1EL8000 – Electronic Systems

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Department: DÉPARTEMENT ÉLECTRONIQUE ET ÉLECTROMAGNÉTISME
Language of instruction: ANGLAIS, FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 35,00

Description

Analog and digital electronic systems are today ubiquitous in our lives, whether in the use of connected objects for domotic applications, in the areas of communication, transport and health, in the fields of defense and space, or in the billions of computers connected across the WEB.
Despite a constantly evolving domain (Moore's law), there are a number of constant fundamentals that are common to most systems no matter their complexity:
- interfaces with the physical world (sensors) and persons (display devices, HMI),
- processing of analog signals (filtering, wavelets, ... and soon neuromorphic systems),
- analog-to-digital conversion (with or without data compression) and digital-to-analog (transducers)
- digital processing units onboard or remote (HPC, cloud ...).
This course is conducted in a top-down approach to prepare students to specify and develop electronic systems from existing hardware components and software solutions.
Also, the principles and physical quantities related to the operation of these components are covered. Nevertheless, the microelectronic design and realization (i.e. Computer Aided Design and microelectronic technologies) will be addressed in more advanced courses to students who want to develop their skills in that field.

Quarter number
SG1 and SG3

Prerequisites (in terms of CS courses)
None

Syllabus
Analogue electronics :

- lecture 1: Understanding of the different electronic technologies and basic reminders
- lecture 2: Operational Amplifier-based diagram
- tutorial class 1: Simple circuits and ideal operational amplifier
- lecture 3: Electronics for signal processing
- lecture 4: Study of nonlinear circuits
- tutorial class 2: Active filtering based on operational amplifier
- lecture 5: Interface and sensors
- tutorial class 3: Predeterminations and electronic simulations for the Laboratory Study
- LAB : design, simulation and implementation of an interface for a sensor

Analogue to digital conversion :

- lecture : sampling and quantizing, ADC and DAC families, non idealities and characterization
- Tutorial : ADC specification using MATLAB

Digital electronics :

1. lecture 1: Introduction to logic and digital components, Complex system design: software vs. hardware solutions, design methodology
2. tutorial class 1: Discovering the Arduino
3. lecture 2: Data representation, logic, gates, flip-flops
4. lecture 3: Advanced functions, operators, state machines
5. lecture 4: Introduction to VHDL language
6. tutorial class 2: Initiation to VHDL language using FPGA
7. lecture 5: Processing unit architecture
8. tutorial class 3: digital processing of FPGA, lab preparation
9. LAB : Implementation of a digital processing of a FPGA

Class components (lecture, labs, etc.)
The course is divided into 3 parts : Analogue, digital, and conversion. Each analog and digital part is composed of 5 classes, 3 tutorials and one laboratory.

The analog electronics tutorials are essentially modeling and calculations. 2 of the 3 digital tutorials are around electronic boards (Arduino and DE10 Altera) in initiation to C programming and design in VHDL language.

The two labs are a single project comprising a sensor, an analog stage, an ADC and a digital processing. The aim of the first lab is to design, simulate and test the analog stage, while the 2nd lab will focus on the design of the digital part using VHDL language.

The course is given in French for the occurrences 1.1, 1.2 and 1.3. It is given in English at occurrence 1.4

Grading
The course is evaluated on the basis of 2 laboratories and a written exam lasting 2 hours with document.
Final Evaluation = 60% written exam score, 20% analog lab and 20% digital lab.
The 'analog' labs are prepared by a tutorial which allows to pre-determine the functions that will be tested. The supervisors will check that this preliminary work has been done and will take into account in their notation.
The Labs are evaluated on the basis of the report written in real time and the simulation and measurement elements produced, as well as the observation by supervisors of students in situation.
The 2-hour written exam poses an engineering problem for an electronic system for which students must provide a solution by choosing a sensor, an analog processing system, an analog-to-digital converter digital and digital processing.
Assessment of learning outcomes: The skills mentioned above are all assessed at a level 1, that is to say in the case of simple, relatively closed problems, and in a way guided by the professors. The skills will be assessed in 2 ways: - theoretically by means of the written exam and practically by laboratories.

