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	Advanced digital communications	6	3	3:00 a.m.	1h30		67h30	82h30	40%	60%
	Random Signals and Stochastic Processes	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental EU Code: UEF 1.1.2 Credits: 8 Coefficients: 4	Radiocommunication	4	2	1h30	1h30		45h00	55h00	40%	60%
	FPGA programmable circuits	4	2	1h30	1h30		45h00	55h00	40%	60%
Methodological EU Code: UEM 1.1 Credits: 9 Coefficients: 5	Advanced Digital Communications TP	2	1			1h30	10:30 p.m.	27:30	100%	
	TPSordom Signals and Stochastic Processes	2	1			1h30	10:30 p.m.	27:30	100%	
	TPFPGA programmable circuits	2	1			1h30	10:30 p.m.	27:30	100%	
	Object-oriented programming in Phyton	3	2	1h30		1 hour	37h30	37h30	40%	60%
EU Discovery Code: UED 1.1 Credits: 2 Coefficients: 2	Subject of your choice	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
	Subject of your choice	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
Transversal EU Code: UET 1.1 Credits: 1 Coefficients: 1	Technical English and Terminology	1	1	1h30			10:30 p.m.	2:30 a.m.		100%

Total semester 1		**30**	**17**	**1:30 p.m.**	**6:00 a.m.**	**5:30 a.m.**	**375 hours**	**375 hours**		

Semester 2

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	Digital signal processing	6	3	3:00 a.m.	1h30		67h30	82h30	40%	60%
	Antennas	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental EU Code: UEF 1.2.2 Credits: 8 Coefficients: 4	Transmission lines and waveguides	4	2	1h30	1h30		45h00	55h00	40%	60%
	Coding and Compression	4	2	1h30	1h30		45h00	55h00	40%	60%
Methodological EU Code: UEM 1.2 Credits: 9 Coefficients: 5	Digital Signal Processing TP	2	1			1h30	10:30 p.m.	27:30	100%	
	TP Antennas, transmission lines and waveguides	2	1			1h30	10:30 p.m.	27:30	100%	
	TPCoding and Compression	2	1			1h30	10:30 p.m.	27:30	100%	
	Image processing	3	2	1h30		1 hour	37h30	37h30	40%	60%
EU Discovery Code: UED 1.2 Credits: 2 Coefficients: 2	Subject of your choice	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
	Subject of your choice	1	1	1h30			10:30 p.m.	2:30 a.m.		100%

Transversal EU Code: UET 1.2 Credits: 1 Coefficients: 1	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	Wireless and Mobile Networks	6	3	3:00 a.m.	1h30		67h30	82h30	40%	60%
	Optical communications	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental EU Code: UEF 2.1.2 Credits: 8 Coefficients: 4	Technology and Protocols for Multimedia	4	2	1h30	1h30		45h00	55h00	40%	60%
	RF and Microwave (Passive/Active) Devices	4	2	1h30	1h30		45h00	55h00	40%	60%
Methodological EU Code: UEM 2.1	TPWireless and Mobile Networks	2	1			1h30	10:30 p.m.	27:30	100%	
	Optical Communications TP	2	1			1h30	10:30 p.m.	27:30	100%	

Credits: 9 Coefficients: 5	Practical work on devices (passive/active RF and microwaves)	2	1			1h30	10:30 p.m.	27:30	100%	
	Digital television	3	2	1h30		1 hour	37h30	37h30	40%	60%
EU Discovery Code: UED 2.1 Credits: 2 Coefficients: 2	Subject of your choice	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
	Subject of your choice	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
Transversal EU Code: UET 2.1 Credits: 1 Coefficients: 1	Documentary research and dissertation design	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
Total semester 3		**30**	**17**	**1:30 p.m.**	**6:00 a.m.**	**5:30 a.m.**	**375 hours**	**375 hours**		

Basket of choice of subjects from the Discovery Units (S1, S2 and S3)

1. Electromagnetic compatibility
2. Standards and Protocols
3. Embedded systems and telecommunications
4. Radar Techniques
5. Space telecommunications
6. Radio navigation system
7. Emerging technologies in telecommunications
8. Radiofrequency electronics,
9. Emerging systems,
10. Linux system
11. Operator networks
12. Satellite networks
13. Wireless sensor networks
14. Field networks
15. Emerging areas of optical telecommunications
16. Installation and maintenance of optical fibers
17. Radio Engineering
18. *VSAT technology*
19. Propagation of acoustic microwaves in piezoelectric solids
20. RF and microwave measurements
21. Portable micro-antennas
22. Emerging telecommunications systems
23. Theoretical physics of optical and microwave analogies
24. Biological Effects of Electromagnetic Waves (Bio Electromagnetism)
25. Routing and access networks
26. CAD of telecom circuits
27. Characterization of RF devices
28. Web Programming

Semester 4

Internship in a company or in a research laboratory leading to a dissertation and a defense.

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

This table is given for information purposes only.

Evaluation of the End of Master's Cycle Project

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

- Presentation of the internship report (Jury assessment) /3

I - Detailed program by subject for semester S1

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

Teaching objectives:

At the end of this course, students will be able to identify the functions performed in advanced digital communication systems. This subject covers various concepts related to non-ideal channels, multiple access techniques, and MIMO systems.

Recommended prior knowledge:

Basic notions on theinformation theory and signal processing as well as on themodulation and demodulation are necessary to follow this material.

Content of the subject:

Chapter 1. Reminders (1 Week)

- Principle of a global digital transmission chain
- Parameters for evaluating a transmission chain (Signal to noise ratio, Error probability, Spectral efficiency, Bit Error Rate BER)

Chapter 2. Radio Transmission Channels (4 Weeks)

- Time and frequency behavior of radio channels
- Radio channel models
- Coherence band, Coherence time, Time spread, Doppler spread, Selective channel, Non-selective channel, Rayleigh fading, Rayleigh channel,Rice Canal,
- Classification of channels.

Chapter 3. Radio Channel Equalization (2 Weeks)

- Introduction to Equalization
- Classical equalization structures, Zero-forcing equalizer, Minimum square error equalizer, Maximum likelihood equalization.

Chapter 4. Multiplexing and Multiple Access Techniques (4 Weeks)

- Multiplexing
- Duplexing

- Time Division Multiple Access (TDMA)
- Frequency Division Multiple Access (FDMA)
- Code Division Multiple Access (CDMA)
-Orthogonal Frequency Division Multiplexing (OFDM)

Chapter 5. MIMO Systems (4 Weeks)

- Diversity on transmission, Space-time coding, Spatial multiplexing
- Joint demodulation, Multi-user MIMO

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. *G. Baudouin, "Digital Radiocommunications", Dunod, 2002.*
2. *JM Brossier, "Signal and digital communication: equalization and synchronization", Hermès Science, 97*
3. *P. Comon, "Digital Communications - Courses and exercises for engineering students", Harmattan editions, 2010.*
4. *A. Glavieux, M. Joindot, "Digital Communications, Introduction",Educational collection of telecommunications,Masson,1996.*
5. *A. Glavieux, M. Joindot, "Introduction to digital communications", Collection: Sciences Sup, Dunod, 2007.*
6. *HP Hsu, "Analog and Digital Communications: Courses and Issues", McGraw-Hill, 1994.*

7. *G. Mahé, ""Digital Communications Systems", Ellipses.*
8. *LW Couch, "Digital and Analog Communication Systems", Prentice-Hall, New Jersey, 2007.*
9. *S. Haykin, "Communication Systems", John Wiley and Sons, Hoboken, New Jersey, 2001.*
10. *J. Proakis, M. Salehi, "Communication Systems Engineering", 2nd edition, Prentice-Hall, New Jersey, 2002.*
11. *B. Rimoldi, "Principles of Digital Communications", Ecole Polytechnique de Lausanne (EPFL), Switzerland.*
12. *J. Proakis, "Digital Communications",McGraw-Hill, 2000.*
13. *B. Sklar, "Digital Communications, Fundamentals and applications", Prentice Hall, 2001.*
14. *BP Lathi, "Modern Digital and Analog Communication Systems", Oxford University Press, 1998.*

Semester: 1
Teaching unit: UEF 1.1.1
Subject 2:Random signals andStochastic processes
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The student receives the basic concepts that allow him to understand and apply signal processing methods concerning random signals and stochastic processes.

Recommended prior knowledge:

Knowledge of deterministic signal processing and probabilities is required to follow this subject.

Content of the subject:

Chapter 1. Concepts of correlation and convolution (3 Weeks)

- Reminders on linear systems (Definition, properties, dynamic filters, etc.)
- Concept of correlation and convolution
- Application of the concept of correlation to physical quantities
- Fundamental application of correlation methods
  - Identification of processes and detection of signals drowned in noise
  - Spectral analysis (by filtering, Fourier transform, correlation, spectral densities)

Chapter 2.Concepts of random variables (4 Weeks)

- Physical notion of random phenomena
- Reminders on probabilities and statistics (probability density, distribution function, etc.)
- Continuous and discrete random variables
- Moments and conditional statistics
- Sequences of random variables-Functions of random variables-Covariance

Chapter 3. Processing of random signals (4 Weeks)

- Random signals (statistical and temporal representations)
- Stationarity and statistical properties (mean, variance, standard deviation, etc.)
- Power spectral density
- Sampling of random signals
- Filtering of random signals - Matched filter, Wiener filter
- Statistical estimation and spectral estimation
- Periodogram, correlogram, averaged periodogram, smoothed periodogram
- AR, MA and ARMA models

Chapter 4.Stochastic processes (4 Weeks)

- Notions of stochastic processes
- Stationarities in the broad and strict sense,ergodicity
- Stochastic input systems
- Examples of stochastic processes (Poisson, Gaussian and Markovian processes)
- Higher order statistics (Moments and cumulants, Polyspectra, non-Gaussian processes, non-linear processing)
- Introduction to particle filtering

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. S. Haykin, "Signals and systems", John Wiley & sons, 2ed, 2003.
2. AV Oppenheim, "Signals and systems", Prentice-Hall, 2004.
3. Mori Yvon, "Random signals and stochastic processes", Lavoisier,2014
4. A. Papoulis,"Probability, Random variable and Stochastic Processes", Mc Graw Hill 1984.
5. E. Robine,"Introduction to Communication Theory, Volume II: Random Signals", Masson 1970.
6. N. Hermann,"Engineering Probabilities: Random Variables and Simulations Birch", 2002.
7. Ruegg, Alan,"Stochastic process", Lausanne: Polytechnic and University Presses of Romandie, 1989.

