الجمهورية الجزائرية الديمقراطية الشعبية

People's Democratic Republic of Algeria

وزارة التعليم العالي والبحث العلمي

Ministry of Higher Education and Scientific Research

اللجنة البيداغوجية الوطنية لميدان العلوم و التكنولوجيا

National Educational Committee for the field of Science and Technology

ACADEMIC MASTER HARMONIZE

National program

2022 updated

Domain	Sector	Speciality
Science And Technologies	***Automatics***	***Automatics and industrial informatique***

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National Educational Committee for the field of Science and Technology

مواءمة
ماستر أكاديمي

نسخة 2022

الميدان	الفرع	التخصص
علوم و تكنولوجيا	آلية	آلية وإعلام آلي صناعي

I– File of the master identity

Access conditions

(To Indicate the license specialties which can give access to the Master)

Sector	Harmonized Master	Access licenses to the master's degree	Ranking according to license compatibility	Coefficient assigned to the license
Automatics	Automatics and industrial informatique	Automatics	**1**	**1.00**
		Electronic	**2**	**0.80**
		Electrical engineering	**2**	**0.80**
		Other licenses in the ST domain	**3**	**0.60**

II – Half-yearly teaching organization sheets of the specialty

Semester 1

Teaching unit	Modules	Credits	Coefficient	Weekly hourly volume			Half-yearly Hourly Volume (15 weeks)	Additional Work in Consultation (15 weeks)	Evaluation mode	
	Titled			**Course**	**T.D.**	**TP**			**Continuous monitoring**	**Exam**
Fundamental EU Code: UEF 1.1.1 Credits: 10 Coefficients: 5	Multivariable Linear Systems	6	3	3:00	1h30		67h30	82h30	40%	60%
	Signal processing	4	2	1h30	1h30		45:00	55:00	40%	60%
Fundamental EU Code: UEF 1.1.2 Credits: 8 Coefficients: 4	Converter-machine association	4	2	1h30	1h30		45:00	55:00	40%	60%
	Optimization	4	2	1h30	1h30		45:00	55:00	40%	60%
Methodological EU Code: UEM 1.1 Credits: 9 Coefficients: 5	Industrial communication networks and protocols	3	2	1h30		1h00	37:30	37:30	40%	60%
	Practical Multivariable Linear Systems	2	1			1h30	10:30	27:30	100%	
	Signal processing TP / Optimization TP	2	1			1h30	10:30	27:30	100%	
	TP Converter-machine association	2	1			1h30	10:30	27:30	100%	
EU Discovery Code: UED 1.1 Credits: 2 Coefficients: 2	Material of your choice	1	1	1h30			10:30.	02:30		100%
	Material of your choice	1	1	1h30			10:30	02:30		100%
Transversal EU Code: UET 1.1 Credits: 1	Technical English and terminology	1	1	1h30			10:30	02:30		100%

Coefficients: 1										
Total semester 1		**30**	**17**	**1:30**	**6:00**	**5:30**	**375h00**	**375h00**		

Semester 2

Teaching unit	Modules	Credits	Coefficient	Weekly hourly volume			Half-yearly Hourly Volume (15 weeks)	Additional Work in Consultation (15 weeks)	Evaluation mode	
	Titled			**Course**	**T.D.**	**TP**			**Continuous monitoring**	**Exam**
Fundamental EU Code: UEF 1.2.1 Credits: 10 Coefficients: 5	Nonlinear systems	6	3	3:00	1h30		67h30	82h30	40%	60%
	Embedded systems and real-time systems	4	2	1h30	1h30		45:00	55:00	40%	60%
Fundamental EU Code: UEF 1.2.2 Credits: 8 Coefficients: 4	Advanced API programming	4	2	1h30	1h30		45:00	55:00	40%	60%
	Applied Electronics	4	2	1h30	1h30		45:00	55:00	40%	60%
Methodological EU Code: UEM 1.2 Credits: 9 Coefficients: 5	Object Oriented Design	3	2	1h30		1h00	37:30	37:30	40%	60%
	TPNonlinear systems	2	1			1h30	10:30	27:30	100%	
	TPEmbedded systems and real-time systems	2	1			1h30	10:30	27:30	100%	
	TP Advanced API programming/Applied Electronics TP	2	1			1h30	10:30	27:30	100%	

EU Discovery Code: UED 1.2 Credits: 2 Coefficients: 2	Material of your choice	1	1	1h30			10:30	02:30		100%
	Material of your choice	1	1	1h30			10:30	02:30		100%
Transversal EU Code: UET 1.2 Credits: 1 Coefficients: 1	Compliance with standards and rules of ethics and integrity	1	1	1h30			10:30	02:30		100%
Total semester 2		**30**	**17**	**1:30**	**6:00**	**5:30**	**375h00**	**375h00**		

Semester 3

Teaching unit	Modules	Credits	Coefficient	Weekly hourly volume			Half-yearly Hourly Volume (15 weeks)	Additional Work in Consultation (15 weeks)	Evaluation mode	
	Titled			**Course**	**T.D.**	**TP**			**Continuous monitoring**	**Exam**
Fundamental EU Code: UEF 2.1.1 Credits: 10 Coefficients: 5	Advanced command	6	3	3:00	1h30		67h30	82h30	40%	60%
	Control of handling robots	4	2	1h30	1h30		45:00	55:00	40%	60%
Fundamental EU Code: UEF 2.1.2 Credits: 8 Coefficients: 4	Discrete event systems	4	2	1h30	1h30		45:00	55:00	40%	60%
	FPGA and VHDL programming	4	2	1h30	1h30		45:00	55:00	40%	60%
Methodological EU Code: UEM 2.1 Credits: 9 Coefficients: 5	Industrial supervision	3	2	1h30		1h00	37:30	37:30	40%	60%
	TPAdvanced command	2	1			1h30	10:30	27:30	100%	
	TP Control of handling robots	2	1			1h30	10:30	27:30	100%	
	FPGA practical work and VHDL programming	2	1			1h30	10:30	27:30	100%	
EU Discovery Code: UED 2.1 Credits: 2 Coefficients: 2	Material of your choice	1	1	1h30			10:30	02:30		100%
	Material of your choice	1	1	1h30			10:30	02:30		100%
Transversal EU Code: UET 2.1 Credits: 1 Coefficients: 1	Documentary research and dissertation design	1	1	1h30			10:30	02:30		100%

Total semester 3		**30**	**17**	**1:30**	**6:00**	**5:30**	**375h00**	**375h00**		

EU Discovery*(S1, S2 and S3)*

1- Virtual instrumentation
2- Image processing and vision
3- Smart sensors
4- Artificial intelligence
5- Intelligent vision
6- Robotics (Mobile robotics, Humanoid robotics, Service robotics, Environmental robotics, etc.)
7- CAD computer-aided design
8- Electric vehicles
9- Hydraulics and pneumatics
10- Web programming
11- Operational safety
12- Maintenance management
13- Applications of theTelecommunication
14- Biotechnology
15- Biomedical Technologies

Semester 4

Internship in a company or in a research laboratory culminating in a dissertation and a defense.

	VHS	coefficient	Credits
Personal work	550	09	18
Internship in a company or laboratory	100	04	06
Seminars	50	02	03
Other (Framing)	50	02	03
Total Semester 4	750	17	30

This table is given for information purposes only.

Evaluation of the End of Master Cycle Project

- Scientific value (jury assessment) /6
- Writing of the dissertation (jury assessment) /4
- Presentation and response to questions (Jury assessment) /4
- Appreciation of the supervisor /3
- Presentation of the internship report (Jury assessment) /3

III - Detailed program by subject for the first semester (S1)

Semester: 1
Teaching unit: UEF 1.1.1
Matter: multivariable linear systems
VHS: 67h30 (Class: 3h00, tutorial: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:

The objective of the course is to provide a methodology for the design of different control laws for multivariable invariant linear systems, in the context of the state approach.

Recommended prior knowledge:

The student must have the following knowledge:

- Linear closed-loop systems
- Discret Systems

Material content:

Chapter 1.Introduction (2 weeks)
Objectives of this course, Reminder of matrix calculation, Reminder of the notions of the state approach, Difference between SISO and MIMO.

