FOURTH YEAR INSA TOULOUSE

Autumn semester

SYSTEM ENGINEERING

Multiphysic modeling	6 credits	72,75h
Digital signal acquisition architectures and computed controlled systems	4 credits	60h
Hardware	4 credits	55h
Power systems and instrumentation	7 credits	85,5h
Improving autonomy and building a professional project	4 credits	39h
Communicating within organizations	6 credits	75h

EMBEDDED ELECTRONICS

Device modeling and digital circuit architectures	4 credits	55h
Analog electronic system architecture	4 credits	54h
Systems analysis complex	4 credits	50h
Digital signal acquisition architectures and computed controlled systems	4 credits	60h
Hardware	4 credits	55h
QSE APS 4A GEI	4 credits	47h
Communicating within organizations	6 credits	75h

Spring semester

SYSTEM ENGINEERING

Tutored projects	4 credits	60h
Object oriented and real time programming	6 credits	89h
Modelling and Optimization	4 credits	48h
Systems Engineering processes	5 credits	76h
QSE , Projet mécatronique et APS		55h
Improve your management abilities	4 credits	45h

EMBEDDED ELECTRONICS

Practical Work in Control	3 credits	35h
Energy management for embedded systems	3 credits	40h
Discrete and Continuous Systems Optimisation	6 credits	68h
Tutored projects	4 credits	60h
Improving autonomy and building a professional project	4 credits	39h
Improve your management abilities	4 credits	45h
Object oriented and real time programming	6 credits	

Multiphysic modeling

ECTS
6 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
72,75h

Presentation

Objectives

To design and analyse high-level models of multidomain energy-transfer

systems or mechatronic systems.

Formalisation of physics concepts from previous years as lumped-parameter

modelling (0D-1D) in electrical, magnetic, hydraulic, thermal and

mechanical systems. Lectures, tutorial, lab-work with Modelica or Amesim.

Implementation and analysis of multiphysics systems with block diagrams and

state-space simulation models. Several modelling problems using lumped

parameter systems: setting to equations in various domains, simulation using

simulink, time and frequency analysis. Lectures, tutorials, lab-with Matlab /

Simulink or Amesim.

Defining and designing models using the bond-graph formalism.

Lectures and modelling project

Pre-requisites

General physics (mechanics, electricity, fluid mechanics, thermodynamics).

Useful info

Place

Toulouse

Digital signal acquisition architectures and computed controlled systems

ECTS
4 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
60h

Presentation

Description

Programme (detailed contents):

Lecture is divided in three complementary axes:

* **Electronics design**: different techniques used in analog and digital converters, with their associated architectures are detailed. Companding techniques are presented (A–law). The complete chain gauging techniques are studied based on the signal noise ratio extraction.
* **Command design**: discrete time linear models: input/output model, state space models. Sampling with zero holder. Stability criteria. How to obtain a discrete time controller from a continuous time one. RST controller: Regulation and tracking. Relation with state space methods.
* **Project**: the purpose is to cover several items such as treating an analogue sensor, controlling an A/N converter, the necessary digital processing (minimal control law) and finally the N/A conversion to drive the actuator. The whole chain will be operated by a microcontroller.

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

The complete modelling from sensor to actuator is presented, associated with digital control technics. A specific labwork deal with the implementation of a complete chain of acquisition and digital processing in order to carry out the control of an actuator.

Useful info

Place

Toulouse

Hardware

ECTS
4 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
55h

Presentation

Description

Programme (detailed contents):

* System Design part:

The lecture begins with a presentation of the object paradigm. In this part, many various examples are given to illustrate the object world: systems of services or software and hardware systems. The second part deals with the specificity of an object-oriented design process. This process is compared to a functional approach. The lecture moves on to an UML introduction. The last part details the most widely used UML diagrams. It starts with use case and sequence diagrams, then structure (class and composite structure) diagrams are studied. Finally, behaviour (state and activity) diagrams are presented. Students assess their knowledge with exercises and labworks during which they have to model several complex systems.

* Programming of microcontroller part :

The functions and the programming of the STM32 (based on a ARM/CortexM3 core) is studied essentially in labwork. Half of time is devoted to a project. This project consists with the software development of an embbeded system embarked.

