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

ACADEMIC MASTER HARMONIZE

National program

UPDATE 2022

Domain	Sector	Speciality
Sciences And Technologies	***Electronic***	***Instrumentation***

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

The Lord

2022

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 by license compatibility	Coefficient assigned to the license
Electronic	Instrumentation	Electronic	**1**	**1.00**
		Telecommunications	**2**	**0.80**
		Biomedical Engineering	**2**	**0.80**
		Automatic	**3**	**0.70**
		Electrical engineering	**3**	**0.70**
		Electromechanics	**4**	**0.65**
		Other licenses in the ST domain	**5**	**0.60**

II – Half-yearly teaching organization sheets of the specialty

Semester 1

Teaching unit	Materials	Credits	Coefficient	Weekly hourly volume			Half-yearly Hourly Volume (15 weeks)	Additional Work in Consultation (15 weeks)	Assessment method	
	Titled			**Course**	**TD**	**TP**			**Continuous Assessment**	**Exam**
Fundamental EU Code: UEF 1.1.1 Credits: 10 Coefficients: 5	Instrumentation electronics	6	3	3:00 a.m.	1h30		67h30	82h30	40%	60%
	Sensors in industrial instrumentation	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental EU Code: UEF 1.1.2 Credits: 8 Coefficients: 4	Advanced Signal Processing 01	4	2	1h30	1h30		45h00	55h00	40%	60%
	Industrial metrology	4	2	1h30	1h30		45h00	55h00	40%	60%
Methodological EU Code: UEM 1.1 Credits: 9 Coefficients: 5	Electronic instrumentation practical work	2	1			1h30	10:30 p.m.	27:30	100%	
	TP Sensors in industrial instrumentation	2	1			1h30	10:30 p.m.	27:30	100%	
	Advanced Signal Processing 01/TP Industrial Metrology	2	1			1h30	10:30 p.m.	27:30	100%	
	Python/Java	3	2	1h30		1 hour	37h30	37h30	40%	60%
EU Discovery Code: UED 1.1 Credits: 2 Coefficients: 2	Subject of choice 1	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
	Subject of choice 2	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

Teaching unit	Materials	Credits	Coefficient	Weekly hourly volume			Half-yearly Hourly Volume (15 weeks)	Additional Work in Consultation (15 weeks)	Assessment method	
	Titled			**Course**	**TD**	**TP**			**Continuous Assessment**	**Exam**
Fundamental EU Code: UEF 1.2.1 Credits: 10 Coefficients: 5	Microcontrollers and DSPs	6	3	3:00 a.m.	1h30		67h30	82h30	40%	60%
	Servo systemsdigital	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental EU Code: UEF 1.2.2 Credits: 8 Coefficients: 4	Advanced Digital Electronics: VHDL – FPGA	4	2	1h30	1h30		45h00	55h00	40%	60%
	Advanced Signal Processing 02	4	2	1h30	1h30		45h00	55h00	40%	60%
Methodological EU Code: UEM 1.2 Credits: 9 Coefficients: 5	Microcontrollers and DSP practical work	2	1			1h30	10:30 p.m.	27:30	100%	
	TPServo systemsdigital/TP Advanced signal processing 02	2	1			1h30	10:30 p.m.	27:30	100%	
	VHDL - FPGA practical work	2	1			1h30	10:30 p.m.	27:30	100%	
	Project-based learning	3	2	1h30		1 hour	37h30	37h30	40%	60%
EU Discovery Code: UED 1.2 Credits: 2 Coefficients: 2	Subject of choice 4	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
	5th choice of subject	1	1	1h30			10:30 p.m.	2:30 a.m.		100%

Transversal EU Code: UET 1.2 Credits: 1 Coefficients: 1	Compliance with standards and rules of ethics and integrity	1	1	1h30			10:30 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

Teaching unit	Materials	Credits	Coefficient	Weekly hourly volume			Half-yearly Hourly Volume (15 weeks)	Additional Work in Consultation (15 weeks)	Assessment method	
	Titled			Course	TD	TP			Continuous Assessment	Exam
Fundamental EU Code: UEF 2.1.1 Credits: 10 Coefficients: 5	Industrial actuators	4	2	1h30	1h30		45h00	55h00	40%	60%
	Industrial programmable logic controllers	4	2	1h30	1h30		45h00	55h00	40%	60%
	Advanced sensors and measurement systems	2	1	1h30			10:30 p.m.	27:30		100%
Fundamental EU Code: UEF 2.1.2 Credits: 8 Coefficients: 4	Advanced power electronics	4	2	1h30	1h30		45h00	55h00	40%	60%
	Digital control elements	4	2	1h30	1h30		45h00	55h00	40%	60%
Methodological EU Code: UEM 2.1 Credits: 9 Coefficients: 5	Industrial programmable automation work	2	1			1h30	10:30 p.m.	27:30	100%	
	Industrial actuators TP/Digital regulation TP	2	1			1h30	10:30 p.m.	27:30	100%	
	Advanced Power Electronics TP	2	1			1h30	10:30 p.m.	27:30	100%	
	Reliability and maintenance of electronic systems	3	2	1h30		1 hour	37h30	37h30	40%	60%
EU Discovery Code: UED2.1 Credits: 2 Coefficients: 2	5th choice of subject	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
	6th choice of subject	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
Transversal EU Code: UET2.1	Documentary research and dissertation design	1	1	1h30			10:30 p.m.	2:30 a.m.		100%

Credits: 1 Coefficients: 1										
Total semester 3		**30**	**18**	**1:30 p.m.**	**6:00 a.m.**	**5:30 a.m.**	**375 hours**	**375 hours**		

General guidelines on the choice of cross-curricular and discovery subjects:

Six (discovery) subjects in the Master's Subject Reference "Instrumentation" (Table above) are left to the free choice of establishments which can choose their subjects indifferently from the list presented below according to their priorities.

Materials withdetailed programs:

- Optoelectronics(Discovery)
- Autonomous energy systems(Discovery)
- Electroacoustics and vibration analysis(Discovery)
- Electromagnetic compatibility(Discovery)
- Iindustrial instrumentation and measurement(Discovery)
- Industrial Safety (Discovery)
- Robotics(Discovery)
- Adjusting Electric Drives(Discovery)
- Bio-instrumentation and biosensors(Discovery)
- Methods and tools for non-destructive testing(Discovery)
- Tools for instrumentation maintenance(Discovery)
- Industrial maintenance and diagnostics(Discovery)
- Industrial networks and communications
- Operational research
- ……

Other subjects left to the free choice of establishments (programs open after validation of the CPND)

- Display systems(Discovery)
- Measuring instruments(Discovery)
- High frequency measurements(Discovery)
- Electroacoustics, sound and HIFI(Discovery)
- Industrial remote management (SCADA)(Discovery)
- Theory of control of industrial systems (Discovery)
- Smart sensors in industrial instrumentation(Discovery)
- …

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

III - Detailed program by subject for semester S1

Semester: 1
Teaching unit: UEF 1.1.1
Subject 1:Instrumentation electronics
VHS: 67h30 (Lecture: 3h00, Tutorial: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:

Study and analysis of analog electronic circuits used in measurement and instrumentation chains.

Recommended prior knowledge:

Fundamental Electronics 1 and 2, Functions of Electronics, Pulse Electronics.

Content of the material:

Chapter 1. The operational amplifier and assemblies based on the AOp (2 weeks)
1.1. Introduction
1.2. Operating modes of an operational amplifier (AOp)
1.3. Operation of an AOp in linear mode (Inverting amplifier, Non-inverting amplifier, Voltage follower, Differential amplifier, Adding or summing amplifier, Integrator, Differentiator, Logarithmic and exponential assemblies)
1.4. Operation of an AOp in non-linear mode (comparator, AOp in saturation mode)
1.4.1. Simple comparator (single-threshold comparator)
- Simple zero comparator
- Simple non-inverting comparator
1.4.2. Two-threshold comparator
- Non-inverting Schmitt Trigger Comparator
- Inverting Schmitt Trigger Comparator
1.4.3. Window comparator
- Window comparator-1
- Window comparator-2

Chapter 2. AD and DA Signal Converters (3 weeks)
2.1. Introduction (Role, Digital processing chain of a process, Classification of signals)
2.2.Analog to Digital Conversion (ADC)
2.2.1. Definition
2.2.2. Sample and Hold
2.2.3. Converter characteristics (CAN resolution, Full scale or conversion range, Transfer characteristic, Conversion time, Offset error, Gain error, Linearity error, Quantization error)T_c
2.2.4. Architecture of Analog-Digital Converters
- Integrating converters (single ramp ADC (pulse counting), double ramp ADC (pulse counting))
- Successive approximation or successive weighing converter (SAR Converter)
- Flash converter (parallel comparator converter or direct comparison)
2.2.5. Comparison between CANs
2.2.6. A/D converter based on a D/A converter
2.3. Digital to Analog Converter (DAC)
2.3.1. Definition
2.3.2. Characteristics of DA converters (Resolution of a DAC and conversion range, Transfer characteristic)
2.3.3. Architectures of digital-to-analog converters
- Digital-to-analog converters with weighted resistance network (or weighted current)

- Digital-to-analog converters with R-2R resistor network
2.3.4. Comparison between the CNA

Chapter 3. Pulse or Signal Generation Circuits (4 weeks)
3.1. Reminder on the charging and discharging of a capacitor and the switching transistor
3.1.1. Charging and discharging a capacitor (Preliminary concepts, Electrical model of a capacitor C, charging a capacitor through a resistor (by a voltage step), discharging a capacitor through a resistor R)
3.1.2. Transistor switching
3.2.Linear and nonlinear oscillators
3.2.1. Linear oscillators
- Damped harmonic oscillators,
- Harmonic oscillators (Oscillatornegative resistance)
3.2.2. Nonlinear oscillators
- Van der Pol oscillator (Differential equation, Experimental study, Computer-assisted theoretical approach)
3.3. Voltage Controlled Oscillator (VCO)
3.4. Phase Locked Loop "PLL"
- Generality
- The constituent elements of the PLL (Phase comparator (phase error detector), Low-pass filter, Voltage Controlled Oscillator (VCO)
- Operating principle of the PLL)
3.5. Astables and Monostables (multivibrators).
3.5.1. Astables (transistor, operational amplifier, NE555, logic gate)
3.5.2. Monostables (transistors, operational amplifiers, NE555s, logic gates)

Chapter 4. Signal Processing Circuits (3 weeks)
4.1.Purpose of modulation
4.2. Structure of a telecommunications system
4.3. Amplitude modulation (AM), synchronous detection
4.3.1. Double-sideband amplitude modulation with carrier
4.3.2. Double-sideband suppressed-carrier amplitude modulation
4.3.3. Single Side Band (SSB) amplitude modulation
4.3.4. Quadrature Amplitude Modulation (QAM)
4.3.5. Synchronous or coherent demodulation (Demodulation of AM signal with carrier, Demodulation of AM signal with suppressed carrier, Demodulation of a single-sideband AM signal, Demodulation of a QAM signal)
4.4. Frequency modulation (FM), synchronous detection
4.4.1. General information on FM modulation (Expression of a frequency modulated wave, Spectrum of an FM signal, Frequency band, Power in FM signals; Efficiency)
4.4.2. Frequency modulators (Varicap diode modulation, Armstrong modulator)
4.4.3. Synchronous demodulation of FM signals (Phase-locked loop demodulation)
4.5. Phase modulation (PM: Phase Modulation)
4.6. Pulse modulation
4.6.1. Analog pulse modulation
- Pulse amplitude modulation (PAM)
- Pulse width modulation (PWM)
- Pulse-position modulation (PPM)
4.6.2. Digital (digital) pulse modulation
- Pulse Code Modulation (PCM)

Chapter 5. Study of active filters **(03 weeks)**
5.1. Interest of active filters

5.2. General characteristics (Filtering, Transfer function, Bode diagram, Normalized variables, Passive filter and active filter, Main templates)
5.3. Filter approximation functions
5.3.1. Second degree filters (Biquadratic functions)
5.3.2.Bode plot of the 2nd order low-pass filter
5.3.3. Butterworth filters (low-pass filter)
5.3.4. Bessel filters
5.3.5. Chebyshev filters (low-pass filter)
5.4. Frequency transposition (transformation, change of variable)
5.5. Summaryactive filters
5.5.1. Synthesis phases
5.5.2. First-order filter (First-order low-pass filter (or 20 dB/dec = 6 dB/octave filter), First-order high-pass filter (or 20 dB/dec = 6 dB/octave filter))
5.5.3. Second-order filter (Sallen Key and Rauch filters, 2nd-order low-pass filter (or -40 dB/decade filter), 2nd-order high-pass filter (or 40 dB/decade filter), 2nd-order band-pass filter)

Assessment method:
Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

[1] . R. Damaye, Oscillators, Signal Generators and Synthesizers (2nd revised and expanded edition), Distribution: French Technical and Scientific Editions, Paris Cedex 19.
[2] . AP Malvino, Principles of Electronics, 6th edition; Sciences-Sup, Dunod.
[3] . J. Millman, Microelectronics, Ediscience.
[4] . J. Encinas, Phase-locked system (PLL): achievements and applications.
[5] . HH Ouslimani, A. Ouslimani, Main functions of electronics: Course and solved exercises, Editions CASTEILLA, 2010.
[6] . F. Milsant, Electronics Course Volume 4; Eyrolles, 1994.
[7] . G. Metzger, JP Vabre, Impulse Electronics, Volume 1, 3rd edition; Masson, 1985.
[8] . JD. Chatelain and R. Dessoulavy, Electronics, Volumes 1 and 2; Dunod.
[9] . S. Boubeker, Pulse Electronics, OPU, 1999.
[10] . B. Haraoubia, Operational amplifiers, Operation and applications, ENAG Editions, 1994.

Semester: 1
Teaching unit: UEF 1.1.1
Subject 2:Sensors in industrial instrumentation
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Acquire extensive technological knowledge of the various sensors encountered in industrial environments and their uses (metrology, data acquisition). Understand a specification sheet for any type of sensor.

Recommended prior knowledge:

Analog electronics, Electronic functions, Electrical and electronic measurements, Signal processing.

Content of the material:

Chapter 1: Concepts about Sensors (02 weeks)
Measurable quantities, Vocabulary, Roles of a sensor, Types of measurands, General characteristics of a sensor: measurement range, sensitivity, reproducibility,Linear operation, hysteresis, resolution, drift, measurement errors, etc. Parasites. Ttype of sensors (active, passive, composite, etc.), simple, integrated and/or intelligent sensors.

Chapter 2: Sensor Conditioning (04 weeks)
Definition of a conditioning circuit,Potentiometric assembly (Measuring resistances, Measuring complex impedances, Disadvantages of the potentiometric assembly. Wheatstone bridge, Measuring complex impedances, Kelvin, Wien, Maxwell, Owen, Hay, Anderson, ..., Instrumentation amplifiers, Differential amplifiers, charge amplifiers and isolation amplifiers. Linearization and non-linear conditioning circuits. Evaluation of distortion in conditioning systems. Conditioning and EMC.

Chapter 3: Examples of industrial sensors (04 weeks)
Position and displacement sensor. Pressure sensor. Level sensor. Temperature sensor (thermocouple and Pt100, etc.). Flow sensor. Current sensor, strain gauges, etc.