Chapter 2. State representation of multivariable systems (SM). (2 weeks)
Definitions, Different representations of systems, resolution of the state equation, examples of applications

Chapter 3. Controllability and Observability. (2 weeks)
Introduction, Kalman controllability criterion, Output controllability, Observability criterion, Duality between controllability and observability, Study of some canonical forms.

Chapter 4. Representation of SM by transfer matrix.(3 weeks)
Introduction, Transition from a state representation to the transfer matrix representation, Gilbert method, Invariant method: Smith-McMillan form, Method by reduction of a realization

Chapter 5. Control by SM status feedback.(4 weeks)
Formulation of the pole placement problem by state feedback, Calculation methods for multivariable systems, State observer and control by output feedback (ie with state observer) of SMs. Non-interactive SM control, Implementation.

Evaluation method:
Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

1- De Larminat, Automatic, Hermès, 1995.
2- B. Pradin, G. Garcia; “linear automation: multivariable systems”, course handouts, INSA Toulouse, 2011.
3- Caroline Bérard,Jean-Marc Biannic,David Sausie, ''The multivariable control", Editions Dunod, 2012.
4- GF Franklin, JD Powell and AE Naaeimi, Dynamic Feedback Control Systems. (Addison-Wesly, 1991.
5- KJ Astrom, B. Wittenmark, Computer-Controlled Systems, Theory and design. Prentice Hall, New Jersey, 1990.
6- WM Wonman, Linear Multivariable Control: A Geometric approach. Springer Verlag, New York, 1985.
7- Hervé Guillard, Henri Bourlès, "System Controls. Performance & Robustness. Monovariable Multivariable Regulators Applications Courses & Corrected Exercises", Editions Technosup, 2012.
8- Caroline Bérard, Jean-Marc Biannic, David Saussié, Multivariable control, Dunod, Paris, 2012.

Semester: 1
Teaching unit: UEF 1.1.1
Subject 1: Signal processing
VHS: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Master the tools for temporal and frequency representation of analog and digital signals and systems and carry out basic processing such as filtering and digital spectral analysis.

Recommended prior knowledge:

The student must have the following knowledge:

- Signal theory
- Mathematical basics

Material content:

Chapter 1. Reminders of the main results of signal theory (2 weeks)
Signals, Fourier series, Fourier transform and Parseval's Theorem, convolution and correlation.
Chapter 2. Analysis and synthesis of analog filters (4 weeks)
Time and frequency analysis of analog filters, passive and active filters, first and second order low pass filters, first and second order high pass filters, band pass filters, other filters (Tchebyshev, Butterworth).
Chapter 3.Signal Sampling (1 Weeks)
From continuous signal to digital signal Sampling, reconstruction and quantification.

Chapter 4: Discrete Transforms and Windowing: From Discrete-Time Fourier Transform (TFTD) to Discrete Fourier Transform (TFD), Fast Fourier Transform (FFT)(3 weeks)

Chapter 5: Analysis and synthesis of digital filters (5**Weeks)**

Filter template definition

RIF and RII filters

Lattice filters

Summary of RIF filters: window method

Synthesis of RII digital filters: Bilinear method

Evaluation method:

Continuous monitoring: 40%; Examination: 60%.

Bibliographic references:

1- Francis Cottet, Signal processing and data acquisition - Courses and corrected exercises, 4th edition, Dunod, Paris, 2015.
2- Tahar Neffati, Analog signal processing: Course, Ellipses Marketing, 1999.
3- Messaoud Benidir, Theory and signal processing: Basic methods for signal analysis and processing, Dunod, 2004.
4- Maurice Bellanger, Digital signal processing: Theory and practice, 9th edition, Dunod, Paris, 2012.

5- Étienne Tisserand Jean-François Pautex Patrick Schweitzer, Analysis and processing of signals methods and applications to sound and image 2nd edition, Dunod, Paris, 2008.
6- Patrick Duvaut, François Michaut, Michel Chuc, Introduction to signal processing - exercises, corrections and course reminders, Hermes Science Publications, 1996.

Semester: 1
Teaching unit: UEF 1.1.2
Matter: Converter-machine association
VHS: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Study the different associations of converters with rotating electrical machines in order to control the torque and speed of a system.

Recommended prior knowledge:

The student must have the following knowledge:

- Power electronics.

Material content:

Chapter 1.DC-AC converters (4 Weeks)
- Uninterruptible power supply structures,
- Principle of PWM converters (PWM)

Chapter 2. DC motor: (2 weeks)
- Principle, structure and characteristics
- Speed variation.

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Chapter 3. AC Motor: (2 weeks)
- Principle, structure and characteristics
- Speed variation.

Chapter 4. Converter - machine association:(4 weeks)
- Torque and speed control,
-Speed variators for synchronous machines
-Speed variator for asynchronous machines

Chapter 5. Selection criteria and implementation of a variable speed drive.(3 weeks)

Evaluation method:
Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

1. F. LABRIQUE, G. SEGUIER, R. BAUSIERE, Volume 4: The continuous-alternating conversion, Lavoisier TEC & DOC, 2nd edition, 1992.
2. Daniel Gaude, Electrotechnics volume 2: Power electronics, electromagnetic conversion, regulation and control, Complete course illustrated with 97 solved exercises, Eyrolles, 2014.
3. Francis Milsant, Electrical machines (BTS, IUT, CNAM), vol. 3: Synchronous and asynchronous machines, Ellipses Marketing, 1991.
4. BK Bose, Power Electronics and AC drives, Prentice-Hall, 1986.

5. EDF/TECHNO-NATHAN/GIMELEC, variable speed, electronics control the movement, Nathan, 1992. 1991.
6. P. Mayé, Industrial electric motors, License, Master, engineering schools, Dunod Collection: Sciences sup 2011.
7. J. Bonal, G. Séguier, Variable speed electric drives. Volume 3, Converter-network and converter-motor-load interactions,Tec & Doc, 2000.

Semester: 1
Teaching unit: UEF 1.1.2
Subject 1: Optimization
VHS: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The objective of the course is to master the complex optimization techniques encountered in the management of large production systems, machines and materials, in industry, commerce and administration. The goal is to provide decision-making support to achieve maximum performance.

Recommended prior knowledge:

The student must have the following knowledge:

- Mathematics.

Material content:

Chapter 1. Mathematical reminders (Positivity, Convexity, Minimum, Gradient and Hessian) (2 Weeks)

Chapter 2. Optimization without constraints - local methods (3 Weeks)
One-dimensional search methods
Gradient methods
Methods of conjugate directions
Newton's method
Levenberg-Marquardt method
Quasi-Newton methods

Chapter3. Optimization without constraints - global methods (3 Weeks)

Projected gradient method
Lagrange-Newton method for inequality constraints
Projected Newton method (for bound constraints)
Penalization method
Duality method: Uzawa method

Chapter4. Linear Programming (3 Weeks)

Chapter 5. Nonlinear Programming (4 Weeks)

Evaluation method:

Continuous monitoring: 40%; Examination: 60%.

Bibliographic references: (If possible)

1- Stephen Boyd, Lieven Vandenberghe Convex Optimization,Cambridge University Press, 2004.
2- Michel Bierlaire, Optimization: principles and algorithms, EPFL, 2015.
3- Jean-Christophe Culioli, Introduction to optimization, Ellipses, 2012.
4- Rémi Ruppli,Linear programming: Ideas and methods,Ellipses, 2005.

5- Pierre Borne, Abdelkader El Kamel, Khaled Mellouli, Linear programming and applications: Course elements and solved exercises, Technip, 2004.

Semester: 1
Teaching unit: UEM 1.1
Matter: Industrial communication networks and protocols
VHS: 37h30 (Class: 1h30, TP: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

This course provides an introduction to the field of data and communications networks. It aims to familiarize students with the basic concepts of information communication networks. It introduces students to define a simple solution implementing industrial type networks

Recommended prior knowledge:

The student must have the following knowledge:

- Basic knowledge of industrial network technologies and uses.

Material content:

Chapter 1. Reminders on OSI and TCP/IP network models (1 Week)

Chapter 2. Communications Bus (3 Weeks)

- Traditional
- Emerging

Chapter 3. Industrial wireless communications protocols (WirelessHart) (2 Weeks)

Chapter 4. Security of industrial wireless communication networks (2 Weeks)

Chapter 5. Diagnostics of industrial communications networks (3 Weeks)

Chapter 6. Network monitoring (2 weeks)

Chapter 7.OPC servers/clients (OLE (Object Linking and Embedding) for Process Control) (2 Weeks)

TP Content of the subject:

Provide some practical work in relation to the available material.