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

Teaching objectives:

Study of the behavior of radio waves at ground level and in the atmosphere (troposphere, stratosphere and ionosphere). This subject will also be the subject of study of satellite links.

Recommended prior knowledge:

Knowledge of electromagnetism is required to follow this subject. This knowledge is provided in the "Waves and Propagation" subject of the third year of the Telecommunications degree.

Content of the subject:

Chapter 1.Electromagnetic field theory (3 Weeks)

- Reminders on theMaxwell's equations (Origin and detailed demonstration)
- Propagation of the plane electromagnetic wave in a vacuum (Wave equations, Electromagnetic Energy, Poynting vector)
- Propagation of aelectromagnetic wave in thedielectrics (Reflection, Refraction, Standing Waves)
- Polarization of plane waves
- Propagation in an anisotropic medium

Chapter 2.Propagation of radio waves (3 Weeks)

-Spectrum of Hertzian waves
-Modes of propagation of radio waves(Isoil influence,troposphere,stratosphere,ionosphere)
-Atmospheric refraction(Telectrical theory, Ddefinition of a fictitious land)
-Propagation in inhomogeneous and random media (Statistics of incoherent waves, etc.)

Chapter 3. Reflection on the ground (3 Weeks)

- Reflection on the ground with and without obstacles
-Influence of ground irregularities
-Definition and criteria for a link in optical and radio visibility

Chapter 4. Study of bonds in free space (3 Weeks)

-Definition of gain and equivalent surface area of an antenna
-Free space attenuation: FRIIS equation
-Telecommunications equation for a link with and without passive relay
- Analog and digital connections, Simplex connections, Half-duplex
- Architecture and specifications of a radio system

Chapter 5. Space Radiocommunication (3 Weeks)

-Satellite-ground links and applications (Transmission and location, Ground stations, Artemis system between ground stations and satellites)
-Applications to some Telecommunications services (Fixed ground-to-ground links, fixed satellite service, communications with mobiles)

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. *P. Rosnet, "Elements of electromagnetic propagation: Fundamental physics", 2002.*
2. *G.Dubost, "Free and guided propagation of electromagnetic waves", Masson, 1995.*
3. *M. Jouquet, "Electromagnetic waves 1: free propagation", Dunod, 1973.*
4. *C. Garing, "Electromagnetic waves in dielectric media: Exercises and corrected problems", 1998.*
5. *C. Garing, "Electromagnetic waves in vacuum and conducting media: Exercises and corrected problems", 1998.*

Semester: 1
Teaching unit: UEF 1.1.2
Subject 4:FPGA programmable circuits

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.

Recommended prior knowledge:

Digital electronics (combinatorial and sequential)

Content of the subject:

Chapter 1.Programmable Logic Networks: PLD (3 Weeks)

- Introduction
- Structure of combinational logic networks
- Classification of combinational logic networks

Chapter 2. Lprogrammable element technologies (3 Weeks)

Chapter 3.FPGA Architecture (3 Weeks)

- Presentation of CP (Programmable Circuits type PLA, CPLD)
- Structure of FPGAs & ASICs
- General architecture
- Programmable logic blocks
- Terminologies
- Integrated memory blocks
- Examples of Altera and Xilinx constructors
- Applications

Chapter 4.VHDL Programming (3Weeks)

- Introduction
- Programming tools: Altera Quartus II, Modelsim, Xilinx ISE
- Structure of a program
- Structure of a simple VHDL description
- Entity
- Lthe different descriptions of an architecture (data flow type, behavioral or procedural, structural and test architecture)
- Process
- Control structures in VHDL
- Sequential and concurrent instructions
- Packages and Libraries

Chapter 5.Applications: Implementation of some logic circuits in FPGA circuits

- Multiplexer **(3Weeks)**
- Counter
- Comparator
- Shift register
- Simple filter

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. *Volnei A. Pedroni, "Circuit Design with VHDL", MIT press, 2004.*
2. *Jacques Weber,Sébastien Moutault,Maurice Meaudre,"VHDL language: from language to circuit, from circuit to language",DUNOD, 2007.*
3. *Christian Tavernier,"Programmable logic circuits", DUNOD 1992.*

Semester: 1
Teaching unit: UEM1.1
Subject 1:Advanced Digital Communications TP
VHS: 10:30 p.m. (TP: 1:30)

Credits: 2
Coefficient: 1

Teaching objectives:

This material describes a simulation of a digital communication chain carried out with Matlab and Simulink software: modulation of digital signals in baseband and on the carrier frequency, transmission of signals - noisy and band-limited transmission channel - reception and finally the implementation of new advanced communications concepts.

Recommended prior knowledge:

Signal processing, programming in MATLAB.

Content of the subject:

TP1: Blockset communication under simulink

- Signal terminology: frame or sample
- Source and sink libraries
- simulation of digital communication chains by simulink

TP2: Study of the performance of digital modulation techniques

- Performance of a coherent digital communication system with BASK, BPSK and BFSK modulation
- Performance of a non-coherent digital communication system with BDPSK modulation
- Performance of a coherent digital communication system with QAM modulation

TP3: Simulation of an OFDM and CDMA transmission by simulink

- Theoretical reminder of OFDM and CDMA transmission
- Detailed study of the blocks of the simulated OFDMA system
- Examples of multipath channels

TP4: Simulation of a MIMO transmission chain

Assessment method:

Continuous assessment: 100%

Bibliographic references:

1. *G. Baudouin, "Digital Radiocommunications", Dunod, 2002.*
2. *JM Brossier, "Signal and digital communication: equalization and synchronization", Hermès Science, 97*
3. *P. Comon, "Digital Communications - Courses and exercises for engineering students", Harmattan editions, 2010.*
4. *A. Glavieux, M. Joindot, "Digital Communications, Introduction",Educational collection of telecommunications,Masson,1996.*
5. *A. Glavieux, M. Joindot, "Introduction to digital communications", Collection: Sciences Sup, Dunod, 2007.*
6. *HP Hsu, "Analog and Digital Communications: Courses and Issues", McGraw-Hill, 1994.*
7. *G. Mahé, ""Digital Communications Systems", Ellipses.*
8. *LW Couch, "Digital and Analog Communication Systems", Prentice-Hall, New Jersey, 2007.*
9. *S. Haykin, "Communication Systems", John Wiley and Sons, Hoboken, New Jersey, 2001.*
10. *J. Proakis, M. Salehi, "Communication Systems Engineering", 2nd edition, Prentice-Hall, New Jersey, 2002.*
11. *B. Rimoldi, "Principles of Digital Communications", Ecole Polytechnique de Lausanne (EPFL), Switzerland.*
12. *J. Proakis, "Digital Communications",McGraw-Hill, 2000.*
13. *B. Sklar, "Digital Communications, Fundamentals and applications", Prentice Hall, 2001.*
14. BP Lathi, "Modern Digital and Analog Communication Systems", Oxford University Press, 1998.

Semester: 1
Teaching unit: UEM1.1
Subject 2:TPRandom signals andStochastic processes
VHS: 10:30 p.m. (TP: 1:30)
Credits: 2
Coefficient: 1

Teaching objectives:

Practical work carried out using MATLAB to give a practical aspect to complex theoretical concepts.

Recommended prior knowledge:

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

Content of the subject:

TP 1: Ssimulation of random variables (Different laws).
TP 2: Calculation of power spectral density.
TP 3: Calculation of the autocorrelation and intercorrelation function.
TP4: Filtering random signals.
TP 5: Spectral analysis of random signals.

Assessment method:

Continuous assessment: 100%

Bibliographic references:

1.S. Haykin, "Signals and systems", John Wiley & sons, 2ed, 2003.
2. AV Oppenheim, "Signals and systems", Prentice-Hall, 2004.
3. Mori Yvon, "Random signals and stochastic processes", Lavoisier,2014
4. A. Papoulis,"Probability, Random variable and Stochastic Processes", Mc Graw Hill 1984.
5. E. Robine,"Introduction to Communication Theory, Volume II: Random Signals", Masson 1970.
6. N. Hermann,"Engineering Probabilities: Random Variables and Simulations Birch", 2002.
7.Ruegg, Alan,"Stochastic process", Lausanne: Polytechnic and University Presses of Romandie, 1989.

Semester: 1
Teaching unit: UEM1.1
Subject 3:TPFPGA programmable circuits
VHS: 10:30 p.m. (TP: 1:30)
Credits: 2
Coefficient: 1

Teaching objectives:

This subject allows the student to design an electronic system using the VHDL description language and to test each design on the FPGA.

Recommended prior knowledge:
Digital electronics

Content of the subject:
TP1: Introduction to the VHDL language. Presentation of the development tool: development board and simulation software.
TP2: Operation of the VHDL simulator.
TP3: Development of a first example of a circuit: decimal counter.
TP4: Development of a second circuit example: multiplexer.
TP5: Development of a third circuit example: shift register.
TP6: Implementation of an FPGA.

Assessment method:
Controlcontinuous: 100%

Bibliographic references:

1. *Volnei A. Pedroni, "Circuit Design with VHDL", MIT press, 2004.*
2. *Jacques Weber,Sébastien Moutault,Maurice Meaudre,"VHDL language: from language to circuit, from circuit to language",DUNOD, 2007.*
3. *Christian Tavernier,"Programmable logic circuits", DUNOD 1992.*

Semester: 1
Teaching unit: UEM 1.1
Subject 4:Object-oriented programming in Python
VHS: 37h30 (Lecture: 1h30, Practical work: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

The student will have to learn from this subject the basic foundations of object-oriented programming as well as mastery of advanced program design techniques in Python language.

