP, UDP, ICMP, ARP/RARP, IGMP), routing and DNS, top layers: overview of tools (ping, netstat) and common applications (telnet, FTP, SMTP, http, ...), introduction to security and hacking issues.
- Field networks. I2C bus, Profibus, CAN networks and LIN, FlexRay.
- Software access. Sockets and their use, stacks of communication.

ESE_4 Fundamental techniques for embedded systems (5 ECTS)

ESE_3740 Advanced digital processing (Lectures: 18h / Tutorial classes: 8h / Lab: 12h)

This course focuses on the design and implementation of digital processing in embedded systems. It presents the techniques of filter synthesis with constraints, the modeling of multi-cadence, with an emphasis on the consequences of the effects due to quantification and finite precision of the calculations. Fast processing techniques are presented and illustrated with manipulations. The focus is put on specific architectures offered by specialized processors (DSP), and their implications for the design of systems.
- Synthesis of digital filters. Recursive and non-recursive filters, multi-cadence filtering, filter banks.
- Structure and realization of filters. Number coding, quantization noise modeling, computational noise, Sigma Delta conversion.
- Fast transform and applications. Processing by blocks, fast Fourier transform algorithms, fast convolution algorithm.
- Exploitation of the architecture of a DSP.

ESE_3750 EMC, radiation hardening and reliability (Lectures: 16h / Tutorial classes: -h / Lab: -h)
The objective of this course is to know how to take EMC into account from the very beginning of an embedded system's design.

ESE_3758 Technical presentation (Lectures: -h / Tutorial classes: -h / Lab: 4h)
From an example of a system realization each student must present a synthesis of his study.

ESE_5 Project (6 ECTS)

ESE_3765 Mini Project (Lectures: -h / Tutorial classes: -h / Lab: 40h)
This course aims at designing and building a system or a part of an embedded system. The last session of four hours is dedicated to the defense.

ESE_3736 Connected devices (Lectures: -h / Tutorial classes: -h / Lab: 12h)
The main objective of this course is to give students the fundamental basis related to the development of a connected object, using MicroEJ as an example of a dedicated platform. Several problems related to connected devices are at the heart of the case study: layered system with optimization of RAM and FLASH footprint, device management (I/O, interruptions), development tools (MicroEJ Studio and GCC), REST interface and application store. This lab, performed on Cortex-M targets under FreeRTOS, has two parts:
- Development of a connected application. Application development with MicroEJ, graphic interface, interoperability with lower layers, network implementation, application: cyclic monitoring with REST server.
- Modification of a MicroEJ BSP. Notion of MicroEJ platform, BSP modification, application: implementation of a dedicated sensor.

ESE_3737 Embedded Linux (Lectures: 8h / Tutorial classes: -h / Lab: 12h)
This course presents the architecture of Linux, with a double focus on the user vision and the kernel vision. At the end of this course and of the associated practical exercises, students will know how to configure and parameterize a kernel, how to

build a file system and how to export the whole conception on a hardware target. They will have the sufficient notions to manage interruptions, create new peripherals, develop drivers and multi-process applications. This course is intended for students with
basic knowledge of microprocessor architecture, real-time kernels (tasks and communication intertasking) and device drivers.
- Development of a multi-process application under Linux. The life cycle of processes, threads, demons, scheduler, inter-process communication: signals, semaphores and Posix message queues, hardware protection by MMU, memory management, communication by shared memory, communication by tubes.
- Generation of an embedded Linux system. The "bootstrap loader" (Uboot), the boot steps, the init process, use of a disk in memory, use of NFS, kernel configuration, creation of a file system, memory management, development methods, and debugging.
- Development of a driver under Linux. Notion of modules, driver architecture, interruptions, synchronization, memory management in the kernel, management of time in the kernel, peripheral model.

ESE_3755 Introduction to System on Chip design (Lectures: 4h / Tutorial classes: -h / Lab: 8h)
A System On Chip (SoC), is a complete system embedded on a single chip, which can include one or more processors, memory, and interface peripherals. This course is an introduction to systems-on-chip with the presentation of new technologies (ASIP, IP, SoC) and the flow of software-hardware co-design (Co-design,
use of IP) using the FPGA as a material platform. Interested students will be able to deepen this field within the framework of the mini-project
- Design flow for a SoC
- Hard and soft IP concepts.
- Processor cores: NIOS, MicroBlase, ARM, LEON,
- Communication bus: AMBA, AVALON, ...

ESE_3770 Conferences (Lectures: 10h / Tutorial classes: -h / Lab: -h)
These conferences allow the students to discover some industrial applications, with themes varying from one year to the next.

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.