Chapter 4: Transmission Systems for Sensors (03 weeks)
Transmitters (The purpose of a transmitter, Setting up transmitters, choosing a transmitter, 4-20mA current loop, Symbols, smart transmitters). Analog and digital transmission systems. Voltage and current transmission (4-20 mA). Modulation/demodulation techniques. Synchronous or asynchronous serial digital transmission. Principles, characteristics and protocols (RS232C, RS422, RS485, etc.).

Chapter 5: Introduction to Smart Sensors (2 weeks)
Interest and principles, general architecture (capture module, processing unit, communication interface, power supply module), advantages and disadvantages, Smart sensor networks, examples of communication protocols.

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references

[1] . Georges Asch and Collaborators. Sensors in Industrial Instrumentation, Dunod 2006
[2] . Ian R. Sintclair. Sensors and transducers, Newnes, 2001.

[3] . JG Webster. Measurement, Instrumentation and Sensors Handbook, Taylor & Francis Ltd.
[4] . M. Grout. Industrial instrumentation: Specification and installation of sensors and control valves, Dunod, 2002.
[5] . R. Palas-Areny, JG Webster. Sensors and signal conditioning, Wiley and Sons, 1991.
[6] . R. Sinclair, Sensors and Transducers, Newness, Oxford, 2001.
[7] . M. Cerr, Industrial Instrumentation: T.1 and T.2, Tec and Doc Edition.
[8] . N. Ichinose, Practical guide to sensors, Masson
[9] . P. Dassonvalle, The Sensors, Dunod 2013.

Semester: 1
Teaching unit: UEF 1.1.2
Subject 3:Advanced Signal Processing 1
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

This course is designed to enable the student to:

- ✓ Master and apply digital filtering methods
- ✓ Evaluate the performance of a digital filter
- ✓ Understanding the transition from analog to digital domain.

Recommended prior knowledge:

The student must have the following knowledge:

- ✓ The basics of mathematics;
- ✓ Discrete Fourier Transform (DFT)
- ✓ Analog filtering (analysis and syntheses);

Content of the material:

Chapter 1. Reminders on analog filters (3 weeks)

- Filter characteristics
- Different types of analog filters
- Sizing of filters: Butterworth, Bessel, Chebychev I and II, Elliptic. Normalization and denormalization of frequencies.

Chapter 2.Time-invariant discrete linear systems(3 weeks)

- Reminders on sampling
- Z-Transform and Inverse Z-Transform
- Characteristics of linear invariant discrete systems (linearity,recurrent equation, recursion, time invariance, impulse response, transfer function, causality stability criterion,…)

Chapter 3. Analysis and synthesis of digital filters (4 weeks)

- Digital filters
- Frequency template
- Structure of RIF and RII filters
- Stability and implementation of digital filters (RIF and RII)
- Digital minimum phase filter
- Analysis of RIF and RII filters
- Synthesis of RIF filters (by windowing, by frequency sampling)
- Synthesis of IIR filters (by impulse invariance, by bilinear transformation)

Chapter 4. Multi-rate digital filters (2 Weeks)

- Undersampling and oversampling
- Multi-rate systems and spectral analysis
- Filter bank and polyphase decomposition
- Multi-rate processing applications

Chapter 6. Wavelet Transform (3 weeks)

- Time-frequency duality and short-term Fourier transform. Disadvantages.
- Continuous, discrete wavelets (DWT) and dyadic wavelets
- Examples of DWT (Haar, Daubechies, etc.)
- Multi-resolution analysis
- Facelift version of the DWT
- Examples of applications

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

[1] . I. G. Proakis and DG Manolakis, Digital Signal Processing: Principles, Algorithms and Applications. Third Edition, Macmillan, 1996.

[2] . AV Oppenheim, RW Schafer: Discrete-time signal processing, Prentice Hall, 1999, 2nd edition

[3] . M. Bellanger: Digital Signal Processing: Theory and Practice, 8th edition, Dunod, 2006.

[4] . Messaoud Benidir: Basic methods for signal analysis and processing, Dunod, 2004.

[5] . Y. Mori, "Digital Filtering." Vol. IV, Hermès-Lavoisier. 2006

[6] . Y. Mori, "Digital Filtering in Signal Processing - Exercises and Practical Work." Hermès-Lavoisier.

[7] . M. Kunt, "Digital Signal Processing", Dunod, Paris, 1981;

[8] . D. Schlichthärle, "Digital Filters Basics and Design" 2nd edition, Springer, 2011;

[9] . [9]. F. Cottet, Signal processing and data acquisition - Course and corrected exercises, 4th edition, Dunod, Paris, 2015.

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

Teaching objectives:

At the end of this subject, the student will normally be able to validate a process, to make the necessary parameter adjustments within the framework of controlling a manufacturing process or to define the safety conditions of a product or a system.

Recommended prior knowledge:

- ✓ Electrical and electronic measurements

Content of the material:

Chapter 1: General Information on Industrial Metrology (02 weeks)
Definition.Vocabulary and role of metrology.Different metrologies (fundamental, scientific, industrial, legal, etc.). Role of metrology in business. Relationship between metrology and quality. Official international organizations. Standards and recommendations in metrology.

Chapter 2: International System of Units. (02 weeks)
Base units. Symbols. Derived units. Other units. Models of relationships between units of measurement. Measurement. Errorsand uncertainties. Notions of errors (random, systematic, accidental, "fidelity and accuracy"). Terminology of measurement uncertainties.Methods of evaluating measurement uncertainties. Law of composition of measurement uncertainties.

Chapter 3: Measurement System (03 weeks)
Principle and characteristics. Calibration. Sensitivity. Accuracy. Repeatability. Reproducibility. Rangeability. Metrological confirmation. Causes of errors (calibration, sensitivity, linearity, accuracy, repeatability, reproducibility, resolution, hysteresis, etc.). Error calculations. General measurement methods. Measurements by deviation. Measurements by comparison.

Chapter 4:Metrological traceability (03 weeks)
Definition and interest. Notions of standard. Calibration hierarchies (SI, National Reference, etc.), Examples of traceability chain. Evaluation of uncertainty balances. Statistical study.

Chapter 5: Metrology and Quality Control (02 weeks)
Impact of measurement on production. Concept of measurement capability. Methods for declaring conformity. Management and identification of measurement equipment. Choice of calibration frequency. Control charts.

Chapter 6:Statistical analysis of data (03 weeks)
Statistical dispersion. The mean. Other types of means. The median. Variance and standard deviation. Histogram. Constructing a histogram. Estimation by the least squares method.The normal or Gaussian distribution. Confidence interval. Normality criteria.

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

[1] .Lorenzo Zago, Basics of Metrology, High School of Engineering and Management of the Canton of Vaud, 2012.
[2] .PA. Paratte, Treatise on Electricity, Volume XVII, Measurement Systems, Presses polytechniques romandes.
[3] .JP Bentley, Principles of measurement systems, Pearson education, 2005.
[4] .J. Niard et al, Electrical Measurements, Nathan, 1981
[5] .D.Barchesi, Physical Measurement and Instrumentation, Ellipses 2003.
[6] .JP Holman, Experimental Methods for Engineers, McGraw-Hill 1994.
[7] .https://langloisp.users.greyc.fr/metrologie/cm/index.html
[8] .http://www.doc-etudiant.fr/Sciences/Physique/Cours-Introduction-a-la-Metrologie-Industrielle-8223.htmlFM

Semester: 1
Teaching unit: UEM1.1
Subject 1:Electronic instrumentation practical work
VHS: 10:30 p.m. (TP: 1:30 p.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

Put into practice the theoretical knowledge learned on electronic circuits associated with instrumentation.

Recommended prior knowledge:

Instrumentation electronics

Content of the material:

TP1 Study of a relaxation oscillator: square wave generator and a monostable.
TP2 Study of A/D Conversion (Sampling Time and theorem of Shannon, quantification errors-tification and conversion time).
TP3 Study of AM, FM and PWM modulation circuits
TP4 Active filtering, Characterization of filters, Creation of a noisy signal generator, Filtering noisy signals
TP5 Study of a PLL phase-locked loop
TP6 Study of a voltage-controlled oscillator (VCO)

Assessment method:

Continuous assessment: 100%.

Bibliographic references:

[1] .AP Malvino, Principles of Electronics, 6th edition; Sciences-Sup, Dunod.
[2] .J. Millman, Microelectronics, Ediscience.
[3] .J. Encinas, Phase-locked system (PLL): achievements and applications.
[4] .HH Ouslimani, A. Ouslimani, Main functions of electronics, Casteilla, 2010.
[5] .F. Milsant, Electronics Course Volume 4, Eyrolles, 1994.
[6] .G. Metzger, JP Vabre, Impulse Electronics, Volume 1, 3rd edition, Masson, 1985.
[7] .JD. Chatelain and R. Dessoulavy, Electronics, Volumes 1 and 2, Dunod.
[8] .S. Boubeker, Pulse Electronics, OPU, 1999.

Semester: 1
Teaching unit: UEM1.1
Subject 2:TP Sensors in industrial instrumentation
VHS: 10:30 p.m. (TP: 1:30 p.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

Put into practice the theoretical knowledge learned on electronic circuits associated with sensors as well as the study of some of the most common sensors.

Recommended prior knowledge:

Sensors in industrial instrumentation

Content of the material:

TP1: Evaluation of a measurement and study of a conditioning circuit based on a divider of voltage and a Wheatstone bridge.
TP2: Study of an instrumentation amplifier and evaluation of the common mode.
TP3:Conditioning a passive sensor (example Pt100)
TP4: Conditioning of an active sensor (example thermocouple and compensation of the weld cold)
TP5: Study of a level sensor
TP6: Study of a pressure sensor

Assessment method:

Continuous assessment: 100%

Bibliographic references:

[1] .Georges Asch and Collaborators. Sensors in Industrial Instrumentation, Dunod 2006
[2] .M. Grout. Industrial instrumentation: Specification and installation of sensors and control valves, Dunod, 2002.
[3] .N. Ichinose, Practical guide to sensors, Masson
[4] .P. Dassonvalle, The Sensors, Dunod 2013.

Semester: 1
Teaching unit: UEM 1.1
Subject 3:Advanced Signal Processing 1/TPIndustrial metrology
VHS: 10:30 p.m. (TP: 1:30 p.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

Practical work carried out using MATLAB to give a practical aspect to complex theoretical concepts. The practical work in the second part is carried out using Proteus/ISIS software and experimentally.

Recommended prior knowledge:

Mathematics (Theory and calculus of probabilities,Complex analysis).Deterministic signal theory,Probability and statistics.Industrial metrology.

Content of the material:

Advanced Signal Processing 1

TP1: Analysis, Synthesis (window method) and implementation of a digital RIF filter

TP2: Analysis, Synthesis by bilinear transformation (case of Butterworth and Tchebychev filters) and implementation of a digital RII filter

TP3: Application of digital filtering

TP4: Implementation of a digital filter bank

TP5: Denoising a signal using discrete wavelet transform

TPIndustrial metrology

TP1: Study of methods for evaluating measurement uncertainties.
TP2: Study of metrological traceability**.**
TP3: Estimation of the measurement by the least squares method.

Assessment method:

Continuous assessment: 100%.

Bibliographic references:

[1] .Mori Yvon, "Random Signals and Stochastic Processes", Lavoisier, 2014.
[2] .N. Hermann, "Engineering Probabilities: Random Variables and Birch Simulations", 2002.
[3] .M. Kunt, "Digital Signal Processing", Dunod, Paris, 1981.
[4] .M. Bellanger, "Digital Signal Processing: Theory and Practice", 8th edition, Dunod, 2006
[5] .Lorenzo Zago, Basics of Metrology, School of Engineering and Management of the Canton of Vaud, 2012.
[6] .PA. Paratte, Treatise on Electricity, Volume XVII, Measurement Systems, Presses polytechniques romandes.
[7] .JP Bentley, Principles of measurement systems, Pearson education, 2005.
[8] .D. Barchesi, Physical Measurement and Instrumentation, Ellipses 2003.
[9] .JP Holman, Experimental Methods for Engineers, McGraw-Hill 1994.

Semester 1
Teaching unit: UEM1.1

Subject 4:Python/Java
VHS: 37h30 (Class: 1h30, TP: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

At the end of this course, the student will be able to:

- **Understand the role of calculation in problem solving;**
- **Help write small programs that allow them to achieve useful goals.**

Recommended prior knowledge:

✓ No prior programming experience required.

Content of the material:

I) Python (Choosing between Python or Java) :

Chapter 1. Introduction to Computer Science and Problem Solving (01 week)
An introduction to computer science and Python, program development lifecycle, programming tools and an introduction to Python.
Chapter 2. Basic Objects, Variables, Input, and Output (02 weeks)
Data and variables, strings, output, lists, tuples and files.
Chapter 3. Structures that control flow (02 weeks)
Relational and logical operators, decision structures, the while loop, the for loop.
Chapter 4. Functions (02 weeks)
Principle and generalities, passing arguments, returning results, positional arguments and keyword arguments, local variables and global variables.
Chapter 5. Data Processing (02 weeks)
Reading text files, creation of text files, adding lineshasan existing text file, etc.
Chapter 6. Miscellaneous Topics (02 weeks)
Exception handling, random value selection, turtle graphs, recursion.
Chapter 7. Object-Oriented Programming (02 weeks)
Classes, objects, attributes, legacy.
Chapter 8 Graphical User Interface (02 weeks)
Widgets, grid geometry manager, writing programs.

Practical work topics should include:
• Variables, functions and control flow
• Data structures such as lists and dictionaries
• Logic, decomposition and overall structure of the program
• Object-oriented program
• Debugging and testing skills

II) Java (Choosing between Python or Java) :

Chapter 1: Introduction to Java (1 week)
Chapter 2: Control Instructions (3 weeks)

A) Choice statements: The if statement (The simple yew,*THE*if with partial else, nested ifs and if-else if), 2.4 Logical operators, The switch statement, Conditional operators, 2.7 Operator precedence and associativity
B)The loops
2.9 The while loop
2.10 The do...while loop
2.11 The for loop
2.12 Nested Loops
2.13 The keywords break and continue
The break statement
The break statement with label
The instruction continues
The instruction continues with label

Chapter 3: Mathematical Functions, Characters and Strings **(3 weeks)**

3.2 Commonly Used Mathematical Functions
3.2.1 Trigonometric methods
3.2.2 Exponent Methods (Exponentials and Powers)
3.2.3 Rounding methods
3.2.4 The min, max and abs methods
3.2.5 The random method
3.3 Character Data Type and Operations
3.4 The String type
3.4.1 Getting the Length of a String
3.4.2 Getting Characters from a String
3.4.3 Concatenation of character strings
3.4.4 Converting character strings
3.4.5 Reading a string from the keyboard
3.4.6 Reading a character from the keyboard
3.5 Formatted output to screen (System.out.printf instruction)

Chapter 4: Methods **(2 weeks)**

4.2 Definition of a method
4.3 Calling a method
4.4 Void methods and methods allowing a value return
4.5 Passing parameters by values
4.6 Scope of variables
4.7 Method Overloading

Chapter 5: Tables **(3 weeks)**

A) One-dimensional arrays
5.2 Basics of Tables
5.2.1 Declaration of tables
5.2.2 Creating tables
5.2.3 Table size and default values
5.2.4 Accessing array elements
5.2.5 Array Initializers
5.2.6 Foreach Loop
5.3 Passing Arrays to Methods
5.4 Returning an array from a method
5.5 Variable-length argument lists
B) Two-dimensional arrays
5.7 Basics of Two-Dimensional Arrays
5.7.1 Declaring and Creating Two-Dimensional Arrays
5.7.2 Obtaining the lengths of two-dimensional arrays
5.7.3 Jagged (perforated) tables
C) Multidimensional arrays

Chapter 6: Objects and Classes **(2 weeks)**

6.2 Defining Classes for Objects
6.3 Example: Defining classes and creating objects

6.4 Constructing Objects Using Constructors
6.5 Accessing Objects via Reference Variables
6.5.1 Reference variables and reference types
6.5.2 Accessing an object's data and methods
6.6 Static variables, constants and static methods

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

[1] .Gérard Swinnen, Learn to program with Python, 3rd Edition, Eyrolles, 2012.
[2] .Vincent Le Goff, Learn to program in Python, 3rd Edition, Eyrolles, 2019.
[3] .Luciano Ramalho, Programming in Python, O'Reilly collection, 2019.
[4] .John Guttag, Introduction to Computation and Programming Using Python: With Application to Understanding Data, Second Edition, MIT Press, 2016.
[5] .David I. Schneider, An Introduction to Programming using Python, Global edition, Pearson, 2016.
[6] .Harvey Deitel, Java: How to Program, 9th Edition, Prentice Hall.
[7] .Robert Sedgewick and Kevin Wayne, Introduction to Programming in Java: An Interdisciplinary Approach, Addison Wesley, 2007
[8] .Claude Delannoy, Programming in Java, Editions Eyrolles
[9] .J. Hunter, Java servlets, O'Reilly
[10] . P. Niemeyer, J. Knudsen, Introduction to Java, Ed. O'Reilly

Semester: 1
Teaching unit: UED 1.1
Matter :Subject 1 of your choice
VHS: 10:30 p.m. (lesson: 1.5 hours)
Credits: 1
Coefficient: 1

Semester: 1
Teaching unit: UED 1.1
Matter :Subject 2 of your choice
VHS: 10:30 p.m. (lesson: 1.5 hours)
Credits: 1
Coefficient: 1

Semester: 1
Teaching unit: UET 1.1
Matter :Technical English and Terminology
VHS: 10:30 p.m. (lesson: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

Introduce the student to technical vocabulary. Strengthen their knowledge of the language. Help themunderstand and synthesize a technical document. Enable him to understand a conversation in English held in a scientific setting.