Recommended prior knowledge:

- Notions on programming (Pasacal/Matlab language);
- Computer Science 1, Computer Science 2, Computer Science 3.

Content of the subject:

Chapter 1. Introduction to Object-Oriented Programming (OOP) (2 Weeks)
Principle of OOP, Encapsulation and abstraction, Introduction to the Python language, Python libraries, Running programs in Python, Development environment (IDLE, PyCharm, Jupiter, Spyder).

Chapter 2. Basic Concepts (3 Weeks)
Python Object Types, Operators, Lists, Dictionaries, Tuples, Sets, Strings, Execution Flow Control, Repeating Statements, Numpy Arrays, Recursion, Modules, Creating Modules, Functions, Python Packages.

Chapter 3. Classes and Objects (3 Weeks)
Class Declaration, Instance Variables and Methods, Method Definition,Access Rights, Encapsulation of Attributes and Methods, Constructor, Destructor, Interacting Objects, Equality and Cloning of Objects in Python, Sending Messages, Association of Classes, Dependency of Classes, Friend Classes,Nested classes.

Chapter 4. Inheritance and Polymorphism (3 Weeks)
Object aggregation and composition, Inheritance, Inheritance rules, Constructor chaining, Base classes, Protected attributes and methods, Multi-inheritance, Method and attribute overloading, Polymorphism, Method overriding, Virtual methods, Abstract classes.

Chapter 5.Advanced concepts: Design patterns (2 Weeks)
Function Objects, Design Patterns, Creation Patterns, Structural Patterns (Composites, Decorators), Function Decorators, Class Decorators.

Chapter 6. Containers, Iterators, and Object Collections (2 Weeks)
Containers, Iterators, Function Generators, Coroutines, Collections (Queues, Stacks, Filters, Map, Reduce).

TPObject-oriented programming in Python

- TP1: Introduction to and familiarization with the Python language (Modules: NumPy, matplotlib, Pandas, CSV files, etc.)
- TP2:Python Programming (Loops, Control Statements, Functions)
- TP3:Classes and objects
- TP4:Inheritance and polymorphism
- TP5:Design patterns and decorators
- TP6: Containers, Iterators, Standard Library Modules (Itertool, Pickle, Socket, Urllib2, ftplib, etc.)

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. Anaconda:Anaconda Environments (AEN 4.0) — Anaconda documentation
2. T. Ziadé., 2009. Python programming design and optimization, Edition Eyrolles.PYTHON Programming (zenk-security.com)
3. J.Chan, 2014. Learn python in one day and learn it well, Edition Eyrolles.
4. J. Hunt, 2020. A beginners guide for python 3 programming, Edition Springer

5. H. Bersini, 2013. Object-oriented programming course and exercises, Edition Eyrolles.Object-Oriented Programming: Courses and Exercises in UML2, Python, PHP, C#, C++ and Java (including Android) (Noire) (French Edition) (livre21.com)
6. M. Lutz., 2009. Learning python: Powerful object-oriented programming,Learning Python (ehu.es)
7. D. Phillips, 2015. Python 3 object oriented programming, 2nd edition, PACKT publishing,book.pdf
8. V. Boucheny, 2020. Learn object-oriented programming with the Python language, 2nd edition, Eyrolles.
9. HP Langtangen, 2014. A primer on scientific programming with python, 4th edition, Springer.

G. Swinnen, 2012. Learn to program with Python3,learn_python3_5.pdf (inforef.be)

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 non-native speakers of English, McGraw-Hill 1991.*
7. *J. Orasanu, Reading Comprehension from Research to Practice, Erlbaum Associates 1986.*

Suggestion of some discovery subjects (S1)

Semester: 1
Teaching unit: UED1.1
Subject 1:Standards and Protocols
VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

Introduce the student to the most common communications protocols. Teach the student how tosspecify the protocolsand standards. Ddistinguish between networks and protocols related to each layer (level) of the OSI and TCP/IP models, acquire good knowledge of the concepts related to the different types of networks and protocols.

Recommended prior knowledge:

Information theory, the elements of a network.

Content of the subject:

Chapter 1. Basic Concepts (2Weeks)

Telecommunications standardization institutions (ITU, IEC, OSI, IEEE, etc.).History and evolution.Standards, recommendations, norms and protocols (definitions and differences). Role of a protocol.

Chapter 2. Standards associated with analog and digital broadcasting (2 weeks)

Analog audio and video standards (CCIR and NTSC, etc.), Digital audio and video standards (DVB, ATSC, ISDB, NICAM, etc.).

Chapter 3. Standards associated with digital communication networks (4 weeks)

Classifications of communication networks. Networks and standardization.History and evolution of networks. RIntegrated Services Digital Network, Reminders on the OSI and TCP/IP models.The different frame and packet level protocols. The different segment and message level protocols.ADSL protocols.

Chapter 4. Wireless and Mobile Network Protocols (4 Weeks)

802.11 protocols. 802.15 protocols. 802.16 protocols. GSM protocols. 3G (UMTS) protocols. 4G (LTE) protocols. 5G technologies and protocols.

Chapter 5. Internet Protocols (3 Weeks)

Internet (History and Evolution). Classification of Internet Protocols. Email Service Protocols (SMTP, POP, IMAP). Information Service Protocols (http, ftp, application protocols).

Assessment method:

Exam: 100%.

Bibliographic references:

1. Michel Kadoch,"Protocols and Local Networks", Presses de l'université du Québec, 2012.
2.José Dordoigne,"Local and Wide Area Networks: Fundamental Concepts", ENI Editions, 2005.
3. Guy Pujolle,"Networks", Eyrolles, 2008.
4. Claude Rigault,""IP-based telecom networks and their interconnections", Hermes-Lavoisier, 2015.

Semester: 1
Teaching unit: UED1.1
Subject 2:Electromagnetic compatibility
VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

This subject will introduce students to low-frequency and high-frequency disturbances, as well as mechanisms in electronic circuits (EMC). The theoretical foundations of electromagnetic compatibility (EMC) with descriptions of the main electromagnetic interactions are described.

Recommended prior knowledge:

The basics of electrostatics and electromagnetism.

Content of the subject:

Chapter 1. Electrostatic and Magnetostatic Phenomena (3 Weeks)

Origin of electrostatic and magnetostatic phenomena, Problems of ECM disturbances in BF and HF, Electrostatic field lines, Characteristics of the electrostatic and electromagnetic field, Application in the case of electromagnetic compatibility.

Chapter 2. Method of calculating electromagnetic interactions (3 Weeks)

Concept of graph representation by the Kron Method, Impedance Matrix, Source Vector and Connectivity, Resolution of the system of equations, General principle of guided waves, Potential and Poynting vector.

Chapter 3. Penetration into cable shields (3Weeks)

Treatment of shielded enclosures, Noise sources in electronic circuits, Evolution of technologies, Consequences on EMC, EMC modeling and components, E, H radiation.**Chapter 4. EMF Investigation Techniques (3 Weeks)**

Electrostatic and magnetic discharge immunity tests, Conducted disturbance immunity tests, Radiated disturbance immunity tests.

Chapter 5. EMF Protection Techniques (3 Weeks)

Protection of components and shields, Filtering, Surge protection.

Assessment method:

Exam: 100%.

Bibliographic references:

1. *D.Cheng ''Field and Wave Electromagnetics, Pearson Education, New York, 2006.*
2. *D.Pozar 'Microwave engineering, Addisson Wesley publishing Company New York, 1995.*
3. *M. Mardiguian, "Practical Manual of Electromagnetic Compatibility", Lavoisier.*

II - Detailed program by subject for semester S2

Semester: 2
Teaching unit: UEF 1.2.1
Subject 1:Digital signal processing
VHS: 67h30 (Lecture: 3h00, Tutorial: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:
This subject covers the fundamentals of digital signal processing. It mainly covers the various digital signal filtering techniques and some of their applications.

Recommended prior knowledge:
Mathematics, signal theory and signal processing.

Content of the material:

Chapter 1.Discrete Fourier Transform (2 Weeks)
- Reminders on sampling and quantification operations
- TFTD (Discrete Time Fourier Transform)
- Definition and properties of the DFT (Discrete Fourier Transform)
- Fast Fourier Transform (FFT)

Chapter 2.Digital filters (3 Weeks)
- Discrete linear and invariant systems
- Definition and properties
- Discrete convolution
- Finite difference equation
- Z-transformation - Properties and convergence conditions
- Structures, transfer functions in z, notions of poles and zeros, stability and implementation of digital filters (RIF and RII)
- RIF vs RII

Chapter 3. Synthesis of digital RIF filters (2 Weeks)
- Linear phase RIF filters (all four cases)
- Synthesis by the window method
- Synthesis by the frequency sampling method
- Iterative synthesis and Remez algorithm
- Comparison

Chapter 4. Summary of IIR digital filters (3 Weeks)
- Reminders on analog filters of the Butterworth, Bessel, Chebychev I and II, Elliptic type. Normalization and denormalization of frequencies.
- RII synthesis by transformation methods, particularly bilinear
- Effects of quantization noise
- Examples of IIR filter structures
- Digital minimum phase filter (filter and its inverse are stable)
- Advantages and disadvantages

Chapter 5. 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. Discrete Wavelet Transform (DWT) (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. M. Kunt, ''Digital Signal Processing'', Dunod, Paris, 1981.
2.J. M Brossier, ''Signal and Digital Communications'', Signal Processing Collection, Hermès, Paris, 1997.
3.G. Blanchet and M. Charbit, ''Signals and Images under Matlab: Methods, Applications and Corrected Exercises'', Hermès, Paris, 2001.
4. M. Bellanger, ''Digital Signal Processing: Theory and Practice'', 8th edition, Dunod, 2006.
5.MessaoudBenidir,''Basic methods for signal analysis and processing'',Dunod 2004.
6. Yvon Mori,''Digital filtering''. Vol. IV, Hermès-Lavoisier. 2006
7. Yvon Mori,''Digital Filtering in Signal Processing - Exercises and Practical Work''. Hermès-Lavoisier.

