الجمهورية الجزائرية الديمقراطية الشعبية People's Democratic Republic of Algeria

وزارة التعليم العالي والبحث العلمي

Ministry of Higher Education and Scientific Research

اللجنة البيداغوجية الوطنية لميدان العلوم و التكنولوجيا

National Educational Committee for the field of Science and Technology

ACADEMIC MASTER HARMONIZE

National program

2022 update

Domain	Sector	Speciality
Science And Technologies	***Electrical engineering***	***Electrical Networks***

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National Educational Committee for the field of Science and Technology

ماستر أكاديمي
مواءم

برنامج وطني

تحديث 2022

الميدان	الفرع	التخصص
علوم و تكنولوجيا	كهروتقني	شبكات كهربائية

I–Master's identity sheet

Access conditions

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

Sector	Harmonized Master	Access licenses to the master's degree	Ranking according to license compatibility	Coefficient assigned to the license
Electrical engineering	Electrical networks	Electrical engineering	**1**	**1.00**
		Electronic	**3**	**0.70**
		Automatic	**3**	**0.70**
		Other licenses in the ST domain	**5**	**0.60**

II – Half-yearly teaching organization sheets of the specialty

Semester 1 Master:NetworksElectric

Teaching unit	Modules Titled	Credits	Coefficient	Weekly hourly volume			Half-yearly Hourly Volume (15 weeks)	Additional Work in Consultation (15 weeks)	Evaluation mode	
				Course	**T.D.**	**TP**			**Continuous monitoring**	**Exam**
Fundamental EU Code: UEF 1.1.1 Credits: 10 Coefficients: 5	Electric energy transmission and distribution networks	4	2	1h30	1h30		45:00	55:00	40%	60%
	Advanced power electronics	4	2	1h30	1h30		45:00	55:00	40%	60%
	μ-processors and μ-controllers	2	1	1h30			10:30	27:30		100%
Fundamental EU Code: UEF 1.1.2 Credits: 8 Coefficients: 4	In-depth electrical machines	4	2	1h30	1h30		45:00	55:00	40%	60%
	Applied numerical methods and optimization	4	2	1h30	1h30		45:00	55:00	40%	60%
Methodological EU Code: UEM 1.1 Credits: 9 Coefficients: 5	TP: - μ-processors and μ-controllers	1	1			1h00	3:00	10:	100%	
	TP: - Electric energy transport and distribution networks	2	1			1h30	10:30	27:30	100%	
	TP: - Advanced power electronics	2	1			1h30	10:30.	27:30	100%	
	TP: Applied numerical methods and optimization	2	1			1h30	10:30	27:30	100%	
	TP: - in-depth electrical machines	2	1			1h30	10:30	27:30	100%	
EU Discovery Code: UED 1.1 Credits: 2 Coefficients: 2	Material of your choice	1	1	1h30			10:30	02:30		100%
	Material of your choice	1	1	1h30			10:30	02:30		100%
Transversal EU Code: UET 1.1 Credits: 1 Coefficients: 1	Technical English and terminology	1	1	1h30			10:30	02:30		100%

Total semester 1		**30**	**17**	**12:00**	**6:00**	**7:00**	**375h00**	**375h00**		

Semester 2 Master: Electrical Networks

Teaching unit	**Modules**	Credits	Coefficient	Weekly hourly volume			Volume Semester Schedule (15 weeks)	Work Complementary in Consultation (15 weeks)	Evaluation mode	
	Titled			**Course**	**T.D.**	**TP**			**Continuous monitoring**	**Exam**
Fundamental EU Code: UEF 1.2.1 Credits: 10 Coefficients: 5	Modeling and optimization of electrical networks	4	2	1h30	1h30		45:00	55:00	40%	60%
	Quality of electrical energy	4	2	1h30	1h30		45:00	55:00	40%	60%
	Centralized and decentralized production	2	1	1h30			10:30	27:30		100%
Fundamental EU Code: UEF 1.2.2 Credits: 8 Coefficients: 4	Planning of electrical networks	4	2	1h30	1h30		45:00	55:00	40%	60%
	Control of electro-energetic systems	4	2	1h30	1h30		45:00	55:00	40%	60%
Methodological EU Code: UEM 1.2 Credits: 9 Coefficients: 5	Electrical network protection techniques	3	2	1h30		1h00	37:30	37:30	40%	60%
	TP: Modeling and optimization of electrical networks	2	1			1h30	10:30	27:30	100%	
	TP: Quality of electrical energy	2	1			1h30	10:30	27:30	100%	
	TP: Control of electro-energetic systems	2	1			1h30	10:30	27:30	100%	
EU Discovery Code: UED 1.2 Credits: 2	Material of your choice	1	1	1h30			10:30	02:30		100%
	Material of your choice	1	1	1h30			10:30	02:30		100%

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

Semester 3 Master: Electrical Networks

Teaching unit	Modules	Credits	Coefficient	Weekly hourly volume			Half-yearly Hourly Volume (15 weeks)	Work Complementary in Consultation (15 weeks)	Evaluation mode	
	Titled			**Course**	**T.D.**	**TP**			**Continuous monitoring**	**Exam**
Fundamental EU Code: UEF 2.1.1 Credits: 10 Coefficients: 5	Operation of electrical networks	4	2	1h30	1h30		45:00	55:00	40%	60%
	Stability and dynamics of electrical networks	4	2	1h30	1h30		45:00	55:00	40%	60%
	Smart power grids	2	1	1h30			10:30	27:30		100%
Fundamental EU Code: UEF 2.1.2 Credits: 8 Coefficients: 4	Integration of renewable resources into electricity networks	4	2	1h30	1h30		45:00	55:00	40%	60%
	Industrial electrical networks	4	2	1h30	1h30		45:00	55:00	40%	60%
Methodological EU Code: UEM 2.1 Credits: 9	High voltage techniques	5	3	1h30	1h30	1h00	60:00	65h00	50%	50%
	TP: Stability and dynamics of electrical networks	2	1			1h30	10:30	27:30	100%	

Coefficients: 5	TP: Industrial electrical networks	2	1			1h30	10:30	27:30	100%	
EU Discovery Code: UED 2.1 Credits: 2 Coefficients: 2	Material of your choice	1	1	1h30			10:30	02:30		100%
	Material of your choice	1	1	1h30			10:30	02:30		100%
Transversal EU Code: UET 2.1 Credits: 1 Coefficients: 1	Documentary research and dissertation design	1	1	1h30			10:30	02:30		100%
Total semester 3		30	17	1:30	7:30	4:00	375h00	375h00		

Discovery Unit (S1, S2 and S3)

1- Erenewable energies
2- Industrial data
3- Electromagnetic compatibility
4- Maintenance and operational safety
5- Implementation of real-time digital control
6- Electrical engineering materials and their applications
7- Techniquesofartificial intelligence
8- Propagation of electrical waves on the energy network
9- Introduction to Software Engineering
10- Industrial Ecology and Sustainable Development
11- Maintenance of electrical networks
12- Embedded electrical networks
13- Electrical energy and building
14- High voltage electrical equipment
15-
16- Others...