Recommended prior knowledge:

Basic English Vocabulary and Grammar

Content of the material:

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

- Oral comprehension: Based on authentic popular science video documents,note taking, summarizing and presenting 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, internship or job application letters.

Recommendation :The subject manager is strongly recommended to 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:Microcontrollers & DSP
VHS: 67h30 (Lecture: 3h00, Tutorial: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:

Understand the operation and internal architecture of dsPICs, which are the integration of the DSP multiplier into a microcontroller. Learn how to program them and understand the techniques used to implement digital signal processing algorithms.

Recommended prior knowledge:

Microprocessor systems. Digital signal processing. Assembly language programming.

Content of the subject:

Chapter 1: Basics of dsPIC Microcontrollers (2 weeks)

- Introduction to 8, 16 and 32-bit PIC microcontrollers.
- General overview of the 16-bit series; especially the dsPIC33F/PIC24H.
- Core CPU architecture.
- Organization of memories: program and data.
- Hardware interrupt handling.
- Basic configuration: configuration bits, oscillators, reset circuit, watchdog.
- Management of input/output ports.

Chapter 2: Programming dsPIC Microcontrollers (4 weeks)

- Assembler instruction set.
- Introduction to embedded C programming with MPLAB-XC16.
- Register manipulation including I/O ports in assembler, in XC16 and in assembler inside XC16.
- Managing timing devices.

Chapter 3: Interfacing Sensors with dsPIC Microcontrollers (4 weeks)

- Analog to Digital Conversion.
- Implementation of digital filtering of measurements in dsPICs.
- Practical example of hardware/firmware development of:
    - Temperature measurement.
    - Measurement of pressures and weights with strain gauges.
    - Measurement of liquid flow rates and levels.

- **Chapter 4: Other Hardware Peripherals of dsPIC Microcontrollers (4 weeks)**
    - I/O capture/compare management for speed measurement.
    - Control of the rotation speed of the motors in PWM.
    - Communication: UART, SPI and I^2C.

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

[1] .Lucio Di Jasio "Programming 16-bit PIC microcontrollers in C: Learning to fly the PIC 24", 2nd edition, Elsevier, 2012.

[2] .Creed Huddleston "Intelligent sensor design using the Microchip dsPIC®", Elsevier, 2007.

[3] .JM Angulo Usategui, A. Etxebarría Ruiz, I. Angulo Martínez, I. Trueba Parra "MicrocontroladoresdsPIC:Diseñopráctico de aplicaciones" Spanish Edition, McGraw-Hill 2006.
[4] .Armstrong Subero "Programming PIC microcontrollers with XC8", Apress 2018.
[5] .Microchip, "16-Bit MCU and DSC Programmer's Reference Manual: High-Performance Microcontrollers (MCU) and Digital Signal Controllers (DSC)", (DS70000157G),
[6] .Microchip, "MPLAB® C compiler for PIC24 MCUs and dsPIC® DSCs user's guide" (DS51284J),
[7] .Microchip, "MPLAB® Assembler, Linker and utilities for PIC24 MCUs and dsPIC® DSCs user's guide" (DS51317H),
*[8] .Microchip, "dsPIC33F/PIC24H Family Reference Manual" (DS70197C),*https://www.microchip.com/doclisting/TechDoc.aspx?type=ReferenceManuals
[9] .Microchip, "dsPIC33F/PIC24H Section 2: CPU" (DS70204),
[10] . Microchip, "dsPIC33F/PIC24H Section 3: Data Memory" (DS70202),
[11] . Microchip, "dsPIC33F/PIC24H Section 4: Program Memory" (DS70203),
[12] . Microchip, "dsPIC33F/PIC24H Section 5: Flash Programming" (DS70191),
[13] . Microchip, "dsPIC33F/PIC24H Section 6: Interrupts" (DS70184),
[14] . Microchip, "dsPIC33F/PIC24H Section 7: Oscillator" (DS70186),
[15] . Microchip, "dsPIC33F/PIC24H Section 8: Reset" (DS70192),
[16] . Microchip, "dsPIC33F/PIC24H Section 9: Watchdog Timer and Power-Saving Modes" (DS70196),
[17] . Microchip, "dsPIC33F/PIC24H Section 25: Device Configuration" (DS70194),
[18] . Microchip, "dsPIC33F/PIC24H Section 10: I/O Ports" (DS70193),
[19] . Microchip, "dsPIC33F/PIC24H Section 11: Timers" (DS70205),
[20] . Microchip, "dsPIC33F/PIC24H Section 12: Input Capture" (DS70198),
[21] . Microchip, "dsPIC33F/PIC24H Section 13: Output Compare" (DS70209),
[22] . Microchip, "dsPIC33F/PIC24H Section 14: Motor Control PWM" (DS70187),
[23] . Microchip, "dsPIC33F/PIC24H Section 15: Quadrature Encoder Interface (QEI)" (DS70208),
[24] . Microchip, "dsPIC33F/PIC24H Section 16: Analog-to-Digital Converter (ADC)" (DS70183),
[25] . Microchip, "dsPIC33F/PIC24H Section 17: UART" (DS70188),
[26] . Microchip, "dsPIC33F/PIC24H Section 18: Serial Peripheral Interface (SPI)" (DS70206),
[27] . Microchip, "dsPIC33F/PIC24H Section 19: Inter-Integrated Circuit™ (I2C™)" (DS70195).

Semester: 2
Teaching unit: UEF 1.2.1
Subject 2:Digital servo systems
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The objective of this course is to address certain aspects of the numerical control of linear dynamic systems.Introduce the properties and representations of discrete-time linear dynamic systems. Analysis and improvement of the performance of digital servo systems.Starting from physical processes modeled by transfer functionsin$p$(Laplace variable) we will successively approach the modeling of discrete and sampled systems, their analysis and finally the synthesis of digital control laws.

Recommended prior knowledge:

- ✓ Signal theory;
- ✓ Mathematical aspectstsuch as the manipulation of functions and sequences, integral calculus and series and the Laplace transform;
- ✓ Automation of continuous-time linear servo-controlled systems;
- ✓ Method of synthesizing correctors;

Content of the subject:

Chapter 1.Modeling of sampled signals and systems (3 weeks)
Sampling and signal reconstruction:Definition, sampled signal and ADC, Shannon's theoremand zeroth and first order blocker and CNA.Z-transform of sampled signals: Definition, properties of the transform, function of$\boldsymbol{z}$sampled transfers, recurrent equation, inverse transform.$\boldsymbol{z}$Relationships between continuous-time and discrete-time models:front discretization,backward discretizationand bilinear transformation(Tustin).

Chapter 2. Performance Analysis of Digital Servo Systems (4 weeks)
Equation of sampled servocontrols: Closed-loop transfer function, Transfer function of complex systems, continuous time – discrete time relationship in closed loop. Stability of sampled servocontrols: mathematical stability criterion, Jury's algebraic criterion, Routh criterion, frequency analysis of stability,Influence of sampling frequency on stability.Accuracy of sampled servos:Position and velocity errors,Accuracy of a class sampled system$\alpha \in \{0,1,..\}$.

Chapter 3.Analysis of sampled systems in state space (4 weeks)
Discretization of the equation of state of a continuous system: Relationship between the equation of state of a continuous system and that of a discrete system. Representation and resolution of the equation of state of a discrete system: Different forms of the evolution matrix (diagonal, companion, observer, controller, observability and controllability). Stability and precision of a discrete system: Roots of the characteristic equation, controllable modes, observable modes from the state representation of the sampled systems. Notions of governability and observability for SISO and MIMO systems.

Chapter 4. Correction of digital servo systems (4 weeks)
Role of the corrector, numerical correction of a continuous-time system,compensation for loss of stability by pole placement,synthesis of a digital corrector by discretization of a continuous corrector, Synthesis of a digital corrector by polynomial method.

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

[1] .P. Borne, G. Dauphin-Tanguy, JP Richard, F. Rotella, and I. Zambettakis. Analysis and Regulation of Industrial Processes. Volume 1: Continuous Regulation. Technip, France, 1993. ;

[2] .B. d'Andréa Novel and M. Cohen de Lara. Linear Control of Dynamic Systems. Masson, France, 1994;

[3] .E. Dieulesaint and D. Royer. Applied Automation: 2. Linear control systems with sampled signals. Masson, France, 1990. ;

[4] .RC Dorf and RH Bishop. Modern Control Systems. Addison-Wesley Publishing Company, Inc., New York, 1995;

[5] .D. Jaume, S. Thelliez, and M. Vergé. Computer Control of Dynamic Systems. Eyrolles, France, 1991;

[6] .B. Pradin. DISCRETE-TIME SYSTEMS - Numerical Process Control. INSA Toulouse, France, 1999. ;

[7] .R. Longchamp, 'Numerical control of dynamic systems', Presses Polytechniques et Universitaires Romandes, 2006;

Semester: 2
Teaching unit: UEF 1.2.2
Subject 3:Advanced Digital Electronics: VHDL and FPGA
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

In this subject, students will have to study the different types of programmable circuits, as well as the different design methods, in particular programming using hardware description languages.

The application of the content of this subject is carried out at the level of the subject "UEM1.1: FPGA & VHDL practical work".

Recommended prior knowledge:

Digital electronics (combinatorial and sequential).

Content of the material:

Chapter 1. Basics of Programmable Circuits (1 week)

- General architecture of programmable logic circuits: PAL, GAL, PLD, CPLD
- Examples of manufacturers and programming tools: Altera Quartus II, Xilinx ISE

Chapter 2. Programming in VHDL (5 weeks)

- History of VHDL.
- Comparison between VHDL and programming languages.
- Different descriptions of an architecture: data flow, behavioral, structural.
- Identifiers and case sensitivity.
- Comments.
- Representing numbers in VHDL
- General structure of a VHDL code: Library, Entity, Ports, Architecture.
- Data types: predefined, user-defined
- Operators: logical, relational, shift, concatenation
- Signal attributes: EVENT, …
- Signal, variable and constant
- Process
- Component
- IF-THEN-ELSE statement
- CASE-WHEN statement
- WHEN-ELSE instruction
- WITH-SELECT-WHEN statement

Chapter 3. Applications on FPGA circuits (5 weeks)

- Multiplexer
- D-Flip
- Adder
- Universal counter with actions: activation, reset, load.
- Frequency divider.
- Frequency management with buttons: selection, division
- 7-segment decoder,
- Serial display on several 7 segments.
- 8-bit arithmetic logic unit

- 8-bit comparator

Chapter 4. Advanced Design with Finite State Machines (FSMs) (4 weeks)

- Introduction: Mealy and Moore structure
- Representation of an FSM machine
- FSM Design Examples

Assessment method:

Exam: 60%, Continuous Assessment: 40%

Bibliographic references:

[1] .Volnei A. Pedroni, "Circuit Design with VHDL," MIT Press, 2004.

[2] .Volnei A. Pedroni, "Circuit Design and Simulation with VHDL", 2nd edition, MIT Press, 2010.

[3] .Bryan Mealy, Fabrizio Tappero, "Free Range VHDL", 2018

[4] .Pong P. Chu, "FPGA prototyping by vhdlexamples: Xilinx Spartan™-3 Version", John Wiley & Sons, 2008.

[5] .Jacques Weber, Sébastien Moutault, Maurice Meaudre, "The VHDL language: from language to circuit, from circuit to language", Dunod, 2007.

[6] .Christian Tavernier, "Programmable Logic Circuits", Dunod 1992.

Semester: 2
Teaching unit: UEF 1.2.2
Subject 3:Advanced Signal Processing 2
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

This course is designed to enable the student to:

- ✓ Identify the concepts of discrete random processes
- ✓ develop the mathematical theory of various realizations of linear adaptive filters

Recommended prior knowledge:

This course assumes that the student has some knowledge of:

- ✓ Probability and statistics
- ✓ Random processes
- ✓ Digital filters
- ✓ Discrete-time signals and systems
- ✓ Matrix algebra.

Content of the material:

Chapter 1: Random Signals and Stochastic Processes (3 weeks)

- Reminder on random processes
- Reminder of the concepts: mean, autocorrelation and stationarity
- Power spectral density
- Concepts of stochastic processes
- Stationarities in the broad and strict sense and Ergodicity
- Examples of stochastic processes (Poisson process, Gaussian process and Markov process)
- Higher-order statistics (Moments and cumulants, Polyspectra, non-Gaussian processes, non-linear processing)

Chapter 2. Discrete Random Processes and Models (4 weeks)

- Discrete-time stochastic processes
- The correlation matrix (definition and properties)
- Stochastic models (AR, MA, ARMA)
- The Yule-Walker equations

Chapter 3.Optimal linear filtering (4 weeks)

- Wiener Filtering: Formulation of the Filtering Problem, Orthogonality Principle, Wiener-Hopf Equation, Mean Square Error Surface, Minimum Mean Square Error (MSE)
- Linear Prediction: Forward Linear Prediction, Backward Linear Prediction, Levinson-Durbin Algorithm
- Prediction error

Chapter 4. Adaptive Digital Filtering Algorithms (4 weeks)

- Steepestdescent algorithm
- Stochastic gradient algorithm (least-mean square – LMS)
- Variants of the LMS algorithm
- Recursive least-squares algorithm – RLS

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

[1] .S. Haykin, "Adaptive Filter Theory",5th edition, Pearson Prentice Hall, 2014;

[2] .JG Proakis and DG Manolakis, "Digital Signal Processing: Principles, Algorithms and Applications". Third Edition, Macmillan, 1996.

