الجمهورية الجزائرية الديمقراطية الشعبيةDemocratic and Popular 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 Science and Technology sector

HARMONIZATION
OTRAINING OFFER
ACADEMIC MASTER

2016 - 2017

Domain	Sector	Speciality
Sciences And Technologies	***Automatic***	***Automatic and Computer science industrial***

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مواءمة

The Lord

ماستر أكاديمي

2017-2016

الميدان	الفرع	التخصص
علوم و تكنولوجيا	آلية	آلية وإعلام آلي صناعي

I–Master's identity card

Access conditions

(Indicate the bachelor's degree specializations that can provide access to the Master's degree)

Sector	Harmonized Master	Licenses providing access at the master's level	Ranking according to the compatibility of the license	Coefficient assigned to the license
Automatic	Automatic and systems	Automatic	**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

Unit teaching	Materials Titled	Credits	Coefficient	Hourly volume weekly Course	TD	TP	Volume Hourly Biannual (15 weeks)	Work Complementary in consultation (15 weeks)	Assessment method Control Continuous	Exam
Fundamental EU Code: UEF 1.1.1 Credits: 10 Coefficients: 5	Linear Systems Multivariables	6	3	3:00 a.m.	1h30		67h30	82h30	40%	60%
	Signal processing	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental EU Code: UEF 1.1.2 Credits: 8 Coefficients: 4	Association converter-machines	4	2	1h30	1h30		45h00	55h00	40%	60%
	Optimization	4	2	1h30	1h30		45h00	55h00	40%	60%
EU Methodological Code: UEM 1.1 Credits: 9 Coefficients: 5	Networks and communication protocols industrial	3	2	1h30		1 hour	37h30	37h30	40%	60%
	Linear Systems Practical Work Multivariables	2	1			1h30	10:30 p.m.	27:30	100%	
	Signal Processing Practical Work / Practical WorkOptimization	2	1			1h30	10:30 p.m.	27:30	100%	
	TPAssociation converter-machines	2	1			1h30	10:30 p.m.	27:30	100%	
EU Discovery Code: UED 1.1 Credits: 2 Coefficients: 2	Basket of your choice	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
	Basket of your choice	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
Transversal EU Code: UET 1.1 Credits: 1 Coefficients: 1	Technical English and terminology	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
Total semester 1		**30**	**17**	**1:30 p.m.**	**6:00 a.m.**	**5:30 a.m.**	**375 hours**	**375 hours**		

Semester 2

Unit teaching	Materials Titled	Credits	Coefficient	Hourly volume weekly Course	TD	TP	Hourly Volume Biannual (15 weeks)	Work Complementary in consultation (15 weeks)	Assessment method Control Continuous	Exam
Fundamental EU Code: UEF 1.2.1 Credits: 10 Coefficients: 5	Nonlinear systems	6	3	3:00 a.m.	1h30		67h30	82h30	40%	60%
	Embedded Systems and real-time systems	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental EU Code: UEF 1.2.2 Credits: 8 Coefficients: 4	Advanced Programming APIs	4	2	1h30	1h30		45h00	55h00	40%	60%
	Applied Electronics	4	2	1h30	1h30		45h00	55h00	40%	60%
EU Methodological Code: UEM 1.2 Credits: 9 Coefficients: 5	Object-oriented design	3	2	1h30		1 hour	37h30	37h30	40%	
	Nonlinear Systems TP	2	1			1h30	10:30 p.m.	27:30	**40%**	
	Embedded Systems TP and real-time systems	2	1			1h30	10:30 p.m.	27:30	100%	
	TP Programming advanced APIs/TPs Applied Electronics	2	1			1h30	10:30 p.m.	27:30	100%	
EU Discovery Code: UED 1.2 Credits: 2 Coefficients: 2	Basket of your choice	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
	Basket of your choice	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
Transversal EU Code: UET 1.2 Credits: 1 Coefficients: 1	Ethics, professional conduct and intellectual property	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
Total semester 2		**30**	**17**	**1:30 p.m.**	**6:00 a.m.**	**5:30 a.m.**	**375 hours**	**375 hours**		