Organisation:

The 2 parts are held in parallel and are the subject of distinct evaluations

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

* Programming of microcontroller part :
  * Programming specificities of the peripheral units for microcontroller.
  * How to take into account hardware constraints for the design of embedded system.
* System Design part:
  * o the concepts of object paradigm.
  * o the concepts of object-oriented design process
  * o the main UML diagrams involved in an object modelling: use case diagram, sequence diagram, state and activity diagram and composite structure diagram.

The student will be able to:

* Programming of microcontroller part :
  * To select an architecture processor adapted to the software application and to the process configuration.
  * To conceive and test the techniques of the programming by hardware interruption.
  * To use debug tools o and test in the context of cross-development.
  * To find information into datasheet.
* System Design part:
  * o breakdown a system (which could be software or hardware) with an object-oriented approach
  * o choose the diagrams which are most appropriated according the student viewpoint: structure, behaviour, interaction

propose an object-oriented UML model of a software or hardware system

Useful info

Place

Toulouse

Power systems and instrumentation

ECTS
7 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
85,5h

Presentation

Objectives

To be able to identify standard power transmission architectures. To be able to generate

or to analyse architectures of power systems

To acquire a global knowledge in the technology for power transmission (mechanical,

hydraulic, electrical and thermal). To able to characterise them with respect to

performance, advantages and drawbacks.

Acquire knowledge in measurement and computer-controlled data acquisition:

-selection and design of the components involved in an acquisition circuit

- use a graphical programming language dedicated to data acquisition (Labview).

Pre-requisites

1D multiphysics

Electro-kinetics. Algorithms and textual language programming (C, ADA)

Useful info

Place

Toulouse

Improving autonomy and building a professional project

ECTS
4 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
39h

Presentation

Objectives

Construire une équipe projet, Approfondir ses connaissances,

Investir le métier, les domaines d'activité, les fonctions.

L'étudiant devra être capable de :

- d'analyser avec les autres un problème posé (Identifier le problème, définir les axes d'approche dans un bilan interactif : organisation, physique, technique, stratégique, motivation, confiance...

- de décider ensemble (permettre à tout le monde d'exprimer son avis, ajuster et réguler sa conduite en fonction de l'analyse collective),

- d'identifier les ressources du groupe (sens critique, repérage des points forts et faibles de chacun).

Place

Toulouse

Useful info

Communicating within organizations

ECTS
6 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
75h

Presentation

Objectives

The classes given in French will focus on :

- How to react to society's demand for technical and scientific information

- How to foster critical thinking in order to give appropriate answers when questioned about such issues

- How to communicate effectively in the workplace

The classes given in English will focus on the specific linguistic characteristics of English used in such contexts in order for the students to understand and master them.

The students will also be made aware of the specificity of professional communication within the English-speaking world

Module L2

The objectives, defined in reference to the CEFRL for the 5 language activities, depend on the language studied - Chinese, German, Spanish - and the level of the student.

They can be consulted on :

https://moodle.insa-toulouse.fr/course/view.php?id=44

In certain cases, students may be authorised to follow an English module instead of another language.

Pre-requisites

For classes in English : mastery of general English.

Useful info

Place

Toulouse

Device modeling and digital circuit architectures

ECTS
4 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
55h

Presentation

Description

Programme (detailed contents):

The next concepts will be taught in detail during courses and laboratory work:

-the electronic phenomena in semiconductor devices and circuits

-the structure of MOS,CMOS and logical gates

-the modeling of transistors (MOS, bipolaire) and their environment sensitive parameters

-the CMOS implementation of logical functions. The high-speed, low power and gate clocking issues for CMOS gates will be presented

-the VHDL language and model for digital systems

-the synthesis and FPGA implementation of digital architectures

-the performance optimization, especially in power consumption and frequency for digital architectures

Organisation:

These concepts will be first presented during courses. Supervised exercised are then proposed on these topics. Laboratory classes are proposed to illustrate the main concepts. A part of laboratory classes are organized in a project on the design and performance optimization of digital systems. In this part the students will use a real world specification of a digital system (Ethernet controller, microprocessor).

Lectures slides, exercises and laboratory specifications will be given to students.

