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 والتكنولوجيا
National Pedagogical Committee of the Science and Technology field

HARMONIZATION OF ACADEMIC MASTER'S TRAINING PROGRAMS

2016 - 2017

Field	Branch	Speciality
Sciences and Technologies	**Automatic**	**Automatic and Industrial Computing**

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مواءمة
عرض تكوين
ماستر أكاديمي

2017 - 2016

Field	الفرع	الميدان
آلية وإعلام آلي صناعي	آلية	علوم و تكنولوجيا

I - Master's Identity Sheet

Admission requirements

(Indicate the Bachelor's degree specializations that can grant access to the Master's program)

Field	Harmonized Master's Program	Bachelor's degrees granting access to the Master's	Ranking based on compatibility with the Master's program	Coefficient assigned to the Bachelor's degree
Automatic	Automatic and systems	Automatic	**1**	**1.00**
		Electronics	**2**	**0.80**
		Electrical Engineering	**2**	**0.80**
		Other Bachelor's degrees in the field of ST	**3**	**0.60**

II - Semester-based organization sheets for courses in the specialization

Semester 1

Teaching unit	Subjects title	Credits	Coefficient	Weekly volume hour			Semester volume hour (15 weeks)	Complementary work in consultation (15 weeks)	Evaluation mode	
				C	T	PW			Continuous assessment	Exam
Fundamental Unit Code : UEF 1.1.1 Credits : 10 Coefficients : 5	Multivariable Linear Systems	6	3	3h00	1h30		67h30	82h30	40%	60%
	Signal processing	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental Unit Code : UEF 1.1.2 Credits : 8 Coefficients : 4	Converters-Machines Association	4	2	1h30	1h30		45h00	55h00	40%	60%
	Optimization	4	2	1h30	1h30		45h00	55h00	40%	60%
Methodological Unit Code : UEM 1.1 Credits : 9 Coefficients : 5	Networks and protocols of industrial communication	3	2	1h30		1h00	37h30	37h30	40%	60%
	Practical Work in Multivariable Linear Systems	2	1			1h30	22h30	27h30	100%	
	Practical Work in Signal processing/ Practical Work in Optimization	2	1			1h30	22h30	27h30	100%	
	Practical Work in converters – machines association	2	1			1h30	22h30	27h30	100%	
Discovery Unit Code : UED 1.1 Credits : 2 Coefficients : 2	Elective subjects	1	1	1h30			22h30	02h30		100%
	Elective subjects	1	1	1h30			22h30	02h30		100%
Transversal Unit Code : UET 1.1 Credits : 1 Coefficients : 1	Technical English and terminology	1	1	1h30			22h30	02h30		100%
Total semester 1		**30**	**17**	**13h30**	**6h00**	**5h30**	**375h00**	**375h00**		

Semester 2

Teaching unit	Subjects title	Credits	Coefficient	Weekly volume hour			Semester volume hour (15 weeks)	Complementary work in consultation (15 weeks)	Evaluation mode	
				C	T	Pw			Continuous assessment	Exam
Fundamental Unit Code : UEF 1.2.1 Credits : 10 Coefficients : 5	Nonlinear systems	6	3	3h00	1h30		67h30	82h30	40%	60%
	Embedded systems and real-time systems	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental Unit Code : UEF 1.2.2 Credits : 8 Coefficients : 4	Advanced programming of PLCs	4	2	1h30	1h30		45h00	55h00	40%	60%
	Applied Electronics	4	2	1h30	1h30		45h00	55h00	40%	60%
Methodological Unit Code : UEM 1.2 Credits : 9 Coefficients : 5	Object-oriented design	3	2	1h30		1h00	37h30	37h30	40%	60%
	Practical Work in Nonlinear systems	2	1			1h30	22h30	27h30	40%	60%
	Practical Work in Embedded systems and real-time systems	2	1			1h30	22h30	27h30	100%	
	Practical Work in Advanced Programming of PLCs/ Practical Work in Applied Electronics	2	1			1h30	22h30	27h30	100%	
Discovery Unit Code : UED 1.2 Credits : 2 Coefficients : 2	Elective subjects	1	1	1h30			22h30	02h30		100%
	Elective subjects	1	1	1h30			22h30	02h30		100%
Transversal Unit Code : UET 1.2 Credits : 1 Coefficients : 1	Ethics, deontology and intellectual property	1	1	1h30			22h30	02h30		100%
Total semester 2		**30**	**17**	**13h30**	**6h00**	**5h30**	**375h00**	**375h00**		

Semester 3

Teaching unit	Subjects title	Credits	Coefficient	Weekly volume hour			Semester volume hour (15 weeks)	Complementary work in consultation (15 weeks)	Evaluation mode	
				C	T	Pw			Continuous assessment	Exam
Fundamental Unit Code : UEF 2.1.1 Credits : 10 Coefficients : 5	Advanced control	6	3	3h00	1h30		67h30	82h30	40%	60%
	Manipulation Robots Control	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental Unit Code : UEF 2.1.2 Credits : 8 Coefficients : 4	Discrete Event Systems	4	2	1h30	1h30		45h00	55h00	40%	60%
	FPGA and VHDL programming	4	2	1h30	1h30		45h00	55h00	40%	60%
Methodological Unit Code : UEM 2.1 Credits : 9 Coefficients : 5	Industrial supervision	3	2	1h30		1h00	37h30	37h30	40%	60%
	Practical Work in Advanced control	2	1			1h30	22h30	27h30	100%	
	Practical Work in Manipulator Robots Control	2	1			1h30	22h30	27h30	100%	
	Practical Work in FPGA and VHDL programming	2	1			1h30	22h30	27h30	100%	
Discovery Unit Code : UED 2.1 Credits : 2 Coefficients : 2	Elective units *	1	1	1h30			22h30	02h30		100%
	Elective units *	1	1	1h30			22h30	02h30		100%
Transversal Unit Code : UET 2.1 Credits : 1 Coefficients : 1	Document research and thesis design	1	1	1h30			22h30	02h30		100%
Total semester 3		**30**	**17**	**13h30**	**6h00**	**5h30**	**375h00**	**375h00**		

Discovery Unit (S1, S2 and S3)

1. Nanotechnology
2. Reliability engineering
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, Environmental Robotics, etc.)
12. Image processing and vision
13. Others...

Semester 4

Internship in a company sanctioned by a thesis and a defense.

	SVH	Coeff	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 provided for informational purposes

Evaluation of the Master's End of Cycle Project

- Scientific value (Assessment by the jury) /6
- Writing of the thesis (Assessment by the jury) /4
- Presentation and response to questions (Assessment by the jury) /4
- Supervisor's evaluation /3
- Internship report presentation (Assessment by the jury) /3

III. Detailed program by subject for semester S1

Semester: 1
Teaching Unit: UEF 1.1
Subject : Multivariable linear systems
SVH: 67h30 (Class: 3h00, Tutorial: 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 linear systems, in the context of the state-space approach.