Semester 3

Unit teaching	Materials Titled	Credits	Coefficient	Hourly volume weekly Course	TD	TP	Volume Hourly Biannual (15 weeks)	Work Complementary in consultation (15 weeks)	Assessment method Control Continuous	Exam
Fundamental EU Code: UEF 2.1.1 Credits: 10 Coefficients: 5	Advanced order	6	3	3:00 a.m.	1h30		67h30	82h30	40%	60%
	Control of handling robots	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental EU Code: UEF 2.1.2 Credits: 8 Coefficients: 4	Event-driven systems discreet	4	2	1h30	1h30		45h00	55h00	40%	60%
	FPGA and programming VHDL	4	2	1h30	1h30		45h00	55h00	40%	60%
EU Methodological Code: UEM 2.1 Credits: 9 Coefficients: 5	Industrial supervision	3	2	1h30		1 hour	37h30	37h30	40%	60%
	Advanced Command TP	2	1			1h30	10:30 p.m.	27:30	100%	
	TPControl of handling robots	2	1			1h30	10:30 p.m.	27:30	100%	
	TPFPGA and VHDL programming	2	1			1h30	10:30 p.m.	27:30	100%	
EU Discovery Code: UED 2.1 Credits: 2 Coefficients: 2	Basket of your choice	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
	Basket of your choice	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
Transversal EU Code: UET 2.1 Credits: 1 Coefficients: 1	Documentary research and design of memory	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
Total semester 3		**30**	**17**	**1:30 p.m.**	**6:00 a.m.**	**5:30 a.m.**	**375 hours**	**375 hours**		

EU Discovery*(S1, S2 and S3)*

1- Nanotechnology
2- Operational safety
3- Maintenance management
4- Biotechnology
5- Biomedical Technologies
6- Telecommunication Applications
7- Electric vehicles
8- Hydraulics and pneumatics
9- Smart sensors
10-Intelligent Vision
11-Robotics (Mobile Robotics,Humanoid robotics, Service robotics, Robotics for the environment, ...)
12- Image processing and vision
13-*Others...*

Semester 4

Internship in a company leading to a dissertation and a defense.

	VHS	Coefficient	Credits
Personal Work	550	09	18
Internship in a company	100	04	06
Seminars	50	02	03
Other (Supervision)	50	02	03
Total Semester 4	750	17	30

This table is given for information purposes only.

Evaluation of the End of Master's Cycle Project

- Scientific value (Jury assessment) /6
- Writing the Dissertation (Jury Assessment) /4
- Presentation and answer to questions (Jury assessment) /4
- Supervisor's assessment /3
- Presentation of the internship report (Jury assessment) /3

III - Detailed program by subject for semester S1

Semester: 1
Teaching unit: UEF 1.1.1 Subject:
Multivariable linear systems VHS: 67h30
(Lecture: 3h00, TD: 1h30) Credits: 4

Coefficient: 2

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 servo systems
- Sampled systems;

Content of the subject:

Chapter 1. Introduction **(2 Weeks)**

Objectives of this course, Reminder on matrix calculation, Reminder of the concepts of the state approach, Difference between SISO and MIMO.

Chapter 2. State representation of multivariable systems (MS). **(2 Weeks)**

Definitions, Different representations of systems, Solving the equation of state, 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 SMs by transfer matrix. **(3 Weeks)**

Introduction, Transition from a state representation to a transfer matrix representation, Gilbert's method, Invariant method: Smith-McMillan form, Method by reduction of a realization

Chapter 5. SM status feedback control. **(4 Weeks)**

Formulation of the pole placement problem by state feedback, Calculation methods for multivariable systems, State observer and control by output feedback (i.e. with state observer) of SMs. Non-interactive control of SMs, Implementation.

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1- From 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 Saussié, "Multivariable Control", Dunod Editions, 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 Course & 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:
VHS signal processing: 45h00
(Lecture: 1h30, TD: 1h30) Credits: 4

Coefficient: 2

Teaching objectives:

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

Recommended prior knowledge:

The student must have the following knowledge:

- Signal theory
- The basics of mathematics

Content of the subject:

Chapter 1. Reminders of the main results of signal theory **(2 Week)**
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 (Chebyshev, Butterworth).
Chapter 3. Signal Sampling **(1 Week)**
From continuous signal to digital signal Sampling, reconstruction and quantization.

Chapter 4: Discrete Transforms and Windowing: From Discrete-Time Fourier Transform (DTFT) to Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT) **(3 Weeks)**

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

Definition of filter template

RIF and RII filters

Lattice filters

Synthesis of RIF filters: window method Synthesis of

RII digital filters: bilinear method

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1- Francis Cottet, Signal Processing and Data Acquisition - Course and Corrected Exercises, 4th edition, Dunod, Paris, 2015.
2- Tahar Neffati, Analog Signal Processing: Course, Ellipses Marketing, 1999. Messaoud
3- Benidir, Signal Theory and Processing: Basic Methods for Signal Analysis and Processing, Dunod, 2004.

