ESIEE
PARIS

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Master of
Wireless Communicant Sensors

Courses Curriculum – May 2013

2014/2015

1 Content

2 General Description

The master of "Wireless Communicant Sensors" has been recently created to start on September 2014.

More compact (2 semesters + 1 internship semester) and more focused than other international masters of ESIEE Paris, it has been designed to welcome:

- Double-degree exchange students from partner's universities;
- Master students from abroad desiring to get a further specialization;
- Students having pursued a 4 year Bachelor, seeking for an international career in the industry;
- Companies willing to train their staff to foster their international development.

Objective and applications

Trained students after graduation can enter the field of:

- Sensors and sensor networks;
- Electronics;

together with skills on the management of technology.

The central domain of application is clearly about communicant sensors thus, with a centered interest in the development of system based upon miniaturized sensors in MEMS and NEMS technologies.

Applications cover a vast domain including:

- Monitoring adduction networks in cities (water, gas)
- Measuring pollution in cities and in houses (COV, CO, particles…)
- Monitoring transport systems (automotive, aeronautics)
- Health applications, and remote monitoring of patients, micro biological analysis in vivo
- Consumer electronics…

The applied hands-on nature of program will provide students with qualifications very sought-after in both the current industrial environment, and in academic research.

Courses organization

Students enroll for a 3 semester's program (2 academic semesters + 1 internship semester). A total of 120 ECTS must be validated to get graduated. Equivalences are considered to afford up to 30ECTS accounting for incoming students previous experience and studies (Master and Bachelors courses).

The program accepts students over two sessions: Fall Session, starting in September; Spring Session, starting in mid-January. Admission in one or the other session is submitted to the decision of the admission jury.

Available technical courses during the two academic semesters are:

	Fall semesters 1 & 2 (one possible only)		Spring semester
	Period 1		
	4 courses + 1 workshop	**4 courses out of:**	**4 courses + 1 workshop:**
	Review of Electronic Fundamentals (3ECTS)	Distributed control systems (3ECTS)	Electron devices (3ECTS)
	Material sciences (3ECTS)	Optoelectronic and Photonic Applications (3ECTS)	Propagation technologies (3ECTS)
	Optoelectronic and photonic (3ECTS)	WiFi and ZigBee architectures (3ECTS)	RF circuits (3ECTS)
	Signals and systems (3ECTS)	Energy Harvesting for Autonomous Sensor (3ECTS)	Analog IC design (3ECTS)
	Workshop: C programming for Electronics (2.5ECTS)	RF and Microwave Circuits (3ECTS)	Workshop: Design of a MEMS Device (2.5ECTS)
	Period 2		
	4 courses + 1 workshop	**4 courses out of:**	
	Analog circuits for sensors and receivers (3ECTS)	Nano & bio-chemical technologies and devices (3ECTS)	Project and Topical workshops (15ECTS)
	Discrete time electronics (3ECTS)	Advanced micro-fabrication technologies for ICs end MEMS (3ECTS)	
	Introduction to communication systems (3ECTS)	Antennas and wireless systems characterization (3ECTS)	
	Principles of MEMS Sensors and Actuators (3ECTS)	Topical MEMS Design (3ECTS)	
	Workshop: Introduction to FPGA (2.5ECTS)	RF Front-End (3ECTS)	
		RF and Millimeter wave circuits: from design to layout (3ECTS)	
		Networks and applications to embedded systems and sensor networks (3ECTS)	
		Electromagnetic Modeling for circuits and packages (3ECTS)	

Additionally Management and language courses are:

Unit Code	Course Title	Volume
FLE	French as a Foreign Language (level 1 to 4)	90h
OB1	Intercultural Management	30h
OB1	Introduction to corporate Finance and International Marketing	30h
IPM1	International Project Management	30h
IM	Innovation Management	30h

3rd semester: Final Internship (6months minimum)

The third semester is devoted to a final master thesis Internship, either in a company or in a lab.

The duration is at minimum 6months. The internship is concluded by a master thesis and gives 30ECTS.

3 Detailed Curriculum

3.1 Fall semester 1: courses details

P1-A - Review of Electronic Fundamentals

This course aims at providing a review of electronic basics to students from different background. It provides the common terminology and consolidates competences in analog electronics, electrical circuits, electronic devices and operational amplifier.

P1-B - Material sciences

This course develops the electronic properties of materials and semiconductors. Crystallography and bands theory are exposed together with fundamentals to analyze interaction of materials with electronic, magnetic and optical waves.

P1-C - Optoelectronic and photonic

Along this course, semiconductor based photodetectors and lasers will be developed. Optical interactions with the semiconductor are detailed, as well as waveguiding properties into fibers and integrated optical waveguides.