Evaluation method:

Continuous monitoring: 40%; Examination: 60%.

Bibliographic references:

1- A. Tanenbaum, Networks: Architecture, protocol, applications, Inter Editions - Collection iia

2- Gildas Avoine, Pascal Junod, Philippe Oechslin: Computer Security, Vuibert.
3- Malek Rahoual, Patrick Siarry, Computer networks: design and optimization, Editions Technip, 2006.
4- Guy Pujolle, Networks, 5th edition, Eyrolles, 2006.
5- Paul Mühlethaler, 802.11 and Wireless Networks, Eyrolles, 2002.
6- Khaldoun Al Agha, Guy Pujolle, Guillaume Vivier, Mobile networks and wireless networks, Eyrolles, 2001.

Semester: 1
Teaching unit: UEM 1.1
Material: TP multivariable linear systems
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

The objective is to provide a methodology for the design of different control laws for multivariable invariant linear systems, namely: control by state and output feedback.

Recommended prior knowledge

Prior knowledge of linear algebra, multivariable linear servo systems.

Material content:

TP1 Introduction to Matlab
TP2 Representation state of multivariable systems
TP3 Controllability and Observability.
TP4 Representation of SM by transfer matrix.
TP5 Control by SM status feedback.
TP6: SM state observation

Evaluation method:100% continuous assessment

Semester: 1
Teaching unit: UEM 1.1
Material: TP Signal processing/ Optimization TP
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

For the TP TS, Consolidate the knowledge acquired during the course of the subject "Signal processing" through practical work to better understand and assimilate the content of this subject.

For the optimization TP, allow students to use and master the theoretical concepts studied during the course.

Recommended prior knowledge

Course content

Material content:

TP Signal processing:

TP 1 – Signal representation and applications of the Fourier transform in Matlab
TP 2 - Analog Filtering
TP3- Discrete Fourier Transform
TP 4- RII Digital Filtering
TP5- RIF Digital Filtering

Optimization TP:

TP1 Introduction to Matlab
TP2 Optimization without constraints
TP3 Optimization without constraints
TP4 Linear programming
TP5 Nonlinear programming

Evaluation method: 100% continuous assessment

Semester: 1
Teaching unit: UEM 1.1
Material: TP Converter-machine association
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

This practical work will allow the student to put into practice and consolidate the knowledge acquired in the converter-machine association module.

Recommended prior knowledge

Course content.

Material content:

TP 1 DC-AC converters
TP 2 Speed variator for DC motor
TP 3 Speed variator for AC motor
TP 4 Speed variator for synchronous machines
TP 5 Speed variator for asynchronous machines

Evaluation method: 100% continuous assessment

Semester: 1
Teaching unit: UET 1.1
Subject 1:Technical English and terminology
VHS: 10:30 p.m. (Class: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

Introduce the student to technical vocabulary. Strengthen your knowledge of the language. Help him to understand and synthesize a technical document. Allow him to understand a conversation in English held in a scientific framework.

Recommended prior knowledge:

Basic English vocabulary and grammar

Material content:

- Written comprehension : Reading and analysis of texts relating to the specialty.

- Oral comprehension: Based on authentic popular science video documents, note taking, summary and presentation of the document.

- Oral expression: Presentation of a scientific or technical subject, development and exchange of oral messages (ideas and data), Telephone communication, Gestural expression.

- Written expression : Extraction of ideas from a scientific document, Writing a scientific message, Exchange of information in writing, writing CVs, application letters for internships or jobs.

Recommendation :It is strongly recommended that the person responsible for the subject presents and explains at the end of each session (at most) around ten technical words of the specialty in the three languages (if possible) English, French and Arabic.

Evaluation method:

Review: 100%.

Bibliographic references:

1. *PT Danison, Practical guide to writing in English: uses and rules, practical advice, Editions d'Organization 2007*
2. *A.Chamberlain, R. Steele, Practical guide to communication: English, Didier 1992*
3. *R. Ernst, Dictionary of applied techniques and sciences: French-English, Dunod 2002.*
4. *J. Comfort, S. Hick, and A. Savage, Basic Technical English, Oxford University Press, 1980*
5. *EH Glendinning and N. Glendinning, Oxford English for Electrical and Mechanical Engineering, Oxford University Press 1995*
6. *TN Huckin, and AL Olsen, Technical writing and professional communication for nonnative speakers of English, McGraw-Hill 1991*
7. *J. Orasanu, Reading Comprehension from Research to Practice, Erlbaum Associates 1986.*

IV - Detailed program by subject for the second semester

Semester: 2
Teaching unit: UEF 1.2.1
Subject 1: Nonlinear systems
VHS: 67h30 (Class: 3h00, tutorial: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:

The objective of this course is: to make students aware of the stability problems of nonlinear systems and to provide them with mathematical analysis tools, to introduce nonlinear control methods such as techniques based on differential geometry and approach using sliding modes. The methodologies presented use both temporal and frequency representations.

Recommended prior knowledge:

The student must have the following knowledge:

- Signal theory
- Mathematical basics

Material content:

Chapter 1: Introduction: **(1 Weeks)**
Static nonlinearity and Balance Points, examples of nonlinear systems.
The simple pendulum. The nonlinear electric oscillator. Limit cycles. Chaotic orbits. The chaotic pendulum. The polar pendulum. The crane.

Chapter2: Phase plan: **(3 weeks)**
Second order systems. Construction of the phase portrait. Elimination of implicit/explicit tense. Isocline method. Van der Pol oscillator. Recall linear systems: characterization of orbits by eigenvalues. Index of singular points. The index theorem. The Poincaré-Bendixson theorem. Bendixson's condition.

Chapter 3: First harmonic method: **(3 weeks)**
Hypotheses. Decomposition into harmonics. Equivalent to the first harmonic. Common nonlinearities. Saturation. Dead zone. Relay. Hysteresis. Linear system and regulator. Nyquist criterion. Additional complex gain. Modified Nyquist criterion. Estimation of limit cycle parameters. Equivalent independent of frequency. Reliability of the analysis by the first harmonic.

Chapter 4: Foundations of Lyapunov Theory: **(2 weeks)**
Stability: intuitive definition. Distance concept. Stability: formal definition. Asymptotic stability. Direct Lyapunov method. Positive definite function. Lyapunov function. Example: robot. Local stability theorem. Exponential stability. Overall stability. Lyapunov function for linear systems. Local stability and linearization. Disadvantages of the indirect method. LaSalle invariance theorem. Krasovskii method. Variable gradient method. Instability and Chetaev's theorem.

Chapter 5: Theory of Passivity: **(2 weeks)**
Intuition. Static system. Storage function. Parallel / serial / feedback connection. Passivity and linear system SISO. Positive real system. Link between Lyapunov and positive real system. Kalman-Yakubovich-Popov theorem. Absolute stability. Aizerman conjecture. Circle criterion. Popov criterion.

Chapter 6: Concept of differential geometry: **(3 weeks)**
Vector field. Dual space. Covector. The gradient seen as a field of covectors. Lie derivative. Lie hook.

Diffeomorphism. Frobenius' theorem. Involutionary family. Linearization conditions. Return to the flexible joint robot example.

Chapter 7. Control of nonlinear systems (3 weeks)
1. General
2. Control by linearization
3. Control by sliding modes

Evaluation method:

Continuous monitoring: 40%; Examination: 60%.