4- Maurice Bellanger, Digital Signal Processing: Theory and Practice, 9thedition, Dunod, Paris, 2012.
5- Étienne Tisserand Jean-François Pautex Patrick Schweitzer, Analysis and processing of signals methods and applications to sound and image 2thedition, 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

Subject: Association of converters and VHS machines: 45 hours (Lecture: 1.5 hours, Tutorial: 1.5 hours)

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.

Content of the subject:

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

Chapter 2. Direct current motor: **(2 Weeks)**
- Principle, structure and characteristics
- Speed variation.

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Chapter 3. Alternating Current Motor: **(2 Weeks)**
- Principle, structure and characteristics
- Speed variation.

Chapter 4. Association of converters and machines: **(4 Weeks)**
- Torque and speed control,
-Variable speed drives for synchronous machines
- Speed variator for asynchronous machines

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

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. F. LABRIQUE, G. SEGUIER, R. BAUSIERE, Volume 4: 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 controls movement, Nathan, 1992. 1991.

6. P. Mayé, Industrial electric motors, Bachelor's, Master's, engineering schools, Dunod Collection: Sciences sup 2011.

7.J. Bonal, G. Séguier,Variable-speed electric drives. Volume 3, Converter-mains and converter-motor-load interactions, Tec & Doc, 2000.

Semester: 1
Teaching unit: UEF 1.1.2

Subject 1: Optimization
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The course objective 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 for maximum performance.

Recommended prior knowledge:

The student must have the following knowledge:

-Mathematics.

Content of the subject:

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

Chapter 2. Unconstrained Optimization - Local Methods (3 Weeks)

One-dimensional search methods
Gradient methods
Conjugate Direction Methods
Newton's Method
Levenberg-Marquardt method
Quasi-Newton methods

Chapter 3. Unconstrained Optimization - 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

Chapter 4. Linear Programming (3 Weeks)

Chapter 5. Nonlinear Programming (4 Weeks)

Assessment method:

Continuous assessment: 40%; Exam: 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. Jean-Christophe Culioli,
3- Introduction to optimization, Ellipses, 2012. Rémi Ruppli, Linear programming: Ideas and methods,
4- 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
Subject: Industrial communication networks and protocols VHS: 37h30
(Lecture: 1h30, Practical work: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

This course provides an introduction to the field of data and communication networks. It aims to familiarize students with the basic concepts of information communication networks. It introduces students to defining 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.

Content of the subject:

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

Chapter 2. Communications bus **(3 Weeks)**

- Traditional
- Emerging

Chapter 3. Wireless Industrial 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 supervision **(2 Weeks)**

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

TP Content of the subject:

Plan some practical work related to the available material.

Assessment method:

Continuous assessment: 40%; Exam: 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, Technip Editions, 2006.
4- Guy Pujolle, Networks, 5th edition, Eyrolles, 2006. Paul
5- 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

Subject: Practical work Multivariable linear systems VHS: 10:30 p.m.

(Practical work: 1:30 p.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.

Content of the subject:

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

Assessment method:100% continuous assessment

Semester: 1

Teaching unit: UEM 1.1

Subject: Signal Processing Practical Work/VHS Optimization Practical Work: 10:30 p.m. (Practical Work: 1:30 p.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 practical work, allow students to use and master the theoretical concepts studied during the course.

Recommended prior knowledge

Course content

Content of the subject:

Signal processing practical work:

TP 1 – Representation of signals and applications of the Fourier transform under Matlab
TP 2 - Analog Filtering
TP3- Discrete Fourier Transform TP 4-
IIR Digital Filtering
TP5- RIF Digital Filtering

Optimization work:

TP1 Introduction to Matlab **TP2**
Optimization without constraints

TP3 Optimization without constraints

TP4 Linear programming **TP5**

Nonlinear programming

Assessment method:100% continuous assessment

Semester: 1

Teaching unit: UEM 1.1

Subject: Practical work on VHS converter-machine association: 10:30 p.m.

(practical work: 1:30 p.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.

Content of the subject:

TP 1DC-AC converters
TP 2 Speed variator for DC motor
TP 3 Variable speed drive for AC motor
TP 4. Variable speed drive for synchronous machines **TP 5.**
Variable speed drive for asynchronous machines

Assessment method:100% continuous assessment

Semester: 1
Teaching unit: UET 1.1
Subject 1: Technical English and VHS terminology:
10:30 p.m. (Course: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

Introduce students to technical vocabulary. Strengthen their language skills. Help them understand and summarize a technical document. Enable them to understand a conversation in English held in a scientific setting.