Semester 4

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

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

This table is given for information purposes only.

Evaluation of the End of Master Cycle Project

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

III - Detailed program by subject for the S1 semesters

Semester: 1
Fundamental EU Code: UEF 1.1.1
Matter:Electric energy transmission and distribution networks
VHS: 45h (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The objective of this course can be divided into two: on the one hand the broadening of the knowledge acquired during the 'Electric Networks' course in License, and on the other hand introducing the necessary knowledge on the management and operation of electrical networks.

Recommended prior knowledge:

Fundamental laws of electrical engineering (Ohm's law, Kirchhoff's laws, etc.), Analysis of alternating current electrical circuits, complex calculation. Modeling of electrical lines (Bachelor's Electrical Networks Course).

Material content:

Chapter 1. Global architecture of the electricity network (2 weeks)
Equipment and architecture of substations (bar-coupled substations, circuit breaker-coupled substations), topologies of energy transport and distribution networks.
Chapter 2. Organization of electric energy transportation
2.1. Power transmission lines (3 weeks)
Calculation of transmission lines: Choice of conductor section, insulation, mechanical calculation of lines, Operation of transmission lines in steady state. Operation of transmission lines in transitional regime. Direct current (HVDC) energy transport.
2.2. Distribution networks (2 weeks)
Introduction to electrical power distribution, primary distribution, secondary distribution, distribution transformers, reactive energy compensation in distribution networks, distribution reliability.
Chapter 3. Operation of MV and LV electricity networks(3 weeks)
Protection of HT/MV substations against overcurrents and overvoltages). Models of electrical network elements. Control of reactive power on an electrical network
Chapter 4. Neutral diets (2 weeks)
Neutral regimes (insulated, earthed, impedant), artificial neutral.
Chapter 5. Adjusting the tension (3 weeks)
Voltage drop in electrical networks, voltage adjustment method (automatic adjustment of the voltage at the generator terminals, AVR, reactive energy compensation by conventional and modern means, voltage adjustment by autotransformer), introduction to the voltage stability.

Evaluation method:

Continuous monitoring: 40%; Examination: 60%.

Bibliographic references:

1. *F. Kiessling et al, 'Overhead Power Lines, Planning, design, construction'. Springer, 2003.*
2. *T. Gonen et al, 'Power distribution', book chapter in Electrical Engineering Handbook. Elsevier Academic Press, London, 2004.*
3. *E. Acha and VG Agelidis, 'Power Electronic Control in Power Systems', Newns, London 2002.*
4. *TuranGönen: Electric power distribution system engineering. McGraw-Hill, 1986*
5. *TuränGonen: Electric power transmission system engineering. Analysis and Design. John Wiley & Sons, 1988*
6. *Mohamed e. el-hawary; electrical power systems, the institute of electrical and electronics engineers, inc., new york, 1995.*
7. *J. Duncan glover, thomas j. Overbye, Munukutla s. sarma, power system analysis & design, Cengage learning, sixth edition, 2017*

Semester: 1
Fundamental EU Code: UEF 1.1.1
Matter:Advanced power electronics
VHS: 45h (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

To provide the electrical circuit concepts behind the different modes of operation of inverters to enable deep understanding of their working. To equip with the necessary skills to obtain the criteria for designing power converters for UPS, Drives etc.,
Ability to analyze and understand the different modes of operation of different power converter configurations.
Ability to design different single-phase and three-phase inverters

Recommended prior knowledge:

Power components, basic power electronics,

Material content:

Chapter 1: Methods for modeling and simulation of power semiconductors
Idealized characteristic of different types of semiconductors, logical equations of semiconductors, simulation methods of static converters (2 weeks)
Chapter 2: Switching mechanisms in static converters Natural switching principle, forced switching principle, calculation of switching losses.
(3 weeks)
Chapter 3: Design methods for static converters with natural switching
Switching rules, definition of the switching cell, different types of sources, power exchange rules, direct and indirect converters example: study of a cyclo converter. (2 weeks)
Chapter 4: Design methods for forced switching static converters
- PWM inverter
- Sinusoidal absorption rectifier
- PWM dimmer
- Switching power supplies (3 weeks)

Chapter 5: Multi-level inverter (3 weeks)
Multi-level concept, topologies, Comparison of multi-level inverters. PWM control techniques for PWM inverter - single phase and three phase impedance source.
Chapter 6: Energy quality of static converters (3 weeks)
- Harmonic pollution due to static converters (Case study: rectifier, dimmer).
- Study of harmonics in voltage inverters.
- Introduction to depollution techniques

Evaluation method:

Continuous monitoring: 40%; Examination: 60%.

Bibliographic references:

1. *Power electronics, from switching cells to industrial applications. Courses and exercises, A. Cunière, G. Feld, M. Lavabre, Casteilla editions, 544 p. 2012.*
2. *-Technical encyclopedia "Engineering techniques", treatise on Electrical Engineering, vol. D4 items D3000 to D3300.*

Semester: 1

Fundamental EU Code: UEF 1.1.1
Matter:µ-processors and µ-controllers
VHS: 10:30 p.m. (Class: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives

Know the structure of a microprocessor and its usefulness. Differentiate between microprocessor, microcontroller and calculator. Know the organization of a memory. Know assembly programming. Understand the use of I/O interfaces and interrupts. Use of the micro controller (programming, system control).

Recommended prior knowledge

Combinatorial and sequential logic, industrial automation

Content of the material:

Chapter 1: Architecture and operation of a microprocessor(3 weeks)
Structure of a computer, Circulation of information in a computer, Hardware description of a microprocessor, Operation of a microprocessor, memories
Example: The Intel 8086 microprocessor
Chapter 2: Assembler programming(2 weeks)
General, The instruction set, Programming method.
Chapter 3: Interrupts and I/O interfaces(3 weeks)
Definition of an interrupt, Support for an interrupt by the microprocessor, Addressing of interrupt subroutines,
I/O port addressing, I/O port management
Chapter 4: Architecture and Operation of a Microcontroller(3 weeks)
Hardware description of a µ-controller and its operation. Programming the µ-controller
Example: The PIC µ-controller
Chapter 5: Applications of Microprocessors and Microcontrollers(4 weeks)
LCD Interface - Keypad Interface - Port Signal Generation Gate for Converters - Motor - Control - Control of DC/AC Devices - Frequency Measurement - Data Acquisition System

Evaluation method:

100% review.