Bibliographic references:

1. Ph. Müllhaupt,Introduction to the analysis and control of nonlinear systems, PPUR, 2009.
2. Gille, JC, Decaulne, P., Pelegrin, M., Methods for studying nonlinear servo systems, Dunod, 1975.
3. Atherton, DP, 'Nonlinear Control Engineering. Describing Function Analysis and Design', Van Nostrand Reinhold Company, 1975.
4. Utkin, VI, 'Sliding modes and their application to variable structure systems', MIR Publishers, 1978.
5. Khalil, HK, 'Nonlinear systems', Prentice Hall, Englewood Cliffs, NJ, 1980.
6. Nijmeijer, H., Van der Shaft. AJ, 'Nonlinear dynamical control systems', Springer Verlag, 1990.
7. Isidori, A., 'Nonlinear control systems.', Springer Verlag, 1995.
8. Yves Granjon, Automatic - Linear and nonlinear systems - 2nd edition: Courses and corrected exercises, Dunod; Edition: 2nd edition, 2010.
9. RASVAN Vladimir, STEFAN Radu, Nonlinear systems: theory and applications, Lavoisier, 2007.
10. J.-C. Chauveau, Linear and nonlinear servo systems: Exercises and solved problems, Educalivre, 1995.
11. Philippe Müllhaupt, Introduction to the analysis and control of nonlinear systems, PPUR, 2009.

Semester: 2
Teaching unit: UEF 1.2.1
Matter: Embedded systems and real-time systems
VHS: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The objective of this course is to give students an introduction to real-time systems. These systems are generally embedded systems (several communicating hardware and software components) and are used in environments known by their critical nature where any failure can have serious consequences on human life and the environment. The course gives a precise definition of real-time and embedded systems and discusses their characteristics as well as the methods, mechanisms and languages used for the design and development of such systems.

Recommended prior knowledge:

The student must have the following knowledge:

- Programming in C
- Basics in digital electronics and micro controllers

Content of the material:

A. Embedded systems

Chapter 1 Architecture of Embedded Systems Based on Microcontrollers **(1 week)**
History, Definition, Types of Embedded Systems, Introduction of the architecture of the microcontroller used in this course (AVR, PIC, etc.) as an embedded system
Chapter 2–digital and analog inputs/outputs **(1 week)**
Chapter 3 –synchronous/asynchronous serial communication **(3 weeks)**
Chapter 4 –Timers and counters **(2 weeks)**

B. Real-Time Core

Chapter 5 –interruptions **(1 week)**
Chapter 6 –Introduction to real-time systems **(1 week)**
Chapter 7 –Osa – RTOS operation **(1 week)**
Chapter 8 –Core and services **(3 weeks)**
Chapter 9 –Automatic applications **(2 weeks)**

Evaluation method:

Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

1. Francis Cottet, Emmanuel Grolleau, Embedded real-time systems - 2nd ed. - Specification, design, implementation and temporal validation, Dunod, 2014.
2. Nicolas Navet, Real-time systems - Volume 2: Scheduling, networks and quality of service, Hermès – Lavoisier, 2006.
3. Philippe Louvel, Embedded electronic systems and transport, 2012, Dunod
4. Yassine Manai, Embedded systems design methodology, 2011, Dunod
5. Bernard Chauvière, Embedded real-time systems: Scheduling techniques and evaluation of quality of service European University Editions, 2010.

Semester: 2
Teaching unit: UEF 1.2.2
Matter: Advanced PLC programming
VHS: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Learn more about programming complex functions and Inputs/Outputs. Implement and use programming and development tools for a project with practical applications, master the exchange of information between automatons and intelligent equipment via a field network.

Recommended prior knowledge:

API taught in L3-S4; combinatorial and sequential logic; Sensors and actuators.

Material content:

Chapter 1 :General information on automated production systems (1 week)
- Concepts of automated systems
- Hardware and software architecture of an automated system
- Examples of automated systems
- From hardwired logic to programmed logic

Chapter 2: Programmable Logic controllers (3 weeks)
- What is a programmable controller
- The different types of automata
- The constituent elements of automata
- The criteria for choosing an automaton
- The different types of PLC data
- Discrete input/output cards
- Analog input/output cards
- PLC regulation cards
- Axis control cards
- Quick counting cards

Chapter 3: Programming PLCs (5 weeks)
- Introduction to combinatorial logic
- Logic equations and logic gates
- Introduction to grafcet
- Ladder language
- Translation of a grafcet into ladder
- Transcription of specifications in grafcet
- Programming languages

Chapter 4: SCADA supervision systems (2 weeks)
- Usefulness and importance of industrial supervision
- Industrial supervision software
- Criteria for choosing supervision software

Chapter 5: Introduction to field networks for PLCs (4 weeks)
- Introduction: Role and interest of communication networks

Network characteristics:

• General information on standardization.
• Transmission media: twisted pair, coaxial cable, optical fiber.
• Transmission standards: BC20mA, RS232, RS422/485…
• Network principles: topologies, access methods, protocols, etc.
Level networks
• TELWAY7, FIPWAY / FIPIO
• MODBUS PLUS.
• PROFIBUS DP
• UPS
• DEVICE NET, ETHERNET
Choice and implementation of communication networks:
• Decomposition of an automation into sub-assemblies.
• Synchronization of subsets.
• Presentation of heterogeneous networks
• Presentation of communication modules and possible gateways between different types of networks.
• Application on an example project

Evaluation method:

Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

1. William Bolton, "Industrial programmable logic controllers", 2nd ed, Dunod, 2015.
2. Guide to automation solutions, Technical Publications, Schneider, 2008
3. John R. Hackworth and Frederick D. Hackworth, Jr. Programmable Logic Controllers: Programming Methods and Applications, Ed, Prentice Hall, 2004.
4. LA Bryan, EA Bryan, Programmable Controllers Theory and Implementation: Theory and Implementation, Amer Technical Pub; 2 Sub edition, 2003.
5. Madhuchhand Mitra & Samarjit Sengupta, Programmable Logic Controllers and Industrial Automation: An Introduction, Penram International Publishing, 2009.
6. Frank Petruzella Programmable Logic Controllers 5th Edition, McGraw-Hill Education; 5 edition, 2016.
7. Max Rabiee Programmable Logic Controllers: Hardware and Programming 3rd Edition, Goodheart-Willcox; 3 edition, 2012.
8. William Bolton Programmable Logic Controllers, Sixth Edition 6th Edition, Newnes; 6 edition, 2015.

Semester:2
Teaching unit: UEF 1.2.2
Subject: Applied electronics
VHS: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Introduce the student to other main functions of electronics. The student must first be able to identify the type and function of an electronic component in a global system (even in industry). It must then be able to carry out measurements on an electronic circuit (possibility of modifications or troubleshooting). He must be able to provide a solution to problem situations (design and carry out analog electronic circuits).

Recommended prior knowledge:

The student must have the following knowledge:

- Fundamental electronics
- Power electronics

Material content:

Chapter 1: Reminder on the transistor in switching and charging and discharging of a capacitor (1 week)
Chapter 2: The operational amplifier and AO-based assemblies (2 weeks)

- Linear mode operation
- Non-linear mode operation

Chapter 3: Generation of Pulses (signals) (3 weeks) - Astable (at AOP, at NE555, with logic gates) - Monostable (at AOP, at NE555, with logic gates)
- Schmitt Trigger (at AOP).
Chapter 4: CAN converter, CNA (3 weeks)
Chapter 5: Study of active filters (2 weeks)
Chapter 6: Introduction to the principles of producing PCB printed circuits (4 weeks)

- PCB manufacturing technology
- Realization rules (routing, multilayers)

Evaluation method:

Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

1. Yves Granjon, Bruno Estibals, Serge Weber, Electronics - The whole course in files, Collection: The whole course in files, Dunod, 2015.
2. Albert Paul Malvino, David J. Bates Principles of electronics, Courses and corrected exercises, 8th edition, Dunod, 2016.
3. Charles Adams Platt, Xavier Guesnu, Eric Bernauer, Antoine Derouin, Electronics in practice: 36 fun experiences, Eyrolles, 2013.
4. François de Dieuleveult, Hervé Fane, Principles and practice of electronics, volume 1: Calculation of circuits and functions, Dunod, 1997.
5. François de Dieuleveult, Hervé Fanet Principles and practice of electronics, volume 2: Digital and mixed functions, Dunod, 1997.
6. Christophe François, Romain Dardevet, Patrick Soleilhac, Electrical Engineering: Analog Electronics Digital Electronics Exercises and Corrected Problems, Ellipses Marketing 2006.

7. Mohand Mokhtari Applied Electronics, Electromechanics under Simscape & Sim Power Systems (Matlab/Simulink), Springer-Verlag Berlin and Heidelberg GmbH & Co 2012.
8. 6. P. Mayeux, “Learning electronics through experimentation and simulation”, ETSF, 2006.