Recommended prerequisite knowledge:

The student should have the following knowledge:

- Linear control systems;
- Sampled systems;

Subject content:

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

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

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

Chapter 3. Controllability and observability **(2 weeks)**

Introduction, Kalman's 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, Conversion from state representation to transfer matrix representation, Gilbert's method, Invariants method: Smith-McMillan form, Reduction method of a realization.

Chapter 5. State feedback control of SM. **(4 weeks)**

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

Evaluation mode :

Continuous assessment : 40%; Exam: 60%.

Bibliographic References

1- De Larminat, Automatique, Hermès, 1995.
2- B. Pradin, G. Garcia ; "automatique linéaire : systèmes multivariables", polycopies de cours,

INSA de Toulouse, 2011.

3- Caroline Bérard, Jean-Marc Biannic, David Saussié, ''La commande multivariable", Editions Dunod, 2012.
4- G. F. Franklin, J. D. Powell and A. E. Naaeimi, Feedback Control Dynamique Systems. (Addison-Wesly, 1991.
5- K. J. Astrôm, B. Wittenmark, Computer-Controlled Systems, Theory and design. Prentice Hall, New Jersy, 1990.
6- W. M. Wonman, Linear Multivariable Control :A Geometric approach. Springer Verlag, New York, 1985.
7- Hervé Guillard, Henri Bourlès, "Commandes des Systèmes. Performance & Robustesse. Régulateurs Monovariables Multivariables Applications Cours & Exercices Corrigés", Editions Technosup, 2012.
8- Caroline Bérard , Jean-Marc Biannic , David Saussié, Commande multivariable, Dunod, Paris, 2012.

Semester: 1
Teaching Unit: UEF 1.1
Subject : Signal Processing
SVH: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

To master the tools for temporal and frequency representation of analog and digital signals and systems, and to perform basic processing such as filtering and digital spectral analysis.

Recommended prerequisite knowledge:

The student should have the following knowledge:

- Signal theory
- Basic mathematical concepts

Subject content:

Chapter 1. Review 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)** Temporal 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 to digital signals Sampling, reconstruction, and quantization.

Chapter 4: Discrete transforms and windowing: From the Discrete-Time Fourier Transform (DTFT) to the Discrete Fourier Transform (DFT), the Fast Fourier Transform (FFT) **(3 weeks)**

Chapter 5: Analysis and synthesis of digital filters **(5 weeks)** Filter specifications Finite impulse response (FIR) filters Infinite impulse response (IIR) filters Lattice filters FIR filter synthesis: window method IIR filter synthesis: bilinear method.

Evaluation mode :

Continuous assessment : 40% ; Exam: 60%.

Bibliographic references:

1- Francis Cottet, Traitement des signaux et acquisition de données - Cours et exercices corrigés, 4ième édition, Dunod, Paris, 2015.
2- Tahar Neffati, Traitement du signal analogique : Cours, Ellipses Marketing, 1999.
3- Messaoud Benidir, Théorie et traitement du signal : Méthodes de base pour l'analyse et le traitement du signal, Dunod, 2004.
4- Maurice Bellanger, Traitement numérique du signal : Théorie et pratique, 9ième édition, Dunod, Paris, 2012.
5- Étienne Tisserand Jean-François Pautex Patrick Schweitzer, Analyse et traitement des signaux

méthodes et applications au son et à l'image 2ième édition, Dunod, Paris, 2008.

6- Patrick Duvaut, François Michaut, Michel Chuc, Introduction au traitement du signal - exercices, corrigés et rappels de cours, Hermes Science Publications, 1996.

Semester: 1
Teaching Unit: UEF 1.1
Subject : Converters-Machines Association
SVH: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching Objectives:

To study the different converter-machine associations in rotating electrical machines in order to control the torque and speed of a system.

Recommended prerequisite knowledge:

The student should have the following knowledge:

- Power electronics.

Subject content:

Chapter 1. DC-AC converters (4 weeks)
- Uninterruptible power supply structures
- PWM converter principle

Chapter 2. DC motor (2 weeks)
- Principle, structure, and characteristics
- Variation of speed.

Chapter 3. AC motor (2 weeks)
- Principle, structure, and characteristics
- Variation of speed.

Chapter 4. Converter-machine association (4 weeks)
- Torque and speed control
- Speed controllers for synchronous machines
- Speed controllers for asynchronous machines

Chapter 5. Criteria for choosing and implementing a variable speed drive (3 weeks)

Evaluation mode :

Continuous assessment : 40% ; Exam: 60%.

Bibliographic references:

1. F. LABRIQUE, G. SEGUIER, R. BAUSIERE, Volume 4 : La conversion continu-alternatif, Lavoisier TEC & DOC, 2° édition, 1992.
2. Daniel Gaude, Electrotechnique tome 2 : Electronique de puissance, conversion électromagnétique, régulation et asservissement, Cours complet illustré de 97 exercices résolus, Eyrolles, 2014.
3. Francis Milsant, Machines électriques (BTS, IUT, CNAM), vol. 3 : Machines synchrones et asynchrones, Ellipses Marketing, 1991.
4. B.K. Bose, Power Electronics and AC drives, Prentice-Hall, 1986.

Semester: 1
Teaching Unit: UEF 1.1
Subject : Optimization
SVH: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching Objectives:

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

Recommended prerequisite knowledge:

Students should have a background in mathematics.

Subject content:

Chapter 1. Mathematical Review (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. Constrained Optimization - Global Methods (3 weeks)
Projected gradient method Lagrange-Newton method for inequality constraints,
Projected Newton method (for bound constraints),
Penalty method Duality method: Uzawa's method

Chapter 4. Linear Programming (3 weeks)

Chapter 5. Nonlinear Programming (4 weeks)

Haut du formulaire

Assessment mode :

Continuous assessment : 40% ; Exam: 60%.

Bibliographic references:

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 à l'optimisation, Ellipses, 2012.
4- Rémi Ruppli, Programmation linéaire : Idées et méthodes, Ellipses, 2005.
5- Pierre Borne, Abdelkader El Kamel, Khaled Mellouli, Programmation linéaire et applications : Eléments de cours et exercices résolus, Technip, 2004.

Semester: 1
Teaching Unit: UEM 1.1
Subject : Networks and protocols of industrial communication
SVH: 37h30 (Class: 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 that implements industrial type networks.

Recommended prerequisite knowledge:

The student should have the following knowledge:

• Basic knowledge of industrial network technologies and uses.

Subject content:

Chapter 1. Overview of OSI and TCP/IP network models **(1 week)**

Chapter 2. Communication buses **(3 weeks)**

• Traditional

• Emerging

Chapter 3. Wireless industrial communication protocols (WirelessHart) **(2 weeks)**

Chapter 4. Security of industrial communication networks without wires **(2 weeks)**

Chapter 5. Diagnostics of industrial communication networks **(3 weeks)**

Chapter 6. Network supervision (2 weeks)

Chapter 7. OPC (OLE for Process Control) servers/clients **(2 weeks)**

Subject content:

Include a few Practical Work sessions related to available hardware.

Evaluation mode :

Continuous assessment : 40% ; Exam: 60%.