Recommended prior knowledge:

Basic English Vocabulary and Grammar

Content of the subject:

- 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: Extracting ideas from a scientific document, Writing a scientific message, Exchanging information in writing, writing CVs, letters of application for internships or jobs.

Recommendation: It is strongly recommended that the subject manager present and explain 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.

Assessment method:

Review: 100%.

Bibliographic references:

1. *PT Danison, Practical guide to writing in English: usages and rules, practical advice, Editions d'Organisation 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 semester S2

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

Coefficient: 3

Teaching objectives:

The objective of this course is: to raise students' awareness of stability issues in nonlinear systems and to provide them with mathematical analysis tools, to introduce nonlinear control methods such as techniques based on differential geometry and the sliding mode approach. The methodologies presented use both time-domain and frequency-domain representations.

Recommended prior knowledge:

The student must have the following knowledge:

- Signal theory
- The basics of mathematics

Content of the subject:

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

Chapter 2: Phase Plan: **(3 Weeks)**
Second-order systems. Construction of the phase portrait. Elimination of implicit/explicit time. Isocline method. Van der Pol oscillator. Review of linear systems: characterization of orbits by eigenvalues. Index of singular points. The index theorem. The Poincaré-Bendixson theorem. The Bendixson condition.

Chapter 3: First Harmonic Method: **(3 Weeks)**
Assumptions. Harmonic decomposition. First harmonic equivalent. Common nonlinearities. Saturation. Dead zone. Relay. Hysteresis. Linear system and controller. Nyquist criterion. Additional complex gain. Modified Nyquist criterion. Estimation of limit cycle parameters. Frequency-independent equivalent. Reliability of first harmonic analysis.

Chapter 4: Foundations of Lyapunov's Theory: **(2 Weeks)**
Stability: intuitive definition. Notion of distance. Stability: formal definition. Asymptotic stability. Direct Lyapunov method. Positive definite function. Lyapunov function. Example: robot. Local stability theorem. Exponential stability. Global 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 / series / feedback connection. Passivity and linear SISO system. Positive real system. Link between Lyapunov and positive real system. Theorem

Kalman-Yakubovich-Popov. 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 bracket. Diffeomorphism. Frobenius's theorem. Involutional family. Linearization conditions. Return to the example of the flexible joint robot.

Chapter 7. Control of nonlinear systems **(3 weeks)**

1. General information
2. Linearization control
3. Sliding mode control

Assessment method:

Continuous assessment: 40%; Exam: 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-controlled systems, Dunod, 1975.
3. Atherton, D.P., '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, Automatics - Linear and nonlinear systems - 2nd edition: Course 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-controlled 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
Subject: Embedded Systems and Real-Time Systems VHS:
45h00 (Lecture: 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 (multiple communicating hardware and software components) and are used in environments known for their critical nature where any failure can have serious consequences on human life and the environment. The course provides 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 of digital electronics and microcontrollers

Content of the subject:

A. Embedded Systems

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

B. Real-Time Kernel

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

Assessment method:

Continuous assessment: 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, On-board 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 Subject:
Advanced programming of VHS APIs:
45h00 (Lecture: 1h30, TD: 1h30) Credits:
4
Coefficient: 2

Teaching objectives:

Deepen your understanding of programming complex functions and Input/Outputs. Implement and use programming tools and project development with practical applications, master the exchange of information between PLCs and intelligent equipment via a field network.

Recommended prior knowledge:

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

Content of the subject:

Chapter 1: General information on automated production systems (1 week)

- Notions of automated systems
- Hardware and software architecture of an automated system
- Examples of automated systems
- From hard-wired logic to programmed logic **Chapter 2:**

Industrial programmable logic controllers (3 weeks)

- What is a programmable logic controller?
- The different types of automatons
- The constituent elements of automatons
- The criteria for choosing an automaton
- The different types of API data
- TOR input/output cards
- Analog input/output cards
- PID control 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
- The ladder language
- Translation of a grafcet into a ladder
- Transcription of specifications in Grafcet
- Programming languages

Chapter 4: SCADA supervision systems (2 weeks)

- Usefulness and importance of industrial supervision
- Industrial supervision software
- The criteria for choosing monitoring software

Chapter 5:Introduction to field networks for PLCs (4 weeks)

- Introduction: Role and interest of communication networks

Characteristics of the networks:

• 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
• ASI
• DEVICE NET, ETHERNET

Choice and Implementation of Communication Networks:

• Breakdown 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

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. William Bolton, "Programmable Logic Controllers," 2eed., Dunod, 2015.
2. Automation Solutions Guide, 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 RabieeProgrammable 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
(Lecture: 1h30, TD: 1h30) Credits: 4

Coefficient: 2

Teaching objectives:

To 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 an overall system (even in industry). He must then be able to take measurements on an electronic circuit (possibility of modifications or troubleshooting). He must be able to provide a solution to problem situations (design and produce analog electronic circuits).