Semester: 2
Teaching unit: UEF 1.2.1
Subject 2:Antennas

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

Teaching objectives:

This subject aims at the detailed calculation of the radiation of the electric doublet and antennas. In this subject, uniform and non-uniform antenna arrays as well as antenna curtains, radiating apertures (rectangular and circular) and planar antennas are also studied.

Recommended prior knowledge:

Knowledge of electromagnetic radiation is required to pursue this course. This knowledge is provided in the "Antennas and Transmission Lines" subject of the third year of the Telecommunications degree.

Content of the material:

Chapter 1. Generality and characteristic parameters of antennas (3 Weeks)

- Reminders on the pcharacteristic parameters of an antenna (E and H planes, tuning wavelength, polarization, radiation patterns, effective height, radiated power, radiation resistance, antenna impedance, gain, directivity, received power, effective area).
- Notion of pvector potential and scalar potential.
- Radiation of the electric doublet(ccalculation of the electromagnetic field in the far zone, ssurface characteristic, pradiated power, hequivalent author, rradiation resistance, radiation pattern).

Chapter 2. Wire Antennas (3 Weeks)

- HASrectilinear antenna isolated in space (Characteristic function, radiation pattern).
- Antenna fed in its center.
- Vertical antenna above the ground.
- Traveling wave wire antennas (Horizontal antenna, V-shaped antenna, Diamond antenna).

Chapter 3. Antenna Arrays (3 Weeks)

- Antenna arrays, Type of antenna arrays (Longitudinal and transverse radiation).
- Uniform network.
- Non-uniform network (Dolph-Chebyshev weighting).
- Other methods of synthesizing antenna networks (Shelkunof method, Fourier transform method, etc.).
- Curtain of antennas.

Chapter 4. Radiation from Planar Apertures (3 Weeks)

- General study of the radiation of an opening (Pprinciple of Huygens – Fresnel, relations of Green and Kottler).
- Radiation from a rectangular opening.
- Radiation from a circular aperture.

Chapter 5. Planar Antennas (3Weeks)

- Patch antennas, application of Wheeler relations, patch antenna networks, adaptation and radiation of planar antennas.

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. F. Gardiol, "Electromagnetism: Treatise on Electricity", Edition Lausanne.
2. P. Combes, "Microwaves, passive circuits, propagation, antennas, Courses and exercises", Dunod, 1997.
2. R.-C. Houzé, "Antennas, Fundamentals", Dunod, 2006.
3. A. Ducros, "Antennas: Theory and Practice", Transmission and Reception, Elektor, 2008.
4. WL Stutzman, GA Thiele, "Antenna Theory and Design", John Wiley.
5. C. Balanis, "Antenna Theory: Analysis and Design", 3rd Edition, John Wiley & Sons Inc, 2005.
6. R. Aksas, "Telecommunications: Antennas Theory and Applications", Ellipses Marketing, 2013.
7. O. Picon et al, "Antennas: Theory, design and applications", Dunod, 2009.

Semester: 2
Teaching unit: UEF 1.2.2
Subject 3:Transmission lines and waveguides
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:
This subject focuses on the principle of wave propagation in transmission lines and waveguides as well as their adaptations.

Recommended prior knowledge:
Knowledge of electromagnetic radiation is required to follow this subject. This knowledge is provided in the subjects "Transmission Media" and "Antennas and Transmission Lines" of the third year of the Telecommunications degree.

Content of the material:

Chapter 1. Introduction to Transmission Lines (4 Weeks)

-Fundamental equation of a line in sinusoidal mode (diagram of a line, equations of a line,line impedance, telegraphers' equations).
-Progressive waves, Standing waves, Group velocity, Phase velocity,reflection coefficient, standing wave ratio TOS-VSWR.
- Power transmission.
- Transient phenomena on transmission lines (study in pulse mode, study in voltage step mode, superposition diagrams, applications: Matched and unmatched generator - with resistive load, ccapacitive load, inductive load).

Chapter 2.Impedance matching in transmission lines (4 Weeks)

- Impedance transformer matching under line section, by quarter-wave line, using LC reactive circuits, using one stub, two stubs, three stubs, broadband matching, etc.
- Smith chart(foundations, construction and description of the abacus).
- Determination of the reflection coefficient, the standing wave ratio and resolution of impedance matching problems in a line using the Smith chart.
- Use of the abacus in admittance.

Chapter 3. Waveguides (4 Weeks)

- Rectangular waveguides: TM and TE modes, dispersion equation, propagation constant, cut-off frequency, impedance, etc.
-Rectangular electromagnetic cavities.
- Cylindrical waveguides: TM and TE modes, dispersion equation, propagation constant, cut-off frequency, Impedance, etc.
- Cylindrical electromagnetic cavities.

Chapter 4. Other types of lines and planar structures **(3 Weeks)**

- Wired lines (two-wire line, coaxial line,twisted).
- Planar strip lines (lMicro ribbon line, strip line, suspended substrate line)and slotted (lslotted line, coplanar line, finned line).

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

Bibliographic references:

1. F. Gardiol, "Electromagnetism: Treatise on Electricity", Edition Lausanne.
2. P. Combes, "Microwaves, passive circuits, propagation, antennas, Courses and exercises", Dunod, 1997.
3. G. DUBOST,"Free and guided propagation of electromagnetic waves / Radiation - Exercises with solutions and course reminders".
4. J. Quinet,"Theory and practice of electronic circuits and amplifiers, Propagation of HF current along lines; Smith chart - Antenna. Maxwell's equations and applications".

Semester: 2
Teaching unit: UEF 1.2.2
Subject 4:Coding and Compression
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

To familiarize the student with data coding and compression techniques such as channel coding, source coding, and image compression. From this subject, the student will have to learn the basic foundations for evaluating the advantages and disadvantages of different compression techniques as well as the criteria for choosing a data compression technique.

Recommended prior knowledge:

Probability and statistics, information theory, signal processing.

Content of the material:

Chapter 1. Fundamentals of Source Coding and Channel Coding(3 Weeks)

- Reminder of the fundamental results of information theory

- Sources and source coding
- Definition, difference and interest of source coding

- Properties of a code
- Kraft-McMillan inequality
- Shannon's First Theorem

- Channel and channel coding
- Concepts on joint coding

Chapter 2. Entropic Codings (4 Weeks)

- Reminders on information theory.
- Entropy and measurement of information
- Huffman coding - the adaptive versions of Huffman and Shannon-Fano
- Arithmetic coding
- LZW coding
- Evaluation criteria (calculation of entropy, average length, redundancy and efficiency for each method)

- Application on images.

Chapter 3: Channel Coding (4 Weeks)

- Main concepts and definitions
- General communication diagram and transmission channel
- Type of channels
- Efficiency, redundancy and channel capacity
- Channel coding and Shannon's second theorem. Channel coding strategies
- Error-correcting coding (Hamming codes, linear codes, cyclic codes, Reed-Solomon codes, etc.)

- Convolutional codes: State diagram, Coding lattice, Decoding (Viterbi algorithm).

- Turbo codes and LDPC code
- Performance of an encoder
- Application examples

Chapter 4. Lossy Compression Methods (4 Weeks)

- General concepts and definition.
- General diagram of compression methods based on transformations
- Evaluation criteria (MSE, PSNR, CR, SSIM, etc.)
- Description of the different parts (Transformation, Quantification and entropic coding)
- Effects of transformation on the compression method
- Effects of quantization and different types of quantization
- Image compression standards and standards bodies

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1.M. Cover and JA Thomas, "Elements of information theory", 2nd edition, Wiley Series in telecommunications and signal processing, 2006.
2. M. Barlaud, C. Labit, "Compression and coding of images and videos", treatise Collection IC2, Ed. Hermés, 319p, 2002.
3.K. Sayood, "Introduction to Data Compression, Third Edition", Elsevier Inc. 2006.
4. Olivier Rioul, "Information and Coding Theory", Lavoisier Publishing, 2007.
5. N. Moreau, "Tools for signal compression: applications to audio signals", Collection
6. Telecom, Lavoisier Edition, October 2009.
7. JC, Moreira, PG, Farrell, "Essentials of Error-Control Coding", John Wiley and Sons, Ltd, 2006.
8. C. Berrou, "Codes and turbocodes", Springer-verlag France, 2007.

Semester: 2

Teaching unit: UEM1.2
Subject 1:TPDigital signal processing
VHS: 10:30 p.m. (TP: 1:30)
Credits: 2
Coefficient: 1

Teaching objectives:
Upon completion of this course, students will be able to manipulate digital signals through implementation, programming, and analysis. Students will be taught common digital processing techniques such as digital filtering and data denoising.

Recommended prior knowledge:
Mathematics, signal theory and signal processing.

Content of the material:

TP1: Comparison between TFD and FFT (calculation time depending on the number of points, restitution errors, etc.)

TP2: Analysis, Synthesis (window method) and implementation of a digital RIF filter

TP3: Analysis, Synthesis by bilinear transformation (case of Butterworth and Tchebychev filters) and implementation of a digital RII filter

TP4: Application of digital filtering to an audio signal

TP5: Implementation of a digital filter bank (application to a speech signal)

TP6: Denoising a signal using discrete wavelet transform

Assessment method:
Controlcontinuous: 100%

Bibliographic references:
1. M. Kunt, ''Digital Signal Processing'', Dunod, Paris, 1981.
2. J. M Brossier, ''Signal and Digital Communications'', Signal Processing Collection, Hermès, Paris, 1997.
3. G. Blanchet and M. Charbit, ''Signals and Images under Matlab: Methods, Applications and Corrected Exercises'', Hermès, Paris, 2001.
4. M. Bellanger, ''Digital Signal Processing: Theory and Practice'', 8th edition, Dunod, 2006.
5. MessaoudBenidir,''Basic methods for signal analysis and processing'',Dunod 2004.
6. Yvon Mori,''Digital filtering''. Vol. IV, Hermès-Lavoisier. 2006
7. Yvon Mori,''Digital Filtering in Signal Processing - Exercises and Practical Work''. Hermès-Lavoisier.