C1 is validated if the average of the 2 labs is greater than 12 and the average of the questions marked C1 during the written exam is greater than 10
C2 is valid if the average of the questions marked C2 during the written exam is greater than 10

Course support, bibliography
"Digital Design and Computer Architecture"
David and Sarah Harris
Morgan Kaufmann Publishers

« Foundations of analog and digital electronic circuits »
Anant Agarwal and Jeffrey H Lang
Morgan Kaufmann Publishers

Resources
• Teaching staff (instructor(s) names):
- Digital : P. Bénabès, C. Lelandais, A Kolar, E. Libessart
- Sensors : J. Juillard & L. Bourgois
- Analogue : E. Avignon, P. Maris, M. Roger.

• Maximum enrollment (default 35 students): 100 students for classes, 35 for tutorials, ans 16-18 for laboratories

• Software, number of licenses required: Quartus Student edition (Free softwares)

• Equipment-specific classrooms (specify the department and room capacity)

3 laboratories in the department of electronic systems and telecommunications, 16-20 students by laboratory.

Learning outcomes covered on the course

The "Electronic Systems" course will provide students with a basic understanding of :

• A) Specify an analog processing chain

- Understand the different electronic technologies (integrated circuits vs printed circuits) and their evolutions (traditional technologies towards 'more than Moore' or 'beyond CMOS'), Systems on Chip, packaging, interconnections
- Design analog architectures from simple models (Laplace block for example) up to AOP-based circuits, capacitors, resistors, inductors.
- Analyze in matrix form the simple Kirchoff networks (RLC + AOP circuits).
- Determine if the limitations of the AOPs are respected (bandwidth, Gain-band product, input and output impedances, sweep rate) with respect to a given application
- Choose a sensor interface between the physical world and electronic signals

• B) Simulate and test a simple circuit

- Take control of Spice simulation software (schematic input, AC, DC, and transient simulation)
- Set up a simulation efficiently: simulation time and not adapted, solving possible convergence problems in simple cases (RLC + AOP circuits).
- Make clean montages on test plates (simulation versus measurement)
- Measure currents, voltages, impedances with the appropriate equipment (oscilloscopes, impedance meters, ...).
- Choose the appropriate component from its documentation (AOP limitations)

• C) Specify and select the correct analog-to-digital converter adapted to a given problem in terms of sampling frequency, resolution, family, and analyze the effect of sampling and quantification on the signal to be processed (effects of aliasing, saturation or non-linearity).

• D) Specify and choose a digital processing architecture adapted to a given problem
- Type of processing unit adapted to the problem (processor, microcontroller, DSP, programmable circuit, dedicated ASIC)
- Choice of the development tools necessary for the implementation of these components

• E) Implement a simple application with a microcontroller or a FPGA.
- Available peripherals in a microcontroller according to their potential use, and their simple implementation in C language
- Program, download and test a simple application on a microcontroller or FPGA in VHDL language

Description of the skills acquired at the end of the course
This course allows you to validate certain skills of type C1 - Analyze, design and build complex systems.
This validation is done by means of practicals (C13 Solve, C14 design) and the written exam (C11-Analyze, C12 Model).
The written exam also makes it possible to validate C2-type skills (C21-Deepen an engineering field, C22-Import knowledge from other fields)

So we will learn during this course who to :
A) Specify a simple analogue processing chain
B) Simulate and test a simple circuit
C) Specify and choose the right analogue-to-digital converter
D) Specify and choose a digital processing architecture adapted to a given simple problem
E) Implement a simple application with a micro-controller or a programmable logic device

Some basic concepts will need to be learned or reviewed independently (the basics of logic), and we will use
mathematical concepts studied elsewhere (sampling theory, filtering, signal processing)