Bibliographic references:

1. M. Tischer and B. Jennrich. The PC bible – System programming. Micro Application, Paris, 1997.
2. R. Tourki. The PC computer – Architecture and programming – Courses and exercises. University Publication Center, Tunis, 2002.
3. H. Schakel. Programming in assembler on PC. Micro Application, Paris, 1995.
4. E. Pissaloux. Practice of the I80x86 assembler – Courses and exercises. Hermès, Paris, 1994
5. R Zaks and A. Wolfe. From component to system – Introduction to microprocessors. Sybex, Paris, 1988.

Semester: 1
Fundamental EU Code: UEF 1.1.2

Matter:In-depth electrical machines
VHS: 45h (Class: 1h30, tutorial 1h30)
Credits: 4
Coefficient: 2

Teaching objectives

At the end of this course, the student will be able to establish the general electromechanical energy conversion equations applied to synchronous, asynchronous and direct current machines and will be able to determine their characteristics in static or variable regimes. This makes it possible in particular to take into account the association of machines with static converters.

Recommended prior knowledge

Three-phase electrical circuits, alternating current, power. Magnetic circuits, Single-phase and three-phase transformers, Direct and alternating current electrical machines (motor and generator operation).

Content of the material:

Chapter 1: General principles (3 weeks)

Principle of electromechanical energy conversion. Principle of stator/rotor coupling: the primitive machine. Windings of electrical machines.calculation of magnetomotive forces. Mechanical equation;

Chapter 2: Synchronous machines (4 weeks) Generalities and equations of the synchronous machine with smooth poles. Study of the operation of the synchronous machine. Ddifferent excitation systems.Induce reactions. Elements on the salient pole synchronous machine without and with shock absorbers. Potier diagrams, two reactance diagrams and Blondel diagrams. Elements on permanent magnet machines. Alternators andParallel coupling.Synchronous motors, starting...

Chapter 3: Asynchronous machines (4 weeks) General. Equation. Equivalent schemes. Torque of the asynchronous machine. Characteristics and diagram of the asynchronous machine. Engine/generator operation, starting, braking. Deep slot and double cage motors, Single-phase asynchronous motors.

Chapter 4: Direct current machines (4 weeks)

Structure of direct current machines. Equations of DC machines. Modes for starting, braking and speed adjustment of DC motors.Switching phenomena. Saturation and armature reaction. Auxiliary switching poles. Engine/generator operation.

Evaluation method:

Continuous monitoring: 40%; Examination: 60%.

Bibliographic references:

1. *J.-P. Caron, JP Hautier: Modeling and control of the asynchronous machine, Technip, 1995.*
2. *G. Grellet, G. Clerc: Electric actuators, Principles, Models, Controls, Eyrolles, 1996*.
3. J. Lesenne, F. Notelet, G. Séguier: Introduction to in-depth electrical engineering, Technique and Documentation, 1981.
4. Paul C. Krause, Oleg Wasyzczuk, Scott S, Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley, Second Edition, 2010.
   PS Bimbhra, “Generalized Theory of Electrical Machines”, Khanna Publishers, 2008.
5. AE, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, “Electric Machinery”, Tata McGraw Hill, 5th Edition, 1992

Semester: 1
Fundamental EU Code: UEF 1.1.2
Matter:Applied numerical methods and optimization
VHS: 45h (Class: 1h30, tutorial 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The objective of this course is to present the tools necessary for numerical analysis and optimization, with or without constraints, of physical systems, in the field ofengineering.

Recommended prior knowledge:

Mathematics, programming, mastery of the MATLAB environment.

Material content:

Chapter I: Reminders on some numerical methods (3 weeks)

- Resolution of nonlinear systems of equations by iterative methods.
- Digital integration and differentiation.
- Methods for solving ordinary differential equations (ODE): Euler methods; Runge-Kutta methods; Adams method.
- System resolutionEDO.

Chapter II: Partial Differential Equations (PDE) (6 weeks)

- Introduction and classifications of partial differential problems and boundary conditions;
- Methods for solving PDEs: Finite difference method (FDM); Finite Volume Method (FVM); Finite element method (FEM).

Chapter III: Optimization techniques (6 weeks)

- Definition and formulation of aoptimization problems.
- Single and multiple optimization with or without constraints.
- Optimization algorithms without constraints (deterministic methods, stochastic methods).
- Treatment of constraints (Transformation methods, Direct methods).

Evaluation method:

Continuous monitoring: 40%; Examination: 60%.

Bibliographic references:

1. *G.Allaire, Numerical Analysis and Optimization, Edition of the polytechnic school, 2012*
2. *SS Rao, 'Optimization – Theory and Applications', Wiley-Eastern Limited, 1984*
3. *A. Fortin, Numerical analysis for engineers, Presses Internationales Polytechnique, 2011.*
4. *J. Bastien, JN Martin, Introduction to numerical analysis: Application under Matlab, Dunod, 2003.*
5. *A. Quarteroni, F. Saleri, P. Gervasio, Scientific computing, Springer, 2008.*
6. *TA Miloud, Numerical methods: Finite difference method, integral and variational method, University Publications Office, 2013.*
7. *JP Pelletier, Numerical techniques applied to scientific computing, Masson, 1982.*
8. *F. Jedrzejewski, Introduction to numerical methods, springer, 2001.*
9. *P. Faurre, Numerical analysis, optimization notes, Ecole polytechnique, 1988.*
10. *Fort. Numerical analysis for engineers, international polytechnic presses, 2011.*
11. *J. Bastien, JN Martin. Introduction to numerical analysis: Application in Matlab, Dunod, 2003.*
12. *Quarteroni, F. Saleri, P. Gervasio. Scientific computing, Springer, 2008.*

Semester: 1
Methodological EUCode: UEM 1.1
Matter:TP: - µ-processors and µ-controllers
VHS: 15h (TP: 1h)
Credits: 1
Coefficient: 1

Teaching objectives

Know assembly programming. Know the principle and execution steps of each instruction. Understand the use of I/O interfaces and interrupts. Use of the microcontroller (programming, system control).

Recommended prior knowledge

Combinatorial and sequential logic, industrial automation, algorithms.

Content of the subject

TP1: Getting started with a programming environment on a µ-processor (1 week)
TP2: Programming arithmetic and logic operations in a µ-processor
(1 weeks)
TP3: Use of video memory in a µ-processor (1 week)
TP4: Management of µ-processor memory. (2 weeks)
TP5: Control of a stepper motor by a µ-processor (2 weeks)
TP6: Screen management (1 week)
TP7: Programming the PIC µ-microcontroller (2 weeks)
TP8: Control of a stepper motor by a PIC µ-microcontroller (2 weeks)

Evaluation method:

Continuous control: 100%.