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

-the electronic device and digital electronic systems modelling

-the issue of the integration of electronic circuits

-the design and performance optimisation of digital architectures

The student will be able to understand the models of main electronics active devices and digital complex architectures. The student will be prepared for the future technological breakout in their professional life.

Pre-requisites

Electrical circuits, electrostatics, analog and digital electronics, digital hardware.

Useful info

Place

Toulouse

Analog electronic system architecture

ECTS
4 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
54h

Presentation

Description

Programme (detailed contents):

Lecture is divided in three main parts :

* **Active filtering and modeling of noise sources**:

ü Identify sources of noise and maximize signal to noise ratio on each floor of a chain of analog signal processing.

ü Build filters from the specification to the electronic choice with the constraints and drift components.

ü Transcribe a transfer function of biquadratic filter functions and the decline in active analog filter architecture based on feedback montages (Sallen Key, Rauch, UAF, ...) or synthesis of switched capacitor filter.

ü Optimize the order of a filter based on criteria of cost, integration, stability and sensitivity.

* **Architectures for analog information transmission** :

ü In many electronic systems, such as telecommunication or measurement systems, oscillations play an essential role in the information processing. Each electronic system poses different requirements on these oscillations, depending on the type and performance level of that specific system. It is the designer's challenge to find the specifications for the desired oscillation and to implement an electronic circuit meeting these specifications. As the desired oscillations have to fulfill many requirements, the design process can become very complex. To find an optimal solution, the designer requires a design methodology that is preferably completely top-down oriented. To achieve such a methodology, it must be assured that each property of the system can be optimized independently of all other properties. Oscillators and Oscillator Systems: Classification, Analysis and Synthesis takes a systematic approach to the design of high-performance filters and oscillator systems. A fundamental classification of oscillators, based on their internal timing references, forms the basis of this approach.

* **Establish a system prototype design of programmable analog circuits such FPAA.**

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

* Dimension and design of analog electronic functions of information processing (filtering, amplification, automatic gain control, voltage controlled oscillators, modulators / demodulators AM and FM;

* Optimize the signal to noise ratio in each subset of an embedded system
* Modeling architectures for robust usage constraints (consumption, temperature to dissipate), the thermal variations of the environment and dispersions characteristics of components

Useful info

Place

Toulouse

Systems analysis complex

ECTS
4 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
50h

Presentation

Description

This UF is composed of two distinct and autonomous parts:

* Multivariable systems
* Nonlinear systems analysis

Organisation:

Semestre 1

This two courses proceed in parallel without any particular interaction. Some exercises are performed on computer using Matlab.

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

* Principles, difficulties and limits of the modeling of systems with multiple inputs and multiple outputs.
* Design and implementation of control of systems with multiple inputs and multiple outputs.
* Main possible and observable behaviors which can occur in the nonlinear systems (equilibrium states, limit cycles, complex behaviors) and their evolution by variation of the parameters.
* Basis of the theory of Lyapunov

The student will be able to:

* To apprehend the implementation of the control of a process with multiple inputs and multiple outputs.
* To begin the analysis of a nonlinear system by various techniques (qualitative, geometrical, and simulations)
* To lean on numerical analysis (Matlab©) to establish, confirm, validate, simulate and implement the theoretical results discussed during the courses.

Useful info

Place

Toulouse

QSE APS 4A GEI

ECTS
4 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
47h

Useful info

Place

Toulouse

Tutored projects

ECTS
4 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
60h

Presentation

Description

The work is composed of two parts :

* a bibliographical study dealing with a research theme in relationship with the project. This study is concluded by the witting of a document whose content and form have to follow the recommendations given by the tutors,
* a technical realization which is performed during a full semester.

Organisation:

4 hours of documentary research teaching then 10 hours of project management teaching, then 30h of project.

Objectives

The module is aimed at motivating students with research activities by means "tutored projects" involving groups of several students and directed by an academic or an industrial tutor. Those projects are completed by a formation to documentary research. A course of project management allows guiding the realisation part of the project.

At the end of this module, the student will have understood and be able to explain (main concepts):

* the concepts, norms and techniques related to the building of a state of the art in relationship with the subject of the project subject,
* the concepts and techniques in relationship with the management of the project involving several persons.