Semester: 2
Teaching unit: UEM1.2

Subject 2:TPAntennas,Transmission lines and waveguides
VHS: 10:30 p.m. (TP: 1:30)
Credits: 2
Coefficient: 1

Teaching objectives:
In this subject, the student will learn to use software dedicated tomicrowaves for the simulation of radiating structures. As for the practical side, it will be devoted to antenna measurements andguided propagation (transmission channels).

Recommended prior knowledge:
Knowledge of electromagnetic radiation is required to follow this subject. This knowledge is provided in the subjects "Transmission Media" and "Antennas and Transmission Lines" of the third year of the Telecommunications degree.

Content of the material:

TP 1: Simulation of different antenna structures using microwave CAD software (CST,Momentum, HFSS ...).

TP 2: Antenna measurement (Cornet -Helical Antenna - Slotted Antenna - Parabolic Antenna)

TP 3: Calculation of secondary parameters of a transmission line (case of coaxial cable).

TP 4: Lines in impulse mode.

TP 5: Measurement on a waveguide transmission chain.

- Measurement of guided wavelength, reflection coefficient and SWR
- Measurement of an unknown impedance
- Measurement and evaluation of the dielectric constant

Assessment method:
Controlcontinuous: 100%

Bibliographic references:
1. F. Gardiol, "Electromagnetism: Treatise on Electricity", Edition Lausanne.
2. P. Combes, "Microwaves, passive circuits, propagation, antennas, Courses and exercises", Dunod, 1997.
2. R.-C. Houzé, "Antennas, Fundamentals", Dunod, 2006.
3. A. Ducros, "Antennas: Theory and Practice", Transmission and Reception, Elektor, 2008.
4. WL Stutzman, GA Thiele, "Antenna Theory and Design", John Wiley.
5. C. Balanis, "Antenna Theory: Analysis and Design", 3rd Edition, John Wiley & Sons Inc, 2005.
6. R. Aksas, "Telecommunications: Antennas Theory and Applications", Ellipses Marketing, 2013.
7. O. Picon et al, "Antennas: Theory, design and applications", Dunod, 2009.
8. G. Dubost,"Free and guided propagation of electromagnetic waves / Radiation - Exercises with solutions and course reminders".
9. J. Quinet,"Theory and practice of electronic circuits and amplifiers, Propagation of HF current along lines; Smith chart - Antenna. Maxwell's equations and applications".

Semester: 2
Teaching unit: UEM1.2
Subject 3:Coding and compression practical work
VHS: 10:30 p.m. (TP: 1:30)
Credits: 2
Coefficient: 1

Teaching objectives:

To familiarize the student with data coding and compression techniques such as channel coding, source coding and image compression.

Recommended prior knowledge:

Probability and statistics, information theory, signal processing.

TP1: Study and simulation of codingby Shannon Fano andof Huffman.(Calculation of entropy, mean length and efficiency; determination of the alphabet, probabilities and frequencies)
Application to image compression.

TP2: Study and simulation of Shannon Fano codingarithmetic

TP3:Study and simulation of LZW coding

TP4: Study and simulation of channel coding (block code and convolutional coding)

TP5: Modeling a chain with source coding and channel coding on a binary then Gaussian channel.

TP6: Example of implementation of the fast DCT with low arithmetic complexity.

Assessment method:

Controlcontinuous: 100%

Bibliographic references:

1.M. Cover and JA Thomas, "Elements of information theory", 2nd edition, Wiley Series in telecommunications and signal processing, 2006.
2. M. Barlaud, C. Labit, "Compression and coding of images and videos", treatise Collection IC2, Ed. Hermés, 319p, 2002.
3.K. Sayood, "Introduction to Data Compression, Third Edition", Elsevier Inc. 2006.
4. Olivier Rioul, "Information and Coding Theory", Lavoisier Publishing, 2007.
5. N. Moreau, "Tools for signal compression: applications to audio signals", Collection
6. Telecom, Lavoisier Edition, October 2009.
7. JC, Moreira, PG, Farrell, "Essentials of Error-Control Coding", John Wiley and Sons, Ltd, 2006.
8. C. Berrou, "Codes and turbocodes", Springer-verlag France, 2007.

Semester: 2
Teaching unit: UEM1.2
Subject 4:Image processing
VHS: 37h30 (Lecture: 1h30, Practical work: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

Understand the concepts of image capture and digitization. Understand the different parameters and formats of digital images. Master the basic foundations of image analysis. Learn to use preliminary tools in low-level digital image processing with an introduction to high-level processing.

Recommended prior knowledge:

Signal processing.

Content of the material:

Chapter 1. Color Perception (2 Weeks)

- Colorimetry. Light and color in human perception
- Color representation systems: RGB, XYZ, YUV, HSV, YIQ
- Color formats and color image processing strategies

Chapter 2.Image sensors and digital acquisition devices (2 Weeks)

- Schematic diagram of an image processing chain.
- Principle of CCD and CMOS sensors
- Color sensor specifications
-Scanning an image
- Concepts of definition, resolution and quantification of a digital image (size, dpi, ppi, bpp, etc.)
- Examples of digital image formats (BMP, TIFF, JPG, GIF and PNG)

Chapter 3.Basic image processing (3 Weeks)

- Concept of histogram and contrast
- Correction of image dynamics by affine transformations on the histogram
- Histogram equalization and gamma correction
- Logical and arithmetic operations on images

Chapter 4.Digital filtering of images (2 Weeks)

- Spatial filtering and C2D onvolution: notion of mask (averaging, Gaussian, binomial, etc.)
- Linear then non-linear smoothing of the image (median, etc.)
- Frequency filtering: (2D FFT and separability property, low-pass filter, high-pass filter, etc.)

Chapter 5. Edge Detection (3 Weeks)

- Objectives and generalities
- Types of outlines
- 1st derivatives: convolution mask (Gradient operators: Roberts mask, Prewitt, Sobel, etc.)
- 2nd derivatives of an image (Laplacian operators,Marr-Hildreth filter)
- Laplacian operators vs. gradient operators (noise sensitivity, localization, etc.)
- Optimal filter (optimality criteria, Canny and Derriche, etc.)

Chapter 6. Segmentation and Classification(3 Weeks)

- Principle and different segmentation approaches (by thresholding, by regions, classification approach, etc.)
-Image thresholding: global thresholding, local thresholding, valley detection thresholding, dynamic thresholding, variance minimization thresholding, Bayesian classification methods, etc.
- Morphological operations (dilation, erosion, opening, closing, etc.)
- Extraction of parameters and classification of objects (Euclidean distance, Kppv, etc.)

TP Image Processing

TP1: Matlab Toolbox for image and video processing

- Representation of digital images in Matlab
- Color and palette treatments
- Image and video sequences (multi frame array)

TP2: Digital image processing using MATLAB

- Handling images: reading, writing, display
- Point transformations on the image
- Processing on the histogram
- Geometric transformations on the image

TP3: Frequency processing of images in Matlab

- FFT2D and linear filtering
- Noise models: image denoising
- Generation of filters from spatial filters or directly in the spectral domain

TP4: Contour detection and segmentation

TP5: Binarization of images and morphological operations

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. Stéphane Bres, Jean-Michel Jolion, Frank Lebourgeois, "Processing and analysis of digital images". Hermès-Lavoisier. 2003.

2. Richard Berry, James Burnell,''The Handbook of astronomical Image processing''. 2nd Edition. 2006.

3. Rafael C. Gonzalez & Richard E Woods, "Digital Image Processing", Prentice Hall, 2008.

4. Radu Horaud and Olivier, "Computer Vision". Editions Hermès, 1995 – 2nd edition.

5. JP Cocquerez andSylvie Philipp, **''Image Analysis: Filtering and Segmentation''. Elsevier-Masson.**

6. Diane Lingrand, "Introduction to Image Processing". Vuibert 2008.

7.Gilles Burel, "Introduction to image processing. Simulation in Matlab".*Hermès - Lavoisier. 2001.*

Semester: 2

Teaching unit: UED 1.2
Matter: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
Matter :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: Respect forstandards 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. Charter of University Ethics and Professional Conduct,https://www.mesrs.dz/documents/12221/26200/Charte+fran__ais+d__f.pdf/50d6de61-aabd-4829-84b3-8302b790bdce
2. Order No. 933 of July 28, 2016 establishing the rules relating to the prevention and fight against plagiarism
3. The ABCs of Copyright, United Nations Educational, Scientific and Cultural Organization (UNESCO)
4. E. Prairat, On teaching ethics. Paris, PUF, 2009.
5. Racine L., Legault GA, Bégin, L., Ethics and engineering, Montreal, McGraw Hill, 1991.
6. Siroux, D., Deontology: Dictionary of Ethics and Moral Philosophy, Paris, Quadrige, 2004, pp. 474-477.
7. Medina Y., Ethics, what will change in the company, Editions d'Organisation, 2003.
8. Didier Ch., Thinking about the ethics of engineers, Presses Universitaires de France, 2008.
9. Gavarini L. and Ottavi D., Editorial. of professional ethics in training and research, Research and training, 52 | 2006, 5-11.
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11. Jacquet-Francillon, François. Concept: professional ethics. Le télémaque, May 2000, no. 17
12. Carr, D. Professionalism and Ethics in Teaching. New York, NY Routledge. 2000.
13. Galloux, JC, Industrial Property Law. Dalloz 2003.
14. Wagret F. and JM., Patents, trademarks and industrial property. PUF 2001
15. Dekermadec, Y., Innovating through patents: a revolution with the internet. Insep 1999
16. AEUTBM. The engineer at the heart of innovation. Belfort-Montbéliard University of Technology
17. Fanny Rinck and Leda Mansour, Literacy in the Digital Age: Copy and Paste Among Students, Grenoble 3 University and Paris-Ouest Nanterre La Défense University, Nanterre, France
18. Didier DUGUEST IEMN, Citing your sources, IAE Nantes 2008
19. Similarity Detection Software: A Solution to Electronic Plagiarism? Report of the Working Group on Electronic Plagiarism Presented to the CREPUQ Subcommittee on Pedagogy and ICT
20. Emanuela Chiriac, Monique Filiatrault and André Régimbald, Student Guide: Intellectual Integrity, Plagiarism, Cheating and Fraud... Avoiding Them and, Above All, How to Properly Cite Your Sources, 2014.
21. Publication of the University of Montreal, Strategies for preventing plagiarism, Integrity, fraud and plagiarism, 2010.
22. Pierrick Malissard, Intellectual Property: Origin and Evolution, 2010.