Bibliographic references:

1- A. Tanenbaum, Réseaux : Architecture, protocole, applications, Inter Editions - Collection iia
2- Gildas Avoine, Pascal Junod, Philippe Oechslin: Sécurité Informatique, Vuibert.

3- Malek Rahoual, Patrick Siarry, Réseaux informatiques : conception et optimisation, Editions Technip, 2006.
4- Guy Pujolle, Les réseaux, 5ième édition, Eyrolles, 2006.
5- Paul Mühlethaler, 802.11 et les Réseaux sans fil, Eyrolles, 2002.
6- Khaldoun Al Agha, Guy Pujolle, Guillaume Vivier, Réseaux de mobiles et réseaux sans fil, Eyrolles, 2001.

Semester: 1
Teaching Unit: UEM 1.1
Subject : Practical work in Multivariable Linear Systems
SVH: 22h30 (Pw: 1h30)
Credits: 2
Coefficient: 1

Teaching Objectives:

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

Recommended prerequisite knowledge:

Prior knowledge of linear algebra and multivariable linear control systems is recommended.

Subject content:

Pw 1: Introduction to Matlab
Pw 2: State-space representation of multivariable systems
Pw 3: Controllability and Observability.
Pw 4: Representation of multivariable systems using transfer matrices.
Pw 5: State feedback control of multivariable systems.
Pw 6: State observation of multivariable systems.

Evaluation mode : 100% continuous assessment.

Semester: 1
Teaching Unit: UEM 1.1
Subject : Practical Work in Signal processing / Practical Work in Optimization
SVH: 22h30 (Pw: 1h30)
Credits: 2
Coefficient: 1

Teaching Objectives:

For the Practical Work in Signal Processing, consolidate the knowledge acquired during the Signal Processing course through practical work in order to better understand and assimilate the content of this subject.

For the Practical Work in Optimization, enable students to exploit and master the theoretical concepts studied in the course.

Recommended prerequisite knowledge:

Courses content.

Subject content:

Practical Work in Signal Processing:

Pw 1 – Signal representation and applications of the Fourier transform under Matlab
Pw 2 - Analog filtering
Pw 3 - Discrete Fourier Transform
Pw 4 - Digital filtering RII
Pw 5 - Digital filtering RIF

Practical Work in Optimization:

Pw 1 - Introduction to Matlab
Pw 2 - Unconstrained optimization
Pw 3 - Unconstrained optimization
Pw 4 - Linear programming
Pw 5 - Non-linear programming

Evaluation mode: 100% continuous assessment.

Semester: 1
Teaching Unit: UEM 1.1
Subject : Practical Work in Converters-Machines Association
SVH: 22h30 (Pw: 1h30)
Credits: 2
Coefficient: 1

Teaching Objectives:

This Practical Work in aims to provide students with practical application and consolidation of the knowledge acquired in the "Association Converters-Machines" module.

Recommended prerequisite knowledge:

Courses content.

Subject content:

Pw 1: DC-AC Converters

Pw 2: Speed control for DC motors

Pw 3: Speed control for AC motors

Pw 4: Speed control for synchronous machines

Pw 5: Speed control for asynchronous machines

Evaluation mode: 100% continuous assessment.

Semester: 1
Teaching Unit: UET 1.1
Subject : Technical English and Terminology
SVH: 22h30 (Class: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

To introduce the student to technical vocabulary. To reinforce their language skills. To help them understand and synthesize technical documents. To enable them to understand a conversation in English held in a scientific context.

Recommended prerequisite knowledge:

Basic English vocabulary and grammar.

Subject Content:

- Written comprehension: Reading and analysis of texts related to the specialty.
- Oral comprehension: From authentic scientific popularization video documents, note-taking, summary, and presentation of the document.
- Oral expression: Presentation of a scientific or technical topic, 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, letters requesting internships or jobs.

Recommendation : It is strongly recommended for the course instructor to present and explain at the end of each session (at most) ten technical words related to the specialty in the three languages (if possible) English, French, and Arabic.

Assessment method: Exam: 100%.

Bibliographic references:

1. P.T. Danison, Guide pratique pour rédiger en anglais : usages et règles, conseils pratiques, Editions d'Organisation 2007
2. A.Chamberlain, R. Steele, Guide pratique de la communication: anglais, Didier 1992
3. R. Ernst, Dictionnaire des techniques et sciences appliquées : français-anglais, Dunod 2002.
4. J. Comfort, S. Hick, and A. Savage, Basic Technical English, Oxford University Press, 1980
5. E. H. Glendinning and N. Glendinning, Oxford English for Electrical and Mechanical Engineering, Oxford University Press 1995
6. T. N. Huckin, and A. L. Olsen, Technical writing and professional communication for nonnative speakers of English, Mc Graw-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 : Nonlinear Systems
SVH: 67h30 (Class: 3h00, Tutorial: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:

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

Recommended prerequisite knowledge:

The student should possess the following knowledge:
- Signal theory
- Mathematical basics

Subject content:

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

Chapter 2: Phase plane analysis: (3 weeks)
Second-order systems. Phase portrait construction. Elimination of implicit/explicit time. Isocline method. Van der Pol oscillator. Reminder of linear systems: characterization of orbits by eigenvalues. Index of singular points. Poincaré-Bendixson theorem. 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 regulator. 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 theory: (2 weeks)
Stability: intuitive definition. Notion of distance. Formal definition of stability. 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 indirect method. LaSalle's invariance theorem. Krasovskii's method. Variable gradient method. Instability and Chetaev's theorem.

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

Chapter 6: Differential geometry concepts: (3 weeks)
Vector field. Dual space. Covector. Gradient viewed as a covector field. Lie derivative. Lie bracket. Diffeomorphism. Frobenius' theorem. Involutive family. Linearization conditions. Returning to the example of the flexible joint robot.

Chapter 7. Nonlinear systems control: (3 weeks)

1. Generalities
2. Control by linearization
3. Control by sliding modes

Evaluation mode:

Continuous assessment : 40% ; Exam: 60%.

Bibliographic references:

1. Ph. Müllhaupt, Introduction à l'analyse et à la commande des systèmes non linéaires, PPUR, 2009.
2. Gille, J.C., Decaulne, P., Pelegrin, M., Méthodes d'étude des systèmes asservis non linéaires, Dunod, 1975.
3. Atherton, D.P., 'Nonlinear Control Engineering. Describing Function Analysis and Design', Van Nostrand Reinhold Company, 1975.
4. Utkin, V.I., 'Sliding modes and their application to variable structure systems', MIR Publishers, 1978.
5. Khalil, H.K., 'Nonlinear systems', Prentice Hall, Englewood Cliffs, NJ, 1980.
6. Nijmeijer, H., Van der Shaft. A.J., 'Nonlinear dynamical control systems', Springer Verlag, 1990.
7. Isidori, A., 'Nonlinear control systems.', Springer Verlag, 1995.
8. Yves Granjon, Automatique - Systèmes linéaires, non linéaires - 2e édition: Cours et exercices corrigés, Dunod; Édition : 2e édition, 2010.
9. RASVAN Vladimir, STEFAN Radu, Systèmes non linéaires : théorie et applications, Lavoisier, 2007.
10. J.-C. Chauveau, Systèmes asservis linéaires et non linéaires: Exercices et problèmes résolus, Educalivre, 1995.
11. Philippe Müllhaupt, Introduction à l'analyse et à la commande des systèmes non linéaires, PPUR, 2009.