The student will be able to:

* elaborate a state of the art dealing with a domain in relationship with the project,
* manage a project involving several persons,
* integrate techniques of different scientific domains to reach the realization goals of the project.

Pre-requisites

Depends of the subject of the project.

Useful info

Contacts

Education manager

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Place

Toulouse

Object oriented and real time programming

ECTS
6 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
89h

Presentation

Description

Program (detailed contents):

The module addresses the specification and design of real time systems, an introduction to main real-time operating systems services, method to program and to test a real-time application.

Objectives

This module presents real time systems, concepts, attributes, constraints, applications, and teach how to program these systems using object oriented languages and using real time operating systems.

Useful info

Place

Toulouse

Modelling and Optimization

ECTS
4 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
48h

Presentation

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts) :

- Various approaches to analyse and evaluate the performance of discrete event

system DES,

- Various types of modelling for these systems (deterministic or

stochastic models, numerical and combinatorial optimisation models, models of

concurrency)

- Algorithms to solve these problems.

The student will be able to:

Model and solve operational research problems (optimisation, graphs, stochastic

process) and discrete-event systems problems.

Model stochastic systems, such as a network of queues using Markov chains,

compute the stationary measures, and compute its capacity.

Model a DES with Petri nets, analyse the properties of the Petri net using various methods

of analysis (exhaustive and structural).

Pre-requisites

Linear Algebra, Probabilities, Dynamic systems, Basic concepts in logics and in Petri Nets.

Useful info

Place

Toulouse

Systems Engineering processes

ECTS
5 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
76h

Presentation

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts) :

Learn to define, gather, analyse and express the needs and expectations of

involved parties in order to design and implement a system, a product, a service.

Learn to translate the needs and expectations into technical requirements, define

and analyse technical requirements in order to design and implement a

system, a product, a service.

Useful info

Place

Toulouse

QSE , Projet mécatronique et APS

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
55h

Useful info

Place

Toulouse

Improve your management abilities

ECTS
4 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
45h

Presentation

Objectives

At the end of this module, the student will have understood and be able to explain :

* The basic rules of business law

* The objectives, principles and means of marketing

* The principles and procedures of financial diagnosis and / or investment

The student will be able to :

Apply principles and rules of management and law in simple situations. Take into account the parameters of the management (customer needs, cost effectiveness and legal compliance).

Useful info

Contacts

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Place

Toulouse

Practical Work in Control

ECTS
3 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
35h

Presentation

Description

This teaching includes 6 laboratories and a project. From these experiments, the students address the main problems stated by the study of real systems (tanks, temperature control, robot, segway.), but also handle several simulation and developpment tools (Matlab, XPCTarget, Keil....).

Organisation: Semester 2

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

This practical teaching illustrates all the courses in automatic control during the 4the year at INSA (numerical control, non linear systems, optimal control, multivariate control, graph).

The student will be able to:

* Model/identify a system
* Synthesize a control following specifications (performance) and implement it
* be critical on a command
* write a report

Pre-requisites

Non-linear control - Optimal control -Multi-variables systems - Digital control -

Useful info

Place

Toulouse

Energy management for embedded systems

ECTS
3 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
40h

Presentation

Description

Ragone chart, power and energy density of various sources (primary and secondary batteries, fuel cells...)

Photovoltaic panels, thermogenerators, piezoelectric generators...

MPPT, multi-sources, auto-powering circuits ...

Composition of a DC machine with brushes; relations between external voltage and speed, between the electromagnetic torque and the current, torque to speed characteristic; electrical and mechanical equations for transient behavior; machine block diagram. Single-phase transformer; equations and electrical models; equivalent diagrams. Single and three phase diode rectifiers, instantaneous rectified voltage and average voltage; period and ripple rate; diodes sizing, power factor. Choppers, buck, boost, half and full bridge; continuous and discontinuous conduction mode; control strategies, power components for hard switching modes.

Organisation:

- The principles and theoretical basis are presented in lectures using Power Point slides whose copies are provided to students.

- In the tutorials case studies are presented for the design of certain specific elements such as machine parameters, transformer models, rectifier and converter. A handout of the tutorials is provided to students.