Bibliographic references:

1. R. Zaks and A. Wolfe. From component to system – Introduction to microprocessors. Sybex, Paris, 1988.
2. M. Tischer and B. Jennrich. The PC bible – System programming. Micro Application, Paris, 1997.
3. R. Tourki. The PC computer – Architecture and programming – Courses and exercises. University Publication Center, Tunis, 2002.
4. H. Schakel. Programming in assembler on PC. Micro Application, Paris, 1995.
5. E. Pissaloux. Practice of the I80x86 assembler – Courses and exercises. Hermès, Paris, 1994

Semester: 1
Methodological EUCode: UEM 1.1
Matter:TP Electrical energy transport and distribution networks
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

Allow the student to have all the necessary tools to manage, design and operate electro-energy systems and more particularly electrical networks

Recommended prior knowledge:

General information on electrical transmission and distribution networks

Material content:

TP No. 1: Voltage adjustment by synchronous motor
TP No. 2: Power distribution and calculation of voltage drops
TP No. 3: Voltage adjustment by reactive energy compensation
TP No. 4: Neutral regime
TP No. 5: Interconnected Networks

Evaluation method:

Continuous control: 100%.

Bibliographic references:

1. Sabonnadière, Jean Claude, Electric lines and networks, Vol. 1, Electric Power Lines, 2007.
2. Sabonnadière, Jean Claude, Electric lines and networks, Vol. 2, Methods for analyzing electrical networks, 2007.
3. Lasne, Luc, Exercises and problems in electrical engineering: basic notions, networks and electrical machines, 2011.
4. J. Grainger, Power system analysis, McGraw Hill, 2003
5. WD Stevenson, Elements of Power System Analysis, McGraw Hill, 1998.

Semester: 1
Methodological EUCode: UEM 1.1
Matter:Advanced power electronics TP
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

Allow the studentto understand the operating principles of new power electronics converter structures.

Recommended prior knowledge:

Basic principle of power electronics

Material content:

TP1: New converter structures
TP2: Improvement of the power factor;
TP3: Elimination of harmonics
TP4: Static reactive power compensators

Evaluation method:

Continuous control: 100%;

Bibliographic references:

1. GuySéguier and Francis Labrique, "Power electronics converters – volumes 1 to 4"
2. Ed. Lavoisier Tec and very rich documentation available in the library. - Website: "Courses and Documentation"
3. Valérie Léger, Alain Jameau Energy conversion, electrotechnics, power electronics. Course summary, problems corrected", ,: ELLIPSES MARKETING

Semester: 1
Methodological EUCode: UEM 1.1
Matter:TPApplied numerical methods and optimization
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

Program numerical solution methods and those associated with optimization problems.

Recommended prior knowledge:

Algorithmic and programming.

Material content:

- Initialization to the MATLAB environment (Introduction, Basic aspects, comments, vectors and matrices, M-Files or scripts, functions, loops and control, graphics, etc.). (01 week)

- Write a program for:
    - ❖ Calculate the integral by the following methods: Trapezoid, Simpson and general; (01 week)
    - ❖ Solve equations and systems of ordinary differential equations using the different Euler, Runge-Kutta methods of order 2 and 4 (02 weeks)
    - ❖ Solve systems of linear and non-linear equations: Jacobi; Gauss-Seidel; Newton-Raphson; (01 week)
    - ❖ Solve PDEs using MDF and MEF for the three (03) types of equations (Elliptic, parabolic and elliptic); (06 weeks)
    - ❖ Minimize a function with several variables without constraints (02 weeks)
    - ❖ Minimize a multivariable function with constraints (inequalities and equalities). (02 weeks)

Evaluation method: Continuous control: 100%;

Bibliographic references:

1. G.Allaire, Numerical Analysis and Optimization, Edition of the polytechnic school, 2012
2. Computational methods in Optimization, Polak, Academic Press, 1971.
3. Optimization Theory with applications, Pierre DA, Wiley Publications, 1969.
4. Taha, HA, Operations Research: An Introduction, Seventh Edition, Pearson Education Edition, Asia, New Delhi, 2002.
5. SS Rao, “Optimization – Theory and Applications”, Wiley-Eastern Limited, 1984.

Semester: 1
Methodological EUCode: UEM 1.1
Matter:TPIn-depth electrical machines
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives:

Complete, consolidate and verify the knowledge already acquired in the course.

Recommended prior knowledge:

Good command of IT tools and MATLAB-SIMULINK software.

Material content:

1. Electromechanical characteristics of the asynchronous machine;
2. Circle diagram;
3. Asynchronous generator autonomous operation;
4. Coupling of an alternator to the network and its operation with the synchronous motor;
5. Determination of the parameters of a synchronous machine;

Evaluation method:

Continuous control: 100%

Bibliographic references:

1. *Th. Wildi, G. Sybille "electrotechnics", 2005.*
2. *J. Lesenne, F. Noielet, G. Seguier, "Introduction to in-depth electrical engineering" Univ. Lille. nineteen eighty one.*
3. *MRetif "Vector Control of asynchronous and synchronous machines" INSA, Pedg course. 2008.*
4. *R. Abdessemed "Modeling and simulation of electrical machines" ellipses,2011.*

Semester: 1
Teaching unit: UED 1.1
Matter :Subject 1 of your choice
VHS: 10:30 p.m. (class: 1h30)
Credits: 1
Coefficient: 1

Semester: 1
Teaching unit: UED 1.1
Matter :Subject 2 of your choice
VHS: 10:30 p.m. (class: 1h30)
Credits: 1
Coefficient: 1

Noticed:
It is possible for the specialty team to freely choose two discoveries among those offered or choose other discovered subjects according to the needs and interest of the training..

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

Teaching objectives:

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

Recommended prior knowledge:

Basic English vocabulary and grammar

Material content:

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

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

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

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

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

Evaluation method:

Review: 100%.

Bibliographic references:

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

III - Detailed program by subject of the S2 semester

Semester: 2
Fundamental EU Code: UEF 1.2.1
Matter:Modeling and optimization of electrical networks
VHS: 45h (Class: 1h30, Tutorial: 1h30)
Credits:4
Coefficient:2

Teaching objectives

At the end of this subject the student will be able to model an electrical network, to calculate power flow, to calculate fault currents, to deal with the problem of optimal calculation of the power of the prediction of the state of a network.

Recommended prior knowledge

Fundamental electrical engineering, - Electric energy transport and distribution networks. Matrix Calculation (Numerical Methods)

Content of the subject

I. Basic modeling of electrical networks **3 weeks**

Reminder on (Representation of sinusoidal signals, Modeling of the elements of the electrical network (Source, Line, Transformer, Load), System of relative units).
Graph theory applied to electrical networks, Algorithm for forming admittance and impedance matrices of an RE, - Modification and inversion of the admittance matrix, Sparse matrix techniques.