Semester: 2
Teaching unit: UEM 1.2
Matter: Object Oriented Design
VHS: 37h30 (Class: 1h30, TP: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

Teach the student the basic concepts of object-oriented programming as well as mastery of project development techniques, at the end the student will be able to:
Create computer applications based on the object programming approach.
Develop human machine interface applications (C++, Java) under Windows or Android environment.

Recommended prior knowledge:

Basic knowledge of C programming, Algorithmics.

Material content:

Chapter 01: Introduction to the Object approach **(01 week)**
Why use object-based technologies?, The challenges of new IT: modularity (Plug-Ins), reusability, scalability. The use of component libraries.

Chapter 2. Basics **(2 weeks)**
Reminders on control structures, functions, arrays, recursion, files, pointers and references, pointers and arrays, dynamic memory allocation.

Chapter 3. Classes and objects **(3 weeks)**
Class declaration, Instance variables and methods, Definition of methods, Access rights and encapsulation, Prototype and definition separations, Constructor and destructor, Constant methods, Association of classes with each other, Classes and pointers.

Chapter 4. Inheritance and polymorphism **(3 weeks)**
Inheritance, Inheritance rules, Constructor chaining, Base classes, Preprocessor and compilation directives, Polymorphism, Abstract methods and classes, Interfaces, Uniform processing, Dynamic arrays, Method chaining, Implementation of virtual methods, Nested classes.

Chapter 5. Containers, iterators and functors **(3 weeks)**
Sequences and their adapters, Associative tables, Choosing the right container, Iterators: boosted pointers, The full power of list and map, Functor: the object version of functions, Fusion of the two concepts.

Chapter 6. Advanced concepts **(2 weeks)**
Exception handling, Standard exceptions, Assertions, Template functions, template specialization, Template classes.

Evaluation method:

Continuous monitoring: 40%; Exam: 60%.

TPObject-oriented design:

TP1: Classes and objects
TP2: Inheritance and polymorphism
TP3: Memory management
TP4: Templates
TP 5: Object-oriented example (for example Create a small object-oriented game in C++ or Java)

Evaluation method:

Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

1- Bertrand Meyer,Object-oriented design and programming,Eyrolles, 2000.
2- Franck Barbier,Object-oriented design in Java and C++: A comparative approach,Pearson Education, 2009.
3- Edward Yourdon, Peter Coad,Object-oriented design,Dunod, 1997.
4- Hugues Bersini,Object-oriented programming. UML 2 courses and exercises with Java, C#, C++, Python, PHP and LINQ,Eyrolles; 6th edition, 2013.
5- Claude Delannoy,Learn about programming and object-oriented: With examples in C, C++, C#, Python, Java and PHP,Eyrolles; 2nd edition, 2016.
6- Luc GERVAIS, Learn Object Oriented Programming with the C# language (2nd edition),ENI Editions; 2nd edition, 2016.
7- Thierry GROUSSARD Luc GERVAIS, Java 8 - Learn Object Oriented Programming and master the language (with exercises and answers),ENI Editions, 2015.
8- Luc GERVAIS, Learn Object Oriented Programming with the Java language,ENI, 2014.

Semester: 2
Teaching unit: UEM 1.2
Matter: TP Nonlinear systems
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

SNL TP: Show the difference between the dynamic behavior of linear and nonlinear systems. Show the concept of a point of balance. Show by simulation the interest of the phase plane. Synthesis of nonlinear systems.

Recommended prior knowledge

Course content

Content of the subject Nonlinear Systems:

TP 1: Advanced simulation into Matlab
TP 2: Simulation of the equilibrium points of some nonlinear systems
TP 3: Simulation of some nonlinear systems in the phase plane
TP4: Simulation of the inverse pendulum in open loop
TP5: Simulation of linearizing control
TP6: Control by sliding modes

Evaluation method: 100% continuous assessment

Semester: 2
Teaching unit: UEM 1.2
Matter: TP Embedded systems and real-time systems
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

For this practical work, the objective is to provide a methodology for the design of embedded applications, namely: the implementation of digital and analog input/output operations (sensors and actuators), the means of communication with the environment exterior (HMI, Labview, etc.) and an introduction to programming real-time systems. The practical work will be done on an ArduinoMega type development board and programming will be done with the AVR Studio IDE.

The AVR was chosen, since the Arduino card (widespread development card) is based on this architecture; However, any other architecture fits this course perfectly.

Recommended prior knowledge

Course content.

Material content:

TP1: Introduction to the AVR Studio IDE: Project creation, C compilation, Debugging, Uploading to the Arduino board.
TP2: Digital inputs/outputs: LED display, Relay, 7 segments, 16-key keyboard reading.
TP3: Analog/digital conversion: LM35 temperature sensor, reading of voltages, currents.
TP4: USART serial communication: Display of analog quantities on PC.
TP5: PWM signal generation, control of a DC motor.
TP6: Introduction to the OSA real-time system, creation of OSA projects.
TP7: Application of real-time control to the speed regulation of a DC motor.

Evaluation method:100% continuous assessment

Semester: 2
Teaching unit: UEM 1.2
Matter: TP Advanced PLC programming/Applied Electronics TP
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

TP Prog PLC: Consolidation of knowledge acquired in advanced PLC programming subjects to better understand and assimilate:

The structure of an automated system, the programming of complex functions and Inputs and Outputs and the communication interfaces between automatons.

TP EA: The aim of the practical work is to give students the opportunity to produce electronic assemblies on a test board and then validate their operation using measuring devices.

Recommended prior knowledge

Course content.

Content of the Advanced API Programming TP subject:

Provide some practical work in relation to the available material.

Content of the Applied Electronics TP subject:

TP1: Study of the FET and MOS field effect transistor amplifier:
TP2: Operational amplifiers
TP3: Study of an example of a CAN circuit, Study of an example of a CNA circuit.
TP4: Oscillators
TP5: Active filters(low pass, high pass…)
TP6:**Creating an electronic assembly:**
The person responsible for this subject as well as the student are free to propose the creation of other arrangements.

Evaluation method:100% continuous assessment

Semester: 2
Teaching unit: UET 1.2
Subject: Respect for standards and rules of ethics and integrity.
VHS: 10h30 (Class: 1h30)
Credit: 1
Coefficient: 1

Teaching objectives:

Develop students' awareness of respect for ethical principles and the rules that govern life at university and in the world of work. Raise awareness about respecting and valuing intellectual property. Explain to them the risks of moral evils such as corruption and how to combat them, alert them to the ethical issues raised by new technologies and sustainable development.

Recommended prior knowledge:

Ethics and professional conduct (the foundations)

Content of the material:

A. The respect of the rulesethics and integrity,

1. **Reminder on the MESRS Charter of Ethics and Professional Conduct:** Integrity and honesty. Academic freedom. Mutual respect. Requirement for scientific truth, objectivity and critical thinking. Equity. Rights and obligations of the student, the teacher, administrative and technical staff,

2. Integrity and responsible research

- Respect for ethical principles in teaching and research
- Responsibilities in teamwork: Professional equality of treatment. Conduct against discrimination. The search for the general interest. Inappropriate conduct in the context of collective work
- Adopt responsible conduct and combat abuses: Adopt responsible conduct in research. Scientific fraud. Conduct against fraud. Plagiarism (definition of plagiarism, different forms of plagiarism, procedures to avoid unintentional plagiarism, detection of plagiarism, sanctions against plagiarists, etc.). Falsification and fabrication of data.

3. Ethics and professional conduct in the world of work:

Legal confidentiality in business. Loyalty to the company. Responsibility within the company, Conflicts of interest. Integrity (corruption in the workplace, its forms, its consequences, methods of combating and sanctions against corruption)

B- Intellectual property

I- Fundamentals of intellectual property

1- Industrial property. Literary and artistic property.
2- Rules for citing references (books, scientific articles, communications in a congress, theses, dissertations, etc.)

II- Copyright

1. Copyright in the digital environment

Introduction. Copyright data bases, software copyright. Specific case of free software.

2. Copyright in the Internet and e-commerce

Domain name law. Intellectual property on the internet. E-commerce site law. Intellectual property and social networks.

3. Patent

Definition. Rights in a patent. Usefulness of a patent. There patentability. Patent application in Algeria and around the world.