- The labworks deal with generation of PWM control signals for a chopper and the waveforms of current and voltage resulting in an inductive load. The H bridge is also controlled as a multilevel DC-AC inverter and an audio amplification application (class D) is implemented. Another part is devoted to the control via a microcontroller to a synchronous motor (brushless DC), this part has equal modeling with Matlab and Spice

Objectives

- At the end of this module, the student will have understood and be able to explain (main concepts):

- The performances of energy sources likely to be used in embedded systems,

- The methods of energy capture (harvesting / scavenging)

- circuit topologies for embedded energy management,

- The operation mode of a classical DC motor (actuator) as well as its electrical and mechanical characteristics.

- The operation mode of a AC transformer and its associated electrical models.

- The main structures and electrical characteristics of single and three phase rectifiers.

- The main structures of choppers, their properties, their reversibility and control strategies.

- The principle of torque and/or speed control of a DC machine using a chopper

The student will be able to:

- Analyze the energy requirements of an embedded system and to devise a solution,

- Analyze a mechanical system and identify its needs for motorizing, the type of converter that should be associated with the actuator.

- Dimension the elements of the electrical energy conversion chain which will drive the actuator.

- Choose the control strategy for the electronic switches of the converter in order to ensure its reliability.

Pre-requisites

General knowledge of electricity, alternating current, electrical circuits, analog and digital electronics as well as mathematical tools (Fourier and Laplace transforms) and the basics of automatic control (transfer functions and block diagrams).

Useful info

Place

Toulouse

Discrete and Continuous Systems Optimisation

ECTS
6 credits

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Number of hours
68h

Presentation

Description

Programme (detailed contents):

Linear programming basic concepts – Graph modelling and algorithms for paths search, trees and maximal flows. Branch and bounds methods. Application areas: allocation, transportation, production planning and scheduling.

- Markov chains with continuous and discrete time. Basic queuing systems. Performance evaluation. Applications: computer and industrial systems.

- Basic concepts of Petri Nets – analysis by marking enumeration - Structural analysis- Applications: computer and industrial systems.

- Main concepts of nonlinear programming without and with constraints (equality or inequality types).

- Application to the control of linear systems with quadratic criterion (LGR, LQG) to reach to the resolution of Riccati equations. A parallel is performed with Model Predictive Control seen as a quadratic optimization problem on a finite horizon.

- Application to the dynamic programming

Documents:

- Lecture notes on "Linear programming, Graphs and network theory"

- Lecture notes on "Stochastic processes and queuing systems"

- Lecture notes on "Petri nets"

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- different approaches to analyse, evaluate the performance of discrete event systems through different models (deterministic or stochastic, graphs) and to optimise them (linear programming)

- the optimisation methods for continuous systems :

-static (first and second order conditions)

- dynamic (dynamic programming)

- their applications to optimal or model predictive control

mainly for linear systems

The student will be able to:

- to analyse, model and solve an optimization problem of discrete systems by a linear programming or a graph, by applying relevant algorithms (simplex or usual graphs and networks algorithms)

- to model and to characterize: stationary Makovian processes with discrete state space (chains) and continuous or discrete time, queuing systems, to analyse their transient and stationary behaviours, to evaluate their performances

- to model and analyse discrete event systems by Petri nets

- to formalise and solve a quadratic criterion, nonlinear, without or with constraints optimisation problem in the case of systems with real variables

-to develop and design an optimal control law (LQG) for a linear or linearized process.

Pre-requisites

Linear algebra - Probabilities - Dynamic systems (state concept). Basic elements in

logic systems and Petri nets.

Useful info

Place

› Toulouse

Object oriented and real time programming

ECTS
6 credits

Presentation

Description

Program (detailed contents):

The module addresses the specification and design of real time systems, an introduction to main real-time operating systems services, method to program and to test a real-time application.

The construction of programs requiring the basic notions of C++ and java: class, constructor, protection, inheritance, overload, polymorphism and genericity wil be explain. Some extra Library will be used.

Organisation:

Lectures and lab work are mixed.

Main difficulties for students:

· use of parallel computing · Master the multitasking side of applications · understand the different concepts of object programming.

Objectives

This module presents real time systems, concepts, attributes, constraints, applications, and teach how to program these systems using object oriented languages and using real time operating systems. The concepts of the programming object and the use of programming language will be described.

Useful info

Contacts

Education manager
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