II. Calculation of fault currents **3 weeks**

Reminder (Symmetrical components, Short circuit analysis: Thevenin equivalent circuit), Symmetrical and asymmetrical short-circuit currents of a large network, Fault voltages, Fault currents in lines, generators and motors, Readjustment of voltage phase shift, Calculation of short-circuit power, Algorithm for calculating fault currents.

III. Power flow **3 weeks**

Introduction,
Load distribution equations,
Numerical methods applied for the resolution of the flow of charges (Gauss-Seidel, Newton Raphson, Fast decoupled method, others…, Algorithms and examples)

IV. Optimal distribution of power flow **3 weeks**

Introduction, Nonlinear optimization function, Cost characteristics -Production,
Numerical methods applied to a network without constraints and with constraints
Economic calculation of power without losses, Economic calculation of power with losses.

V. Estimation of the state of an electrical network **3 weeks**

Measurements of P, Q, I and V,
Methods applied for the Estimation of the state of an electrical network, Detection and identification of bad measurements, Observability of the network and pseudo-measurements, Taking into consideration power flow constraints.

Evaluation method:

Continuous control: 40%; Exam: 60%.

Bibliographic references

8. *F. Kiessling et al, 'Overhead Power Lines, Planning, design, construction'. Springer, 2003.*
9. *T. Gonen et al, 'Power distribution', book chapter in Electrical Engineering Handbook. Elsevier Academic Press, London, 2004.*
10. *E. Acha and VG Agelidis, 'Power Electronic Control in Power Systems', Newns, London 2002.*
11. *TuranGönen: Electric power distribution system engineering. McGraw-Hill, 1986*
12. *TuränGonen: Electric power transmission system engineering. Analysis and Design. John Wiley & Sons, 1988*

Semester:2

Fundamental EU Code: UEF 1.2.1
Matter :Quality of electrical energy
VHS: 45h (Class: 1h30, Tutorial: 1h30)
Credits:4
Coefficient:2

Teaching objectives

The objective of the subject is to study the quality of electrical energy in an electrical network through the degradation of voltage and/or current, disturbances on electrical networks. It is also a question of understanding how non-linear loads can be incriminated. Study solutions to improve the quality of electrical energy by remedying disturbances by preventing them from occurring when possible or by mitigating them when they are unavoidable.

Recommended prior knowledge

Fundamental electrical engineering. Power Electronics.

Content of the subject

I. Introduction to the concepts of energy quality (2 weeks)

II. Degradation of power quality (6 weeks)

a. Distortion of the voltage and current wave: voltage dips, fluctuations, harmonic distortions.
b. Origins of the degradation of energy quality: Non-linear loads, network faults, special loads.
c. Characterization of wave deformations: Reminder of the frequency decomposition of a non-sinusoidal periodic signal. Electrical quantities in the presence of non-sinusoidal signals (effective value, instantaneous powers, average powers, power factor and Joule losses, etc.).
d. Effects of energy quality degradation: Instantaneous and long-term effects on the network and loads.

III. Standards in force: IEC and IEEE standards concerning the emission of harmonics at low and medium voltage (2 weeks)

has. Reminder on the frequency decomposition of a non-sinusoidal periodic signal.
b. Effective value, instantaneous powers, average powers, power factor and Joule losses.

IV. Solutions for improving energy quality (5 weeks)

has. Preventive solutions: Network reinforcement, modification of load characteristics (sinusoidal sampling loads).
b. Corrective solutions: Passive filtering (choice and calculation of passive filters), Active filtering (choice and calculation of active filters).
vs. Solutions to minimize imbalances and outages

Evaluation mode

Continuous assessment: 40%, Examination: 60%.

Bibliographic references

1. *GJ WAKILEH, 'Power system harmonics-Fundamental Analysis and Filter Design', Springer-Verlag, 2001.*
2. *Roger C. Dugan, Mark F. Granaghan, 'Electrical Power system Quality', McGraw Hill, 2001*
3. *Energy quality – Course by Delphine RIU – INP Grenoble*
4. *Scheider technical notebooks No. CT199, CT152, CT159, CT160 and CT1*

Semester: 2
Fundamental EU Code: UEF 1.2.1
Matter :Centralized and decentralized production
VHS: 10:30 p.m. (Class: 1h30)

Credits: 2
Coefficient: 1

Teaching objectives

This course aims to present the fundamental evolution of energy systems induced by the energy transition which is a decentralization of these systems.

Recommended prior knowledge

Principle of eclectic energy production

Content of the subject

Chapter I: General electricity production techniques (3 weeks)
Sources of electrical energy, conventional power plants (thermal and nuclear),
Systems, management and performance service.

Chapter II: Decentralized electricity production (PD) (3 weeks)
Energy and environmental context, decentralized production technologies (conventional sources, new and renewable sources (geothermal, small hydro, biomass, micro cogeneration, solar and wind)), advantages.

Chapter III: Connection of the PD to the electrical network (5 weeks)
PD connection conditions in the electrical system, regulatory and organizational aspects of PD development, technical aspects of connection to MV networks, interactions between PD and electrical network and the standards in force.

Chapter IV: Microgrids with integration of renewable energies (4 weeks)
Concept of microgrids, advantages of microgrid deployment, technical and economic challenges, modes of operation (connected/disconnected) of the network, structures (centralized/decentralized) and control architectures, intelligent management of energy flow, electrical energy storage strategies.

Evaluation method:

Review: 100%.

Bibliographic references:

1. N. Hadjsaïd, "Distribution of electrical energy in the presence of decentralized production", Hermès edition, 2010.
2. R. Caire, "Decentralized Production and distribution networks", European University Editions EUE, 2010.
3. B. Multon, "Production of Electric Energy by Renewable Sources", Engineering Techniques, Electrical Engineering treatise, D4, 2003.
4. A. Maczulak, 'Renewable Energy: Sources and Methods', Green technology, 2010.
5. N. Hatziargyriou, "Microgrids: Architectures and Control", Wiley-IEEE Press, 201**4**.

Semester:2
Fundamental EU Code: UEF 1.2.2
Matter :Planning of electrical networks
VHS: 45h (Class: 1h30, tutorial 1h30)
Credits:4
Coefficient:2

Teaching objectives

This course allows students to know how to anticipate the future needs of the electrical system in terms of lines, stations and production units in order to satisfy the growing demand for electrical energy in an optimal manner from a technical-economic point of view. while respecting constraints.

Recommended prior knowledge

Electric energy transport and distribution networks, - Applied numerical methods and optimization.