Semester: 2
Teaching Unit: UEF 1.2.1
Subject : Embedded Systems and Real-time Systems
SVH: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The objective of this course is to provide students with an introduction to real-time systems. These systems are usually embedded systems (consisting of multiple hardware and software components) and are used in environments known for their critical nature, where any failure can have serious consequences for 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 prerequisite knowledge:

The student should have the following knowledge:

- Programming in C
- Basics of digital electronics and microcontrollers

Subject content:

A. Embedded Systems

Chapter 1 Embedded Systems Architecture Based on Microcontroller **(1 week)**
History, Definition, Types of Embedded Systems, Introduction to the microcontroller architecture 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 Kernel

Chapter 5 - Interrupts **(1 week)**
Chapter 6 - Introduction to Real-Time Systems **(1 week)**
Chapter 7 - Osa-RTOS Operation **(1 week)**
Chapter 8 - Kernel and Services **(3 weeks)**
Chapter 9 - Automatic Applications **(2 weeks)**

Haut du formulaire

Evaluation mode :

Continuous assessment : 40% ; Exam: 60%.

Bibliographic references:

1. Francis Cottet, Emmanuel Grolleau, Systèmes temps réel embarqués - 2e éd. - Spécification, conception, implémentation et validation temporelle, Dunod, 2014.
2. Nicolas Navet, Systèmes temps réel - Volume 2 : Ordonnancement, réseaux et qualité de service, Hermès – Lavoisier, 2006.
3. Philippe Louvel, Systèmes électroniques embarqués et transports, , 2012, Dunod
4. Yassine Manai, Méthodologie de conception de systèmes embarqués, 2011, Dunod
5. Bernard Chauvière, Systèmes temps-réel embarqués: Techniques d'ordonnancement et Evaluation de la qualité de service Editions universitaires europeennes, 2010.

Semester: 2
Teaching Unit: UEF 1.2.2
Subject : Advanced programming of PLCs
SVH: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

To deepen the programming of complex functions and Inputs/Outputs. To implement and use programming and project development tools with practical applications, to master the exchange of information between automated systems and intelligent equipment via a field network.

Recommended prerequisite knowledge:

PLCs taught in Y3-S4; combinational and sequential logic; sensors and actuators.

Subject content:

Chapter 1: Generalities on automated production systems (1 week)

- Concepts of automated systems
- Hardware and software architecture of an automated system
- Examples of automated systems
- From wired logic to programmed logic

Chapter 2: Industrial Programmable Logic Controllers (3 weeks)

- What is a programmable logic controller
- Different types of PLCs
- Constituent elements of PLCs
- Criteria for choosing a PLC
- Different types of PLC data
- Digital Input/Output Cards
- Analog Input/Output Cards
- PID Regulation Cards
- Axis Control Cards
- Fast Counting Cards

Chapter 3: PLC Programming (5 weeks)

- Introduction to combinational logic
- Logic equations and logic gates
- Introduction to Grafcet
- Ladder language
- Translation of Grafcet into Ladder
- Transcription of a specification into Grafcet
- Programming languages

Chapter 4: SCADA Supervisory Systems (2 weeks)

- Utility 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 importance of communication networks Characteristics of networks
  - Generalities on standardization.
  - Transmission media: twisted pair, coaxial cable, optical fiber.

  - Transmission standards: BC20mA, RS232, RS422/485…
  - Network principles : topologies, access methods, protocols, …
- Network levels
  - TELWAY7, FIPWAY / FIPIO
  - MODBUS PLUS.
  - PROFIBUS DP
  - ASI
  - DEVICE NET, ETHERNET
- Choice and implementation of communication networks:
  - Decomposition of an automation into subsystems.
  - Synchronization of subsystems.
  - Presentation of heterogeneous networks
  - Presentation of communication modules and possible gateways between different types of networks.
  - Application to a project example.

Evaluation mode :

Continuous assessment : 40% ; Exam: 60%.

Bibliographic references:

1. William Bolton, « Les automates programmables industriels », 2e éd, Dunod, 2015.
2. Guide des solutions d'automatisme, Publications techniques, Schneider, 2008
3. John R. Hackworth and Frederick D. Hackworth, Jr. Programmable Logic Controllers: Programming Methods and Applications, Ed, Prentice Hall, 2004.
4. L. A. Bryan, E. A. 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
SVH: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The teaching aims 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 a global system (even in industry). They must then be able to perform measurements on an electronic circuit (including the possibility of modifications or troubleshooting). They must also be able to provide a solution to problem situations (design and create analogic electronic circuits).

Recommended prerequisite knowledge: The student should have the following knowledge:

- Fundamental electronics
- Power electronics

Subject content:

Chapter 1: Review of switching transistor and capacitor charge and discharge **(1 week)**

Chapter 2: Operational amplifier and AO-based circuits **(2 weeks)**
- Linear mode operation
- Non-linear mode operation

Chapter 3: Pulse (signal) generation **(3 weeks)**
- Astable (with AO, NE555, logical gates)
- Monostable (with AO, NE555, logical gates)
- Schmitt trigger (with AO)

Chapter 4: ADC and DAC converters **(3 weeks)**
Chapter 5: Study of active filters **(2 weeks)**
Chapter 6: Introduction to PCB circuit realization principles **(4 weeks)**
- PCB realization technology
- Realization rules (routing, multilayers)

Evaluation mode :

Continuous assessment : 40% ; Exam: 60%.

Bibliographic references:

1. Yves Granjon, Bruno Estibals, Serge Weber, Electronique - Tout le cours en fiches, Collection: Tout le cours en fiches, Dunod, 2015 .
2. Albert Paul Malvino, David J. Bates Principes d'électronique, Cours et exercices corrigés, 8ème édition, Dunod, 2016.
3. Charles Adams Platt, Xavier Guesnu, Eric Bernauer, Antoine Derouin, L'électronique en pratique : 36 expériences ludiques , Eyrolles, 2013.
4. François de Dieuleveult, Hervé Fane, Principes et pratique de l'électronique, tome 1 : Calcul des circuits et fonctions, Dunod, 1997.

5. François de Dieuleveult, Hervé Fanet Principes et pratique de l'électronique, tome 2 : Fonctions numériques et mixtes, Dunod, 1997.
6. Christophe François, Romain Dardevet, Patrick Soleilhac, Génie Électrique : Électronique Analogique Électronique Numérique Exercices et Problèmes Corrigés, Ellipses Marketing 2006.
7. Mohand Mokhtari Electronique Appliquée, Electromécanique sous Simscape & Sim Power Systems (Matlab/Simulink), Springer-Verlag Berlin and Heidelberg GmbH & Co 2012.
8. 6. P. Mayeux, « Apprendre l'électronique par l'expérimentation et la simulation », ETSF, 2006.