[3] .JG Boroujeny, Adaptive Filters: Theory and Applications. John Wiley and Son, 1998.

[4] . A. Antoniou, "Digital Filters Analysis, Design, and Signal Processing Applications", McGraw-Hill, 2018;

[5] .P. Stoica and R. Moses, "Spectral Analysis of Signals", Pearson Prentice Hall, 2005;

[6] . F. Cottet, Signal Processing and Data Acquisition - Course and Corrected Exercises, 4th edition, Dunod, Paris, 2015.

Semester: 2
Teaching unit: UEM 1.2
Subject 1:Microcontrollers TP&DSP
VHS: 10:30 p.m. (TP: 1:30 p.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

Put into practice the theoretical knowledge learned in the course through the design of different applications and programming with a focus on assembler to fully understand the internal architecture of dsPIC and embedded C to achieve the objectives quickly.

Recommended prior knowledge:

Programming language, microprocessors.

Content of the material:

TP1:MPLAB X / Proteus simulation development environment: Creation of LED flashing projects with the MCC (MPLAB® Code Configurator) graphical tool.

TP2: Managing I/O ports in Assembler: configuration, writing, reading.

TP3-4: Debugging program memory and data memory (manipulating special registers like STATUS, and controlling I/O ports like TRIS/LATCH/PORT).

TP5-6: Programming the same previous operations in XC16, and comparing compilation results in terms of optimization.

TP7: Configuring the ADC module in assembler and C.

TP8-9: Measurement of an analog quantity according to the equipment existing in the establishment, otherwise in simulation (temperature, pressure, flow rate, speed, etc.) and display of the measurement result on 4x7 segments (to clearly see the instability of the display of the last character).

TP10-11: Digital filteringin real timemeasurement noise and display of the result on 4x7 segments and on LCD.

TP12-15: Application of a motor speed control while integrating a communication protocol; example of storing measured data on a PC.

Assessment method:

Continuous assessment: 100%

Bibliographic references:

[1] .Lucio Di Jasio "Programming 16-bit PIC microcontrollers in C: Learning to fly the PIC 24", 2nd edition, Elsevier, 2012.

[2] .Creed Huddleston "Intelligent sensor design using the Microchip dsPIC®", Elsevier, 2007.
[3] .JM Angulo Usategui, A. Etxebarría Ruiz, I. Angulo Martínez, I. Trueba Parra "MicrocontroladoresdsPIC:Diseñopráctico de aplicaciones" Spanish Edition, McGraw-Hill 2006.
[4] .Armstrong Subero "Programming PIC microcontrollers with XC8", Apress 2018.
[5] .Microchip, "16-Bit MCU and DSC Programmer's Reference Manual: High-Performance Microcontrollers (MCU) and Digital Signal Controllers (DSC)", (DS70000157G),
[6] .Microchip, "MPLAB® C compiler for PIC24 MCUs and dsPIC® DSCs user's guide" (DS51284J),
[7] .Microchip, "MPLAB® Assembler, Linker and utilities for PIC24 MCUs and dsPIC® DSCs user's guide" (DS51317H),
*[8] .Microchip, "dsPIC33F/PIC24H Family Reference Manual" (DS70197C),*https://www.microchip.com/doclisting/TechDoc.aspx?type=ReferenceManuals
[9] .Microchip, "dsPIC33F/PIC24H Section 2: CPU" (DS70204),
[10] . Microchip, "dsPIC33F/PIC24H Section 3: Data Memory" (DS70202),
[11] . Microchip, "dsPIC33F/PIC24H Section 4: Program Memory" (DS70203),
[12] . Microchip, "dsPIC33F/PIC24H Section 5: Flash Programming" (DS70191),
[13] . Microchip, "dsPIC33F/PIC24H Section 6: Interrupts" (DS70184),
[14] . Microchip, "dsPIC33F/PIC24H Section 7: Oscillator" (DS70186),
[15] . Microchip, "dsPIC33F/PIC24H Section 8: Reset" (DS70192),
[16] . Microchip, "dsPIC33F/PIC24H Section 9: Watchdog Timer and Power-Saving Modes" (DS70196),
[17] . Microchip, "dsPIC33F/PIC24H Section 25: Device Configuration" (DS70194),
[18] . Microchip, "dsPIC33F/PIC24H Section 10: I/O Ports" (DS70193),
[19] . Microchip, "dsPIC33F/PIC24H Section 11: Timers" (DS70205),
[20] . Microchip, "dsPIC33F/PIC24H Section 12: Input Capture" (DS70198),
[21] . Microchip, "dsPIC33F/PIC24H Section 13: Output Compare" (DS70209),
[22] . Microchip, "dsPIC33F/PIC24H Section 14: Motor Control PWM" (DS70187),
[23] . Microchip, "dsPIC33F/PIC24H Section 15: Quadrature Encoder Interface (QEI)" (DS70208),
[24] . Microchip, "dsPIC33F/PIC24H Section 16: Analog-to-Digital Converter (ADC)" (DS70183),
[25] . Microchip, "dsPIC33F/PIC24H Section 17: UART" (DS70188),
[26] . Microchip, "dsPIC33F/PIC24H Section 18: Serial Peripheral Interface (SPI)" (DS70206),
[27] . Microchip, "dsPIC33F/PIC24H Section 19: Inter-Integrated Circuit™ (I2C™)" (DS70195),

Semester: 2
Teaching unit: UEM 1.2
Subject 2: Practical work on digital servo systems. /Advanced Signal Processing 02
VHS: 10:30 p.m. (TP: 1:30 p.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

Put into practice the theoretical knowledge learned in the courses on digital servo systems and advanced signal processing 2.

Recommended prior knowledge:

- ✓ Programming of digital circuits;
- ✓ Automation of digital servo systems;

Content of the subject:

Part I - Digital servo systems practical work

TP1: Modeling a physical system with Simulink/Matlab

Modeling a DC machine (or a permanent magnet synchronous machine, a chemical process, etc.). Linearization by a discrete model (using Matlab commands)***dlinmod***,***trim*****,**etc.), Comparison of model/system time responses for different excitations using Simulink/Matlab blocks.

TP2: Analysis of a sampled system

Application of some transformations on the model of the**TP1**(use of commands:***cannon, bilin***,***c2dm***,***d2cm ssdata***,***tfdata***,***ss2ss,***etc.). Review of controllability and observability (commands***ctrb***,***obsv***)

TP3: Modeling and correction by discrete state representation

Modeling and synthesis of control laws from the state representation of the physical system of**TP1**(commands:***dreg, dlqr,***etc.**).**Examination of the frequency responses of the corrected system (commands:***dbode, dnyquist, dsigma,***etc.).

TP4: Implementation of sampled controllers

Use of Simulink to implement control laws (state feedback, output feedback) or standard sampled controllers (P, PI PID). Examination of the time responses of the looped system for different inputs of the setpoint, disturbance and measurement noise

Part II - Advanced Signal Processing 02

TP 1: Ssimulation of random signals,Calculation of power spectral density, Calculation of autocorrelation and intercorrelation function.
TP 2: Filtering random signals.
TP 3: Spectral analysis of random signals.
TP4: Parametric spectral analysis AR and/or ARMAof sound signals (example of non-signals stationary)
TP5: Elimination of 50Hz interference by the LMS gradient algorithm

Assessment method:

Continuous assessment: 100%.

Bibliographic references:

[1] .P. Borne, G. Dauphin-Tanguy, JP Richard, F. Rotella, and I. Zambettakis. Analysis and Regulation of Industrial Processes. Volume 1: Continuous Regulation. Technip, France, 1993;

[2] .J. L Abatut, Sampled Linear Systems and Servo Control, Dunod Edition.

[3] .H. Buhler, Sampled Settings Volume 1, Dunod Edition.

[4] .B. d'Andréa Novel and M. Cohen de Lara. Linear Control of Dynamic Systems. Masson, France, 1994;

[5] .E. Dieulesaint and D. Royer. Applied Automation: 2. Linear control systems with sampled signals. Masson, France, 1990. ;

[6] .D. Jaume, S. Thelliez, and M. Vergé. Computer Control of Dynamic Systems. Eyrolles, France, 1991;

[7] .B. Pradin. DISCRETE-TIME SYSTEMS - Numerical Process Control. INSA Toulouse, France, 1999.

[8] .1. S. Haykin, "Signals and systems", John Wiley & sons, 2ed, 2003.

[9] .2. AV Oppenheim, "Signals and systems", Prentice-Hall, 2004.

[10] . *3. Mori Yvon, "Random Signals and Stochastic Processes", Lavoisier*,2014

[11] . 4. A. Papoulis, "Probability, Random variable and Stochastic Processes", McGraw Hill 1984.

[12] . 5. E. Robine, "Introduction to the theory of communication, Volume II: Random signals", Masson 1970.

[13] . 6. N. Hermann, "Engineering Probabilities: Random Variables and Birch Simulations", 2002.

[14] . 7. Ruegg, Alan, "Stochastic Processes", Lausanne: Presses polytechniques et universitaires romandes, 1989.

Semester: 2
Teaching unit: UEM 1.2
Subject 3:VHDL – FPGA practical work / Industrial Network practical work
VHS: 10:30 p.m. (TP: 1:30 p.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

The practical work should allow the theoretical elements covered in class to be put into practice.

Recommended prior knowledge:

Digital electronics. Industrial communication networks and protocols.

Content of the material:

*Below are two lists of practical exercises that meet the objectives of the subject. Training teams are requested to choose at least 5 practical exercises based on the availability of both hardware and software. Furthermore, it is permitted to add or replace some practical exercises from the attached list with other practical exercises related to the subject.**Precision**: Any changes made to these lists must be reported to the CPND so that other establishments can benefit from them.*

VHDL – FPGA practical work

TP1: Presentation of the development and simulation tool:Altera Quartus II or Xilinx ISE.
TP2: Exploitation of the development board through a given example of an adder.
TP3: First circuit examples: multiplexer, D flip-flop.
TP4: Simple 48-bit decimal counter.
TP5:48-bit decimal counter with actions: enable, reset, load.
TP6: Traffic light.
TP7: Multiplier/divider with shift registers.
TP8: Serial display on several 7 segments.
TP9: Digital clock.
TP10: Frequency division.
TP11: Frequency division controllable with buttons.
TP12:VGA display.

Industrial Networks TP

TP1: Implementation and setup on RS232, RS485, Ethernet
TP2: Transmitting a data frame over a CAN bus
TP3: Transmission of a data frame via a wireless connection
TP4: Development of a wireless local area network
TP5: Data exchange via Ethernet network
TP6: Study of an example of an industrial network

Assessment method:

Continuous assessment: 100%

Bibliographic references:

[1] .J. Weber,Sébastien Moutault,Maurice Meaudre, "The VHDL language: from language to circuit, from circuit to language", Dunod, 2007.
[2] .C. Tavernier, "Programmable logic circuits", Dunod 1992.

[3] .JP. Thomesse, Local Industrial Networks, Eyrolles, 1994.
[4] .P. Vrignat, Local industrial networks - Courses and practical work, Gaëtan Morin, 1999.
[5] .P. Rolin, Gilbert Martineau, Laurent Toutain, Alain Leroy, Networks, fundamental principles, Hermes, 1996.
[6] .JL. Montagnier, Practice of corporate networks - From cabling to administration - From local network to telecom networks, Eyrolles, 1996.
[7] .Ciame, Field networks: Description and selection criteria, Hermes, 2001.
[8] .http://www.comsol.com/shared/downloads/IntroductionToCOMSOLMultiphysics.pdf

Semester: 2
Teaching unit: UEM 1.2
Subject 4: Project-based learning
VHS: 37h30 (Lecture: 1h30, Practical work: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

HASAnalyze specifications. Methodically implement and manage an electronics project. Raise student awareness of project time management. Learn how to validate a technical solution. Write technical documents.

Recommended prior knowledge:

Know how to find, use and produce technical documentation for a project.

Content of the material:

1. Analyze an existing technical solution.
2. Search for documents and use information.
3. Manage a project: specifications, technical choices, cost, schedule, planning of the execution of the work, taking charge of constraints of the specifications and the quality approach.
4. Implement hardware and software components using manufacturer's instructions.
5. Design all or part of a functional or structural diagram, an algorithm and its associated coding, a sequencer and its associated coding.
6. Make a prototype.
7. Validate a technical solution (measurements or simulations) in compliance with specifications,
8. Write technical documents associated with the project.

General instructions:
From the beginning of the semester, students are asked to choose a project (at master's level) from a list provided by the subject head or to propose their own project (which must have the prior approval of the subject head).

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

[1] .H. Prevost, Project Management, Technip, 1996.
[2] .I. Chvidchenko, Management of major projects, Cepadues, 1993.
[3] .V. Giard, Project Management, Economica, 1991.
[4] .M. Joly & JLG Muller, From project management to project management, Afnor, 1994.
[5] .GM Caupin & J. Le Bissonnais, Managing an investment project, Afnor - A Savoir, 1996.
[6] .Manufacturer documentation (Data Books).

Semester: 2
Teaching unit: UED 1.2
Subject 1:of your choice
VHS: 10:30 p.m. (lesson: 1.5 hours)
Credits: 1
Coefficient: 1

Semester: 2
Teaching unit: UED 1.2
Subject 2:of your choice
VHS: 10:30 p.m. (lesson: 1.5 hours)
Credits: 1
Coefficient: 1

Semester: 2
Teaching unit: UET 1.2
Subject: Compliance with standards and rules of ethics and integrity
VHS: 10:30 p.m. (Class: 1.5 hours)
Credit: 1
Coefficient: 1

Teaching objectives:

To raise student awareness of the ethical principles and rules that govern life at university and in the workplace. To raise awareness of the need to respect and value intellectual property. To explain the risks of moral evils such as corruption and how to combat them, and to alert them to the ethical issues raised by new technologies and sustainable development.

Recommended prior knowledge:

Ethics and professional conduct (the foundations)

Content of the subject:

A.Respect for the rulesof ethics and integrity,

1. **Reminder of the MESRS Ethics and Professional Conduct Charter:**Integrity and honesty. Academic freedom. Mutual respect. Demand for scientific truth, Objectivity and critical thinking. Fairness.Rights andbondsof the student,of the teacher, administrative and technical staff,

2. Integrity and responsible research

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

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

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

B- Intellectual property

I- Fundamentals of intellectual property

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

II- Copyright

1. Copyright in the digital environment

Introduction. Copyrightdatabases, 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. Rightsin a patent. Usefulness of a patent. Thepatentability. Patent applicationin Algeria and around the world.

III- Protection and promotion of intellectual property

How to protect intellectual property. Rights infringement and legal tools. Vintellectual property protection. Intellectual property protectionin Algeria.

C. Ethics, sustainable development and new technologies

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

Assessment method:

Exam: 100%

Bibliographic references:

[1] .The World Intellectual Property Organization websitewww.wipo.int

[2] .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

[3] .Order No. 933 of July 28, 2016 establishing the rules relating to the prevention and fight against plagiarism

[4] .The ABCs of Copyright, United Nations Educational, Scientific and Cultural Organization (UNESCO)

[5] .E. Prairat, On teaching ethics. Paris, PUF, 2009.

[6] .Racine L., Legault GA, Bégin, L., Ethics and engineering, Montreal, McGraw Hill, 1991.

[7] .Siroux, D., Deontology: Dictionary of Ethics and Moral Philosophy, Paris, Quadrige, 2004, pp. 474-477.