Content of the material:

Part 1 Distribution network planning

Chapter 1: Costs and reliability indices in electricity networks (2 weeks)

Cost of transformer stations, cost of a feeder system, maintenance and operating cost, discounted cost of electrical losses, cost of a connection, reliability indices (SAIFI, SAIDI, etc.).

Chapter 2 : Planning for the expansion of distribution networks (3 weeks)

Procedure for planning MV and LV distribution networks,planning horizons, constraints to be respected, choice of the optimal solution, planning of distribution networks in the presence of decentralized production.

Part 2 Planning of the production-transport system

Chapter 1 : Long-term electrical load forecast(2 weeks)

Main determining factors of electricity demand, long-term electricity load forecasting methods (trend analysis, econometric models, end-use approach, etc.)

Chapter 2 : Planning for production expansion(2 weeks)

Planning of production expansion with a single access (problem description, expressions of costs and constraints to be satisfied, problem formulation), planning of production expansion with multiple accesses.

Chapter 3: Planning for job expansion(2 weeks)

Description of the problem, expressions of costs and constraints to satisfy, formulation of the problem.

Chapter 4: Planning for transportation network expansion(2 weeks)

Description of the problem, expressions of costs and constraints to satisfy, formulation of the problem.

Chapter 4: Reactive power planning (2 weeks)

Description of the problem, expressions of costs and constraints to satisfy, formulation of the problem.

Evaluation method:

Continuous assessment: 40%, Examination 60%

Bibliographic references:

1. D4210 Distribution networks Structure and Planning by Philippe CARRIVE
2. D 4240 Operation of distribution networks: computer systems by Marc LECOQ and Robert MICHON
3. D 4070 electrical energy transport and interconnection networks, development and planning. By François MESLIER and Henri PERSOZ.
4. Planning of electrical networks¨, Edition EDF, EYROLS collection
5. Technical rules for connection to the electricity transmission network and rules for operating the electrical system, by Ministry of Energy and Mines, 2008

Semester:2
Fundamental EU Code: UEF 1.2.2
Matter:Control of electro-energetic systems
VHS: 45h (Class: 1h30, Tutorial: 1h30)
Credits:4
Coefficient:2

Teaching objectives

- Know the different electrical actuation systems (motor + power electronics)
- Know the different types of electric actuator control.
- Be able to establish a simulation model of an electrical system including motor, power electronics and control
- Be able to simulate a model in the Matlab/Simulink environment
- Be able to adjust the PI correctors present in the motor servos using a suitable method

Recommended prior knowledge

Electrical machines, machine modeling, power electronics, notions of mechanics, control and regulation.

Content of the material:

1. **Reminders** **(1 week)**
   (Use of electrical systems, Laws of electrical circuits, Laws of magnetostatics).
2. **Static converters** **(3 weeks)**
   (General information on modeling, Rectifier, Chopper, Inverter).
3. **The DC motor** **(3 weeks)**
   (Modeling, Power supply with chopper, Current control, Speed control, Position control).
4. **The three-phase synchronous machine** **(2 weeks)**
   (Structure, Modeling, Vector control).
5. **The three-phase asynchronous motor** **(2 weeks)**
   (Modeling, Oriented rotor flow (FRO or FOC), Direct torque control (DTC)).
6. **The variable reluctance motor** **(2 weeks)**
   (Principle, Power supply, Field of use).
7. **The piezoelectric motor** **(2 weeks)**
   (Principle, Characteristics)

Evaluation mode

Continuous monitoring: 40%; Examination: 60%.

Bibliographic references

1. *J.-P. Caron, JP Hautier: Modeling and control of the asynchronous machine, Technip, 1995.*
2. *G. Grellet, G. Clerc: Electric actuators, Principles, Models, Controls, Eyrolles, 1996*.
3. J. Lesenne, F. Notelet, G. Séguier: Introduction to in-depth electrical engineering, Technique and Documentation, 1981.
4. Paul C. Krause, Oleg Wasyzczuk, Scott S, Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley, Second Edition, 2010.
5. PS Bimbhra, “Generalized Theory of Electrical Machines”, Khanna Publishers, 2008.
6. AE, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, “Electric Machinery”, Tata McGraw Hill, 5th Edition, 1992

Semester:2
Methodological EUCode: UEM 1.2

Matter:Electrical network protection techniques

VHS: 37h30 (Class: 1h30; TP: 1h)

Credits:3

Coefficient:2

Teaching objectives

The objective of the course is the study of the organization of the protection of electrical networks, disturbances of measurement techniques. The student must know how to do fault detection and how to protect elements of the electrical network and how to coordinate the protection.

Recommended prior knowledge

Electrical networks, fundamental electrotechnics.

Content of the subject

I. General information on faults in electrical power transmission lines

II. Components of a protection system: Instrument transformers,Power relay, Time relay, Intermediate relay, Executing body (circuit breaker)

III. Functions and Principles of Protection:
-The different protection functions and their codes, -Principle of selectivity
-Different types of discrimination, - Protection zones

IV. LV and HT protection plans

V. System protection
- Protection of a simple radial network (protection with simple discriminations)
- Protection of a two-source network (directional protection)
- Line protection (differential protection, distance protection)
- Protection of busbars (differential protection), - Protection of transformers (differential protection), - Protection of generators.

VI. Basic properties of protection elements: Electromagnetic principle elements, Semiconductor elements, Analog principle, Microprocessor elements

VII. Digitally controlled control: Digital relays, Digital distance relays, Digital differential relays

VIII. Digital relays: Block diagram of a digital relay, Multiplexing, Analog/digital conversion, Algorithms for evaluating phase quantities, Microprocessor, Control of switching devices

IX. Protection against overvoltages (spark gaps, grounding cables and surge arresters)

Content of the practicals

TP1: Overcurrent protection, Reverse time relay
TP2: Directional protection, directional relay
TP3: Over/under voltage protection, over/under voltage time delay relay
TP4: Optimization of overcurrent protection

Evaluation method:

Continuous monitoring: 40%; Examination: 60%.

Bibliographic references

6. P. Kundur, “Power System Stability and Control”, McGraw-Hill, 1993.
7. Protective Relaying for Power System II Stanley Horowitz, IEEE press, New York, 2008
8. TSM Rao, Digital Relay / Numerical relays, Tata McGraw Hill, New Delhi, 1989
9. YG Paithankar and SR Bhide, “Fundamentals of Power System Protection”, Prentice-Hall of India, 2003

Semester:2

Methodological EUCode: UEM 1.2

Matter:TPModeling and optimization of electrical networks

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

Credits:2

Coefficient: 1

Teaching objectives

The objective of the subject is the creation of programs for the modeling and analysis of electrical networks in steady state.
The programs to be developed, in the case of power flow and calculation of fault currents, allow the calculation of the voltages at the access points as well as the currents and powers passing through the network elements. In the case of Economic Dispatching, the program calculates optimal production to minimize costs and finally the state estimation program will make it possible to estimate the state of an electrical network using optimization techniques.