III- Protection and valorization of intellectual property

How to protect intellectual property. Violation of rights and legal tool. Evaluation of intellectual property. Protection of intellectual property in Algeria.

C. Ethics, sustainable development and new technologies

Link between ethics and sustainable development, energy saving, bioethics and new technologies (artificial intelligence, scientific progress, Humanoids, Robots, drones,

Evaluation method:

Review: 100%

Bibliographic references:

1. Charter of university ethics and professional conduct,https://www.mesrs.dz/documents/12221/26200/Charte+fran__ais+d__f.pdf/50d6de61-aabd-4829-84b3-8302b790bdce
2. Orders No. 933 of July 28, 2016 setting the rules relating to the prevention and fight against plagiarism
3. The ABCs of Copyright, United Nations Educational, Scientific and Cultural Organization (UNESCO)
4. E. Prairat, On teaching ethics. Paris, PUF, 2009.
5. Racine L., Legault GA, Bégin, L., Ethics and engineering, Montreal, McGraw Hill, 1991.
6. Siroux, D., Deontology: Dictionary of Ethics and Moral Philosophy, Paris, Quadrige, 2004, p. 474-477.
7. Medina Y., Ethics, what will change in the company, Editions d'Organisation, 2003.
8. Didier Ch., Thinking about the ethics of engineers, Presses Universitaires de France, 2008.
9. Gavarini L. and Ottavi D., Editorial. of professional ethics in training and research, Research and training, 52 | 2006, 5-11.
10. Caré C., Morality, ethics, deontology. Administration and education, 2nd quarter 2002, n°94.
11. Jacquet-Francillon, François. Concept: professional ethics. The telemaque, May 2000, n° 17
12. Carr, D. Professionalism and Ethics in Teaching. New York, NY Routledge. 2000.
13. Galloux, JC, Industrial property law. Dalloz 2003.
14. Wagret F. and JM., Patent of invention, trademarks and industrial property. PUF 2001
15. Dekermadec, Y., Innovating through patents: a revolution with the internet. INSEP 1999
16. AEUTBM. The engineer at the heart of innovation. Belfort-Montbéliard University of Technology
17. Fanny Rinck and Léda Mansour, literacy in the digital age: copying and pasting among students, University of Grenoble 3 and University of Paris-Ouest Nanterre la Défense Nanterre, France
18. Didier DUGUEST IEMN, Cite your sources, IAE Nantes 2008
19. Similarity detection software: a solution to electronic plagiarism? Report of the Working Group on Electronic Plagiarism presented to the CREPUQ Subcommittee on Pedagogy and ICT
20. Emanuela Chiriac, Monique Filiatrault and André Régimbald, Student guide: intellectual integrity plagiarism, cheating and fraud… avoiding them and, above all, how to properly cite your sources, 2014.
21. Publication of the University of Montreal, Plagiarism prevention strategies, Integrity, fraud and plagiarism, 2010.

22. Pierrick Malissard, Intellectual property: origin and evolution, 2010.
23. The website of the World Intellectual Property Organizationwww.wipo.int
24. http://www.app.asso.fr/

III - Detailed program by subject for the third semester

Semester: 3
Teaching unit: UEF 2.1.1
Matter: Advanced command
VHS: 67h30 (Class: 3h00, tutorial: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:

This subject aims to enable students to master efficient correction synthesis tools which take into account the real operating conditions of physical systems: Parametric uncertainties, neglected dynamics, parameters varying over time, presence of disturbances and measurement noise . The control techniques taught make it possible to maintain a level of performance despite the presence of all these constraints.

Recommended prior knowledge:

Continuous and sampled linear systems, analysis of nonlinear systems, optimization

Content of the material:

Part 1: Optimal Order (5 weeks)

1.1. Introduction and mathematical tools for dynamic optimization
1.2. Order in minimum time
1.3. Quadratic Linear Control
1.4. Gaussian Quadratic Linear Control

Part 2: Adaptive Control (5 weeks)

3.1. Direct and indirect adaptive control
3.2. Reference Model Adaptive Control (MRAC)
3.3. Summary of MRAC by MIT approach
3.4. Synthesis of MRAC by Lyapunov approach
3.5. Synthesis of MRAC in state space
3.6. Self-adjusting regulators (STR): Direct approach
3.7. Self-adjusting regulators (STR): Indirect approach

Part 3: Predictive ordering (5 weeks)

4.1. Principle of predictive control
4.2. Predictor of a numerical system
4.3. GPC control, optimal predictor
4.4. GPC control under constraints
4.5. Predictive control using a state approach (State Space Model Predictive Control)

Evaluation method:

Continuous monitoring: 40%; Exam: 60%

Bibliographic references:

1- ID Landau Identification and control of systems, Hermès, 1993.
2- KJ Astrom and B. Wittenmark, Adaptive control., Dover, 2008.
3- ID Landau, R. Lozano, M. M'Saad, and A. Karimi, Adaptive control. Springer, 2011.
4- VV Chalam, Adaptive control systems: Techniques and applications. Marcel Dekker, 1987
5- P. Boucher and D. Dumur, Predictive control, Technip, 1996.
6- JA Rossister, Model-Based Predictive Control: A Practical Approach, CRC Press, 2003
7- JM Maciejowski, Predictive Control: With Constraints, Prentice Hall, 2002
8- EFCamacho, CB Alba, Model predictive control. Springer, 2013
9- K. Zhou and JC Doyle, Essentials of Robust Control,. Prentice Hall, 1997.
10- D. Alazard, et al. Robustness and optimal control. Editions Cépaduès (2000)
11- G. Duc, S. Font, H∞ Command and μ-Analysis, tools for robustness, Hermes (1999)
12- S. Skogestand, I. Postlethwaite, Multivariable Feedback Control. Analysis and Design. Wiley 2005.
13- Daniel Liberzon. Calculus of Variations and Optimal Control Theory: A Concise Introduction. Princeton University Press, 2012.
14- Kemin zhou,John C. Doyle,**Keith Glover.***Robust and Optimal Control*.Prentice Hall, 1995.
15- Hence P. Geering. Optimal control with engineering application. Springer, 2007.
16- Joao P. Hespanha. Undergraduate reading notes on LQG LQR controller design. 2007.

Semester: 3
Teaching unit: UEF 2.1.1
Subject 1: Control of handling robots
VHS: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

This subject aims to enable students to master the modeling tools and control techniques of manipulating robots. It aims to give students the opportunity to independently undertake the resolution of a certain number of basic robotics problems such as configuration, trajectory generation, dynamic control.

Recommended prior knowledge:

- Linear automatic and servo control.
- Basic notions in: kinematics and dynamics.

Content of the material:

I-Introduction (1 week)

- 1. Definition and history
- 2. Different categories of robots
- 3. Robotics vocabulary
- 4. Characterization of robots
- 5. The different types of manipulator robots
- 6. Use of robots
- 7. Future of robotics

II- Theoretical foundations and preliminary mathematics (2 weeks)

- 1. Positioning
  - 1.1. Rotation
  - 1.2. Rotation representations
  - 1.3. Attitude
  - 1.4. Homogeneous transformation matrices
- *2.*Cinematic
  - 2.1. Speed of a solid
  - 2.2. Rotation speed vector
  - 2.3. Rigid movement
  - 2.4. Kinematic torque and speed composition

III- Modeling a manipulator robot (3 weeks)

- 1. Geometric model
  - •Denavit-Hartenberg Convention
  - • Direct geometric model
  - • Inverse geometric model
- 2. Kinematic model
  - •Direct analysis (use of direct Jacobian)
  - •Reverse analysis (use of the inverse Jacobian)
  - •Notion of Singularity
- 3. Dynamic model
  - •Formalisms for dynamic modeling
    - •Lagrange method: Lagrange equation, matrix representation (inertia matrix, Coriolis matrix, gravity matrix).
      - • Example (Plane robot with 1 or 2 DOF)

IV- Trajectory generation (3 weeks)

- generation of trajectories and control loops
- generation of point-to-point movement: basic method, acceleration profile method, speed profile method, application in joint space, application in Cartesian space.
- Generation of movement by interpolation: application in joint space and Cartesian space

V- Ordering robots (3 weeks)

- 1.Dynamic control
- 2. Control by sliding mode

VI- Robot programming (3 weeks)

- 1. Generalities and objectives of programming systems
- 2. Programming methods
- 3. Characteristics of different programming languages

Evaluation method:

Continuous monitoring: 40%; Exam: 60%

Bibliographic references:

1. MW Spong, S. Hutchinson, M. Vidyasagar, Robot Modeling and Control, Wiley, 1st ed., 2006.
2. JJ Craig, Introduction to Robotics: Mechanics and Control, Pearson Education, 3rd ed., 2008.
3. Philippe Coiffet, Robotics, Principles and Applications,Hermes, 1992.
4. Reza N. Jazar, Theory of Applied Robotics, Kinematics, Dynamics and Control. Springer 2007.
5. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, Robot Modeling and Control, Wiley, 1989.
6. Bruno Siciliano et al, Robotics, Modeling planning and Control, Springer, 2009.
7. W. Khalil & E. Dombre, modeling, identification and control of robots, Hermès, 1999.