[8] .Medina Y., Ethics, what will change in the company, Editions d'Organisation, 2003.

[9] .Didier Ch., Thinking about the ethics of engineers, Presses Universitaires de France, 2008.

[10] . Gavarini L. and Ottavi D., Editorial. of professional ethics in training and research, Research and training, 52 | 2006, 5-11.

[11] . Caré C., Morality, Ethics, Deontology. Administration and Education, 2nd quarter 2002, no. 94.

[12] . Jacquet-Francillon, François. Concept: professional ethics. Le télémaque, May 2000, no. 17

[13] . Carr, D. Professionalism and Ethics in Teaching. New York, NY Routledge. 2000.

[14] . Galloux, JC, Industrial Property Law. Dalloz 2003.

[15] . Wagret F. and JM., Patents, trademarks and industrial property. PUF 2001

[16] . Dekermadec, Y., Innovating through patents: a revolution with the internet. Insep 1999

[17] . AEUTBM. The engineer at the heart of innovation. Belfort-Montbéliard University of Technology

[18] . Fanny Rinck and Leda Mansour, Literacy in the Digital Age: Copy and Paste Among Students, Grenoble 3 University and Paris-Ouest Nanterre La Défense University, Nanterre, France

[19] . Didier DUGUEST IEMN, Citing your sources, IAE Nantes 2008

[20] . 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

[21] . 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.

[22] . Publication of the University of Montreal, Strategies for preventing plagiarism, Integrity, fraud and plagiarism, 2010.
[23] . Pierrick Malissard, Intellectual Property: Origin and Evolution, 2010.
[24] . http://www.app.asso.fr/
[25] . http://ressources.univ-rennes2.fr/propriete-intellectuelle/cours-2-54.html

V - Detailed program by subject for semester S3

Semester: 3
Teaching unit: UEF 2.1.1
Subject 2:Industrial actuators
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

To provide students with the necessary knowledge on the most common actuators in industrial instrumentation.

Recommended prior knowledge:

Notions of power electronics, electrical engineering.

Content of the subject:

Chapter 1: Electric actuators(3 weeks)
1.1 Electrical pre-actuators: The relay, The contactor, The disconnector, The fuses, The thermal relay.
1.2 Electromechanical converters: Machine organization, Operating principle, Starting the DC motor, Power balance, Reversibility of the DC machine, Motor power supply, Variable speed operation 1.3 Stepper motors: Permanent magnet motor, Variable reluctance motor, Hybrid motor

Chapter 2: Pneumatic and Hydraulic Actuators(3 weeks)
2.1 Pneumatic energy: Construction of a pneumatic installation, Production of pneumatic energy, Physical principles.
2.2 Pneumatic pre-actuators: Function, Components of a distributor, The main pneumatic distributors, The control devices, Application: pneumatic press.
2.3 Pneumatic actuators: Cylinders, Vacuum generator or venturi.
2.4 Hydraulic actuators: Definition, Main types of cylinders, Cylinder sizing, Applications.

Chapter 3: Electrostatic Actuators (2 weeks)
Chapter 4: Material Deformation Actuators(1 week)
Chapter 5: Ultrasonic Actuators(1 week)
Chapter 6: Inertial Actuators ('impact drives')(1 week)
Chapter 7: Stick and slip actuators: the stick-slip effect(1 week)
Chapter 8: Smart Actuators(2 weeks)

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

[1] .Guy Clerc, Guy Grellet, Electric actuators, Models, Control, Eyrolles, 1999.
[2] .Gérard Lacroux, Electric actuators for robotics and servocontrol, 1994.
[3] .Yves Granjon, Automatics: Linear, nonlinear systems, continuous time, discrete time, state representation, Dunod, 2010.
[4] .J. Faisandier, Hydraulic and pneumatic mechanisms, Dunod, 1999.
[5] .R. Labonville, Design of hydraulic circuits, an energy approach, Editions de l'Ecole Polytechnique de Montréal, 1991.
[6] .P. Maye, Electric motors for robotics, Dunod, 2000.
[7] .Michel Grout, Patrick Salaun, Industrial Instrumentation, 3rd edition, Dunod, 2012.
[8] .Michel Pinard, Control of electric motors, Dunod collection l'usine nouvelle 2004
[9] .M. Portelli, Industrial hydraulics technology, course and solved exercises, Educalivres, Casteila, 2005.

[10]. https://infoscience.epfl.ch/record/32233/files/EPFL_TH1756.pdf
[11]. http://www.technologuepro.com/cours-genie-electrique/cours-27-capteurs-acteurs-instrumentation/

Teaching unit: UEF 2.1.1
Subject 1:Industrial Programmable Controllers
VHS: 67h30 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient 4: 2

Teaching objectives:

This course allows the student to understand the hardware and software organization of APIs, to choose an API and the associated components according to the desired application and to use a programming language adapted to the API.

Recommended prior knowledge:

Combinational and sequential logic, Microprocessors, Microcontrollers, Sensors.

Content of the subject:

Chapter 1: Machine Automation (4 weeks)

1. Structural models
1.1 Block diagram
1.2 Process diagrams
1.3 Circuit diagrams
1.3.1 Nomenclature and codification
1.4 Functional models
1.4.1 Binary Logic and Boolean Algebra
1.4.2 Combinatorial logic
1.4.3 Sequential logic
1.4.4 Synthesis of sequential systems

Chapter 2: The GRAFCET(3 weeks)

2.1. Introduction to GRAFCET
2.2. The ladder language
2.3. Translation of a grafcet into a ladder
2.4. Transcription of a specification in Grafcet

Chapter 3: Petri Nets(3 weeks)

3.1 Basic Notions
3.2 RdP Individuals
3.3 Properties of RdP
3.4 Markup Graph & Coverage Tree
3.5 Linear Algebra
3.6 Test your knowledge

Chapter 4: Programmable Logic Controllers(4 weeks)

4.1 Hardware – Architecture and range of PLCs
4.2 THE CENTRAL UNIT
4.2.1 Introduction
4.2.2 Software functions of the Central Unit
4.2.3 The processor
4.2.4 Memory

4.2.5 The operating cycle
4.2.6 Operational safety
4.3 INDUSTRIAL COUPLERS
4.3.1 General
4.3.2 Input couplers
4.3.3 Output couplers
4.3.4 I/O Architecture
4.3.5 Smart Couplers
4.4 POWERING AN AUTOMATED SYSTEM
4.4.1 Power supply
4.4.2 Pneumatic supply

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

[1] .F. Baccelli, G. Cohen, GJ Olsder, and J.-P. Quadrat, Synchronization and linearity, an Algebra for Discrete Event Systems, Wiley, 1992.
[2] .CG Cassandras and S. Lafortune, Introduction to Discrete Event Systems, Kluwer Academic Publishers, 1999.
[3] .CG Cassandras, Discrete Event Systems: Modeling and Performance Analysis, Aksen Associates Inc. Publishers, Homewood, IL and Boston, MA, 1993.
[4] .G. DeMicheli, Digital Design, McGraw Hill, New York, 1993.
[5] .HR Lewis and CH Papadimitriou, Elements of the Theory of Computation, Prentice Hall, Englewood Cliffs, 1981.
[6] .René David and Hassan Alla, Discrete Continuous and Hybrid Petri Nets, Springer Verlag, 2005.
[7] .Adepa - Afcet, Le Grafcet, Edition Cepadues, 2nd ed., 1995
[8] .René David, Hassan Alla. From Grafcet to Petri Nets. Hermès Edition, 1992.
[9] .JC Bossy, P. Brard, P. Faugère, C. Merlaud, Le Grafcet: its practice and its applications, Educalivre, Ed. Casteilla, 1995.
[10] . Simon Moreno, Edmond Peulot. Grafcet: Design-Implementation in Industrial Programmable Logic Controllers. Casteilla Edition, 2009.
[11] . G. Michel. APIs: Architecture and applications of industrial programmable logic controllers. Dunod Edition 1988.
[12] . William Bolton. Industrial Programmable Logic Controllers. Dunod Edition 2010.
[13] . JC Humblot, Industrial Programmable Automation, Hermes Science Publications, 1993.
[14] . M. Diaz, Petri Nets: Fundamental Models. IC2 Treatise - Computer Science and Information Systems Series, Hermes Science, 2001.
[15] . A. Choquet-Geniet, Petri Nets: A Modeling Tool, Dunod, 2006.
[16] . Daniel Bouteille et al., Programmable automation, Cepadues-Editions, 2nd edition, 1997.
[17] . Henri Ney, Elements of automation, Electrotechnical and standardization collection, Edition Nathan, 1996.
[18] . P. Borne, G. Dauphin-Tanguy, JP. Richard, F. Rotella, I. Zambettakis, Automatic Analysis and Regulation of Industrial Processes, Volume 2 Digital Regulation, Technip editions

Semester: 3

Teaching unit: UEF 2.1.1
Subject 1:advanced sensors and measurement systems
VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 2,
Coefficient: 1

Semester: 3
Teaching unit: UEF 2.1.2
Subject 3:Advanced power electronics
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Master the operation of the main static converters, acquire the knowledge for a technical choice according to the field of application of a power converter.

Recommended prior knowledge:

Power electronics.

Content of the material:

Chapter 01: Theoretical Aspects(2 weeks)

1.1 Acquisition of an analog signal
1.1.1 The sampling theorem
1.1.1.1 Definition
1.1.1.2 Case study
1.1.1.3 Shannon's Theorem
1.2 Quantification
1.2.1 Description
1.2.2 A/D converter model
1.2.3 Quantization noise
1.2.4 Quantization Signal to Noise Ratio SNQR 13
1.2.5 Example 1: triangular signal
1.2.6 Example 2: sinusoidal signal
1.3 Analog reproduction of a digital signal
1.3.1 Description
1.3.2 The holding element

Chapter 02: Technological aspects of signal conditioning chains(2 weeks)

2.1 General description of an acquisition chain
2.1.1 Inventory of possible topologies
2.1.2 Relationship between measuring range and conversion range
2.1.3 Constraints on operational amplifiers
2.1.4 Amplifier output stage characteristics
2.2 Classic operational amplifier assemblies
2.2.1 Characteristics of operational amplifiers
2.2.2 Voltage amplification and offset
2.2.3 Instrumentation amplifier
2.3 Differential input and balanced output amplifier
2.3.1 General information
2.3.2 Internal functional diagram
2.3.3 Assemblies with common mode input
2.3.4 Application and practical dimensioning
2.3.4.1 Termination of an input referenced to GND (with ideal source)
2.3.4.2 Terminating an input referenced to GND (with real source)

Chapter 03: Input stage and adaptation stage(3 weeks)

3.1 Introduction
3.2 Surge Protection
3.2.2 Common mode inputs outside the limitations
3.2.3 Reverse current in protection diodes
3.2.4 CMOS Common Mode Voltage Limiter
3.3 Applications of overvoltage protections
3.3.1 Voltage trackers
3.3.2 Operational amplifiers
3.3.3 Single supply voltage differential assembly
3.4 Phase reversal protection
3.4.1 Introduction
3.4.2 Choice of protection components
3.5 Common mode input
3.5.1 Introduction
3.5.2 Dual supply
3.5.3 Single supply
3.6 Differential Input
3.6.1 Symmetrical bipolar power supply (dual supply)
3.6.2 Single supply
3.7 Adaptation stage
3.7.1 General
3.7.2 Requirements on the A/D converter input operational amplifier
3.7.3 Common mode input
3.7.4 Differential inputs
3.7.5 Effect of switched capacities
3.7.6 Case of analog multiplexers
3.7.7 Sampler-blocker case

Chapter 04: Signal Generation Circuits (2 weeks)

4.1. Circuit for charging and discharging a capacitor.
4.2. Linear and nonlinear oscillators,
4.3 Voltage Controlled Oscillators (VCO),
4.4 PLL phase-locked loops.
4.5 Astables and Monostables.

Chapter 05: Anti-aliasing filters(3 weeks)

5.1 Introduction
5.1.1 Butterworth
5.1.2 Bessel
5.1.3 Chebyshev
5.1.4 Theoretical aspects
5.1.1 Characteristics of 2nd order low-pass filters
5.1.2 2nd Order Butterworth Filter
5.1.3 2nd order Bessel filter
5.1.4 2nd order Chebyshev filter with 1dB ripple
5.1.5 Comparison between different types of 2nd order low-pass filters
5.2 2nd order low-pass cells
5.2.1 General
5.2.2 Sallen & Key low-pass cell
5.2.3 Multiple feedback cell
5.2.6 AkerbergMossberg cell
5.3 Practical example of sizing a 2nd order low-pass filter
5.3.1 Sallen & Key Cell

5.3.2 MFB Cell
5.4 Theoretical behavior and real behavior
5.4.1 Sallen & Key Cell
5.4.2 MBF Cell
5.5 Characteristics of 2nd order high-pass filters
5.5.1 2nd Order Butterworth Filter
5.5.2 2nd order Bessel filter
5.5.3 2nd order Chebyshev filter with 1dB ripple
5.5.4 Comparison between 2nd order high-pass filter types
5.6 Cascading Filters
5.6.1 Butterworth Filter
5.6.2 Example 1: 6th order low-pass filters
5.6.3 Example 2: 6th order high-pass filter

Chapter 06: Sample-and-hold devices, ADCs and ADCs(3 weeks)
6.1.1 General information on sample-and-hold devices
6.1.2 Sampling Window
6.1.3.2 SHA in acquisition mode (track mode)
6.1.3.3 Transition between acquisition mode and track to hold mode
6.1.3.4 SHA in hold mode
6.1.3.5 Transition between hold mode and acquisition mode
6.1.4.2 SHA internal to an A/D converter
6.1.4.3 Operation with overlap
6.2 Digital-to-Analog Converters
6.2.1 Potentiometric converter
6.2.1 Operation
6.2.2 Advantage
6.2.3 Disadvantage
6.2.4 Weighted resistor converter
6.2.4.1 Operation
6.2.4.2 Voltage switching system
6.2.4.3 Current switching system
6.3 R/2R Scale Converter
6.3.1 Operation of the R/2R network in ladder
6.3.2 Current-switching R/2R scale D/A converters
6.3.3 R/2R scale voltage switching D/A converter
6.4 Converter with weighted current sources
6.5 Weighted capacitance converter
6.6 Analog-to-Digital Converter
6.6.1 Integrating converter
6.6.1.1 Single-ramp analog integrator
6.6.1.2 Dual-ramp analog integrator
6.7 Sigma-Delta Converter

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

[1] .F. Mazda. Power Electronics Handbook: Components, Circuits and Application, 3rd Edition, Newnes, 1997C.W. Lander. Power Electronics, McGraw-Hill, 1981L. Lasne, Power Electronics: Course, Case Studies and Corrected Exercises, Dunod, 2011.
[2] .J. Laroche, Power Electronics – Converters: Course and Corrected Exercises, Dunod, 2005.

[3] .G. Séguier et al. Power Electronics: Course and Corrected Exercises, 8th edition, Dunod, 2004.
[4] .D. Jacob, Power electronics - Operating principle, dimensioning, Ellipses Marketing, 2008.
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[6] .H. Buhler, Power Electronics, Dunod
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[8] .H. Buhler, Electronics for Regulation and Control, Treatise on Electricity.
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[10] . R. Chauprade, Controls of alternating current motors (Power electronics), 1987.
[11] . R. Chauprade, Controls of direct current motors (Power electronics), 1984.

