Le bulletin de troisième année est établi à partir des examens et travaux évalués soit sous la forme de notes affectées de coefficients pondérateurs, soit directement en niveau (travail de fin d’études). Ces coefficients pondérateurs correspondent au nombre de crédits ECTS attribués à l’activité correspondante. Ils permettent d’établir, dans chaque rubrique, une note moyenne d’après laquelle est déterminé le niveau ECTS d’appréciation (A à F).
Les aptitudes en langues sont appréciées dans une grille d’évaluation linguistique de 0 à 4 (débutant à quasi bilingue).

**L’obtention du diplôme d’Ingénieur Supélec nécessite :**
- un niveau au moins satisfaisant (A à D) dans les rubriques 1, 2, 3 et 5
- la validation des modules de langues, du séminaire et d’une expérience internationale
- un niveau minimal égal à 2,5 en anglais (il s’agit d’une obligation de résultat qui n’implique aucune obligation de suivre des cours d’anglais).

<table>
<thead>
<tr>
<th>RUBRIQUES</th>
<th>EXAMENS ET TRAVAUX</th>
<th>Crédits ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 MAJORE</td>
<td>Analyse et synthèse d'images</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Architectures matérielles (FPGA et processeurs)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Compression des images et du son</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Conception de systèmes électroniques</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Réseaux de communication et de diffusion</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Technologies nanoélectroniques</td>
<td>1</td>
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<td></td>
<td>Transmissions numériques et Modulations</td>
<td>1</td>
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<tr>
<td></td>
<td>Validation et test des systèmes électroniques</td>
<td>1</td>
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<td></td>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
</tr>
<tr>
<td>2 MINEURE</td>
<td><em>Le choix des six unités d’enseignement de mineure sera effectué par les élèves en début d’année scolaire</em></td>
<td></td>
</tr>
<tr>
<td>3 ÉTUDES ET PROJET</td>
<td>Études de laboratoire et/ou Etude Industrielle</td>
<td><strong>12</strong></td>
</tr>
<tr>
<td>4 ENSEIGNEMENT ÉLECTIF</td>
<td>Langues vivantes</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Séminaire</td>
<td>2</td>
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<td><strong>Total</strong></td>
<td><strong>4</strong></td>
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<tr>
<td>5 TRAVAIL DE FIN D’ÉTUDES</td>
<td>Stage en entreprise ou dans un laboratoire de recherche</td>
<td><strong>20</strong></td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>NIVEAU EN LANGUES</th>
<th>LANGUES</th>
<th>EXPERIENCE INTERNATIONALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Langue anglaise</td>
<td></td>
<td>Validation d’une expérience internationale d’au minimum 16 semaines pour tout étudiant de nationalité française</td>
</tr>
<tr>
<td>Autres langues</td>
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</tbody>
</table>

EE : examen écrit      EO : examen oral individuel      EXP : exposé
Microprocessors and associated components, which have been available since the first digital integrated circuits appeared in the early ‘70s, now form the core of most electronic products: they are found almost everywhere, particularly in information technology (from pocket calculators to computers), cars (ABS, injection systems, etc), automation equipment (programmable controllers, process control, etc) and domestic appliances (thermometers, remote controls, smart cards, etc).

OBJECTIFS D’APPRENTISSAGE
Upon completion of this course, students will be able to:
• understand the architectures of digital components used in electronic systems,
• involve changes in these architectures to those microelectronic technologies to guide their choice in the construction of electronic systems.

PROGRAMME

Programmable devices (FPGA)
Programmable components can be used to implement extremely fast arithmetic logic functions in a short development time. Due to technology improvements, it is now possible to integrate processor cores, this introduce the concept of SoPC (System On Programmable Chip) which opens up new fields of application.

Design approaches and market for programmable components
Criteria for selecting a particular technology: the technical, industrial and economic aspects.
EDA tools for FPGA : VHDL synthesis, simulation and validation.

Architectures and performances of programmable components
Analysis of various architectures of CPLD and FPGA and their potential.
Concept of SoPC : Hard and Soft cores
Reconfigurable hardware and &nbsp;dynamic reconfiguration with FPGA
Areas of application (signal processing, digital TV, SoPC …). Performance and limitations.

Microprocessors
This course present the main architectural concepts used on processors and microcontrollers with analysis of the optimal adequacy architecture-application. A focus is set on platform approach (processor and peripherals).

Processors architectures
Performance optimizations, power efficiency, memory organization
pipe-line and super-scalar architectures ; branch prediction, speculative execution, hyper-threading.