Recommended prior knowledge:

The student must have the following knowledge:

- Fundamental electronics
- Power electronics

Content of the subject:

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

- Linear mode operation
- Non-linear mode operation

Chapter 3:Pulse Generation (signals) **(3 weeks)**

- Astable (to AOP, to NE555, to logic gates)
- Monostable (to AOP, to NE555, to logic gates)
- Schmitt Trigger (at AOP).

Chapter 4:CAN converter, DAC **(3 weeks)**
Chapter 5:Study of Active Filters **(2 weeks)**
Chapter 6:Introduction to the principles of PCB production **(4 weeks)**

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

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. Yves Granjon, Bruno Estibals, Serge Weber, Electronics - The entire course in files, Collection: The entire course in files, Dunod, 2015.
2. Albert Paul Malvino, David J. Bates Principles of Electronics, Course and Corrected Exercises, 8th edition, Dunod, 2016.
3. Charles Adams Platt, Xavier Guesnu, Eric Bernauer, Antoine Derouin, Electronics in practice: 36 fun experiments, 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 Subject:Object-oriented design VHS: 37h30 (Lecture: 1h30, Practical work: 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:
Develop computer applications based on the object-oriented programming approach. Develop human-machine interface applications (C++, Java) under Windows or Android environments.

Recommended prior knowledge:

Basic knowledge of C programming, Algorithms.

Content of the subject:

Chapter 01:Introduction to the Object Approach **(1 week)**
Why use object-oriented technologies? The challenges of new computing: modularity (plug-ins), reusability, scalability. The use of component libraries.

Chapter 2. Basic Concepts **(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, Method definition, Access rights and encapsulation, Prototype and definition separation, 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 Compiler Directives, Polymorphism, Abstract Methods and Classes, Interfaces, Uniform Processing, Dynamic Arrays, Method Chaining, Implementing 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 lists and maps, Functor: the object version of functions, Merging the two concepts.

Chapter 6. Advanced Concepts **(2 weeks)**
Exception handling, Standard exceptions, Assertions, Template functions, Specialization of templates, The template classes.

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Practical work Object-oriented design:

TP1:Classes and objects
TP2:Inheritance and polymorphism
TP3:Memory management **TP4:**
Templates

TP 5:Object-oriented example (e.g. Create a small object-oriented game in C++ or Java)

Assessment method:

Continuous assessment: 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,Getting started with programming and object-oriented thinking: 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 Subject: Practical work Nonlinear systems VHS: 22h30 (practical work: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

SNL Practical Work: Demonstrate the difference between the dynamic behavior of linear and nonlinear systems. Demonstrate the concept of an equilibrium point. Demonstrate through simulation the importance of the phase plane. Synthesis of nonlinear systems.

Recommended prior knowledge

Course content

Content of the subjectNonlinear Systems:

TP 1: Advanced Simulation on Matlab
TP 2:Simulation of equilibrium points of some nonlinear systems **TP 3**: Simulation of some nonlinear systems in the phase plane **TP4**: Simulation of the reverse pendulum in open loop **TP5**: Simulation of the linearizing control **TP6**:Sliding mode control

Assessment method:100% continuous assessment

Semester: 2

Teaching unit: UEM 1.2

Subject: Practical work on Embedded Systems and Real-Time Systems VHS: 10:30 p.m.

(Practical work: 1:30 p.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), means of communication with the external environment (HMI, Labview, etc.) and an introduction to the programming of real-time systems. The practical work will be done on an Arduino Mega type development board and the programming will be done with the AVR Studio IDE.

The AVR was chosen because the Arduino board (a widely used development board) is based on this architecture; however, any other architecture is perfectly suited to this course.

Recommended prior knowledge

Course content.

Content of the subject:

TP1: Introduction to the AVR Studio IDE: Creating projects, Compiling C, 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.

Assessment method:100% continuous assessment

Semester: 2

Teaching unit: UEM 1.2

Subject: Advanced API Programming Practical Work/Applied Electronics Practical Work VHS: 10:30 p.m. (Practical Work: 1:30 p.m.)

Credits: 2

Coefficient: 1

Teaching objectives:

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

The structure of an automated system, the programming of complex functions and Input/ Outputs and the communication interfaces between PLCs.

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

Recommended prior knowledge

Course content.