Semester: 2
Teaching Unit: UEM 1.2
Subject : Object-Oriented Design
SVH: 37h30 (Class: 1h30, Practical Work: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

The course aims to teach students the basic concepts of object-oriented programming and techniques for developing projects. By the end of the course, students should be able to:

- Develop computer applications based on object-oriented programming.
- Develop human-machine interface applications (using C++ and Java) on Windows or Android environments.

Recommended prerequisite knowledge:

Basic knowledge of programming in C and algorithmic design.

Subject content: Chapter 1: Introduction to Object-oriented Approach (1 week)
Why use object-oriented technologies? Challenges of new computing: modularity (Plug-Ins), reusability, scalability. Use of component libraries.

Chapter 2: Basic Concepts (2 weeks)
Review of 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 definitions, access rights and encapsulation, prototype and definition separation, constructor and destructor, constant methods, class association, 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, virtual method implementation, 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 mode :

Continuous assessment: 40% ; Exam: 60%.

Practical Work in Object-Oriented Design

Pw 1: Classes and Objects
Pw 2: Inheritance and Polymorphism
Pw 3: Memory Management
Pw 4: Templates
Pw5: Object-Oriented Example (for example, creating a small object-oriented game in C++ or Java)

Evaluation mode :

Continuous assessment: 40% ; Exam: 60%.

Bibliographic references:

1. Bertrand Meyer, Conception et Programmation orientées objet, Eyrolles, 2000.
1- Franck Barbier, Conception orientée objet en Java et C++: Une approche comparative, Pearson Education, 2009.
2- Edward Yourdon, Peter Coad, Conception orientée objet, Dunod, 1997.
3- Hugues Bersini, La programmation orientée objet. Cours et exercices UML 2 avec Java, C#, C++, Python, PHP et LINQ, Eyrolles; 6e édition, 2013.
4- Claude Delannoy, S'initier à la programmation et à l'orienté objet : Avec des exemples en C, C++, C#, Python, Java et PHP, Eyrolles; 2e édition, 2016.
5- Luc GERVAIS, Apprendre la Programmation Orientée Objet avec le langage C# (2e édition), Editions ENI; 2e édition, 2016.
6- Thierry GROUSSARD Luc GERVAIS, Java 8 - Apprendre la Programmation Orientée Objet et maîtrisez le langage (avec exercices et corrigés), Editions ENI, 2015.
7- Luc GERVAIS, Apprendre la Programmation Orientée Objet avec le langage Java, ENI, 2014.

Semester: 2
Teaching Unit: UEM 1.2
Subject : Practical Work in Nonlinear Systems
SVH: 22h30 (Practical Work: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

Practical Work in Nonlinear Systems: Demonstrate the difference in dynamic behavior between linear and nonlinear systems. Introduce the concept of equilibrium point. Illustrate the importance of phase plane analysis through simulation. Synthesize nonlinear systems.

Recommended prerequisite knowledge:

Course content.

Subject content: Practical Work in Nonlinear Systems :

Pw 1: Advanced Simulation on Matlab
Pw 2: Simulation of Equilibrium Points for a Few Nonlinear Systems
Pw 3: Simulation of Some Nonlinear Systems in the Phase Plane
Pw 4: Simulation of the Inverted Pendulum in Open Loop
Pw 5: Simulation of Linearizing Control
Pw 6: Sliding Mode Control

Evaluation mode: 100% continuous evaluation.

Semester: 2
Teaching Unit: UEM 1.2
Subject : Practical Work in Embedded Systems and Real-Time Systems
SVH: 22h30 (Practical Work: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

The objective of this Practical work is to provide a methodology for the design of embedded applications, including the implementation of digital and analog input/output operations (sensors and actuators), means of communication with the external environment (IHM, Labview, ...), and an introduction to real-time system programming. The Practical Works will be carried out on an ArduinoMega development board and programming will be done with the AVR Studio IDE.

AVR has been chosen since the Arduino board (a widely used development board) is based on this architecture. Nevertheless, any other architecture is perfectly adapted to this course.

Recommended prerequisite knowledge:

Course content.

Subject content:

Pw1: Introduction to AVR Studio IDE: Project creation, C compilation, debugging, uploading to the Arduino board.
Pw 2: Digital input/output: Display on LED, Relay, 7-segment display, 16-key keyboard reading.
Pw 3: Analog/digital conversion: LM35 temperature sensor, reading voltages, currents.
Pw 4: USART serial communication: Display of analog quantities on PC.
Pw 5: PWM signal generation, DC motor control.
Pw 6: Introduction to real-time system OSA, OSA project creation.
Pw 7: Application of real-time control to speed regulation of a DC motor.

Evaluation mode: 100% continuous evaluation.

Semester: 2
Teaching Unit: UEM 1.2
Subject: Practical Work in Advanced Programming of PLCs/ Practical Work in Applied Electronics
SVH: 22h30 (Practical Work: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

Pw Adv. PLCs Prog : Consolidation of knowledge acquired in advanced API programming courses to better understand and assimilate the structure of an automated system, programming complex functions and inputs/outputs, and communication interfaces between automata.

Pw App. Elec: The purpose of the practical work is to give students the opportunity to build electronic circuits on a breadboard and then validate their operation using measuring instruments.

Recommended prerequisite knowledge:

Course content.

Subject content Practical Work in Advanced PLCs Programming:

Plan some practical work related to the available hardware.

Subject content Practical Work in Applied Electronics:

Pw 1: Study of the FET and MOS transistor amplifier.

Pw 2: Operational amplifiers.

Pw 3: Study of a sample CAN circuit, Study of a sample DAC circuit.

Pw 4: Oscillators.

Pw 5: Active filters (low-pass, high-pass, etc.).

Pw 6: Implementation of an electronic circuit. The course instructor and the student are free to propose the implementation of other circuits.

Evaluation mode: 100% continuous evaluation.

Semester: 2
Teaching Unit: UET 1.2
Subject : Ethics, Deontology and Intellectual Property
SVH: 22h30 (Class : 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

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

Recommended prerequisite knowledge:

Course content.

Subject content:

A- Ethics and Deontology

I. Notions of Ethics and Deontology (3 weeks)

1. Introduction
    1. Definitions: Morality, ethics, deontology
    2. Distinction between ethics and deontology
2. Charter of ethics and deontology of MESRS: Integrity and honesty. Academic freedom. Mutual respect. Requirement of scientific truth, objectivity, and critical thinking. Equity. Rights and obligations of students, teachers, administrative, and technical staff.
3. Ethics and deontology in the workplace Legal confidentiality in the company. Loyalty to the company. Responsibility within the company, conflicts of interest. Integrity (corruption in work, its forms, consequences, methods of fighting, and sanctions against corruption)

II. Honest and Responsible Research (3 weeks)

1. Respect for ethical principles in teaching and research
2. Responsibilities in teamwork: Professional equality of treatment. Conduct against discrimination. The pursuit of the public interest. Inappropriate conduct within the framework of collective work.
3. Adopting responsible conduct and combating abuses: Adopting responsible conduct in research. Scientific fraud. Conduct against fraud. Plagiarism (definition of plagiarism, different forms of plagiarism, procedures to avoid unintentional plagiarism, plagiarism detection, 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 (books, scientific articles, communications in a congress, theses, dissertations, etc.)