P1-E - Signals and Systems

The objective of this course is to give an accessible introduction to signals and systems for electrical engineering, computer engineering, and computer science. **Content:**

- Fundamentals of continuous-time/discrete-time signals: Fourier and Laplace transforms; Convolution and transfer function; Sampling and reconstruction
- Essentials of feedback control: representation of dynamical systems; basic feedback loops and more abstract representations; structural properties; stability and sensitivity; control algorithms and methodologies (PID, state feedback, pole placement, observers)
- Uncertainty and systems' limitations (measurement noise, actuator saturation, process dynamics)

Workshop P1 – C programming for Electronics

This course targets to train students with computer languages. C programming will be developed mainly in on a project basis toward Electronics application and hardware drivers, accompanied by introduction courses. **Content:** Introduction courses on languages and programming of hardwares; Short Project

P2-A - Analog circuits for sensors and receivers

This course provides the audience with knowledge and techniques in building analog circuits for various sensing applications as well as for communication receiver devices. It develops the necessary concepts and continues with circuit design examples, including practical experiments. A strong focus is put on small-signal model of transistors and their related circuits. Noise, frequency stability and power consumption reduction issues are covered.

P2-B - Discrete time electronics	This course is intended to develop techniques at the interface of the digital and analog domains with acquisition chains, converters and digital filters. The subject will first be handled theoretically by studying the theory of acquisition chains, and will be continued with digital filters toward sensors and communications applications. **Content:** Description of acquisition chains and theory; A/D and D/A converters principles; Converters architectures; Digital filters.
P2-C - Introduction to communication systems	This course browses main communication applications with the desire to present the market, the network architecture with an insight in electronic technologies involved. At the end, design requirements will be considered derived from the system level to the individual device. **Content:** Wireless technologies and standards, RFID; Wired and Optical networks; Satellite communications.
P2-E – Principles of MEMS Sensors and Actuators	This course gives an introduction to fundamentals of MEMS Sensors and Actuators. Basic physical principles include structural mechanics and electrostatic transduction. Microfabrication is introduced starting from materials to the corresponding technological processes. **Content:** Introduction to MEMS (History and applications), Fundamentals of MEMS electromechanical transducers, Material Science and microfabrication technologies.
Workshop-P2 – Introduction to FPGA	This course focuses on digital system implementation on FPGA (Field Programmable Gate Array) using VHSIC Hardware Description Language (VHDL). Combinational and sequential circuit design will be briefly covered along with associated hardware description coding. This course will help in understanding the most important issues related to the synthesis of field programmable logic devices using Altera Quartus Software. Modelsim software will be used for a first phase of simulation test bench design. Many system design examples will be considered using an FPGA board from Altera.
P1-D- – Organisational Behavior: Managing Diversity	Intercultural Management: This course aims to: • Identify some of the factors that influence how decisions are made in cross-cultural management contexts • Describe key models and concepts used for comparing/contrasting cultures • Implement and use them appropriately in different cultural & organisational contexts Content includes: Managing Diversity Living in a multi-cultural environment: notions of time, space & environment Hofstede's dimensions of culture Other approaches to the analysis of cultures "Snapshots" of cultures

P2-D – Corporate Finance International Marketing

Corporate Finance

At the end of this course students will be able to :

- Understand the most important accounting principles used to prepare financial statements
- Measure and analyse working capital requirement, net long-term financing, net short-term financing and net working capital
- Prepare and interpret a cash-flow statement
- Measure a firm's profitability
- Calculate the net present value (NPV) of a stream of future cash flows and how to apply it to investment decisions

Introduction to International Marketing

When you have completed this course you will be able to:

- Understand the key role of marketing, particularly with the influence of ICTs
- Understand how a marketing strategy is established.
- Comprehend the difference between B to B and B to C marketing policy
- Implement and use the different tools of marketing analysis appropriately
- Assess your own skill for marketing
- Identify specificities of international marketing
- Be capable of doing a marketing plan
- Be capable of taking the right decisions concerning segmentation, targeting, branding, price and promotion

FLE1 – Français Langue Étrangère 1

Understanding and communicating in French in normal speech. (Work on pronunciation, intonation, gestural)

FLE2 – Français Langue Étrangère 2

Acquire techniques for an oral speech during a meeting (presentations, talks, discussions…). Enhance intercultural relations to enable social integration at school or on a public place.

3.2 Spring semester: courses details

P3-A - Electron devices

The aim of this course is to deal with the elementary electron devices that are commonly used in all integrated circuits, and to develop an understanding of relevant physical effects and their modeling. The focus will be on bipolar structures on one hand, such as PN diodes and bipolar transistors on Silicon, and on unipolar devices on the other hand with Schottky diodes and MOS transistors. Their electrical modeling will be key to the design of integrated circuits. An introduction to compact circuit models topology will be provided before the end of the class.