Content of the TP Advanced API Programming subject:

Plan some practical work related to the available material.

Content of the Applied Electronics practical work 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 DAC circuit. TP4: Oscillators

TP5: Active filters(low pass, high pass...)

TP6:**Creation of an electronic assembly:**

Both the head of this subject and the student are free to suggest the creation of other montages.

Assessment method:100% continuous assessment

Semester: 2
Teaching unit: UET 1.2
Subject: Ethics, professional conduct and intellectual property
VHS: 10:30 p.m. (Course: 1.5 hours) Credit: 1
Coefficient: 1

Teaching objectives:

Develop students' awareness of ethical principles. Introduce them to the rules that govern life at the university (their rights and obligations towards the university community) and in the workplace. Raise their awareness of respecting and promoting intellectual property. Explain to them the risks of moral evils such as corruption and how to combat them.

Recommended prior knowledge:

None

Content of the subject:

A- Ethics and professional conduct

I. Concepts of Ethics and Professional Conduct **(3 weeks)**

1. Introduction
    1. Definitions: Morality, ethics, deontology
    2. Distinction between ethics and deontology
2. MESRS Charter of Ethics and Professional Conduct: Integrity and honesty. Academic freedom. Mutual respect. Demand for scientific truth, Objectivity and critical thinking. Fairness. Rights and obligations of the student, the teacher, the administrative and technical staff.

3. Ethics and professional conduct in the world of work
   Legal confidentiality in business. Corporate loyalty. Corporate responsibility. Conflicts of interest. Integrity (corruption in the workplace, its forms, consequences, methods of combating and sanctions against corruption).

II. Integrity and Responsibility in Research **(3 weeks)**

1. Respect for the principles of ethics in teaching and research
2. Responsibilities in Teamwork: Professional equality of treatment. Conduct against discrimination. Pursuit of the public interest. Inappropriate conduct in the context of teamwork.
3. 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 involuntary plagiarism, detection of plagiarism, sanctions against plagiarists, etc.). Falsification and fabrication of data.

B- Intellectual property

I- Fundamentals of intellectual property (1 week)

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

II- Copyright (5 weeks)

1. Copyright in the digital environment

Introduction. Database copyright, 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 website law. Intellectual property and social networks.

3. Patent

Definition. Rights in a patent. Usefulness of a patent. Patentability. Patent applications in Algeria and around the world.

4. Trademarks, designs and models

Definition. Trademark Law. Design Law. Appellation of Origin. Secrecy. Counterfeiting.

5. Geographical Indications Law

Definitions. Protection of Geographical Indications in Algeria. International Treaties on Geographical Indications.

III- Protection and promotion of intellectual property (3 weeks)

How to protect intellectual property. Rights violations and legal tools. Valuing intellectual property. Protecting intellectual property in Algeria.

Assessment method:
Exam: 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. Order No. 933 of July 28, 2016 establishing 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, no. 94.
11. Jacquet-Francillon, François. Concept: professional ethics. Le télémaque, May 2000, no. 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., Patents, 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: Copy-Paste Among Students, Grenoble 3 University and Paris-Ouest Nanterre La Défense University, Nanterre, France

18. Didier DUGUEST IEMN, Citing 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, Strategies for preventing plagiarism, Integrity, fraud and plagiarism, 2010.
22. Pierrick Malissard, Intellectual Property: Origin and Evolution, 2010.
23. The website of the World Intellectual Property Organization www.wipo.int
24. http://www.app.asso.fr/

III - Detailed program by subject for semester S3

Semester: 3
Teaching unit: UEF 2.1.1
Subject: Advanced control
VHS: 67h30 (Lecture: 3h00, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The objective of this subject is to enable students to master high-performance corrector synthesis tools that take into account the real operating conditions of physical systems: parametric uncertainties, neglected dynamics, time-varying parameters, the 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 subject:

Part 1: Optimal Ordering (5 weeks)

1.1. Introduction and mathematical tools for dynamic optimization
1.2. Minimum time order
1.3. Linear Quadratic Control
1.4. Gaussian Linear Quadratic Control

Part 2: Adaptive Control (5 weeks)

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

Part 3: Predictive Control (5 weeks)

4.1. Principle of predictive control
4.2. Predictor of a digital system
4.3. GPC command, optimal predictor
4.4. GPC control under constraints
4.5. State Space Model Predictive Control

Assessment method:

Continuous assessment: 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∞ Control and μ-Analysis, Tools for Robustness, Hermes (1999) 12- S. Skogestadand, 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 VHS manipulation robots:
45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

This subject aims to enable students to master the modeling tools and control techniques of manipulator robots. Itaims 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.
- Basic concepts in: kinematics and dynamics.