Semester: 3
Teaching unit: UEF 2.1.2
Subject 4: Elements of digital regulation
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The objective of this course is to discover the different digital regulation elements used for the control of dynamic systems. Thus, learn the different components in a regulation chain: transmitter, sensor, actuator, correctors. Provide tools and methods for: analyzing discrete-time linear dynamic systems, designing digital regulation elements andoriented the developed schemes towards their real-time implementation on real physical processes.

Recommended prior knowledge:

- ✓ Analog control elements;
- ✓ Digital signal processing;
- ✓ Linear sampled servoing.

Content of the subject:

Chapter 1. Reminder on analog regulation (2 weeks)
Modeling of physical systems: RLC circuit model, mechanical system model, control valve model. Furnace model. Electrical-mechanical analogies and symbolic representation of analog control. Complex analog control schemes.

Chapter 2.Analog control elements (2 weeks)
Elements of a control loop:Transmitter,regulator,positioner,Servo motor,jacks.Modes of action of regulators:All or nothing action,proportional, integral and derivative (PID), hysteresis.Regulatory strategies:Direct regulation,Cascade regulators,Split-range control,Feedforward regulation,Override regulation.

Chapter 3. Digital Regulation (4 weeks)
Structure of digital regulation: Control diagram,choice of discretization step, Converters (CAN and DAC), digital regulator (computer). Correction objectives: Specifications, Analysis of closed-loop system performance (stability, speed and precision).Industrial digital control elements: digital PID, microcontroller. Advantages and disadvantages of digital control elements: Example Comparisons between analog PI and digital PI.

Chapter 4. Digital Control Elements (4 weeks)
Standard digital control elements: Transposition of analog correctors, Ziegler-Nichols PID, digital phase advance. Takahashi digital P, PI, PID regulators, Anti-windup circuit (Smith predictor). Digital control elements with finite settling time: absolute minimum, non-absolute minimum, with a single response, resolution of the Diophantine equations.

Chapter 5. Advanced Numerical Control Elements (3 weeks)
Digital control diagram and specifications, Synthesis by the Zdan method, Digital RST regulator, Linear quadratic controllers (LQ), Digital adaptive corrector,Selection of the element and the method of digital correction. Time and frequency analysis of the digitally controlled loop system.

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

[1] .*P. Borne, GD Tanguv, JP Richard, F. Rotella, I. Zambetalcis, Analysis and regulation of industrial processes - Digital regulation, Volume 2, Editions Technip, 1993;*

[2] .*Robert L. Williams, Douglas A, Lawrence, Linear State-Space Control Systems, Edition John Wiley & Sons, 2007;*

[3] .*Y. Granjon, Linear, nonlinear, continuous-time, discrete-time systems, state representation, 2nd Edition, Dunod, Paris, 2010;*

[4] .*R. Longchamp, Numerical control of dynamic systems, Presses Polytechniques et Universitaires Romandes, 1995;*

[5] .*D. Lequesne, PID Regulation: Analog, digital and fuzzy, Edition Hermès, 2005;*

[6] .*GF Franklin, JD Powell, LM Workman, Digital Control of Dynamic Systems, Addison-Wesley Series in Electrical and Computer Engineering: Control Engineering, 1990;*

[7] .*M. Retif, Synthesis of a robust control: Sampled correctors, control by PID, by state model and RST-Automatique polynomial, Ellipses Marketing, 2011;*

[8] .*E. Godoy, E. Ostertag, Digital control of systems: Frequency and polynomial approaches, Ellipses Marketing, 2004;*

[9] .*R. Longchamp, Numerical control of dynamic systems, Presses Polytechniques et Universitaires Romandes, 2006;*

[10] . *DV*Bobál, J. Böhm, J. Fessel, J. Machácek, Digital self-tuning controllers: Algorithm, implementation and application, Advanced Textbooks in control and signal processing, Springer-verlag London limited, 2005;

[11] . *E. Gody,*Industrial regulation*: Modeling tools, methods and control architectures, 3rd Edition, Dunod, Paris, 2019;*

Semester: 3
Teaching unit: UEM 2.1
Subject 1: Practical work on industrial programmable controllers
VHS: 10:30 p.m. (TP: 1:30 p.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

At the end of this practical work, the student will be able to:

- Understand the relationship between the operating part (the system to be controlled) and the control part (the programmable controller) for an automated system.
- Carry out the wiring of the input/output interfaces of a programmable controller.
- Program a programmable logic controller to sequentially manage the actions provided for in the specifications.

Recommended prior knowledge:

- ✓ Industrial Programmable Automation Course.

Content of the material:

TP 1. Modeling and simulation of Grafcet. (2 weeks)
Use Grafcets simulation software (EDUGRAF, AUTOMGEN, etc.) to understand the relationship between each Grafcet step and the action(s) to be controlled and the relationship between each transition and the state of the sensor(s) in the operating part.

TP 2.Wiring the PLC with the operating part (2 weeks)
Wiring of the PLC power supply and wiring of the PLC Input/Output interfaces with the actuators and sensors of the operating part.

TP 3. Introduction to programmable logic controller programming software (2 weeks)
Introduction to programming blocks, functional blocks (Timer, Counter, etc.) and programming languages (Contact, List, Graph, etc.)

TP 4. Programming with the different languages of a programmable automaton (4 weeks)
Programming of Grafcets automated systems (educational models) available.

Assessment method:

Continuous assessment: 100%.

Bibliographic references:

[1] .Automation and control technology-SCE;
[2] .https://www.academia.edu/25781071/Automation_and_Control_Technique_SCE
[3] .Wiring of inputs and outputs of programmable controllers;
[4] .https://www.eic2.ch/pdf/cablage_securite_ed905.pdf
[5] .Process automation, control technology, EDS;
[6] .https://www.festo-didactic.com/ov3/media/customers/1100/56845_2019_04_fr_extract_pa_eds_s.pdfS7-1200 programmable controller;
[7] .https://media.automation24.com/manual/fr/61777246_s71200_System_Manual_fr-FR_fr-FR.pdf
[8] .Training document for a complete solution... - Siemens
[9] .https://www.automation.siemens.com/sce-static/learning-training-documents/classic/advanced-programming/b05-struct-prog-fr.pdf

Semester: 3
Teaching unit: UEM 2.1
Subject 2: Practical work Industrial actuators / Practical workDigital regulation
VHS: 10:30 p.m. (TP: 1:30 p.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

Allow students to use and master the theoretical concepts studied in class.

Recommended prior knowledge:

- ✓ Digital regulation elements course;
- ✓ Industrial actuators course;

Content of the subject:

Teachers are asked to choose two to three practical exercises for each subject from the two lists of practical exercises presented below.

Digital Regulation TP

TP1: Modeling and analysis of sampled systems using Matlab-Simulink software.
TP2: Digital PID control of a dynamic system: using the methods ofZiegler-Nichols and Takahashi.
TP3: Analog and digital speed control of a DC motor (Phase advance corrector).
TP4: Digital temperature control (Snap response correction)
TP5: Digital control of a penduluminverse (Zdan Advanced Control Approach or RST).
TP6: Study of a digital servocontrol of a flexible arm (comparisons of performances between a PID and advanced control)

TP Industrial Actuators

TP1: Stepper motor.
TP2: Direct current and alternating current motor.
TP3: Implementation of a pneumatic system.
TP4: Hydraulic servo cylinder.
TP5: Control valve.
TP6: Thermal actuators.

Assessment method:

Continuous assessment: 100%.

Bibliographic references:

[1] .P. Borne, GD Tanguv, JP Richard, F. Rotella, I. Zambetalcis, Analysis and regulation of industrial processes - Digital regulation, Volume 2, Editions Technip, 1993;
[2] .R. Longchamp, Numerical control of dynamic systems, Presses Polytechniques et Universitaires Romandes, 1995;
[3] .D. Lequesne, PID Regulation: Analog, digital and fuzzy, Edition Hermès, 2005;
[4] .M. Retif, Synthesis of a robust control: Sampled correctors, control by PID, by state model and RST-Automatique polynomial, Ellipses Marketing, 2011;
[5] .E. Gody,Industrial regulation: Modeling tools, methods and control architectures, 3rd Edition, Dunod, Paris, 2019;

[6] .G. Clerc, G. Grellet, Electric actuators, Models, Control, Eyrolles, 1999.
[7] .G. Lacroux, Electric actuators for robotics and servocontrol, 1994.
[8] .J. Faisandier, Hydraulic and pneumatic mechanisms, Dunod, 1999.
[9] .R. Labonville, Design of hydraulic circuits, an energy approach, Editions de l'Ecole Polytechnique de Montréal, 1991.
[10] . Michel Grout, Patrick Salaun, Industrial Instrumentation, 3rd edition, Dunod, 2012.

Semester: 3
Teaching unit: UEM2.1
Subject 3:Advanced Power Electronics TP
VHS: 10:30 p.m. (TP: 1:30 p.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

The aim is to understand the operation and know the characteristics of the different types of basic converters and their applications to machines.

Recommended prior knowledge:

Power electronics.

Content of the material:

TP1.AC-DC converter

TP2.DC-AC converter

TP3.AC-AC converter

TP4.DC-DC converter

TP5.....

Assessment method:

Continuous assessment: 100%

Bibliographic references

Semester: 3
Teaching unit: UEM2.1
Subject 4: Reliability and maintenance of electronic systems
VHS: 37h30 (Course: 1h30, Practical work: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

Describe the importance of reliability studies for the proper functioning of systems.Guide the choice of materials, design studies, evaluate durability or economic replacement duration.Know the basic concepts of maintenance.

Recommended prior knowledge:

Probabilities.

Content of the material:

Chapter 1: Definition of the main concepts of maintenance
Maintenance, terotechnology, servicing, reliability, maintainability, availability, breakdown, failure, repair, troubleshooting, diagnosis, CMMS, Meaning of some acronyms: MTTF, MTTR, MUT, MDT, MTBF

Chapter 2: Basic Probability Model:
Combinatorial analysis reminders: arrangement, permutation, combination. Probability: event, experiment. Algebra of events: commutativity of union and intersection, absorption, distribution of union and intersection, neutral element and complementation. Axioms. Probability theorems: total probability, conditional probability, Bayes' theorem. Application of probability in electronics.

Chapter 3: Application to the reliability of probability theorems
Systems: series system, parallel system, mixed system, symmetrically configured series-parallel system, symmetrically configured parallel-series system, non-symmetrically configured mixed system
Application of Bayes' theorem to the different previous configurations.

Chapter 4: Failures
Failure rate, MTBF calculation, Distribution function and probability density of failures. Common reliability laws: exponential law, Weibull law, binomial law, Poisson law. Fault trees.

Chapter 5: Inventory management in maintenance
Definition of maintenance stock, Responsibilities of the different phases of maintenance stock management, Catalog of maintenance stock items, Codification, Maintenance stock management rules, The “maintenance stock” file.

Chapter 6: Maintenance Policies
Corrective maintenance, Predictive maintenance, Different levels of maintenance.

Practical work:

Teachers responsible for the subject are asked to carry out a series of practical work relating to the subject and then return it to the CPND-ST for synthesis, enrichment and dissemination.

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references

[1] .A. Pollard, Reliability and Predictive Statistics
[2] .D. Dacunha-Castelle, M. Duflo, Probabilities and Statistics, Volume 1, Masson, 1982
[3] .MR Spiegel, Probability and Statistics, Lectures and Problems, Schaum Series, McGraw Hill, 1981.
[4] .Jean Heng, Practice of preventive maintenance, Dunod, 2002.
[5] .Renaud Cuignet, Maintenance Management, Dunod, 2002.
[6] .F. Monchy, Maintenance: Methods and organization, Dunod, 2000.
[7] .JM Bleux, JL Fanchon, Maintenance: Automated production systems, Etapes Collection, Nathan, 1997.
[8] .ZwingelsteinG, Failure diagnosis, Hermès, Paris 1997.
[9] .Raymond Magnan, Practice of industrial maintenance, Dunod, 2003.

Semester: 3
Teaching unit: UED 2.1
Subject 1:of your choice
VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 1
Coefficient: 1

Semester: 3
Teaching unit: UED2.1
Subject 2:of your choice
VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 1
Coefficient: 1

Semester: 3
Teaching unit: UET2.1
Matter :Documentary research and dissertation design
VHS: 10:30 p.m. (Class: 1.5 hours)
Credit: 1
Coefficient: 1

Teaching objectives:
Provide the student with the necessary tools to research useful information to better use it in their final year project.Help him to go through the different stages leading to the writing of a scientific document. Inform himthe importance of communication and himlearn to present the work carried out in a rigorous and educational manner.

Recommended prior knowledge:
Writing methodology, Presentation methodology.

Content of the material:

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:Select information sources (2 Weeks)
- Type of documents (Lbooks, 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:Locate documents (01 Week)
- Research techniques
- Search operators

Chapter I-4: Process 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 dissertation (2 Weeks)

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

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

- The shaping.Numbering of chapters, figures and tables.
- The cover page
- Typography and punctuation
- Writing. Scientific language: style, grammar, syntax.
- Spelling.Improvement of general language competence 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. *HAS.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. *Mr. Boeglin, Reading and Writing at University. From the Chaos of Ideas to Structured Text. L'Etudiant, 2005.*
6. *Mr. Beaud, the art of the thesis, Editions Casbah, 1999.*
7. *Mr. Beaud, the art of the thesis, La découverte, 2003.*
8. *Mr. Kalika, Master's thesis, Dunod, 2005.*

Suggestion of some discovery subjects

Half:
Teaching unit: UED
Subject 1: Optoelectronics
VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

To introduce the student to the main optoelectronic components, their characteristics, their operating principle and the areas of use.

Recommended prior knowledge:

Fundamental electronics, Optoelectronic devices.

Content of the material:

Chapter 1: Elements of Photometry
Optical sources (primary, secondary), Luminous flux, Solid angle, Luminous intensity, Luminance and illumination of an optical source. Spectral quantities. Energy and visual photometry. Color temperature. Lambertian source, …

Chapter 2: Photoemitters
Technologies and characteristics, Directivity diagram, …
- The LED source
- The PIN photodiode
- The Laser diode, ….

Chapter 3: Photoreceptors
Photodiode, Phototransistor, Photovoltaic cells, CCD

Chapter 4: Application Examples
Motion detector (fork optocoupler), Optocoupler for galvanic isolation, Luminescence detector, Contrast detector, Color detector, Photovoltaic generator, etc.

Chapter 5: Optical Fibers
Refraction reminders. The different types of optical fibers (technologies and characteristics). Principles of light propagation in an optical fiber. Dispersions, losses and attenuations in an optical fiber.

Assessment method:

Review: 100%.

Bibliographic references:

1. *P. Bhattacharya, Semiconductor optoelectronic devices, Prentice Hall 1997.*
2. *E. Rosencher, Optoelectronics, 2nd edition, Dunod, 2002.*
3. *R. Maciejko, Optoelectronics, International Polytechnic Press, 2002.*
4. *K. Booth, The essence of optoelectronics, Prentice Hall 1998.*
5. *J. Wilson, Optoelectronics – an introduction, 3rd ed., Prentice–Hall 1998.*
6. *J. Singh, Semiconductor optoelectronics, McGraw Hill, Inc., 1995.*
7. *D. Decoster, Optoelectronic Detectors, Lavoisier, 2002*

Semester: 1
Teaching unit: UED
Subject 2: Autonomous energy systems
VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

To stimulate the student's interest in renewable energy in general and in systemsenergy using solar or wind energy in particular. To acquirethe studentsome skill in the sizing of a wind installation orphotovoltaic.