P3-B - Propagation technologies

The course targets to train students in high frequency technologies and techniques. Electromagnetism and propagation fundamentals will be initially reviewed. The course will then provide the audience with the tools to manipulate high frequency signals and will describe elements of technologies such as practical transmission lines, analog filters, resonators and passive components. Applications will be for the design of circuits and systems, also including RF MEMS. **Content:** Propagation basics review; High frequency techniques fundamentals; Transmission lines technologies; Analog RF filters, passives and resonators.

P3-C - RF circuit fundamentals	This course aims to provide students with the description of standard communication systems architecture. It will then describe how those topologies lead to individual requirements for the system itself as well as for individual sub-systems and devices. Several critical sub-systems will then be analyzed in detailed such as non-linear continuous wave amplifier and filters. From this approach, complete linear and non-linear budget of the communication link will be established.
P3-E - Analog IC design	This course provides an extensive study of the use of transistors within analog ICs but also digital fundamental circuit blocks. The first part of the course will focus on high-speed differential stages, extending the knowledge of students from analog circuits to higher speed and sensitive amplifier scheme. The second will be deal with noise limitations within circuits at the device level. The third part of the course will consider the specific topic of the switched-capacitor circuits, giving another example of the full custom methodology to design original and efficient circuits.
Workshop-P3 – Design of a MEMS Device	The objective of the project is to define a given MEMS architecture, to simulate its physical behavior and to provide the corresponding layout, which could be used in a given technological process. MEMS simulation and Design tools will be extensively used during this project. A defense of the project will be organized at the end of the project period.

P3-D - Management seminars	"Management in a Changing World" Change Management, Risk Management, Creative Management, International Financial Markets, etc.
FLE3 – Français Langue Étrangère 3	Through an intensive period, students develop more ease in the oral language with colleagues and friends. Everyday life French is developed to gain autonomy in the environment. A focus is put on the cultural exchange as well.

3.3 Fall semester 2: courses details

P5-A- Distributed Control Systems

Distributed Control and Embedded System (DCES) is a control system having one or more control loops that are closed via a communication network. In these systems, the controller nodes, sensors nodes and the actuators are situated in distant locations due to the physical distribution of DCES and HW/SW distributed architecture.

In order to control such systems, the information is provided by the sensors nodes via real time networks to controller's nodes. Based on the received information, the related control tasks determine the control signal transmitted generally via the same real time network to the actuators nodes which are responsible to apply it. Their widespread use in the vehicles, manufacturing, in the chemical industry, in aerospace and many others sectors of industry or manufacturing cannot be explained solely by productivity gains, their scalability but also by an important increase of reliability. Modelling and control of DCES system will be the may focus of this course. Different modelling granularity level will be given ranging from delayed system model based to hybrid dynamic system model based and going through agent based representation of DCES. Modelling and simulation tools like TrueTime toolbox as well as distributed design control methods applied to real case study will be given.

P5-B - Optoelectronic and photonic

This course covers the application of optoelectronic and photonic devices along two main domains: sensors and communications. The first part will be devoted to Optical MEMS systems and sensors especially in the Gaussian approximation. Second part will cover high speed electronics for communications, microwave photonic, application of photonic in radars and systems, etc. Talks will be mostly given by top leading industrial partners. Electronic and photonic convergence will be a key point.

P5-C-1- WiFi and ZigBee architectures

This course aims at explaining WiFi (802.11) architectures and their deployment: Ad-Hoc, BSS, ESS, performance measurement and exploitation. Consequences of the perturbation of the 802.11 physical layer will be covered.

ZigBee architecture is the second case of study with a focus on the deployment of elementary architectures, dynamic routing, mesh networks and so on…

The course will conclude on WiMax architectures.

P5-C-2- RF and microwave circuits

This course is the following of the "RF circuit fundamental" course and will focus on the design of every typical Radio-Frequency (RF) integrated circuits, from amplifiers to filters and A/D or D/A converters. Finally selection criteria for IC technologies will be given to optimize circuit performances. Content: RF and microwave circuits fundamentals; Design of low-noise and high-power amplifiers; Design of mixers and oscillators; High speed D/A and A/D converters; Filter technologies; Selection criteria for IC technologies versus performances.