Content of the subject:

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- Preliminary theoretical and mathematical foundations **(2 weeks)**

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

III- Modeling of a manipulator robot **(3 weeks)**

- 1. Geometric model
  - • Denavit-Hartenberg Convention
  - • Direct geometric model
  - • Inverse geometric model
- 2. Kinematic model
  - • Direct analysis (use of the direct Jacobian)
  - • Inverse 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
- point-to-point motion generation: basic method, acceleration profile method, velocity profile method, application in joint space, application in Cartesian space.
- Motion generation by interpolation: application in joint space and in Cartesian space

V- Robot control **(3 weeks)**

- 1. Dynamic control
- 2. Sliding mode control

VI- Programming robots **(3 weeks)**

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

Assessment method:

Continuous assessment: 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, Hermès, 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 Subject:
Discrete event systems VHS: 45h00
(Lecture: 1h30, TD: 1h30) Credits: 4

Coefficient: 2

Teaching objectives:

The objective of the first part of this subject consists of the modeling of Discrete Event Systems (DES) by Petri netautonomous,the construction of marking and/or coverage graphs and the analysis of these systems. The second part of the course is devoted to the supervisory control of SEDs. Finally, the third part will look at timed systems.

Recommended prior knowledge:

Basic automation (control and regulation). Algorithmic.

Content of the subject:

Chapter 1: Introduction to SEDs (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. Areas of application**
  - 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 (FSM)
  - 2.3. Design of state machines
- **II.3. Modeling by RDP**
  - 3.1. Regular RDP
  - 3.2. Timed RDP
  - 3.3. Synchronized RDP
  - 3.4. RDP interpreted command
- **II.4. Modeling by Grafcet**
- **II.5. Algebra of dioids or Max+**

Chapter 3: Supervisory control of SEDs (5 weeks)

- **III.1. Introduction to RW theory**
- **III.2. Constrained control**
- **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. Modular, hierarchical, partial observation, Max+ supervision control**
- **IV.2. Taking time into account**
    - 2.1. RDP and Grafcet Timed
    - 2.2. Timed automata
    - 2.3. Algebra of dioids or Max+

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1- BRAMS, Mathematical approach to Petri nets, MASSON 1987 JM
2- 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- R. David and H. Alla. From Grafcet to Petri Nets, Hermes. 1992.
6- C. Cassandras and S. Lafortune. Introduction to discrete Event Systems. Kluwer Academic, 2008.

Semester: 3
Teaching unit: UEF 2.1.2 Subject 1: FPGA and VHDL programming VHS: 45h00 (Lecture: 1h30, TD: 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 high-level hardware description languages.

Recommended prior knowledge:

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

Content of the subject:

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

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

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

Classic digital circuit architectures. Standard circuits: simple functions, microprocessors and DSPs, memories. Application-specific circuits (ASICs): pre-distributed, on-demand circuits, pre-characterized. Programmable circuits (PLDs): simple programmable circuits (SPLDs), complex programmable circuits (CPLDs), programmable logic arrays (FPGAs). Interconnect technologies: fuses, anti-fuses, floating-gate MOS, static memories. Selection criteria. Application areas.

Chapter 3. FPGA Reconfigurable Logic Arrays. **(3 weeks)**

FPGA architecture types: Computing island architecture, Hierarchical architecture, Sea of gates architecture. FPGA elements: Configurable circuit (CLB logic blocks, IOB input/output blocks, Programmable interconnections), Clock manager, SRAM memory network. Current FPGAs: Small multiplier block in an FPGA, DSP blocks in an FPGA, Processor core blocks in an FPGA. Selection criteria. Application areas.

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

Design methods: low-density circuit design, high-density circuit design. Development tools: CAD tools, different approaches to describing a circuit, description languages. Presentation of compilers that contain CAD tools.

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

Representations of relative numbers: shifted binary, sign and absolute value, one's complement, two'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 resources and connectivity, 8. Configuration, 9. Placement methodology, 10. FPGA design.