High performance computing
Optimized hardware architectures for signal processing and intensive calculation.
Dedicated processor : Signal processing (DSP) and Graphical applications (GPU)

PROFESSORS
Jacques WEISS
Amor NAKFHA
Ruben SALVADOR
Rennes - Major SERI - in French

PEDAGOGICAL METHODS
21 h lesson/27 h tutorial

ASSESSMENT METHODS
Presentation (in pairs or trinomial)

ECTS
2 ECTS credits

MODULE REFERENCE
SERI-AM

BIBLIOGRAPHY
R. AIRIAU and al., "VHDL, langage, modélisation, synthèse", 2e édition.
DIGITAL SYSTEMS DESIGN

To optimize performances, systems use lasted technologies for chips and packaging

The product may be “System on Chip” (SoC), “System in Package” (SiP) or “System On Board”, in all cases, it is necessary to use adapted methodology and suitable tools from conception to validation.

OBJECTIFS D’APPRENTISSAGE

Upon completion of this module, students will be able to specify and design complex and heterogeneous electronic systems, by implementing high-level methodologies.

PROGRAMME

Introduction:
Electronic market technologies, prices and trends

Design techniques, description and comparison
Methodology and development cycles for board designs
ASIC technologies; Foundry/customer relationship

Design of circuits libraries
From base circuits up to complex functions (IP : Intellectual Property)

System On a Chip
SOC core blocks; Processors cores, buses, reused logic.

SOC design
Specification, functional, architectural and hardware design

Platforms : system approach
Embedded systems : resources, operating system, connectivity
Complex systems description and design, trends on design approaches
High-level Description Tools and languages, co-design ; hardware/software partitioning ; heterogeneous platforms

Design of complex systems, trends of methods
High level digital flow of heterogeneous systems;SystemC design flow.
Hardware-software partitioning. Cosimulation, modelisation
Abstraction levels

Optimization and Operational research
Graphs theory. Scheduling. Resources allocation. Parallel computing

Security of embedded systems
Hardware and software vulnerabilities ; good practices to avoid attacks.

PROFESSORS
Mathieu BERNARD
Arnaud BOSCHER
Didier LOUIS
Amor NAFKHA
Ruben SALVADOR
Rennes - Major SERI - in French

PEDAGOGICAL METHODS
18 h lesson/9 h comprehensive tutorial

ASSESSMENT METHODS
Presentation (in pairs or trinomial)

ECTS
2 ECTS credits

MODULE REFERENCE
SERI-C5I

BIBLIOGRAPHY
Al-Hashimi Bashir : System-on-Chip : Next Generation Electronics ; IEE Circuits, Devices and Systems Series 18 ; Éd. Iee, 2006
Microelectronic technologies are the basis of any electronic implementation, their changes (as Moore's Law) allow the realization of increasingly complex and sophisticated systems. This course complements the knowledge acquired in the core curriculum by presenting the latest silicon technologies (processes, performances, prospective).

OBJECTIFS D'APPRENTISSAGE
Upon completion of this module, students will be able to:
- understand the behavior and evolution of current technology and anticipate future ones,
- make wise choices of components for the realization of electronic systems,
- understand the origins of the performance limits (speed, power consumption, ...) of the components used.

PROGRAMME
Different technological steps: processes and equipment

Technology ways
Semiconductor technologies: Silicon (CMOS and BiCMOS), Gallium Arsenide and GaN.
MEMS and nanotechnologies.

Faults, degradation mechanisms and technological improvements

Development of IC technology
Silicon on insulator (FinFET et FDSOI), new topologies, 3D-IC.

Production of integrated circuits
VALIDATION AND TEST OF ELECTRONIC SYSTEMS

System testing is an important aspect of a manufacturer’s strategy. It is used to measure the quality and reliability of products, and thus to validate the entire production sequence. The complexity and performance of systems are constantly increasing, so testing equipment is becoming ever more expensive. As a consequence, design strategies are needed that make testing easier, thus cutting costs. Testing must be carried out at every stage of production (from the integrated component and the printed circuit board, right through to the finished system). The testing equipment and strategies are therefore adapted to suit the particular context; characterization and maintenance also impose specific constraints.

OBJECTIFS D’APPRENTISSAGE
Upon completion of this module, students will be able to:
- understand the problem of validation and testing of systems,
- implement development methodologies adapted to the context,
- be aware of hardware and software security.

PROGRAMME
Overview of the instrumentation equipment
Signal integrity, interconnections characterization, disturbance sources.

Power supply and parasitics rejection
Power supply circuits, specific components, decoupling.

Characterization
Functional verification, characterization and tests. Fault diagnosis and location.

Testing printed circuit boards
Methodology and tools for investigation
AOI (Automated Optical Inspection), In-Circuit test. Functional test. JTAG standard.