II- Copyright (5 weeks)

1. **Copyright in the digital environment**
   Introduction. Copyright of databases, software copyright. Specific case of open-source software.

2. **Copyright on 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. Patentability. Patent application in Algeria and the world.

4. **Trademarks, designs, and models**
   Definition. Trademark law. Design and model law. Origin appellation. The secret. Counterfeiting.

5. **Geographical Indications Law**
   Definitions. Protection of Geographical Indications in Algeria. International treaties on geographical indications.

III- Protection and Valorization of Intellectual Property (3 weeks)
How to protect intellectual property. Violation of rights and legal tools. Valorization of intellectual property. Protection of intellectual property in Algeria.

Evaluation mode : Exam : 100%

Bibliographic references:

1. Charte d'éthique et de déontologie universitaires, https://www.mesrs.dz/documents/12221/26200/Charte+fran ais+d_f.pdf/50d6de61-aabd- 4829-84b3-8302b790bdce
2. Arrêtés N°933 du 28 Juillet 2016 fixant les règles relatives à la prévention et la lutte contre le plagiat
3. L'abc du droit d'auteur, organisation des nations unies pour l'éducation, la science et la culture (UNESCO)
4. E. Prairat, De la déontologie enseignante. Paris, PUF, 2009.
5. Racine L., Legault G. A., Bégin, L., Éthique et ingénierie, Montréal, McGraw Hill, 1991.
6. Siroux, D., Déontologie : Dictionnaire d'éthique et de philosophie morale, Paris, Quadrige, 2004, p. 474-477.
7. Medina Y., La déontologie, ce qui va changer dans l'entreprise, éditions d'Organisation, 2003.
8. Didier Ch., Penser l'éthique des ingénieurs, Presses Universitaires de France, 2008.
9. Gavarini L. et Ottavi D., Éditorial. de l'éthique professionnelle en formation et en recherche, Recherche et formation, 52 | 2006, 5-11.
10. Caré C., Morale, éthique, déontologie. Administration et éducation, 2e trimestre 2002, n°94.
11. Jacquet-Francillon, François. Notion : déontologie professionnelle. Le télémaque, mai 2000, n° 17
12. Carr, D. Professionalism and Ethics in Teaching. New York, NY Routledge. 2000.
13. Galloux, J.C., Droit de la propriété industrielle. Dalloz 2003.
14. Wagret F. et J-M., Brevet d'invention, marques et propriété industrielle. PUF 2001
15. Dekermadec, Y., Innover grâce au brevet: une révolution avec internet. Insep 1999
16. AEUTBM. L'ingénieur au cœur de l'innovation. Université de technologie Belfort-Montbéliard
17. Fanny Rinck et léda Mansour, littératie à l'ère du numérique : le copier-coller chez les étudiants, Université grenoble 3 et Université paris-Ouest Nanterre la défense Nanterre, France

18. Didier DUGUEST IEMN, Citer ses sources, IAE Nantes 2008
19. Les logiciels de détection de similitudes : une solution au plagiat électronique? Rapport du Groupe de travail sur le plagiat électronique présenté au Sous-comité sur la pédagogie et les TIC de la CREPUQ
20. Emanuela Chiriac, Monique Filiatrault et André Régimbald, Guide de l'étudiant: l'intégrité intellectuelle plagiat, tricherie et fraude… les éviter et, surtout, comment bien citer ses sources, 2014.
21. Publication de l'université de Montréal, Stratégies de prévention du plagiat, Intégrité, fraude et plagiat, 2010.
22. Pierrick Malissard, La propriété intellectuelle : origine et évolution, 2010.
23. Le site de l'Organisation Mondiale de la Propriété Intellectuelle www.wipo.int
24. http://www.app.asso.fr/

V. Detailed program by subject for semester S3

Semester: 3
Teaching Unit: UEF 2.1.1
Subject : Advanced Control
SVH: 67h30 (Class : 3h00, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The aim of this course is to enable students to master tools for the synthesis of efficient controllers that take into account the real operating conditions of physical systems: parametric uncertainties, neglected dynamics, time-varying parameters, presence of disturbances and measurement noise. The taught control techniques make it possible to maintain a level of performance despite the presence of all these constraints.

Recommended prerequisite knowledge:

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

Subject content:

Part 1: Optimal Control **(5 weeks)**
1.1. Introduction and mathematical tools for dynamic optimization
1.2. Time-minimal control
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. Adaptive control by reference model (MRAC)
3.3. MRAC synthesis by MIT approach
3.4. MRAC synthesis 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 control, optimal predictor
4.4. GPC control under constraints
4.5. State space predictive control approach (State Space Model Predictive Control)

Evaluation mode:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1- D. Landau Identification et commande des systèmes, Hermès, 1993.
2- K. J. Astrom and B. Wittenmark, Adaptive control., Dover, 2008.
3- I. D. Landau, R. Lozano, M. M'Saad, and A. Karimi, Adaptive control. Springer , 2011.
4- V. V. Chalam, Adaptive control systems: Techniques and applications. Marcel Dekker,1987

5- P. Boucher and D. Dumur, La commande prédictive, Technip, 1996.
6- J. A. Rossister, Model-Based Predictive Control: A Practical Approach, CRC Press, 2003 7- J. M. Maciejowski, Predictive Control: With Constraints, Prentice Hall, 2002
7- E. F.Camacho, C. B. Alba, Model predictive control. Springer, 2013
8- K. Zhou and J. C. Doyle, Essentials of Robust Control,. Prentice Hall, 1997.
9- D. Alazard, et al. Robustesse et commande optimale. Editions Cépaduès (2000)
10- G. Duc, S. Font, Commande H∞ et μ-Analysis, des outils pour la robustesse, Hermes (1999)
11- S. Skogestadand, I. Postlethwaite, Multivariable Feedback Control. Analysis and Design. Wiley 2005.
12- Daniel Liberzon. Calculus of Variations and Optimal Control Theory: A Concise Introduction.
13- 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.
15- Joao P. Hespanha. Undergraduate lectures notes on LQG LQR controller design. 2007.

Semester: 3
Teaching Unit: UEF 2.1.1
Subject : Manipulation Robots Control
SVH: 45h00 (Class : 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching Objectives:

This subject aims to enable students to master the tools of modelling and control of manipulator robots. It aims to give students the possibility of independently undertaking the resolution of a number of elementary robotics problems such as configuration setting, trajectory generation, dynamic control.

Recommended prerequisite knowledge:

- Linear control theory
- Basics of kinematics and dynamics.