Semester: 3
Teaching unit: UEF 2.1.2
Matter: Discrete event systems
VHS: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The objective of the first part of this subject consists of the modeling of Discrete Event Systems (SED) by Petri net autonomous, the construction of marking and/or coverage graphs and the analysis of these systems. The second part of the course is devoted to the control by supervision of SEDs. Finally, we will see in the third part, timed systems.

Recommended prior knowledge:

Basic automatic (control and regulation). Algorithmic.

Material content:

Chapter 1: Introduction to SED (1 week)

- **I.1. Models and systems**
  - 1.1 System: definition
  - 1.2 Model: definition
- **I.2. Continuous, discrete, hybrid systems**
  - 2.1 Hybrid system and definitions
  - 2.2 Examples of discrete systems
- **I.3. Application areas**
  - 3.1 Domains
  - 3.2 Characteristics

Chapter 2: Modeling SEDs (6 weeks)

- **II.1. Introduction**
- **II.2. Languages and automata**
  - 2.1. Languages
  - 2.2. Automata: Finite State Machine (MAF)
  - 2.3. Design of state machines
- **II.3. RDP modeling**
  - 3.1. Ordinary RDP
  - 3.2. Timed RDP
  - 3.3. Synchronized RDP
  - 3.4. RDP interpreted command
- **II.4. Grafcet modeling**
- **II.5. Algebra of dioids or Max+**

Chapter 3: Order by supervision of SEDs (5 weeks)

- **III.1. Introduction to RW theory**
- **III.2. Order under constraints**
- **III.3. Controller synthesis for SEDs modeled by Finite State Automata**
- **III.4. Controller synthesis for SEDs modeled by RDP (desinvariant method)**
- **III.5. Controller synthesis for SEDs modeled by Grafcet**

Chapter 4: Extensions and Conclusion (3 weeks)

- **IV.1. Control by modular, hierarchical supervision, partial observation, Max+**
- **IV.2. Taking time into account**
    - 2.1. Timed RDP and Grafcet
    - 2.2. Timed automata
    - 2.3. Algebra of dioids or Max+

Evaluation method:

Continuous monitoring: 40%; Examination: 60%.

Bibliographic references:

1- BRAMS, Mathematical approach to Petri nets, MASSON 1987
2- JM Proth,X. Xie, Modeling of production systems, DUNOD 1992
3- A. Marsan, S. Donatelli. Modeling with generalized stochastic Petri Nets, Willey 1995
4- M. Cassandras, S. Lafortune. Introduction to DES, Willey 1999.
5- A.David and H Alla.From Grafcet to Petri Nets, Hermes. 1992.
6- vs.Cassandras and S. Lafortune.Introduction to discrete Ewind Systems.Kluwer Academic,2008.

Semester: 3
Teaching unit: UEF 2.1.2
Subject 1: FPGA and VHDL programming
VHS: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

This module teaches the different technologies of digital circuits, the design methodologies of high density VLSI integration circuits as well as the development tools necessary for hardware description such as CAD (Computer Aided Design) tools and programming languages. high level of material description.

Recommended prior knowledge:

1. The coding of numbers.
2. Combinatorial circuits.
3. Sequential circuits.

Material content:

Chapter 1. The VHDL language. **(2 weeks)**

Design units. Levels of description. Library organization. The elements of language. The objects of language. Data categories. Modeling by generic parameters. Types of instructions. Subroutines. Functional simulation of circuits: Test-Bench.

Chapter 2. Digital circuits. **(3 weeks)**

Classic architectures of digital circuits. Standard circuits: simple functions, microprocessors and DSPs, memories. Circuits specific to the ASIC application: pre-broadcast, on-demand circuits, pre-characterized. PLD programmable circuits: simple SPLD programmable circuits, complex CPLD programmable circuits, FPGA programmable logic networks. Interconnection technologies: fuses, anti-fuses, floating gate MOS, static memories. The selection criteria. Areas of application.

Chapter 3. FPGA reconfigurable logic networks. **(3 weeks)**

Types of FPGA architectures:Calculation island type architecture, Hierarchical type architecture, Sea of gates type architecture. The different elements of FPGAs: The configurable circuit (CLB logic blocks, IOB input/output blocks, Programmable interconnections), Data manager clock, The SRAM memory network. Current FPGAs: Block of small multipliers in an FPGA, Blocks of DSPs in an FPGA, Blocks of processor cores in an FPGA.The selection criteria. Areas of application.

Chapter 4. Design methodology. **(3 weeks)**

Design methods: circuit design with low integration density, circuit design with high integration density. Development tools: CAD tools, different approaches to describing a circuit, description languages. Presentation of compilers which contains CAD tools.

Chapter 5. Cable operators. **(2 weeks)**

Representations of relative numbers: binary shifted, sign and absolute value, 1's complement, 2's complement. Fixed point representation. Floating point representation.Adders. Multipliers.Divisors. Comparators.

Chapter 6: Study of an example of FPGA - SPARTAN3 (2 weeks)

General characteristics, 2. Input-output block (IOB), 3. Configurable logic block, 4. RAM block, 5. Multiplier, 6. Clock manager, 7. Routing and connectivity resources, 8. Configuration, 9. Methodology placement, 10.Design of an FPGA.

Evaluation method:

Continuous monitoring: 40%; Examination: 60%.

Bibliographic references:

1. Philip Simpson, System design with FPGA - Best practices for collaborative development Poche, Dunod, 2014.
2. Francois ANCEAU & Yvan BONNASSIEUX, Design of VLSI Circuits, From component to system, Dunod, 2007.
3. Pong P. Chu, FPGA Prototyping by VHDL Examples: Xilinx Spartan, Wiley-Blackwell, 2008.
4. Alexandre Nketsa, Programmable logic circuits: PLD, CPLD and FPGA memories, industrial computing, Ellipses Marketing, 1998.
5. Jacques WEBER & Sébastien MOUTAULT & Maurice MEAUDRE, The VHDL language, from language to circuit, from circuit to language, 5th ed.: Courses and corrected exercises, Dunod, 2016.
6. Phillip DARCHE, Computer Architecture, Boolean Logic: implementations and technologies, Vuibert, Paris, 2004.

Semester: 3
Teaching unit: UEM 2.1
Matter: Industrial supervision
VHS: 37h30 (Class: 1h30, TP: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

The aim of the course is to introduce the student to the SCADA supervision system (*Supervisory Control And Data Acquisition*), widely used in the supervision and data acquisition of industrial processes in various sectors. At the end the student can design an interface for supervising an industrial process and know the necessary software and hardware.

Recommended prior knowledge:

API, Industrial networks, Buses and communication protocols, Instrumentation chain, Industrial design,

Material content:

Chapter 1. Definition of a SCADA system (1 week)

Definitionof aSCADA system (supervision = monitoring-command), utilities, functions, etc. . History: moving from the PC-PO loop to the SCADA-PC-PO loop

Chapter 2. Components of an industrial control system. (2 weeks)

Industrial control systems: PLC (Programmable Logic Controller), DCS (Distributed Control Systems), SCADA (Supervisory Control And Data Acquisition), PAC (Programmable Automation Controller), RTU (Remote Terminal Unit), PC-based Control System.