P5-E – Energy Harvesting for autonomous Sensors	Ambient energy harvesting has recently emerged as a solution to power autonomous sensors. The objective of this course is to study various techniques for power generation used in small systems in order to increase the lifetime of abandoned sensors. Special attention will be given to vibration energy harvesting technologies but photovoltaic, thermoelectric and RF waves energy conversion will also be considered. **Content:** - Basics of energy harvesting; - Vibration energy harvesting: transduction techniques, nonlinear phenomena, behavioral modeling; - Introduction to photovoltaic cell, thermoelectric harvesters and RF energy conversion; - Energy harvesting in healthcare applications
P5-A-1 - Nano & bio-chemical technologies and devices	The objective of this course is two-fold: Part 1 - Give a general introduction to the techniques of nanofabrication, including top-down approaches and Bottom-up self-assembly techniques. Part 2 - Introduce principles and technologies for chemical and biological sensors and interfaces as well as problems of their implementation on a micro-chip. **Content:** Top-down nanotechnology (e-beam and ion-beam writing, soft lithography and nano-imprint, Atomic probe techniques, Nanotubes and Nanowires); Emerging Bottom up techniques: block copolymer nanotechnology and DNA self-assembly; Background on surface science and chemistry. Scaling laws in (bio)chemical process. Fundamentals of molecular biology, biochemistry, and cell biology; Electrochemical sensors, functionalized-surface chemical and biochemical sensors; Optical spectroscopy techniques, Chromatography and Mass spectrometry; The Lab-On-Chip implementation: Bio-chips, Bio-Sensors and Bio-MEMS Background on semiconductor physics.
P5-A-2 - RF and Millimeter wave circuits: from design to layout	This course is an intensive and practical training on complete RF and millimeter wave monolithic ICs design. Clear hand-ons will be given to attendees with the highly enriching and exciting occasion to work on the most advanced CMOS or BiCMOS technologies internationally available. Students will design their own circuits and will process them in real in a multi-project-wafer run. Testing will be provided through the "test and measurement" course. **Content:** Si-based and III-V technologies; Practical design training on RF IC / MMIC; **Keynote advanced Lab sessions:** Training on Europractice Technologies
P5-A-3 - Electromagnetic Modeling	This course introduces electromagnetic modeling applied to the integration of a system into its package. This aspect is a key challenge that is crucial to solve in the industry and to which development of numerical tools turned on. Attendees will also investigate system-on-chip and system-in-package integration techniques. **Content:** Numerical tools; Passives electromagnetic modeling; EMC and Packaging; System on chip (SoC) and in Package (SiP) integration
P5-B-1 - Advanced Microfabrication Technologies for ICs and MEMS	This course is intended to give the knowledge of fundamental semiconductor processing, including micro-fabrication of both integrated electronic circuits as well as MEMS devices. The most conventional technology steps will be detailed. Typical process flows will be discussed as well. This course will be concluded by an experimental lab session in which MOS circuits will be fabricated and tested. **Content:** Fundamentals of semiconductor materials and processing; Introduction to MEMS fabrication technologies; Polymer materials and related technologies; Typical process flows of IC and MEMS foundry services. **Keynote advanced Lab session:** Fabrication and test of MEMS in clean-room

P5-B-2 - Networks and applications to embedded systems and sensor networks	This course will develop the upper layer of network architectures such as WiFi and Zigbee to enable the control of distributed systems such as wireless sensor networks. Overviews of industrial approaches will be given with a strong emphasis on applications.
P5-C - Antennas and Wireless systems characterization	This course is two-fold: The first part will focus on the measurement techniques to be involved in the characterization of components, devices, circuits and systems in the various fields of the high-frequency domains. The second part aims to train students toward the techniques of antenna design. Channel modeling will allow deriving most of the constraint to be used in the further integration of single and multi-antenna systems. **Keynote advanced Lab sessions:** Courses mainly turned on Lab sessions practice
P5-E-1 - Topical MEMS Design	This course is dedicated to the design and simulation methods and tools for multi-physics components including MEMS. Important parts will be dedicated to using major CAD software packages, and to device implementation according to a specific design-kit of a MEMS foundry. **Content:** Design Methodologies and flow; Practice of ANSYS and COVENTOR; Detail of the Design-kits used for MUMPS foundry; Structural simulation and Coupled simulation case studies; **Keynote advanced Lab Session:** Design of MEMS inertial sensor for fabrication in MUMPS foundry
P5-E-2 - RF Front-ends	The aim of this course is to develop on the fundamentals of digital communication standards with a special focus on the advanced standards in next generation communication systems. Design of complete RF front-ends will be browsed from both theory and practical point of view through an important training session on OFDM front-ends design. Content: Digital communication standards ; Multi-carrier modulation format (OFDM…); Transceivers for new wireless standards; Keynote advanced Lab sessions: Training on OFDM front-ends design
P5-D International Project Management	International Project Management When you have completed this course you will be able to: • formulate a project vision statement • identify project risks and opportunities • submit a project proposal • construct a work breakdown structure • devise a project dashboard • pilot the project • carry out a post project review.
FLE4 – Français Langue Étrangère 4	Develop written and oral languages structures. Increase French vocabulary.

See http://www.esiee.fr/en/