Subject content:

I- Introduction **(1 week)**

1. Definition and history
2. Different categories of robots
3. Robotics vocabulary
4. Characterization of robots
5. Different types of manipulator robots
6. Robot usage
7. Future of robotics

II- Theoretical foundations and preliminary mathematics **(2 weeks)**

1. Positioning

1.1. Rotation
1.2. Representations of rotation
1.3. Attitude
1.4. Homogeneous transformation matrices

2. Kinematics

2.1. Velocity of a solid
2.2. Vector rotation speed
2.3. Rigid movement
2.4. Kinematic wrench 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 modelling
- Lagrange method: Lagrange equation, matrix representation (inertia matrix, Coriolis matrix, gravity matrix).
- Example (planar robot with 1 or 2 degrees of freedom)

IV- Trajectory generation (3 weeks)

- Trajectory generation and control loops
- Point-to-point movement generation: basic method, acceleration profile method, speed profile method, application in joint space, application in Cartesian space.
- Movement generation by interpolation: application in joint space and Cartesian space.

V- Robot control (3 weeks)

1. Dynamic control
2. Sliding mode control

VI- Robot programming (3 weeks)

1. Overview and objectives of programming systems
2. Programming methods
3. Characteristics of different programming languages."

Evaluation mode :

Continuous assessment: 40% ; Exam: 60%.

Bibliographic references :

1. M.W. Spong, S. Hutchinson, M. Vidyasagar, Robot Modeling and Control, Wiley, 1ère éd., 2006.
2. J.J. Craig, Introduction to Robotics: Mechanics and Control, Pearson Education, 3ème éd., 2008.
3. Philippe Coiffet, La robotique, Principes et 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, Modelling planning and Control, Springer, 2009.
7. W. Khalil & E. Dombre, modélisation, identification et commande des robots, Hermès, 1999.

Semester: 3
Teaching Unit: UEF 2.1.1
Subject : Discrete Event Systems
SVH: 45h00 (Class : 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching Objectives:

The objective of the first part of this course is to model Discrete Event Systems (SED) using autonomous Petri networks, construct marking and/or coverage graphs, and analyze these systems. The second part of the course is devoted to supervision control of SEDs. Finally, the third part will cover timed systems.

Recommended prerequisite knowledge:

Basic control theory (servomechanisms and regulation). Algorithmic.

Subject content:

Chapter 1: Introduction to SED (1 week)
- 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 Areas
- 3.2 Characteristics

Chapter 2: Modeling of SED (6 weeks)

II.1. Introduction

II.2. Languages and automata
- 2.1 Languages
- 2.2 Automata: Finite State Machines (FSM)
- 2.3 Design of state machines

II.3. Modeling by RDP
- 3.1 Ordinary RDP
- 3.2 Timed RDP
- 3.3 Synchronized RDP
- 3.4 Interpreted RDP of control

II.4. Modeling by GRAFCET

II.5. Algebra of Dioids or Max+

Chapter 3: Supervision control of SED (5 weeks)

III.1. Introduction to RW theory

III.2. Control under constraints

III.3. Synthesis of controller for SEDs modeled by Finite State Automata

III.4. Synthesis of controller for SEDs modeled by RDP (method of invariants)

III.5. Synthesis of controller for SEDs modeled by GRAFCET

Chapter 4: Extensions and Conclusion (3 weeks)

IV.1. Modular, hierarchical, partial observation, Max+ supervision control

IV.2. Time considerations
- 2.1 Timed RDP and GRAFCET

2.2 Timed automata
2.3 Algebra of Dioids or Max+"

Evaluation mode :

Continuous assessment: 40% ; Exam: 60%.

Bibliographic references :

1. BRAMS, Approche mathématique des réseaux de Petri, MASSON 1987
2. J.M. Proth,X. Xie, Modélisation des systèmes de production, DUNOD 1992
3. Marsan, S. Donatelli .Modelling with generalized stochasticPetri Nets, Willey 1995
4. M. cassandras, S. Lafortune. Introduction to DES, Willey 1999.

6- R. David et H Alla. Du Grafcet aux Réseaux de Petri, Hermes. 1992.

5. C. Cassandras and S. Lafortune. Introduction to discrete Event Systems. Kluwer Academic, 2008.

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

Teaching Objectives:

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

Recommended prerequisite knowledge:

1. Number coding.
2. Combinatorial circuits.
3. Sequential circuits.

Subject content:

Chapter 1. The VHDL language. (2 weeks)
Design units, levels of description. Organization in a library. Language elements. Language objects. Data categories. Modeling by generic parameters. Instruction types. Subprograms. Functional simulation of circuits: Test-Bench.

Chapter 2. Digital circuits. (3 weeks)
Classical architectures of digital circuits. Standard circuits: simple functions, microprocessors and DSP, memories. ASIC application specific circuits: pre-broadcast, on-demand, pre-characterized, PLD programmable circuits: simple programmable circuits SPLD, complex programmable circuits CPLD, programmable logic arrays FPGA. Interconnection technologies: fuses, anti-fuses, floating gate MOS, static memories. Selection criteria. Application areas.

Chapter 3. Reconfigurable logic networks FPGA. (3 weeks)
Types of FPGA architectures: Computing island architecture, Hierarchical architecture, Sea of gates architecture, Various FPGA elements: Configurable circuit (CLB logic blocks, IOB input/output blocks, Programmable interconnects), Clock manager, SRAM memory array. The current FPGAs: Block of small multipliers in an FPGA, DSP blocks in an FPGA, Blocks of processor cores in an FPGA. The criteria of choice. The fields of application.

Chapter 4: Design Methodology. (3 weeks)
Design methods: design of circuits with low integration density, design of circuits with high integration density. Development tools: CAD tools, different approaches to describing a circuit, description languages. Presentation of the compilers that contain the CAD tools.

Chapter 5. Wired operators. (2 weeks)
Representations of relative numbers: shifted binary, sign and absolute value, complement to 1, complement to 2. Fixed point representation. Adders. Multipliers. Divisors. Comparators.

Chapter 6: Study of an FPGA example - SPARTAN3 (2 weeks)
1. 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.

Evaluation mode :
Continuous assessment: 40% ; Exam: 60%.

Bibliographic references:

1. Philip Simpson, La conception de systèmes avec FPGA - Bonnes pratiques pour le développement collaboratif Poche, Dunod, 2014.
2. Francois ANCEAU & Yvan BONNASSIEUX, Conception Des Circuits VLSI, Du composant au système, Dunod, 2007.
3. Pong P. Chu, FPGA Prototyping by VHDL Examples: Xilinx Spartan, Wiley-Blackwell, 2008.
4. Alexandre Nketsa, Circuits logiques programmables : Mémoires PLD, CPLD et FPGA, informatique industrielle, Ellipses Marketing, 1998.
5. Jacques WEBER & Sébastien MOUTAULT & Maurice MEAUDRE, Le langage VHDL, du langage au circuit, du circuit au langage, 5e éd.: Cours et exercices corrigés, Dunod, 2016.
6. Phillip DARCHE, Architecture Des Ordinateurs, Logique booléenne : implémentations et technologies, Vuibert, Paris, 2004.