Recommended prior knowledge:

General knowledge

Content of the material:

Chapter 1: Electrical energy production devices,
Notions on energy transformations (mechanical; thermal; hydraulic, etc.), History (Volta, Oersted, Faraday, etc.), the alternator, the dynamo, methods of producing electrical energy (hydraulic power station, thermal power stations). Non-renewable energy sources (fossil and nuclear). Renewable energy sources.

Chapter 2: Wind Energy
History, principle and structure, Characteristics and sizing, Map of wind resources in Algeria, Wind farms and power, Standards, Advantages and disadvantages. Example of a wind turbine installation.

Chapter 3: Hybrid Systems
Hybrid Systems (Hydrokinetic Systems, Operating Principle of Hydrokinetic Systems, Different Types of Hydrokinetic Systems and Operators, etc.)

Chapter 4: Photovoltaic solar energy
Principle of a photovoltaic installation, solar deposits in Algeria, photovoltaic cell technologies, photovoltaic modules, MPPT, photovoltaic characteristics and connections, standards. The inverter (role, principle, characteristics and efficiency). Example of a photovoltaic installation.

Chapter 5: Other renewable energy sources
Renewable energy families(solar energy, wind energy, hydroelectric power, biomass, geothermal energy). The different renewable energies in the world. Profitability.

Assessment method:

Review: 100%.

Bibliographic references:

1. *J. Vernier,Renewable energies, PUF edition, 2012*
2. *E. Riolet, The mini-wind turbine, editionEyrolles, 2010*
3. *A. Labouret and M. Villoz, Photovoltaic solar energy, Editions du Moniteur 2009*
4. *B. Fox, Wind Electric Power: Production, Forecasting and Grid Integration, Technical and Engineering Collection, Dunod/L'Usine Nouvelle 2015 (2nd edition)*
5. *A. Damien, Biomass energy: Definitions, resources and transformation methods, Technical and Engineering Collection, Dunod/L'Usine Nouvelle 2013 (2nd edition)*

6. *A. Labouret, M. Villoz, Photovoltaic installations: Design and sizing of installations connected to the network, Technical and Engineering Collection, Dunod/Le Moniteur 2012 (5e edition)*
7. *http://www.cder.dz/spip.php?article1442*

Half
Discovery Teaching Unit: UED
Subject 3:Electroacoustics and vibration analysis
VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

Acquire notions of acoustics, electroacoustics (noise measurements and analyses, sound recording and recording, electroacoustic chain, electro-mechanical-acoustic analogy). Application of Signal Processing to the monitoring of rotating machines by vibration analysis.

Recommended prior knowledge:

Basic concepts in physics (waves and vibrations), Electronics, Electrical Engineering and Signal Processing.

Content of the material:

Chapter 1: Notions of acoustics **(4 weeks)**
Definition of an acoustic wave, acoustic pressure, acoustic velocity, acoustic acceleration and acoustic impedance; Production and modes of propagation of acoustic waves;
General equation of propagation in terms of acoustic pressure and solutions: plane wave and spherical wave,
Reflection and Refraction of acoustic waves,
Acoustic levels, frequency bands for noise and vibration analysis,
Auditory Perception, Isononic Curves and Weighting Filters

Chapter 2: Electro-acoustics **(5 weeks)**
Electroacoustic chain: sound source, electrostatic microphone, power amplifier, loudspeaker (electrodynamic),
Sound recording and recording on different media,
Noise measurements and analysis: description and operation of a sound level meter, microphone calibration, evaluation of noise pollution.
Automatic audiometry
Electro-mechanical-acoustic analogy

Chapter 3 Vibration measurements and analyses **(6 weeks)**
Vibration, origins of vibrations, different types of vibrations (free, forced, resonances, self-excited),
Vibration signals: harmonic, complex periodic, random, transient, time and frequency representations,
Application of signal processing to vibration analysis: notion of Spectrum, Auto-correlation and Cepstrum,
Rotating machine maintenance strategies and monitoring parameters,
Vibration measuring chain,
Use of measurement results (diagnosis and fault detection, etc.)

Assessment method:

Review: 100%.

Bibliographic references:

1. *J. Jouhaneau, Elementary Notions of Acoustics, Electroacoustics.*
2. *Michel Bruneau, Manual of fundamental acoustics*
3. *Mario Rossi, Electroacoustics, EPFL, 1979.*

4. *Graham Kelly, Mechanical Vibrations: Theory and Applications.*
5. *Mr. Kunt, Digital Signal Processing, Polytechnic and University Presses of Romandie (PPUR).*
6. *Vibration analysis of rotating machines, Engineering Techniques.*

Semester:
Teaching unit: UED
Subject 4:Electromagnetic compatibility
VHS: 10:30 p.m. (Class: 1.5 hours)
Credit: 1
Coefficient: 1

Teaching objectives:

Apply the general laws of electromagnetism to the problems of electromagnetic pollution of the environment and its effect on electronic systems. Acquire a comprehensive approach to researching the potential causes of disturbance in a given environment. Choose an optimal protection technique.

Recommended prior knowledge:

Basic concepts in mathematics, statistics and signal processing.

Content of the subject:

Chapter 1: Introduction to Electromagnetic Compatibility (EMC)
Regulatory bodies, Overview, Examples of standards, Terminology used.

Chapter 2: Sources of Disturbances
Classification according to W. Duff, Permanent/Intermittent Sources, Impulse Sources (i-electric arcs, lightning, ESD discharges, ii- electrical contacts and inductive load, iii- electrostatic discharge).

Chapter 3: Study of couplings
Common impedance coupling, Capacitive coupling, Inductive coupling, Electromagnetic radiation coupling

Chapter 4: EMC protection techniques
Layout of components and wiring, Shielding, Filtering, Surge protection.

Chapter 5: Printed Circuits and Integrated Circuits
Emission sources on a circuit, Parameters of some logic series, Static and dynamic noise margins of logic series, Transition currents – "groundbounce", Inductance of through holes "vias", Placement of decoupling capacitors, Single or double-sided circuits, Single/double-sided power supplies, Multilayer circuits, Tracks, transmission lines, Characteristic impedances, Line matching circuits.

Chapter 6: Investigation Methods
Standardized tests, Electrostatic discharge immunity tests, Conducted disturbance immunity tests, Voltage dip and short interruption immunity tests, Radiated disturbance immunity tests, Magnetic field immunity tests, Measurement of emitted conducted disturbances, Measurement of radiated conducted disturbances.

Assessment method:

Exam: 100%

Bibliographic references:

1. *T. Williams, Electromagnetic Compatibility from Design to Approval.*
2. *Guy Gérard Champiot, Electrical and electromagnetic disturbances.*
3. *JL. Cocquerelle, EMC and power electronics.*
4. *A. Charoy, Parasites and disturbances in electronics: Earths, grounds, wiring.*

Semester:
Teaching unit: UED
Subject 5:Industrial instrumentation and measurements
VHS: 45h00 (Course: 3h00)
Credit: 2
Coefficient: 2

Teaching objectives:

To introduce the student to industrial measurement techniques. To familiarize him with industrial measurement systems and to introduce him to the problems ofnoise and interference in industrial instrumentation.

Recommended prior knowledge:

Instrumentation electronics, sensors, electrical and electronic measurements.

Content of the subject:

Chapter 1: Concepts of industrial measurements (2 weeks)
Role of instruments, Symbolization and diagrams, Characteristics of a measuring device (Precision, resolution, response time, measurement range, linearity, physical quantity, etc.), LVoltage generators (0-10V), Current generators (0-20 mA and 4-20 mA). Connections (wired with 2, 3 and 4 wire contact, wireless, ...), static measurements and dynamic measurements.

Chapter 2: Digital Acquisition of Analog Signals (Reminders) (2 weeks)
Principles of an analog and digital measurement chain, Sample and hold, conditioning, Analog to digital conversion (ADC), examples of ADC, Precision and resolution of an ADC. Main functions of electronics in instrumentation (filtering, amplification, pulse generator, etc.)

Chapter 3: Examples of Systemsindustrial measurement (6 weeks)
Introduction, classic equipment (voltmeter, current clamps, megohmmeter, etc.), Thermometry (with and without contacts, connection techniques, tolerances, etc.), Manometry (general principles, different types, failures and anomalies, etc.), Flow measurement (principles and examples, square root extractor, mass density compensation flow meter, flow measurement errors), Tachymetry(principle and apparatus), Hygrometry(principle and apparatus),Viscosity measurement (principle and apparatus), Density and volumetric mass measurement (densimetry), pH measurement (pH meter), Chromatography (principle and apparatus), Conductivity measurement (principle and apparatus), Spectroscopic analysis techniques (principle and apparatus), …

Chapter 4: Noise and Interference in Electronic Instrumentation (2 weeks)
Introduction, Origins of noise in electronic circuits, Examples of noise (thermal, 1/f, etc.), Noise models in amplification, Interference, Sources of coherent interference, Reduction of the effects of interference in instrumentation

Chapter 5: Measurement networks and instrumentation buses (3weeks)
Introduction to instrumentation buses (principle, examples, protocols and standards), Link testers, frame analyzers, protocol analyzers, measurements by the HART protocol forHighway AddressableRemoteTransducer (basic concepts, examples, maintenance via HART)

Assessment method:

Exam: 100%

Bibliographic references:

1. *G. Asch, Sensors in Industrial Instrumentation, Dunod, 2010.*
2. *P. Dassonvalle, The Sensors: Exercises and Corrected Problems, Dunod, 2005.*
3. *A. Migeon, Industrial applications of sensors, Hermès Science Publications, 1997.*

4. *M. Cerr, Industrial Instrumentation, Volumes 1 and 2, Tech and Doc Edition.*
5. *F. Cottet, Signal processing and data acquisition: Courses and exercises, Dunod, 1999.*
6. *G. Asch et al., Data Acquisition, 3rd edition, Dunod, 2011.*
7. *JG Webster, Measurement, Instrumentation and Sensors Handbook,Taylor & Francis Ltd.*

Semester:
Teaching unit: UED
Subject 6:Industrial safety
VHS: 10:30 p.m. (Class: 1.5 hours)
Credit: 1
Coefficient: 1

Teaching objectives:
Raise staff awareness about safety and the environment. Assess and address occupational risks.

Recommended prior knowledge:
Basic concepts in chemistry and electrical engineering.

Content of the subject:

Chapter 1: Elements of risk control
Concepts of risk, The different areas of security, Security results in industry, Success factors in security.

Chapter 2: Approach applied in process industries
Failure Mode, Effects and Criticality Analysis (FMEA), Risk Management Feedback in Process Industries, Safety Management System (SMS), ISO 9000 Quality Standards - Version 2000

Chapter 3: Chemical risks (Identification, assessment, control)
Toxic products, Heat-sensitive products, Dangerous chemical reactions.

Chapter 4: Safety of electrical installations:
Electrical risks, Nature of electrical accidents and dangers of electric current, Protective measures, Safety measures against the indirect effects of electric current, Checks and control of installations.

Chapter 5: Safety of work equipment and pressure vessels
Regulations and technical standards, Inspection of steam and gas pressure devices, Inspection of rotating machines and thermal devices, Inspection of piping and loading stations.

Assessment method:
Exam: 100%

Bibliographic references:

1. *LG Hewitson, Guide to the protection of electrical equipment, Dunod, 2007.*
2. *P. Levalois, D. Gauvin, Review of standards and recommendations for exposure to electromagnetic fields, 1996.*
3. *P. Dyevre, P.Merelan, Health effects of occupational exposure to ultraviolet radiation, 1994.*
4. *Villemeur, Safety of operation of industrial systems, Dunod, 1988.*
5. *A. Lannoy. Risk management and operational safety. Publishers: Tec et Doc*
6. *E. Niel, E. Craye, Control of operational risks in production systems, Hermès, 2005.*
7. *A. Leroy, Dictionary of Risk Analysis and Management, Hermès, 2005.*
8. *T. Tanzy, Risk Engineering, Hermès, 2005.*

Semester:
Teaching unit: UED
Subject 7:Robotics
VHS: 10:30 p.m. (Class: 1.5 hours)
Credit: 1
Coefficient: 1

Teaching objectives:

To introduce the student to the fundamental aspects of robotics and recent developments in the field of industrial robotics.

Recommended prior knowledge:

None.

Content of the subject:

Chapter 1: General Information
Definitions, Components of a robot, Classification of robots, Characteristics of a robot, Generations of robots, Programming robots.

Chapter 2: Degrees of Freedom - Architecture
Positioning of a solid in space, Connection, Mechanisms, Morphology of robots, manipulators

Chapter 3: Geometric model of a simple chain robot
Need for a model, Operational coordinates, Translation and rotation, Homogeneous transformation matrices, Obtaining the geometric model, Modified Denavit-Hartenberg parameters, Inversion of the geometric model - Paul's method, Multiple solutions - Workspace - Aspects

Chapter 4: Simplification Technique
Speed and acceleration of robots, Jacobean matrix and its usefulness, Definition of direct and inverse equations, Meaning of singularities.

Assessment method:

Exam: 100%

Bibliographic references:

1. *H. Asada, JJE Slotine, Robot Analysis and Control, a Wiley Interscience Publication, 1986.*
2. *JJ Craig, Introduction to Robotics, Mechanics and Control, Addison-Wesley, 1989.*

Semester:
Teaching unit: UED
Subject 8:Adjusting Electric Drives
VHS: 45 hours (Course: 3 hours)
Credit: 2
Coefficient: 2

Teaching objectives:

Introduce students to familiarize themselves with the adjustment of electrical drives, namely: Evariable speed drives, or "servo drives" which require constant control of movement.

Recommended prior knowledge:

Basic concepts of electrical engineering and electricity as well as automatic regulation.