Recommended prior knowledge

Fundamental electrical engineering
Electric energy transmission and distribution networks

Content of the subject

TP 1: Modeling of transmission line parameters.
TP2: Construction of busbar admittance and impedance matrices
TP 3: Power flow modeling using the Gauss-seidel algorithm
TP4: Power flow modeling using the Newton-Raphson algorithm
TP 5: Calculation of faults on an electrical network
TP 6: Economic dispatch

Evaluation mode

Continuous control: 100%.

Bibliographic references

6. GöranAndersson, "Modelling and Analysis of Electric Power Systems", ETH Zürich, 2008
7. R. Natarajan, Computer-Aided Power System Analysis, Marcel Dekker, 2002.
8. AR Bergen and V. Vittal: Power System Analysis, Prentice-Hall, 2000.
9. H. Saadat: Power System Analysis, McGraw-Hill, 1999.
10. WILLIAM D. STEVENSEN, "Elements of power system analysis", Edition (Dunod, Paris, 1999).
11. BM Weedy and BJ Cory: Electric Power Systems, John Wiley & Sons, 1998.
12. J. Arrillaga, CP Arnold, "COMPUTER ANALYSIS OF POWER SYSTEMS", University of Canterbury, Christchurch, New Zealand, JOHN WILEY & SONS, 1990.

Semester:2
Methodological EUCode: UEM 1.2
Material: TP Quality of electrical energy
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits:2

Coefficient: 1

Teaching objectives

The objectives of the subject are:
1. Measurement of harmonic distortions of voltage and current in the presence of polluting loads.
2. Simulate the different means of mitigating harmonics.

Recommended prior knowledge

Matlab/Simulink software, Fundamental electrical engineering, Frequency analysis, resonant circuits.

Content of the subject

TP 1: Simulation of usual non-linear loads (current and voltage measurement, harmonic spectra, power).
TP 2: Propagation of harmonics in an electrical network.
TP 3: Improvement in wave quality by sinusoidal sampling structures.
TP 4: Improvement in wave quality through passive filtering.
TP 5: Improvement in wave quality through active filtering (demonstration TP).

Evaluation mode

Continuous control: 100%.

Bibliographic references

1. *GJ WAKILEH, 'Power system harmonics-Fundamental Analysis and Filter Design', Springer-Verlag, 2001.*
2. *Roger C. Dugan, Mark F. Granaghan, 'Electrical Power system Quality', McGraw Hill, 2001*
3. *Energy quality – Course by Delphine RIU – INP Grenoble*
4. *Scheider technical notebooks No. CT199, CT152, CT159, CT160 and CT1*

Semester:2
Methodological EUCode: UEM 1.2
Matter:TP Control of electro-energetic systems
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits:2

Coefficient: 1

Teaching objectives

The objectives of the subject are to understand and be able to:
Build the block diagram of direct current and alternating current machines powered by static converters using Simulink software under Matlab.
- Control the speed of a direct current machine by static converter and by four-quadrant chopper,
- Perform vector control with oriented rotor flow of the MAS as well as autopilot of the synchronous machine

Recommended prior knowledge

Electrical machines, machine modeling, power electronics, notions of mechanics, control and regulation.

Subject content

TP1: Speed variation of a direct current machine by converter by rectifier and series chopper.
TP2: Speed variation of a direct current machine using a four-quadrant chopper
TP3: V/f control of the asynchronous machine,
TP4: Scalar control of the MAS current,
TP5:MAS oriented rotor flux vector control
TP6: Autopilot of the synchronous machine

Evaluation mode

Continuous control: 100%;

Bibliographic references

1. *Industrial electrical engineering, Guy Séguier and Francis Notelet, Tech et Doc, 1994*
2. *Power electronics, Guy Séguier, Dunod, 1990*
3. *Modeling and control of the asynchronous machine, JP Caron and JP Hautier, Technip, 1995*
4. *Control of Electrical Drives, W. Leonard, Springer-Verlag, 1996*
5. *Vector control of AC machines, Peter Vas, Oxford university press, 1990*
6. *Control of variable speed machines, Engineering Techniques, vol D3.III, n°3611, 1996*
7. *Electric actuators, Guy Grellet and Guy Clerc, Eyrolles, 1997*

Semester: 2
Teaching unit: UED 1.2
Matter :Subject 3 of your choice
VHS: 10:30 p.m. (class: 1h30)
Credits: 2
Coefficient: 1

Semester: 2
Teaching unit: UED 1.2
Matter :Subject 4 to choose from
VHS: 10:30 p.m. (class: 1h30)
Credits: 1
Coefficient: 1

<u>Noticed</u>:
It is possible for the specialty team to freely choose two discoveries among those offered or choose other discovered subjects according to the needs and interest of the training.

Semester: 2
Teaching unit: UET 1.2
Subject: Respect forstandards and rules of ethics and integrity.
VHS: 10:30 p.m. (Class: 1h30)
Credit: 1
Coefficient: 1

Teaching objectives:

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

Recommended prior knowledge:

Ethics and professional conduct (the foundations)

Content of the material:

A.The respect of the rulesethics and integrity,

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

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

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

B- Intellectual property

I- Fundamentals of intellectual property

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

II- Copyright

1. **Copyright in the digital environment**

Introduction. 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 site law. Intellectual property and social networks.

3. Patent

Definition. Rightsin a patent. Usefulness of a patent. Therepatentability. Patent applicationin Algeria and around the world.

III- Protection and valorization of intellectual property

How to protect intellectual property. Violation of rights and legal tool. Vvaluation of intellectual property. Protection of intellectual propertyin Algeria.

C. Ethics, sustainable development and new technologies

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

Evaluation method:

Review: 100%

Bibliographic references:

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

III - Detailed program by subject of the S3 semester

Semester: 3
EU Fundamental Code:UEF2.1.1
Matter :Operation of electrical networks
VHS: 45h00 (Class: 1h30, tutorial 1h30)
Credits: 4
Coefficient: 2

Teaching objectives

The objective of the course is to deal with the functions and computer architecture of the control centers of the transport and distribution networks of electrical energy: role of the control centers; real-time aspects; architecture; data acquisition and remote control; network state estimation and prediction; centralized settings; optimization; reliability and security; exchanges of information between applications and between control centers.

Recommended prior knowledge:

Electricity transmission and distribution networks

Content of the subject

Chapter I. General information on the "production-transport-Distribution" system 1 week

Electrical system, Constitution of the electrical system, Direct current Alternating current, Transport of electrical energy, Structure of the transport network, High voltage substations, Long-distance power lines,Perspective of direct current transmission, The Algerian electricity system.