Testing integrated circuits
Testing with and without contact. Testing mixed circuits: analog and digital access.

Developments and trends
CAD and testing equipment. How far should the testing go? Development of new design and testing approaches.

Testability
Access limitations on integrated circuits, testability analysis, fault modelling and simulation; test patterns generation (ATPG); DFT : Design For Test.

PROFESSORS
Yves RICHARD
Jacques WEISS
Rennes - Major SERI - in French

PEDAGOGICAL METHODS
12 h lesson

ASSESSMENT METHODS
Presentation (in pairs or trinomial)

ECTS
1 ECTS credit

MODULE REFERENCE
SERI-VTSE

BIBLIOGRAPHY
Sun Yichuang: Test and Diagnosis of Analogue, Mixed-signal and RF Integrated Circuits ; Ed. Iet, 2008
Rajsuman Rochit : System-on-a-Chip : Design and Test ; Ed. Artech house, 2000
DIGITAL COMMUNICATIONS AND MODULATIONS

**Reliable data transmission in noisy environments requires the use of suitable methods. The aim of this course is to introduce the channel propagation characterisation, the various digital modulation methods and their performance and to show how the combination of coding , modulation and diversity enables transmission performance to be enhanced.**

**OBJECTIFS D'APPRENTISSAGE**

Upon completion of this course, students will be able to understand the channel propagation mechanisms and constraints in a telecommunication context. Ways to transmit informations (in mobile, broadcast or wireless networks contexts) in such environments will be given and trade-offs between bit rates, bandwidths and consumptions will be discussed.

**PROGRAMME**

*Propagation channel modelling*

 Wireless (Radio) channels modelling for indoor and outdoor communication. Wired, phone lines and power-line networks.

*Digital modulation*

 Digital modulation principles. Various types of modulation: PAM, QAM, PSK, FSK, Calculation of performance levels in the presence of noise

 Single and Multi-carrier modulations

 OFDM (DVB-T/H, ADSL) : Principles ; realization using an FFT operator.

 Coded modulation : COFDM.

*Filtered Multi-tones modulations (FBMC)*

 Spread-spectrum modulations

 CDMA (UMTS, WiFi), choice criteria.

*Channel estimation and equalization*

 Time domain equalization

 Frequency domain equalization

**PROFESSORS**

 Carlos BADER  
 Yves LOUET  
 Amor NAKFAKHA  
 Rennes - Major SERI - in French

**PEDAGOGICAL METHODS**

 15 h lesson/9 h tutorial

**ASSESSMENT METHODS**

 Written form examination

**ECTS**

 1 ECTS credit

**MODULE REFERENCE**

 SERI-TNM

**BIBLIOGRAPHY**


Networks for Communication and Broadcast

Any specialist in the field of architecture and integration of electronic systems is affected by data networks in two ways: first as the designer of components and equipment and second as a network user (CAD, production, etc). This course describes the architectural concepts of networks, public networks, local area and long-range networks and the available services; media are also concerned such as radio and power-line networks.

**OBJECTIFS D’APPRENTISSAGE**

Upon completion of this module, students will be able to understand, specify and use communication networks for use in electronic, computer systems and multimedia.

**PROGRAMME**

**Wide Area Networks (WAN)**

- The ATM protocol: physical, ATM and adaptation layers; signalling access control methods.
- Multi Protocol Label Switching (MPLS): notions on IP (Internet Protocol), Quality of Service (QoS), VPN.
- Network characteristics, OSI reference model, QoS, nodal functions.

**Wireless and mobile phone networks**

- Network protocols and topology; structure and frequency planning
- Terrestrial Digital TV broadcast for nomad and mobile TV (DTTV & DVB-H)
- Broadcast networks protocols and topology; structure and frequency planning

**Long-range networks for sensors**

- LoRa, SigFox, NB-Iot: specificities

**PROFESSORS**

- Gérard CORDELIER
- Quentin BODINIER
- Jacques WEISS

Rennes - Major SERI - in French

**PEDAGOGICAL METHODS**

7,5 h lesson

**ASSESSMENT METHODS**

Presentation (in pairs or trinomial)

**ECTS**

1 ECTS credit

**MODULE REFERENCE**

SERI-RCD

**BIBLIOGRAPHY**

- H. NUSSBAUMER, "Téléinformatique", volumes 1 à 4, Presses Polytechniques Romandes.
- P. ROLIN, "Réseaux hauts débits - Réseaux et télécommunications", Hermes.
- C. SERVIN, "Télécoms, de la transmission à l'architecture de réseaux", Collection Systèmes distribués.
The aim of this course is to present bases on 2D and 3D image analysis and on 3D image synthesis.