23. The World Intellectual Property Organization websitewww.wipo.int
24. http://www.app.asso.fr/

Suggestion of some discovery subjects (S2)

Semester: 2
Teaching unit: UED1.2
Subject 1:Embedded Systems and Telecommunications
VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

This subject aims at basic knowledge on a field which brings together two autonomous systems: a systemelectronics and computing known as embedded systems.It will also allow students to understand the different stages of designing an embedded system.

Recommended prior knowledge:

Microprocessor.

Content of the subject:

Chapter 1. Introduction to Embedded Systems (3Weeks)

- Features
- History
- Specificities of an embedded system
- Hardware and software aspects
- Functional description and architecture of embedded systems
- Examples of embedded systems

Chapter 2. Embedded and Real-Time Systems (4Weeks)

- Introduction
- Memory management
- Competition management
- Linux for embedded
- Presentation of embedded real-time systems
- Structure and operationembedded real-time systems

Chapter 3. Embedded processor architecture (4Weeks)

- Main architectural concepts
- Soperating systems for embedded systems
- Special purpose processors and general purpose processors
- Pipeline operation
- Memory hierarchy
- Peripherals and interfaces
- Communication mechanisms and associated protocols
- Example of architecture

Chapter 4. Embedded systems design methodology (3Weeks)

- Design environments
- Life cycle and stages of development of an embedded system
- Control and regulation systems
- Design examples

Chapter 5. Security of Embedded Systems (1Week)

- Hardware and software vulnerabilities
- Communications security

Assessment method:

Exam: 100%.

Bibliographic references:

1. K. Yaghmour, "Building Embedded Linux systems",O'Reilly Media, 2003.
2. Pierre Ficheux, "Embedded Linux", Eyrolles .3rd Edition. 2010.
*3. R. Zurawski, "Embedded systems handbook",*Taylor & Francis Group, LLC*. 2006*
4. D. Paret, "Multiplexed networks for embedded systems", Dunod, 2012.

Semester: 2
Teaching unit: UED1.2
Subject 2:Radar Techniques
VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

The objective of this subject is to offer students advanced notions on: decision and detection theory, Information Processing. These notions will allow students to master the detection techniques relating to the different types of Radar, but also to be able to understand the problems of future remote sensing equipment.

Recommended prior knowledge:

Signal processing.

Content of the subject:

Chapter 1. Reminder on random processes (2Weeks)

- Continuous-time random processes, Discrete-time random processes
- Statistical measures
- Stationarity in the broad sense
- Gaussian process
- Power spectral density
- Statistical signals

Chapter 2. Decision Theory and Estimation (3 weeks)

- Bayes criterion
- Binary hypothesis tests
- Minimax criterion, Neyman-Pearson criterion

- Likelihood estimation
- Cramer-Rao inequality
- Unbiased linear estimation

Chapter 3. Radar Principle (2Weeks)

- Introduction
- Basic concepts
- Target Models
- Doppler Shift

Chapter 4. Target Modeling (3 Weeks)

- Clutter Modeling, Jamming, Target
- Clutter Modeling
- Definition of SER
- Stealth technique

Chapter 5. Constant False Alarm Rate Detection CFAR (3Weeks)

- Principles of adaptive detection
- Target Models
- Types of CFAR detectors

- Distributed CA-CFAR Detection

Chapter 6. Distributed CFAR Detection (2Weeks)

- Distributed CA-CFAR detection
- Merge configurations
- Merger rules

Assessment method:

Exam: 100%.

Bibliographic references:

1. *Tsakalides, P., Trinci, P. and Nikias, CL,"Performance Assessment Of CFAR Processors In Pearson-Distributed Clutter", IEEE Transactions on Aerospace and Electronic Systems, vol. AES-36, No. 4, October. 2000, pp. 1377-1386.*
2. *Tourneret, J.,"Detection And Estimation Of Abrupt Changes Contemned By Multiplicative Gaussian Noise", Signal Processing, 68, pp. 259-270, 1998.*

III - Detailed program by subject for semester S3

Semester: 3
Teaching unit: UEF 2.1.1
Subject 2:Wireless and Mobile Networks
VHS: 67h30 (Lecture: 3h00, Tutorial: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives
This subject is dedicated to wireless networks (WiFi and WiMAX) and 3 and 4G mobile radio networks. At the end of the course, the student will have a complete concept of these networks (architecture, radio interface, radio channel, dimensioning and planning, services offered, security management, roaming, etc.).

Recommended prior knowledge:
TCP networks, digital communications, telephony.

Content of the subject:

Chapter 1. Reminder of basic concepts (2 Weeks)
Reminders and definitions, Types of wireless communications, Modern wireless communications systems, Wireless networks and mobile networks, The concept of cellular networks,Architectures. Base stations, Frequency bands.
Chapter 2. Wireless Personal Area Networks (WPAN) (2 Weeks)
The standardsand features, Ultra-Wide Band or UWB, Standard 802.15, Bluetooth, Zigbee,Access techniques, Implementation, Security. Some examples:WBAN (Wireless Body Area Networks), WSN (Wireless Sensor Networks)…etc
Chapter 3. Wireless Local Area Networks: IEEE 802.11 (Wi-Fi) (3 Weeks)
802.11 Standard, Architecture and Layers, 802.11a, 802.11b, 802.11g, 802.11n and 802.11ac or high-speed WiFi …etc, Routing and Transmission Techniques: Architecture of 802.11 Mode with infrastructure, Access point installation conditions. Architecture of 802.11 Mode without infrastructure, ad-hoc, Security.
Chapter 4. Wireless Metropolitan Area Networks (2 Weeks)
WMAN,Architecture and evolution,Local Multipoint Distribution Service (LMDS), Multichannel Multipoint Distribution System (MMDS), main characteristics of the IEEE 802.16 Standard,WiMAX, spectrum options, WiMAX Subscriber Stations, WiMAX Base Stations, WiMAX technical solutions.
Chapter 5. 3G, 4G and 5G Mobile Networks (4 Weeks)
Structure of a mobile radio system, mobile radio coverage (pico cellular, micro cellular, satellite),Reminders on previous generations (EDGE, GSM, GPRS, services offered: SMS, etc.), The different 3G standards,Technologies and features,UMTS,WCDMA, CDMA2000, TD-SCDMA. HASLTE architecture, LTE Advanced, Features and performance, Standardization,Evolution of cellular technologies, futuristic view of the 5th generation (frequency plan, flow rate, latency, etc.).
Chapter 6. Introduction to Cognitive Radio (2 Weeks)
Problem (Saturated and misused frequency spectrum), History of theCognitive Radio (CR), Architecture, Cognition cycle, Components, Functions (Spectrum detection orSpectrum sensing, Spectrum Management orSpectrum management, Spectrum mobility orSpectrum mobility).
Assessment method:
Continuous assessment: 40%; Exam: 60%.
Bibliographic references:
1. Lin, YB, & Chlamtac, I. (2008). Wireless and mobile network architectures. John Wiley & Sons.2, 2008.
2. Gast, M. (2005). 802.11 wireless networks: the definitive guide. "O'Reilly Media, Inc.", 2005.
3. K. Al Agha, (2016) Wireless and Mobile Networks, Wiley, 2006.
4. AKNayak, SCRai, R.Mall, (2016), Computer Network Simulators Using NS2, Productivity Press, 2016.
5. R.Mutha, (2013), Performance Evaluation of AdHoc Routing Protocols By NS2 Simulation, LAP Lambert Academic Publishing, 2013.
6. G. Baudoin, "T1 Digital Radiocommunications: Principles, Modeling and Simulation," Dunod, Paris, 2007
8.S.TABBANE, Mobile Networks, Hermès science publications, 1997.

9.Stéphane Lohier,Dominique Present.Networks and Transmissions - 6th Edition. Protocols, Infrastructures, and Services. NFO SUP, Dunod, January 2016.
10. Aurélien Géron.Professional WiFi.The 802.11 standard, deployment, security.Dunod09/23/2009
11. Pujolle, "The Networks", Ed Eyrolle, 8th edition, 2014.

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

Teaching objectives:

The aim of this subject is to be able to design and analyze optical communication systems, and in particular optical fiber transmissions.

Recommended prior knowledge:

Basic notions of optoelectronics taught at the third year level of the Telecommunications degree.

Content of the subject:

Chapter 1. Introduction to Optical Communications Systems (2 weeks)

- Introduction and brief history
- Evolution of optical communications systems
- Advantages of optical fibers

Chapter 2. Study of propagation in optical fibers (2 Weeks)

- Geometric approach: Fermat's principle and Snell-Descartes' law - Application to optical fibers (Concept of numerical aperture - Multimode and single-mode fibers)
- Wave approach: Maxwell's equations (Modes of a step-index fiber, Comparison between single-mode and multi-mode fibers)

Chapter 3. Electro-optical Transmitters/Receivers (3 Weeks)

-Semiconductor light sources - Optical emitters: LED diodes, Laser diodes - Optical receivers: PIN photodiode, Avalanche diode

- Noise sources and signal-to-noise ratio

Chapter 4. Fiber Optic Transmission System (4 Weeks)

- Block diagram of an optical transmission chain
- Optical cable and connectors
- Structure and Families of digital links: point to point, with EDFA optical amplifiers, multiplexed links (WDM, OTDM, etc.).