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. Philip Simpson, Designing Systems with FPGAs - Best Practices for Collaborative Development, Paperback, Dunod, 2014.
2. Francois ANCEAU & Yvan BONNASSIEUX, VLSI Circuit Design, 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.: Course 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 Subject:
Industrial supervision VHS: 37h30
(Lecture: 1h30, Practical work: 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, Bus and communication protocols, Instrumentation chain, Drawing industrial,

Content of the subject:

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

Definition of a SCADA system (supervision = monitoring-control), 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. SCADA System Architectures (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 Machine Interface) in SCADA Systems (3 weeks)

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

Chapter 5. SCADA supervision software (2 weeks)

- **Software organization of a SCADA supervision system**
  Variables dedicated to control-command:Internal and external variables, ToR type, Digital, analog, character string
  "Object" variable: Vvariable 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 the hardware (reading, sending, updating, etc.), refresh time (cyclical, configurable cyclical, flash, etc.), etc.
  Programming: Graphics 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. Security of SCADA systems (1 week)

Why secure SCADA?, Attacks (Threats and Dangers) against SCADA systems, Risks and assessment. Possible incident scenarios. Incident sources. Detection and tracking of faults, errors, etc. Security policy. ….

Chapter 7. Demonstrative Applications (3 weeks)

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

Practical work:

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

TP1. Introduction to WinCC flexible (or TIA Portal) software from Siemens
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 ……..

Assessment method:

Continuous assessment: 40%; Exam: 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

Subject: Advanced Control TP

VHS: 10:30 p.m. (TP: 1:30 p.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

Content of the subject:

Tp1: Optimal LQ order

TP2: Optimal LQR ordering

Tp3: Adaptive control by MIT and Lyapunov approaches

Tp4: Adaptive control by self-adjusting regulator

Tp5: Predictive control by transfer function approach

Tp6: State-based predictive control

Assessment method:100% continuous assessment

Semester: 3

Teaching unit: UEM 2.1

Subject: Practical work Control of manipulation robots VHS: 10:30 p.m. (Practical work: 1:30 p.m.)

Credits: 2

Coefficient: 1

Teaching objectives:

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

Recommended prior knowledge

Course content

Content of the subject:

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

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

TP3. Forward and inverse kinematic modeling.

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

TP5. Generation of trajectories in joint and Cartesian mode.

TP6. Dynamic control of a robot

Assessment method:100% continuous assessment

Semester: 3

Teaching unit: UEM 2.1 Subject: FPGA practical work and VHDL programming VHS: 22h30 (practical work: 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 FPGA and VHDL programming subject.

Recommended prior knowledge

Course content.

Content of the subject:

TP1:Proficiency in 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 wide design.

TP6:implementation of the design on an FPGA board

Assessment method:100% continuous assessment

Semester: 3
Teaching unit: UET 2.1
Subject 1: Documentary research and design of VHS dissertation:
10:30 p.m. (Course: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

To give students the tools they need to research useful information and use it more effectively in their final year project. To help them navigate the various stages of writing a scientific document. To demonstrate the importance of communication and to teach them how to present their work 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 **(2 Weeks)**

- Subject title
- List of keywords related 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: Selecting information sources **(2 Weeks)**

- Type of documents (Books, Theses, Dissertations, Periodical articles, Conference proceedings, Audiovisual documents, etc.)
- Type of resources (Libraries, Internet, etc.)
- Evaluate the quality and relevance of information sources

Chapter I-3: Locating documents **(01 Week)**

- Research techniques
- Search operators

Chapter I-4: Processing information **(2 Weeks)**

- Work organization
- The starting questions
- Summary of the documents selected
- Links between different parties
- Final plan of the documentary research

Chapter I-5: Presentation of the bibliography **(01 Week)**

- Bibliography presentation systems (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 report **(2 Weeks)**

- Identify and delimit the subject (Summary)
- Problems and objectives of the thesis
- Other useful sections (Acknowledgments, Table of abbreviations, etc.)
- The introduction (*Writing the introduction last)*
- State of the specialized literature
- Formulation of hypotheses
- Methodology
- Results
- Discussion
- Recommendations
- Conclusion and perspectives
- Table of Contents
- The bibliography
- The annexes

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

- Formatting. Numbering of chapters, figures and tables.
- The cover page
- Typography and punctuation
- Writing. Scientific language: style, grammar, syntax.
- Spelling. Improvement of general language skills in terms of comprehension and expression.
- Save, 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, etc.)

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

Assessment method:

Exam: 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. *A. Mallender Tanner, ABC of technical writing: user guides, instructions, online help, Dunod, 2002.*
4. *M. Greuter, How to write your dissertation or internship report well, L'Etudiant, 2007.*
5. *M. Boeglin, Reading and Writing at University. From the Chaos of Ideas to Structured Text. L'Etudiant, 2005.*
6. *M. Beaud, the art of the thesis, Editions Casbah, 1999.*
7. *M. Beaud, the art of the thesis, La découverte, 2003.*
8. *Mr. Kalika, Master's thesis, Dunod, 2005.*