For pattern recognition, we present global methods and state-of-the-art tools and approaches: deformable models that model and synthetize 3D objects for a better understanding.

Hardware implementation on generic or specialized platforms is studied.

**OBJECTIFS D'APPRENTISSAGE**

Upon completion of this module, students will be able to propose and develop a comprehensive system of image processing (from pretreatment to interpretation) to solve a problem of recognition of 2D or 3D shapes such as monitoring drowsiness of a driver, automatic cartography from a Google car, analysis of facial expressions of a patient in a hospital.

**PROGRAMME**

**Pretreatment**
- Grayscale processing by histogram equalization
- 3D registration (Iterative closest point – ICP)

**Segmentation and extraction**
- Segmentation based thresholding color
- Segmentation classification (k-means)
- Segmentation by region (rising waters, split & merge, region-growing)
- Segmentation boundary (Canny edge detector)

**Representation & description**
- Explicit pattern recognition (Hough transform)
- Implicit pattern recognition – data-based (Principal component analysis – PCA, deformable models, example of active appearance models - AAM)
- Features (Local binary pattern - LBP, Scale-invariant feature transform - SIFT)
- Motion (optical flow)

**Recognition & Interpretation**
- Pattern matching
- Similarity measure (L1 norm, L2, correlation)
- Acceleration (diamond search, multi-resolution pyramid)
- Classification (k-means)
- Optimization (Gauss-Newton, Simplex)
- Neural networks (multilayer perceptron, Kohonen maps)

**3D image synthesis**
- Real-time computer graphics

**Implementation**
- Graphics accelerators, GPUs, GPP, OpenGL, Cuda, Python

**PROFESSORS**
- Vincent BARIELLE
- Renaud SEGUIER
- Catherine SOLADIÉ
- Nicolas STOIBER
  - Rennes - Major SERI - in French

**PEDAGOGICAL METHODS**
- 19,5 h lesson/19,5 h comprehensive tutorial

**ASSESSMENT METHODS**
- Mini-project

**ECTS**
- 2 ECTS credits

**MODULE REFERENCE**
- SERI-ASI

**BIBLIOGRAPHY**
- Computer Vision Three-Dimensional Data from Images
  - av Reinhard Klette, Karsten Schluns, Andreas Koschan
  - Springer2001
- Dynamic Faces Insights from Experiments and Computation
  - av Cristobal Curio, Heinrich H Bulthoff, Martin A Giese
  - MIT Press2011
- Understanding Motion Capture for Computer Animation,
  - A Menache
  - Elsevier 2011
En plus des fonctions de filtrage couramment rencontrées dans les systèmes de traitement, le traitement numérique permet la mise en œuvre d’algorithmes beaucoup plus performants tels que le filtrage adaptatif et la prédiction utilisés notamment dans les opérations de compression de la parole. L’implémentation temps réel de ces algorithmes nécessite de prendre en compte le temps de traitement et imposer un compromis entre performance et nombre de calculs. Les structures multi-cadences vont dans ce sens. Enfin les propriétés des transformées (Transformées de Fourier, en cosinus, en ondelettes) facilitent également l’analyse et le traitement.

OBJECTIFS D’APPRENTISSAGE
À l’issue de ce module, les élèves auront acquis une bonne connaissance des algorithmes et des techniques mis en œuvre dans le domaine du traitement du signal appliqué au codage du son et de l’image. Ils seront capables de les spécifier et de les mettre en œuvre dans des systèmes audiovisuels.

PROGRAMME

Le traitement numérique

Bases de codage du signal
Propriétés statistiques du signal, méthodes de codage
Codages entropiques (Huffman, Arithmétique, LZW, Golomb).

Filtrage adaptatif. Prédiction linéaire
Algorithmes dans les domaines temporels et fréquentiels. Applications au traitement de la parole.

Systèmes de traitement multi-cadence

Transformées (Fourier, DCT, ondelettes…)

Compression du son et des images (MPEG)
Compression du signal audio dans les radiocommunications et la télévision numériques (CELP, MPEG Audio, Dolby AC3, ...). Compression des images : transformation, quantification, estimation de mouvement...
Compression des images fixes (JPEG, JPEG2000...) Standards MPEG -1, -2 et -4/AVC, DCI (cinéma numérique), HEVC

PROFESSORS
Adrien LLAVE
Jacques WEISS
Rennes - Major SERI - in French

PEDAGOGICAL METHODS
16,5 h lesson/3 h tutorial

ASSESSMENT METHODS
Oral exam

ECTS
2 ECTS credits

MODULE REFERENCE
SERI-CIS

BIBLIOGRAPHY
S.J. SOLARI, "Digital Video and Audio Compression", McGRAW-HILL.