Chapter 5. Fiber Optic Networks (4 Weeks)

- Passive and active networks,
- Different FTTX architectures
- Local, metropolitan and long-distance optical networks, Passive optical networks (PON), Optical network topologies, Power budget of an optical network, performance of an optical network.
- Bragg gratings for an optical coding and decoding system

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. Govind P. Agrawal, "Fiber-optic communication systems", 4th Edition, John Wiley & Sons, 2010.
2.Gerd Keizer, 'Optical Communications Essentials', McGraw-Hill Companies, 2003.
3. Pierre Lecoy, "Fiber-optic communications", 3rd edition, John Wiley & Sons, 2008.
4. Enrico Forestieri, "Optical communication: theory and techniques", Springer, 2005.
5. Shiva Kumar and M. Jamal Deen, "Optical fiber communications: Fundamentals and applications", John Wiley & Sons, 2014.
6. Govind P. Agrawal, "Lightwave technology: Telecommunication systems", John Wiley & Sons, 2005.
7. John M. Senior, "Optical fiber communications: Principles and practice", 3rd edition, Prentice Hall, 2009
8. Le Nguyen Binh, 'Optical fiber communications systems, Theory and Practice with MATLAB® and Simulink® Models', CRC press,2010.
9. Michael Barnoski, 'Fundamentals of optical fiber communications, Academic press, 2nd, 1981.
10.AMASWAMY, R., SIVARAJAN, KM, Optical Networks: A Practical Perspective, 3rd Edition, Morgan Kaufmann Publishers, 2010.

Semester: 3
Teaching unit: UEF 2.1.2

Subject 3:Technology and protocols for multimedia
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The objective of this subject is to familiarize students with the different protocols for multimedia as well as the associated technology and applications..

Recommended prior knowledge:

The different types of networks. Coding and compression, Digital communications

Content of the material:

Chapter 1.Analysismultimedia: Standards and Protocols (3 Weeks)

Definitions, standardization, examples of standards, Multimedia and hypertext,foundations of multimedia, Components of Multimedia, Diversity of multimedia applications and needs, Internet (structure and vision).Lprotocols IP, UDP, RTP, TCP/IP, RTSP, Multicast, Resource Reservation…

Chapter 2. Multimedia Signals (3 Weeks)

Sound (Pitch, Intensity, Timbre, Duration, Spectral Analysis, etc.), Image, Video. Reminders on image compression. Description of Audio Signal Compression. Introduction to video compression. Issues of changing formats. Editing multimedia documents.

Chapter 3. Multimedia Synchronization Techniques (3 Weeks)

Principle and definition. Local approaches, distributed approaches. Indexing multimedia files by content. Interactions in multimedia applications.

Chapter 4. Introduction to Access Techniques (3 Weeks)

Categories of transfer networks, Different types of transmission and multiplexing, The telephone network, Switching networks, Access networks: SDH and WDM technologies, Architectures in the local loop: fiber, HFC cable networks, XDSL networks and LMDS radio links.

Chapter 5. Services rebucket and safety(3 Weeks)

HTTP protocol, Email, File transfer, TeleIP telephony, IP video,quality of service QoS,Interactive television. Encryption and Ciphering. Digital watermarking of data. Steganography.Security in networks

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. Marc Van Droogenbroeck. Multimedia, Telecommunications and Internet Technologies, University of Liège, 2004
2. S. Collin, Multimedia on PC, Dunod, Paris, 1994.
3. E. Holsinger, How multimedia works, Ziff-David Press, Emeryville, California, 1994.
4. C. Servin, Networks and telecoms, Dunod, Paris, 2003.
5. S. Déon, IP telephony, Eyrolles, 2010.
6. G. Pujolle, The networks, Eyrolles, 2000.
7. O. Hersent, Voice over IP: Deployment of architectures, Eyrolles, 2006.

Semester: 3
Teaching unit: UEF 2.1.2
Subject 4:RF and Microwave (Passive/Active) Devices
VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)

Credits: 4
Coefficient: 2

Teaching objectives:

This subject aims to provide the basic concepts and an introduction to the tools needed to design various RF or microwave circuits. These circuits are divided into two types: passive devices such as transmission lines, metal waveguides, couplers, dividers, and other active devices such as FET transistors, Schottky diodes, mixers, and oscillators.

Recommended prior knowledge:

Analog Electronics, Digital Electronics and Transmission Line.

Content of the material:

Chapter 1.Passive microwave circuits and devices (4 Weeks)

- Notions on S parameters
- Multipole
- Coupled lines (Directional couplers)
-Circulators, Magic T, Hybrid, power dividers, directional couplers
-Adapters, attenuators, phase shifters
- Analysis methods (S parameters, flow graph)

Chapter 2.Microwave filters (2 Weeks)

- Resonant circuits, Cavities
- Ferrite elements and devices for non-reciprocal passive circuits

Chapter 3. Sstability and noise in quadrupoles (2 weeks)

- Unconditional stability, Conditional stability, stability circles (on the Smith chart), Rollet factor

Chapter 4. Gain of a quadrupole (3 Weeks)

- Description of the different gains (power gain, transducer gain and specific gain)
-Design of a linear amplifier
-Design of a low noise amplifier (LNA)

Chapter 5.Active microwave circuits and devices (3 Weeks)

-RF diodes (Schottky, Gunn,Varicap, PIN),
- RF transistors (MOSFET and MESFET)
- Oscillators and mixers

Chapter 4.Microwave integrated circuits (1 Week)

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. PFCombes ''Microondes'' Volume 2, Dunod 96.
2. PFCombes, J.Graffeuil, JFSautereau''Microwave components, devices and active circuits, Dunod University, 1985.
3. A. Pacaud, "Radiofrequency electronics", Ellipses.
4.PFCombes ''Metric and centimetric waves Lines, passive circuits, antennas Dunod university.
5. M. Helier, Microwave Techniques, Ellipses.

Semester: 3
Teaching unit: UEM2.1
Subject 2:TPWireless and Mobile Networks
VHS: 10:30 p.m. (TP: 1:30)
Credits: 2

Coefficient: 1

Teaching objectives:

Master the different techniques of wireless and mobile transmissions as well as the testing of the different corresponding networks.

Recommended prior knowledge:

Fixed and mobile communications systems.

Content of the subject:

TP 1: Installation and analysis of a Bluetooth network (WPAN)

TP2: Installation and Analysis of a Wifi (WLAN) type network with infrastructure and without infrastructure (ad-hoc)

TP3: Simulation of a WiMAX network, configuration ofWiMAX station: user management and Quality of Service (QoS) etc.

TP 4: Spectral analysis of wireless networks and melectromagnetic field measurement(using where possible a spectrum analyzer, an RF Wattmeter, an electromagnetic field detector, etc.).

TP5: Supervision and evaluation of the quality of service of a 2G, 3G and, where possible, 4G radio network.

TP 6: Simulation and planning of mobile radio networks using software (ATTOL example).

Assessment method:

Controlcontinuous: 100%

Bibliographic references:

1. Lin, YB, & Chlamtac, I. (2008). Wireless and mobile network architectures. John Wiley & Sons.2, 2008.
2. Gast, M. (2005). 802.11 wireless networks: the definitive guide. "O'Reilly Media, Inc.", 2005.
3. K. Al Agha, (2016) Wireless and Mobile Networks, Wiley, 2006.
4. AKNayak, SCRai, R.Mall, (2016), Computer Network Simulators Using NS2, Productivity Press, 2016.
5. R.Mutha, (2013), Performance Evaluation of AdHoc Routing Protocols By NS2 Simulation, LAP Lambert Academic Publishing, 2013.
6. G. Baudoin, "T1 Digital Radiocommunications: Principles, Modeling and Simulation," Dunod, Paris, 2007
8.S.TABBANE, Mobile Networks, Hermès science publications, 1997.
9.Stéphane Lohier,Dominique Present.Networks and Transmissions - 6th Edition. Protocols, Infrastructures, and Services. NFO SUP, Dunod, January 2016.
10. Aurélien Géron.Professional WiFi.The 802.11 standard, deployment, security.Dunod09/23/2009
11. Pujolle, "The Networks", Ed Eyrolle, 8th edition, 2014.

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

Teaching objectives:

This subject allows students to develop a functional description of fiber optic communication chains, emphasizing the main limitations introduced by the different optical components (fiber, laser source, optical amplifier, etc.)

Recommended prior knowledge:

Concepts on analog and digital modulations; Signal processing.

Content of the subject:

TP1: Therechromatic dispersion and its compensation

TP2: Modulation/demodulationin optics

TP3: Lsingle-wavelength point-to-point connection

TP4: Study of an OTDM link

TP5: Study of a WDM link

Assessment method:

Continuous assessment: 100%

Bibliographic references:

1. Govind P. Agrawal, "Fiber-optic communication systems", 4th Edition, John Wiley & Sons, 2010.
2.Gerd Keizer, 'Optical Communications Essentials', McGraw-Hill Companies, 2003.
3. Pierre Lecoy, "Fiber-optic communications", 3rd edition, John Wiley & Sons, 2008.
4. Enrico Forestieri, "Optical communication: theory and techniques", Springer, 2005.
5. Shiva Kumar and M. Jamal Deen, "Optical fiber communications: Fundamentals and applications", John Wiley & Sons, 2014.
6. Govind P. Agrawal, "Lightwave technology: Telecommunication systems", John Wiley & Sons, 2005.
7. John M. Senior, "Optical fiber communications: Principles and practice", 3rd edition, Prentice Hall, 2009
8. Le Nguyen Binh, 'Optical fiber communications systems, Theory and Practice with MATLAB® and Simulink® Models', CRC press,2010.
9. Michael Barnoski, 'Fundamentals of optical fiber communications, Academic press, 2nd, 1981.
10.AMASWAMY, R., SIVARAJAN, KM, Optical Networks: A Practical Perspective, 3rd Edition, Morgan Kaufmann Publishers, 2010.