Semester: 3
Teaching Unit: UEM 2.1
Subject : Industrial Supervision
SVH: 37h30 (Class : 1h30, Practical work: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

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

Recommended previous knowledge:

PLC, Industrial networks, Communication buses and protocols, Instrumentation chain, Industrial drawing,

Subject content:

Chapter 1. definition of a SCADA system (1 week) Definition of a SCADA system (supervision =monitoring-control), utilities, functions, ... 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, ... Management of alarms, Management of messages (error, confirmation, ...), Management of Production-Receipts ranges, Archiving, and Historization, Definition of qlq international standards of IT schematization (Piping and Instrumentation), ISA symbology, PCF, ...

Chapter 5. SCADA supervision software (2 weeks)

- **Software organization of a SCADA system**

Variable dedicated to the control-command: Internal and external variables, type ToR, Numeric, analog, string of characters
Variable "object": Value of the variable, 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 (read, send, update, ...), refresh time (cyclic, configurable cyclic, flash, ...), ...
Programming: Graphic editor, component libraries, instantiations, ...

Remote administration, ...

- **Presentation of some software for SCADA :**

Siemens →SIMATIC WinCC flexible, TIAPortal , Scheinder Electric →Monitor pro, Elution Conrol Maestro, 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 evaluation. Scenarios of possible incidents. Sources of incidents. Detection and identification of failures, errors, ... Security policy. ....

Chapter 7. Demonstrative applications (3 weeks)

Study an illustrative example: Introduce all the notions and the software and hardware concepts studied to elaborate a corresponding SCADA system, according to a well determined specification.

Practical work:

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

Pw1. Introduction to WinCC flexible (or TIA Portal) from Siemens
Pw2. Design and implementation of a SCADA system to control the water level in a tank
Pw3. Design and implementation of a SCADA system for a parking barrier:

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

Evaluation mode :

Continuous assessment: 40% ; Exam: 60%.

Bibliographic references:

1- Ronald L. Krutz Securing SCADA Systems, Wiley, 2005.
2- Stuart A. Boye, Scada: Supervisory Control And Data Acquisition, ISA; Édition : 4th Revised edition, 2009.
3- Robert Radvanovsky et Jacob Brodsky, Handbook of SCADA/Control Systems Security, Second Edition, CRC Press; 2016
4- William Shaw, Cybersecurity for Scada Systems, PennWell Books, 2006.

Semester: 3
Teaching Unit: UEM 2.1
Subject : Practical Work in Advanced Control
SVH: 22h30 (Practical work: 1h30)
Credits: 2
Coefficient: 1

Teaching Objectives:

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

Recommended prerequisite knowledge:

Course Content.

Subject Content:

PW1: LQ Optimal Control

PW2: LQR Optimal Control

PW3: Adaptive Control using MIT and Lyapunov approach

PW4: Adaptive Control using Self-Tuning Regulator

PW5: Predictive Control using Transfer Function approach

PW6: Predictive Control using State-Space approach

Evaluation mode: 100% continuous evaluation.

Semester: 3
Teaching Unit: UEM 2.1
Subject : Practical Work in Robot Manipulation Control
SVH: 22h30 (Practical work: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

To put into practice and give a concrete aspect to the notions seen in the "Robot Manipulation Control" course through practical work in order to better understand and assimilate the content of this subject.

Recommended prerequisite knowledge:

Course content.

Subject content:

Pw1. Introduction to Matlab Robotics Toolbox. (Geometric transformations)

Pw2. Geometric and inverse modeling of a Planar Robot (3DDL).

Pw3. Direct and inverse kinematic modeling.

Pw4. Dynamic modeling of a planar robot (2DDL).

Pw5. Generation of trajectories in articulatory and Cartesian modes.

Pw6. Dynamic control of a robot.

Evaluation mode: 100% continuous evaluation.

Semester: 3
Teaching Unit: UEM 2.1
Subject : Practical Work in FPGA and VHDL programming
SVH: 22h30 (Practical work: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

This Practical Work in session will allow the student to apply and consolidate the knowledge acquired in the subject of FPGA and VHDL programming.

Recommended prerequisite knowledge:

Course content.

Subject content:

Pw1: Mastering a design tool (Xilinx, Altera)

Pw2: Design of a combinational system

Pw3: Design of a sequential system: the process

Pw4: Design of state machines

Pw5: Design of a large design

Pw6: Implementation of the design on an FPGA board

Evaluation mode: 100% continuous evaluation

Semester: 3
Teaching Unit: UET 1.3
Subject : Document research and thesis design
SVH: 22h30 (Class: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

Provide students with the necessary tools to search for useful information and better exploit it in their end-of-studies project. Help them to go through the different steps leading to the writing of a scientific document. Emphasize the importance of communication and teach them to present the work done in a rigorous and pedagogical manner.

Recommended prerequisite knowledge:

Methodology of writing, Methodology of presentation.

Subject content:

Part I-: Documentary research:

Chapter I-1: Definition of the subject (02 weeks)

- Title of the subject
- List of keywords related to the subject
- Gather basic information (acquisition of specialized vocabulary, meaning of terms, linguistic definition)
- Information sought
- Take stock of knowledge in the field

Chapter I-2: Select information sources (02 weeks)

- Type of documents (Books, Theses, Memoirs, Journal articles, Conference proceedings, Audio-visual documents...)
- Type of resources (Libraries, Internet...)
- Evaluate the quality and relevance of information sources

Chapter I-3: Locate documents (01 week)

- Search techniques
- Search operators

Chapter I-4: Process information (02 weeks)

- Work organization
- Starting questions
- Synthesis of selected documents
- Links between different parts
- Final plan of documentary research

Chapter I-5: Presentation of bibliography (01 week)

- Presentation systems for a bibliography (Harvard system, Vancouver system, mixed system...)
- Presentation of documents
- Citation of sources

Part II: Designing the thesis

Chapter II-1: Plan and stages of the thesis (02 weeks)

- Identify and delimit the subject (Summary)
- Problematic and objectives of the thesis
- Other useful sections (Acknowledgments, List of abbreviations...)
- Introduction (Write the introduction last)
- State of the specialized literature
- Formulation of hypotheses
- Methodology
- Results
- Discussion
- Recommendations
- Conclusion and prospects
- Table of contents
- 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. Improving general linguistic competence in terms of understanding and expression.
- Saving, securing, and archiving 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.
- thesis Defense

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

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

- Citation
- Paraphrasing
- Indicating the complete bibliographic reference

Evaluation mode: 100% continuous evaluation.

Bibliographic references:

1. M. Griselin et al., Guide de la communication écrite, 2e édition, Dunod, 1999.
2. J.L. Lebrun, Guide pratique de rédaction scientifique : comment écrire pour le lecteur scientifique international, Les Ulis, EDP Sciences, 2007.
3. A. Mallender Tanner, ABC de la rédaction technique : modes d'emploi, notices d'utilisation, aides en ligne, Dunod, 2002.
4. M. Greuter, Bien rédiger son mémoire ou son rapport de stage, L'Etudiant, 2007.
5. M. Boeglin, lire et rédiger à la fac. Du chaos des idées au texte structuré. L'Etudiant, 2005.
6. M. Beaud, l'art de la thèse, Editions Casbah, 1999.
7. M. Beaud, l'art de la thèse, La découverte, 2003.
8. M. Kalika, Le mémoire de Master, Dunod, 2005.