Chapter 3. System architecturesSCADA (3 weeks)

SCADA Architectures, SCADA Protocols, Data Acquisition.Deployment of SCADA systems. Network architecture. Positioning of SCADA on the CIM pyramid (link with MES and ERP)

Chapter 4. HMI (Human Interface Machine) in systemsSCADA (3 weeks)

HMI definition, Analytical and normative ergonomic presentation: Text, Symbol, Curve, Color, Animations, Signaling, etc. . Alarm management, Message management (error, confirmation, etc.), Management of Production-Recipes, Archiving, and Historization ranges, Definition of some international standards for IT schematization (Piping and Instrumentation), ISA symbology, PCF, etc.

Chapter 5. SCADA supervision software (2 weeks)

- **Software organization of a SCADA supervision system**

  Variable dedicated to control-command: Internal external variables, ToR type, digital, analog, character string

  "Object" variable: variable value, units, scale, limits, timestamp, freshness, hysteresis, static or dynamic object type.

  Real-time specificity of the variable base: Synchronization with the HMI interface, synchronization with hardware (reading, sending, updating, etc.), refresh time (cyclical, configurable cyclical, flash, etc.), etc.

  Programming: Graphical editor, component libraries, instantiations, etc.

  Remote administration, ...
- **Presentation of some software for SCADA:**

Siemens→SIMATIC WinCC flexible, TIAPortal, Scheinder Electric→Monitor pro, Elution→ConrolMaestro, ARC Informatique→PCVue, Codra→Panorama P2, Panorama E2, ICONICS→GENESIS 32, …

Chapter 6. SCADA System Security (1 week)

Why secure SCADA?, Attacks (Threats and dangers)against SCADA systems,Risks and assessment. Possible incident scenarios. Sources of incidents. detection and identification of breakdowns, failures, errors, etc. Security policy. ….

Chapter 7. Demonstrative applications (3 weeks)

Study an illustrative example: Introduce all the notions and software and hardware concepts studied to develop a corresponding SCADA system, following well-defined specifications.

Practical work :

Practical work can be designed and developed by the teacher depending on the availability of hardware and software.

TP1. Introduction to Siemens WinCC flexible (or TIA Portal) software
TP2. Development and Implementation of a SCADA system to control the water level in a reservoir
TP3. Development and Implementation of a SCADA system for a parking barrier:

- Establish the control of the motor used: Control of a direct current motor (PID) or a stepper motor or servomotor (PWM) in Ladder language, SCL, etc.
- Design a corresponding grafcet of the complete system
- Design a SCADA system (HMI, variables to use, etc.)
- Raise some security constraints and propose solutions……..

Evaluation method:

Continuous monitoring: 40%; Examination: 60%.

Bibliographic references:

7- Ronald L. Krutz Securing SCADA Systems, Wiley, 2005.
8- Stuart A. Boye, Scada: Supervisory Control And Data Acquisition, ISA; Edition: 4th Revised edition, 2009.

9- Robert Radvanovsky and Jacob Brodsky, Handbook of SCADA/Control Systems Security, Second Edition,CRC Press;2016
10- William Shaw, Cybersecurity for Scada Systems, PennWell Books, 2006.

Semester: 3
Teaching unit: UEM 2.1
Material: TPAdvanced command
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

The objective is to provide a methodology for the design of different control laws for linear systems.

Recommended prior knowledge

Course content

Material content:

Tp1: Optimal LQ control

TP2: Optimal LQR control

Tp3: Adaptive control by MIT and Lyapunov approach

Tp4: Adaptive control by self-adjusting regulator

Tp5: Predictive control using transfer function approach

Tp6: Predictive control by state approach

Evaluation method:100% continuous assessment

Semester: 3
Teaching unit: UEM 2.1
Material: TP Control of handling robots
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

Put into practice and give a concrete aspect to the concepts seen during the course " Control of manipulation robots " through practical work to better understand and assimilate the content of this subject.

Recommended prior knowledge

Course content

Material content:

TP1. Introduction to Matlab Robotics Toolbox. (Geometric transformations)

TP2. Geometric and inverse modeling of a Plan robot (3DDL).

TP3. Direct and inverse kinematic modeling.

TP4. Dynamic modeling of a planar robot (2DDL).

TP5. Generation of trajectories in articular and Cartesian mode.

TP6. Dynamic control of a robot

Evaluation method:100% continuous assessment

Semester: 3
Teaching unit: UEM 2.1
Subject: FPGA practical work and VHDL programming
VHS: 10:30 p.m. (TP: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

This practical work will allow the student to put into practice and consolidate the knowledge acquired in the subject of FPGA and VHDL programming.

Recommended prior knowledge

Course content.

Material content:

TP1: Mastery of a design tool (xilinx, altera)

TP2. Design of a combinatorial system

TP3. Designing a sequential system: the process

TP4. Design of state machines

TP5. Design of a broad design.

TP6: implementation of the design on an FPGA card

Evaluation method:100% continuous assessment

Semester: 3
Teaching unit: UET 2.1
Subject 1: Documentary research and dissertation design
VHS: 10:30 p.m. (Class: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:
Give the student the necessary tools to search for useful information to better use it in their end-of-studies project.Help them go through the different stages leading to the writing of a scientific document. Tell himthe importance of communication and itlearn to present the work carried out in a rigorous and educational manner.

Recommended prior knowledge:
Writing methodology, Presentation methodology.

Content of the subject:

Part I-: Documentary research:

Chapter I-1: Definition of the subject (02 Weeks)
- Subject title
- List of keywords relating to the subject
- Gather basic information (acquisition of specialized vocabulary,meaning of terms, linguistic definition)
- The information sought
- Take stock of your knowledge in the field

Chapter I-2:Select information sources (02 Weeks)
- Type of documents (Ldrunk, Theses, Memoirs, Periodical articles, Conference proceedings, Audiovisual documents, etc.)
- Type of resources (Libraries, Internet, etc.)
- Evaluate the quality and relevance of information sources

Chapter I-3:Locate documents (01 Week)
- Research techniques
- Search operators

Chapter I-4: To process information (02 Weeks)
- Work organization
- Starting questions
- Summary of documents retained
- Links between different parties
- Final plan of the documentary research

Chapter I-5: Presentation of the bibliography (01 Week)
- Systems for presenting a bibliography (The Harvard system, The Vancouver system, The mixed system, etc.)
- Presentation of documents.
- Citation of sources

Part II: Memory Design

Chapter II-1: Plan and stages of the dissertation (02 Weeks)

- Identify and delimit the subject (Summary)
- Problem and objectives of the dissertation
- Other useful sections (Acknowledgments, Table of abbreviations, etc.)
- The introduction (The writing of*the introduction last)*
- State of the specialized literature
- Formulation of hypotheses
- Methodology
- Results
- Discussion
- Recommendations
- conclusion and perspectives
- Table of contents
- The bibliography
- Annexes

Chapter II-2: Writing techniques and standards (02 Weeks)

- Formatting.Numbering of chapters, figures and tables.
- Cover Page
- Typography and punctuation
- Writing. Scientific language: style, grammar, syntax.
- Spelling.Improved general language skills in terms of comprehension and expression.
- Back up, secure, archive your data.

Chapter II-3:Workshop : Critical study of a manuscript **(01 Week)**

Chapter II-4: Oral presentations and defenses (01 Week)

- How to present a Poster
- How to present an oral communication.
- Defense of a dissertation

Chapter II-5: How to avoid plagiarism? **(01 Week)**

(Formulas, sentences, illustrations, graphs, data, statistics,...)

- The quote
- The paraphrase
- Indicate the complete bibliographic reference

Evaluation method:

Review: 100%

Bibliographic references:

1. *M. Griselin et al., Guide to written communication, 2nd edition, Dunod, 1999.*
2. *JL Lebrun, Practical guide to scientific writing: how to write for the international scientific reader, Les Ulis, EDP Sciences, 2007.*
3. *HAS.Mallender Tanner, ABC of technical writing: instructions for use, user manuals, online help, Dunod, 2002.*
4. *M. Greuter, Write your dissertation or internship report well, L'Etudiant, 2007.*
5. *Mr. Boeglin, reading and writing in college. From the chaos of ideas to structured text. The Student, 2005.*
6. *M. Beaud, the art of the thesis, Editions Casbah, 1999.*
7. *M. Beaud, the art of the thesis, The discovery, 2003.*
8. *M. Kalika, Master's thesis, Dunod, 2005.*