Semester: 3
Teaching unit: UEM 2.1
Subject 3:TPRF and Microwave (Passive/Active) Devices
VHS: 10:30 p.m. (TP: 1:30 p.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

The aim of this practical work is to master the concepts seen in class, relating to RF and microwave devices (planar lines, matched load, fixed and variable attenuator, phase shifter, coupler, circulator, filter and resonant cavity, Schottky diodes, PIN, diode detector, amplifier, mixer, etc.) by using measurement benches, network analyzers and simulation tools such as "Advanced Design System (ADS)".

Recommended prior knowledge:

Analog Electronics, Digital Electronics and Transmission Line.

Content of the subject:

TP1: Study of RF and microwave functions and devices using measuring benches

The aim of the practical work is to understand and master the operation of passive RF and microwave devices such as the matched load, the fixed and variable attenuator or weakener, the phase shifter, the directional coupler, the circulator, the filter and the resonant cavity, the Schottky and PIN diodes, the diode detector, etc.). The methodology consists of injecting power, generated from an RF and microwave source, at the input of the analyzed component and measuring the powers transmitted and reflected at the different ports of the component in order to verify the function performed.

TP2: Study of micro-strip planar lines and their S parameters

The aim of this practical work is to familiarize yourself with the ADS simulation tool, to study passive RF and microwave devices such as planar transmission lines (sizing rules, characteristic impedance, electrical length, use of the Smith chart, etc.) and to learn how to use the [S] parameters to adapt this type of transmission line.

TP3: Design of an RF amplifier: Study of the stability, gain and noise factor of the amplifier

The aim of the lab is to show how to calculate the stability, gain and noise figure of an RF amplifier. The methodology adopted consists of matching the RF transistor at its input and output to maximize its gain and minimize its noise figure, while verifying its stability (this involves defining matching cells at the input and output of the transistor and optimizing them with ADS).

TP4: Measurement of passive and active RF devices with a network analyzer

The aim of the practical work is to explain how a network analyzer works and then show how to measure RF and microwave components studied in practical work 1, practical work 2, and practical work 3.

Assessment method:

Continuous assessment: 100%;

Bibliographic references:

1. PFCombes ''Microondes'' Volume 2, Dunod 96.

2. PFCombes, J.Graffeuil, JFSautereau''Microwave components, devices and active circuits, Dunod University, 1985.
3. A. Pacaud, "Radiofrequency electronics", Ellipses.
4. PFCombes ''Metric and centimetric waves Lines, passive circuits, antennas Dunod university.
5. M. Helier, Microwave Techniques, Ellipses

Semester: 3
Teaching unit: UEM2.1
Subject 4:Digital Television
VHS: 37h30 (Lecture: 1h30, Practical work: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

The student will understand the principle of digital television (transmission and image processing) and its applications as well as the concepts of digital compression and coding.

Recommended prior knowledge:

Knowledge of electricity, basic electronics, and electromagnetism is required to pursue this subject. This knowledge is provided in the ST core curriculum and in the third year of the bachelor's degree program.

Content of the subject:

Chapter 1. Reminders onanalog television (2 weeks)

History, Colorimetric standards for color video, Analog composite color video signal, Chrominance submodulation, Color coding/decoding techniques (PAL, SECAM and NTSC), Transmission bands and channels for analog television (VHF, VHFIII and UHF), Reminders on current standards.

Chapter 2.Digitization of video and audio signals (3 weeks)

Reminders on sampling and quantification of signals, Dynamics and digitization of Y, Cr and Cb components, The different formats of digital videos (4:2:2, 4:2:1, 4:2:0). The digital video line, the digital video frame. Standards and definitions of digital video in p and/or i (SD, HD, Full HD, 4K2K, etc.).
Digitization of the audio signal.

Chapter 3.Video and audio compression techniques (5 weeks)

Introduction, Calculation of digital video transmission rates, Spatial redundancy and temporal redundancy, Principle of intra-image compression (Transformation-Quantization-Coding), Inter-image compression: motion analysis, motion compensation, Video compression standards: MPEG2, MPEG4, H264/AVC and HEVC. Audio compression techniques. Signal multiplexing.

Chapter 4. TheDigital televisions (5 weeks)

History and context, Different types of digital television (DVB-T, DVB-S and DVB-C), Block diagrams. Transmission and broadcasting of digital television (DVB); COFDM for DVB-T, Digital modulations used. DVB-T channels. Reception of digital television. OthersDigital terrestrial broadcasting standards (ATSC, ISDB-T and DMB-T …etc). New generations like DVB-T2, DVB-NGH, etc.

List of practical work

TP1: Reminders on analog television: bands and channels, characteristics of the color composite video signal, etc.

TP2: Satellite TV reception (occupied frequency bands, pointing the dish at an example satellite, azimuth angle, elevation degree, polarization angle, field measurement, role of the LNB, advantages of horizontal and vertical polarization, spectrum analyzer, etc.)
TP3: Evaluation of a DTT (Digital Terrestrial Television) reception: DTT decoder, spectrum analyzer and/or field meter (if the equipment exists)
TP4: Study, Implementation and Evaluation of MPEG2 under Matlab
TP5: Study, Implementation and Evaluation of COFDM under Matlab
TP6: Implementation of DVB-T under simulink

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

1. *Stéphane Paris, "Multimedia and Compression". Publisher:Hermès - Lavoisier*
2. *Andrei Cernasov. ''Digital Video Electronics with 12 complete projects''. Editor:Mc Graw Hill2009*
3. *Ulrich Reimers. ''DVB The Family of International Standards for Digital Video Broadcasting''. Editor:Springer2004*
4. *Hervé Benoît. "Analog and Digital Satellite Television." Publisher:Dunod2005*
5. *Hervé Benoît. "Digital Television Satellite, Cable, Terrestrial - Principles and Applications of the DVB System." Publisher:Dunod2005*
6. *Jean Herben. "PAL and SECAM Color Television: From Analog to Digital." Publisher:Dunod2003*
7. *Hervé Benoît. "Digital Television Satellite, Cable, TNT, ADSL, Mobile TV." Publisher:Dunod2010*
8. *Nicolas Moreau. "Tools for Signal Compression." Publisher:Hermès - Lavoisier2009.*

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

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

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

Semester: 3
Teaching unit: UED2.1
Subject 1:Space telecommunications
VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

The objective of this subject is to present in a general manner the main characteristics of satellite communications systems.

Recommended prior knowledge:

Communication systems.

Content of the material:

Chapter 1. Principle of satellite transmission (5 Weeks)

- Earth and space stations
-Satellite constitution(Platform- Payload- Transponder)
- Earth orbits, geostationary orbits, allocated bands
- Earth and space station technology

Chapter 2. Constellation of satellites (5 Weeks)

- Tilted and polar constellations
-Characteristicsof the different constellations
- Handover problem
- Optical satellites (Problem of vibration sources: external and internal)

Chapter 3. Assessment of a satellite link and atmospheric disturbances (5 Weeks)

- Main parameters of a link: Antenna gain, Free space loss, Atmospheric absorption loss, Noise temperature, Noise figure, Noise temperature equivalent to the input of a circuit, EIRP.
- Power density, Power received by an antenna, Telecommunications equation uplink – downlink.
- Main sources of noise in a satellite communication link, C/N0 ratio of a satellite link,Factorsde DisturbancedeLhasqualityAconnection ssatellite.

Assessment method:

Exam: 100%.

Bibliographic references:

1. *Gerard Maral,Michel Bousquet,Zhili Sun"Satellite Communications Systems: Systems, Techniques and Technology. 5th Edition. 2009*
2. *Journal of Telecommunications, ITU, from 1934 to 1993.*
3. *ITU News, from 1993,http://www.itu/itunews*
4. *ITU Handbook on Satellite Communications, 3rd ed., 2002, 1210 p.*
5. *BENSOUSSAN, Alain, Telecommunications and the Law, Paris, Hermès, 2nd ed., 1996, 205 p.*
6. *Aerospace Law: Telecommunications Satellites, Montreal, McGill University, 1982, 354 p.*

Semester: 3
Teaching unit: UED2.1

Subject 1:Radio navigation system
VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

The objective of this subject is to present in a general manner the main characteristics of satellite radionavigation systems, their applications, advantages and disadvantages.

Recommended prior knowledge:

Communication systems, Signal processing.

Content of the material:

Chapter 1. Satellite radio navigation systems (5 weeks)

- History, Land radio navigation systems (VOR, TACAN, DME, ILS, MLS, LORAN).
- Presentation of the GPS system and GPS signals (Functional architecture of a receiver, Principle of GPS measurement: pseudo distances, pseudo speeds, Calculation of GPS position and speed, Specificities of military GPS receivers: cryptographic modules, direct acquisition in Y code, resistance to jamming).

Chapter 2.GPS Improvements and Future Systems (5 weeks)

GPS limitations: integrity, resistance to jamming, masking, precision, GPS improvement techniques: differential techniques, integrity control, constellation expansion, improved resistance to jamming...The Galileo system and other satellite radionavigation systems (existing or future).

Chapter 3. Non-inertial sensors for navigation (5 weeks)

- Vision sensors (IR, visible, stellar camera), Displacement sensors (odometer, correlation log), speed sensors (log, doppler, anemometry), Distance sensors (radar, sonar, depth sounder), Altitude or immersion sensors, Magnetic field sensors, Hybrid inertial systems.
- Integration of the CNS concept on board modern aircraft.

Assessment method:

Exam: 100%.

Bibliographic references:

1. *Gerard Maral,Michel Bousquet,Zhili Sun"Satellite Communications Systems: Systems, Techniques and Technology. 5th Edition. 2009*
2. *ITU Handbook on Satellite Communications, 3rd ed., 2002, 1210 p.*
3. *Aerospace Law: Telecommunications Satellites, Montreal, McGill University, 1982, 354 p.*
4. *L.Andrade. The Global Navigation Satellite System: Navigating into the New Millennium (Ashgate Studies in Aviation Economics and Management), Ashgate Pub Ltd, 2001, ISBN: 0754618250*