Content of the subject:

Chapter 1: Introduction to Regulated Workouts
1.1 Definition of regulated training
1.2 Users of the training
1.3 Course objectives
1.4 Applications of drives in the machinery industry

Chapter 2: Training with DC machine
2.1 Introduction
2.2 Mathematical modeling
2.2.1 Reminder: construction and operation of the DC motor
2.2.2 Characteristic equations
2.2.3 Functional diagram
2.2.4 Electrical model of the DC machine
2.2.5 Mechanical and electrical time constants
2.2.6 Torque-speed characteristic of the separately excited machine in constant steady state
2.3 Power supply by direct current drive
2.3.1 Operation
2.3.2 Static characteristic
2.3.3 Pulse Width Modulation (PWM) Current Drive Control
2.4 Energy recovery
2.5 Current regulation
2.5.1 Analog PI Linear Regulator
2.6 Cruise control
2.6.1 Structure of the cruise control system
2.6.2 Modeling the system to be adjusted
2.6.3 Choice and adjustment principle of the speed regulator
2.6.4 Regulator synthesis for nominal magnetization

Chapter 3: Drive with self-commutated synchronous machine
3.1 Operating principle of the synchronous machine
3.2 Start-up
3.3 Terminology clarification: brushless DC and brushless AC motors
3.3.1 Introduction
3.3.2 Brushless DC Motor
3.3.3 Structure of the commutatorless DC motor
3.3.4 Torque control
3.3.5 Magnetic distributions of the stator winding and the permanent magnet
3.3.6 Conclusion on the brushless DC machine
3.4 Mathematical modeling of the self-commutated synchronous machine ("AC brushless")

3.4.1 Tension equations
3.4.2 Electromagnetic torque
3.4.3 Phase shift between current and EMF
3.5 Power supply by frequency converter
3.6 A first control strategy: scalar control of the self-commutated synchronous machine
3.6.1 Measurement of angular position
3.6.2 Current control
3.7 Vector control of the self-commutated synchronous machine

Chapter 4: Training with asynchronous machine
4.1 General information on the asynchronous machine
4.1.1 Constitution
4.1.2 Operating principle
4.2 Mathematical modeling in steady sinusoidal regime
4.2.1 Equivalent diagram of a stator phase
4.2.2 Electromagnetic torque in permanent sinusoidal mode
4.3 Scalar control of the asynchronous machine
4.3.1 Constant air gap flux control
4.3.2 Field weakening regime
4.4 Vector control of the asynchronous machine
4.4.1 Equations of the asynchronous machine in the stator frame of reference
4.4.2 Electromagnetic torque
4.4.3 Equations of the asynchronous machine in the frame of reference rotating at synchronous speed
4.4.4 Orientation of the (rotating) axis system relative to the rotor flux
4.4.5 Voltage-current transfer functions

Assessment method:
Exam: 100%

Bibliographic references:

1. *Jean Bonal, Guy Séguier, Variable Speed Electric Drives, Volume 1, Schneider collection 1997.*
2. *Jean Bonal, Guy Séguier, Variable speed electric drives, Volume 2, Schneider collection 1998.*
3. *Jean Bonal, Guy Séguier, Variable speed electric drives, Volume 3, Schneider collection 1998.*
4. *Michel Pinard. Electronic control of electric motors, Dunod, 2004.*
5. *Loron Luc. Control of electrical systems, Lavoisier, 2000.*
6. *J.-P. Caron, JP Hautier, Modeling and control of the asynchronous machine, Technip, 1995.*
7. *G. Grellet, G. Clerc, Electric actuators, Principles, Models, Controls, Eyrolles, 1996.*
8. *J. Lesenne, F. Notelet, G. Séguier, Introduction to advanced electrical engineering, Technique et Documentation, 1981.*
9. *J. Caron, J. Hautier, Modeling and Control of the Asynchronous Machine, Technip Edition, Paris, France, 1995.*
10. *R. Chauprade. Controls of alternating current motors (Power electronics), 1987.*
11. *R. Chauprade. Controls of direct current motors (Power electronics), 1984.*

Semester:
Teaching unit: UED
Subject 9:Bio-instrumentation and biosensors
VHS: 10:30 p.m. (Class: 1.5 hours)
Credit: 1
Coefficient: 1

Teaching objectives:

This course is intended to familiarize you with devices capable of collecting physiological and biological signals.

Recommended prior knowledge:

Fundamental transduction systems, Fundamental electronics, General chemistry.

Content of the subject:

1. Origin of the biological signal
2. Noise in biological systems
3. Electrochemical electrode, Nerst equation, Nickolskii
4. Ionic and amperometric sensors
5. ECG, EMG, EEG recording
6. Recording of the respiratory signal
7. Recording of blood flow signal
8. Enzymatic bioreceptor, Biosensors
9. Biomedical and environmental application

Assessment method:

Exam: 100%

Bibliographic references:

1. *Tran Minh Canh, Biosensors, Elsevier-Masson, 1991*
2. *G. Broun and C. Moreau, Biomedical equipment in hospitals and laboratories, Maloine, 1998.*
3. *R. Normann, Principles of Bioinstrumentation, Wiley, 1988.*
4. *T. Thomas, DA Corlis, J. Bailey, The Psychophysical Measurement of Visual Function, Buttrworth-Heinemann 2003.*

Semester:
Teaching unit: UED
Subject 10:Methods and tools for non-destructive testing
VHS: 10:30 p.m. (Class: 1.5 hours)
Credit: 1
Coefficient: 1

Teaching objectives:

This course provides assistance in choosing non-destructive testing (NDT) methods and techniques for static and dynamic industrial equipment. It allows students to become familiar with this type of advanced testing.

Recommended prior knowledge:

Physics, electronics, sensors, measuring devices, automation.

Content of the subject:

Chapter 1: Reminders of the principles of conditional maintenance
Monitoring parameters, Organization of conditional maintenance.

Chapter 2: Non-destructive testing (NDT) of static equipment:
Adopt an NDT approach, Design pressurized metal capacities, Identify degradation risks, Prepare NDT, Apply regulations, Choose NDT methods and tools.

Chapter 3: Dynamic Equipment Controls
Vibration monitoring of rotating machines, Establishing a budget for the acquisition of vibration monitoring equipment, Analyses of'oil

Chapter 4: Expert Systems

Assessment method:

Exam: 100%

Bibliographic references:

1. Jean Claude Francastel, Maintenance Engineering from Design to Operation of an Asset, Dunod Edition, 2007.
2. Nicolas Liebeaux, Modeling of Electromagnetic Sensors: Application to Non-Destructive Testing by Eddy Currents, European University Editions, 2010.
3. Jean Perdijon, Non-destructive testing by ultrasound, Hermes Science Publications, 1993.
4. ICNDT, The International Committee for Non-Destructive Testing:http://www.icndt.org/
5. EFNDT, European Federation for Non-Destructive Testing:http://www.efndt.org/
6. CIVA, non-destructive testing software developed and published by the CEA:http://www-civa.cea.fr/
7. Cofrend - Who is Cofrend? :*www.cofrend.com*.
8. Precend - Who are we? :www.precend.fr
9. ECND-PdL:www.ecnd-pdl.fr
10. American Society for Non-Destructive Testing:www.asnt.org

Semester:
Teaching unit: UED
Subject 11:Tools for instrumentation maintenance
VHS: 10:30 p.m. (Class: 1.5 hours)
Credit: 1
Coefficient: 1

Teaching objectives:
This subject provides the student with a reference tool for industry practices in the field ofinstrumentation maintenance. It aims to help those involved to apply good methodsmaintenance by ensuring full use of resources, both internal and external.

Recommended prior knowledge:
Concepts in industrial maintenance.

Content of the subject:

Chapter 1: General organization of maintenance
Basic maintenance functions, Preparing for the use of external services.

Chapter 2: Implementation of structures
Maintenance organization, Communication/information systems, Mobilization of personnel resources.

Chapter 3: Maintenance Methods
The common core of maintenance methods, Evaluate failure risks, Make choices among analytical approaches, Make choices among strategic methods, Implement methods, ensure the quality of the maintenance service, Ensure the safety of maintenance work, Prepare the scheduling of maintenance work.

Assessment method:
Exam: 100%

Bibliographic references:

1. *Jean Claude Francastel, Maintenance Engineering from Design to Operation of an Asset, Dunod Edition, 2007.*
2. *Collective work, Industrial Maintenance, Ed. AFNOR, 1996.*
3. *J. Héng, Practice of preventive maintenance: Mechanics–Pneumatics–Hydraulics-Electricity, Cold, Dunod, 2002.*
4. *F. Monchy, The maintenance function, training in industrial maintenance management, Ed. Masson, 1987.*
5. *D. Boitel and C. Hazard, Maintenance Guide, Ed. Nathan Technique, 1987.*
6. *F. Boucly and A. Ogus, Maintenance management, Ed. AFNOR Gestion, 1988.*
7. *E. Niel, E. Craye, Control of operational risks in production systems, Hermès, 2005.*
8. *N. Limnios, Fault Tree, Hermès, 2005.*
9. *A. Leroy, Dictionary of Risk Analysis and Management, Hermès, 2005.*
10. *T. Tanzy, Risk Engineering, Hermès, 2005.*

Semester:
Teaching unit: UED
Subject 12:Industrial maintenance and diagnostics
VHS: 10:30 p.m. (Class: 3:00 a.m.)
Credit: 2
Coefficient: 2

Teaching objectives:
Mastery of the causes, modes and mechanisms of failures. Mastery of internal and external diagnostic methods. Ability to apply decision tests.

Recommended prior knowledge:
Industrial instrumentation, Sensors, Instrumentation maintenance practice, Probabilities and statistics.

Content of the subject:

Chapter 1: Maintenance Concepts
Definition of systems and components - Maintenance and operational safety - Reliability, Maintainability, Availability, Safety - Maintenance tasks - Maintenance levels - Reliability-based maintenance - Total productive maintenance.

Chapter 2: Classification of failures
Definitions - Classification of failures according to causes - Classification of failures according to degree - Classification of failures according to speed of occurrence - Classification of failures according to speed of occurrence and degree - Classification of failures according to date of occurrence - Classification of failures according to effects - Defects and breakdowns.

Chapter 3: Diagnosis and methods
Concept of causality - Definition of diagnosis - Classification of diagnostic methods - Diagnostic procedure - Measurements - Validation of measurements - Characterization of operation by signature analysis - Detection of a malfunction.

Chapter 4: Diagnostic methods using functional and material modeling
Functional analysis techniques - Functional and material trees - Analysis of failure modes and their effects - Fault tree.

Chapter 5: Diagnostic methods using physical modeling
Model method - Diagnostic methods by parameter identification - Diagnostic methods by state vector estimation - Diagnostic methods by signature modeling.

Chapter 6: Diagnostic methods by analysis of external signatures
External diagnostic methods - Pattern recognition diagnostic method - Neural network diagnostic method - Expert system diagnostic method.

Chapter 7: Diagnostic Decision
Statistical decision tests - Bayes tests - Minimax test - Neyman-Pearson test - Composite tests.

Assessment method:
Exam: 100%

Bibliographic references:

1. F. Monchy, Maintenance: Methods and organization, Dunod 2000.
2. G. Zwinglestein, Reliability-Based Maintenance, Hermes 1996.
3. G. Zwinglestein, Fault Diagnosis, Hermes, 1995.
4. *Villemeur, Safety of operation of industrial systems, Dunod, 1988.*

Semester: 2

Teaching unit: UEF 1.2.2
Subject 13: Industrial networks and communication
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

To enable students to become familiar with the concepts of digital data transmission, particularly the different types of networks that exist in the industrial world. Emphasis will be placed on understanding the different topologies and their advantages and disadvantages for a given industrial installation.

Recommended prior knowledge:

- ✓ Local computer networks;
- ✓ Sensors;
- ✓ Industrial programmable logic controllers;

Content of the material:

Chapter 1.General information on fieldbuses (04 weeks)
1.1-Definitions (Bus, Field, Network, Local Area Network, Industrial Local Area Network (ILN), Enterprise Local Area Network, Some names of industrial local area networks). 1.2-Presentation of the industrial environment. 1.3-Architecture of an IDN (field networks, workshop networks, factory networks). 1.4-Characteristics of an IDN (number of nodes, amount of information, transmission time). 1.5-Characteristics of the data exchanged in an IDN (Nature of the messages exchanged, Size of the messages). 1.6-Role of an IDN in an industrial installation. 1.7-OSI and IDN architecture (Adaptation of the OSI model to IDNs, Characteristics of the physical layer for IDNs, Characteristics of the MAC sublayer for IDNs).

Chapter 2.: The 485 Modbus bus (02 weeks)
Reminder of the RS232 standard. The RS485 link. The Modbus protocol. Modbus addressing and framing.

Chapter 3. The BusCAN (Controller Area Network) (03 weeks)
Overview of CAN. CAN OSI models. CAN data frames and characteristics. Access methods and arbitration principle. Data rates. CAN hardware. Application layer services. CANopen.

Chapter 4.Profibus (03 weeks)
Overview of Profibus and its characteristics. The three types of Profibus (DP, FMS, and PA). Access mode. Industrial Ethernet and Profinet. Data rates.

Chapter 5.Overview of Wireless Industrial Networks (03 weeks)
Technologies, protocols and architectures of industrial wireless networks (WLAN 802.11, Bluetooth, HART protocols, Wireless Profibus, Bluetooth, ZigBee, etc.). Security of industrial wireless communication networks.

Assessment method:

Continuous assessment: 60%; Exam: 40%.

Bibliographic references:

1. *G. Pujolle, The networks, Eyrolles, April 1995.*
2. *JP., Thomesse, Local industrial networks, Eyrolles, 1994.*
3. *P. Vrignat, Local industrial networks - Courses and practical work, Gaëtan Morin, 1999.*
4. *P. Rolin, G. Martineau, L. Toutain, A. Leroy, Networks, fundamental principles, Hermes, 1996.*

5. *JL. Montagnier, Practice of corporate networks - From cabling to administration - From local network to telecom networks, Eyrolles, 1996.*
6. *Ciame, Field networks: Description and selection criteria, Hermes, 2001.*
7. *C.Servin,Networks andTelecoms: Dunod courses and corrected exercises.*
8. *D. Present, S. Lohier, Transmissions and Networks, Course and corrected exercises, Dunod.*
9. *P. Hoppenot, Introduction to Local Industrial Networks.*
10. *Emad Aboelela, Network simulation experiments, University of Massachusetts Dartmouth.*
11. *Ir. H. Lecocq, Local industrial networks, University of Liège.*
12. *JF. Hérold, O. Guillotin, P. Anayar,Industrial computing and networks in 20 files*
13. *P. Dumas, Industrial Computing 2nd edition*
14. *D. Paret, The CAN Bus Application, Dunod*
15. *F. Lepage, Local industrial networks, Hermes*
16. *C. Sindjui, The great guide to industrial control systems.*

University.....
Faculty.....
Department.....

Sector :.....
Speciality :.....
Academic year 20.... /20....

THE...../...../20....

MINUTES CONCERNING THE CHOICE OF DISCOVERY SUBJECTS FOR THE FIRST YEAR OF THE MASTER'S DEGREE

The undersigned teachers, after deliberation, have decided on the choice of discovery subjects for the master's degree... proposed in the outline of this master's degree. In this regard, the teachers* whose names follow undertake to ensure the teaching of these subjects. In the event that the training team chooses a subject whose program is not available in the outline, the head of the department undertakes to send this program to the CPND-ST for enrichment and validation.

* For each subject, it is possible to indicate the name of the main teacher and possibly the name of a substitute teacher.

Semesters	Discovery subjects	Teachers
S1	Subject 1: Subject 2:	
S2	Subject 1: Subject 2:	

Observations:.....
.....

Names and surnames of teachers		Subjects taught	Half	Signings
1				
2				
3				
4				
5				
6				
7				
8				
9				

The head of the sector The head of the department

***Reminders**: The nature of the discovery subjects must complement the training and must be chosen according to the needs of the local or regional socio-economic fabric and the availability of specialist teachers in the subject.*

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PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

University.....
Faculty.....
Department.....

Sector :.....
Speciality :.....
Academic year 20.... /20....

THE...../...../20....

MINUTES CONCERNING THE CHOICE OF DISCOVERY SUBJECTS FOR THE SECOND YEAR OF THE MASTER'S DEGREE

The undersigned teachers, after deliberation, have decided on the choice of discovery subjects for the master's degree... proposed in the outline of this master's degree. In this regard, the teachers* whose names follow undertake to ensure the teaching of these subjects. In the event that the training team chooses a subject whose program is not available in the outline, the head of the department undertakes to send this program to the CPND-ST for enrichment and validation.

* For each subject, it is possible to indicate the name of the main teacher and possibly the name of a substitute teacher.

Semesters	Discovery subjects	Teachers
S3	Subject 1: Subject 2:	

Observations:.....
.....

Names and surnames of teachers		Subjects taught	Half	Signings
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

The head of the sector The head of the department

***Reminders**: The nature of the discovery subjects must complement the training and must be chosen according to the needs of the local or regional socio-economic fabric and the availability of specialist teachers in the subject.*

Copies to VRP/VDP