Chapter II. Interconnection of transmission networks and voltage quality 2 weeks

Case of two interconnected networks, Case of several interconnected networks, Reasons for interconnections, Advantages of interconnection, Planning of transport and interconnection networks.

Chapter III. Driving the RPT 2 weeks

Control centers, Production-consumption balance, Consumption forecasting and production scheduling, Frequency adjustment, Management of the voltage plan on the transport network, Control of energy transits in a network interconnection.

Chapter IV. Network setting 3 weeks

Frequency adjustment (primary, secondary and tertiary frequency adjustment), Voltage adjustment (primary, secondary and tertiary voltage adjustment), New installations – reference construction capacities.

Chapter V. Data acquisition and remote control 3 weeks

Data acquisition, Remote monitoring of the power system, Control of the power system or remote control, The SCADA system, The different configurations of SCADA systems, Decision support tools, Computerized control systems,

Chapter VI. Power System Safety and Defense Plans 2 weeks

Operational safety of the electrical system, Main degradation phenomena, System safety in normal and exceptional conditions, Management of separate networks - Reconstitution of the network, Operation in exceptional conditions and support of the network, Maintaining the effectiveness of the means of backup and defense.

Evaluation method: Continuous assessment: 40%exam 60%

Bibliographic References:

1. VIRLOGOUS, "Telecontrol systems for electrical substations", Engineering Techniques, D4850, 1999.
2. Pierre BORNARD, "Management of a production-transport system",Engineering Techniques, D4080, 2000.
3. Gwilherm POULLENNEC, "Discovering the electrical system", Ecole des Mines de Nantes, 2007.
4. RTE, "User contribution to RPT performance", Electricity Transmission Network, 2014

Semester: 3

EU Fundamental Code:UEF2.1.1
Matter:Stability and dynamics of electrical networks
VHS: 45h (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives

- Understand the physics of transient phenomena with a view to limiting their importance and effects
- Master the transient analysis of an electrical power system and understand the problem of stability.
- Understand the technical and economic aspects of adjusting the frequency and amplitude of the voltage.
- To enable the student to develop different security strategies using power flow calculation software and the study of transient and long-term stability.

Recommended prior knowledge:

- Electric transport and distribution networks
- Simulation of electrical networks
- Power electronics.

Content of the subject

I.1. Concepts and definitions;

1.1. Electromechanical transient regimes,
1.2. Electromagnetic transient regimes,
1.3. Elements of the machine-system connection,
1.4. Notions of stability: static, dynamic…

II. Calculation of transient regimes of lines using Laplace and moving wave methods
III. Stability of electrical networks
III.1 Definitions and classification of electricity network stability

- Frequency Stability
- Voltage stability
- Angular stability

III.2 Methods for analyzing the stability of electrical networks
IV. Detailed study of a single-machine system

IV.1. Development of the stability equation
IV.2. Analysis by the equal area criterion method
IV.3. Analysis by numerical methods
IV.4. Overview of a multi-machine system case
V. Stability Improvement Methods: PSS, SVC, TCSC and TCPST

Evaluation method:

Continuous assessment: 40%exam 60%

Bibliographic References:

1.M.Grappe "Stability and safeguarding of electrical networks", Edition HERMES, 2003
2. Yoshihide Hase, Power Systems engineering, British Library Cataloging in Publication Data, USA
3. ARIEH L. SHENKMAN, Transient analysis of electric power circuit hand book, Holon Academic Institute of Technology, Springer revue, Netherlands, 2005.
4. Electric Power Generation, Transmission, and Distribution, Leonard L. Grigsby, University ofCalifornia, Davis, 2006.
5.Recent Advances in Power Systems, Select Proceedings of EPREC-2021, Om Hari Gupta · Vijay Kumar Sood · Om P. Malik Editors, Springer, 2022.
6.Voltage Stability Analysis of Power System, Yong Tang, 2020.
7.B. De Metz-Noblat, G. Jeanjean, Dynamic stability of industrial electrical networks Schneider technical notebook n° 185, 1997.

Semester: 3
EU Fundamental Code:UEF2.1.1

Matter:RIntelligent electricity networks
VHS: 10:30 p.m. (Class: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives

This course aims to present the development of the intelligent electricity network of tomorrow, which is at the same time communicative, interactive and multidirectional thanks to the use of new information and communication technologies.

Recommended prior knowledge:

Concepts on the operation of the electrical network

Content of the subject

Chapter I: Introduction to smart electricity networks "Smart Grids"

I-1 Definition, Causes of their emergence, Expected benefits, Impacts and obstacles, I-2 Intelligent systems technology, I-3 Structural transformation of the electricity system following its provision of ICT, I-4 Reorganization of the company,

Chapter II: Socio-economic issues of smart electricity networks,

II-1 Opening of electricity markets, Pricing, II-2 Regulation, legislation and regulation (standards, directives, compliance));II-3 Industrial standards and practices,

Chapter III: Adaptation of energy systems

III-1 Diversity of renewable resources and particularities; III-2 Exploitation of variable renewable energies, III-2 Valorization of variable energies, III-4 Storage strategies

Chapter IV: Management and control of electrical networks

IV-1 The contribution of intelligent systems: control of energy demand, management of consumption peaks "the Consumption-actor", management and flexibility of demand, crisis management (blackout); IV-2 Smart metering (meter intelligent, or communicative),IV-3 Line carrier currents

Chapter V: Service developments linked to intelligent systems

V-1 Growth of the ICT industry, V-2 Research and development; V-3 IT security; V-4 Techno-economic calculation and decision criteria (Manager-consumer).

Evaluation method:100% review

Bibliographic References:

1. N. Simoni, "From intelligent networks to the new generation of services", Hermès, 2007
2. RC Dugan, MFMcGranaghan, S. Santoso, HW Beaty, 'Electrical Power Systems Quality', McGraw Hill Companies, 2004.
3. S. Znay, MP Gervais, "Intelligent networks", Hermès edition, 1997

Semester: 3
EU Fundamental Code:UEF2.1.2
Matter :Iintegration of renewable resources into electricity networks
VHS: 45h00 (Class: 1h30, tutorial 1h30)
Credits: 4
Coefficient: 2

Teaching objectives

Renewable resources have very interesting potential contributions in terms of energy and economy. However, depending on their penetration rate, these new energy sources could have significant consequences on the operation and security of electricity networks. For a massive insertion of renewable resources into the system, these impacts will not only be at the distribution network level, where most renewable resources are connected, but they will affect the entire system. It is therefore necessary to seek, on the one hand, how to evolve the defense and reconstitution plans of the system in the new context, and on the other hand, how to effectively use the potential of renewable resources to support the system in the critical situations.

Recommended prior knowledge:

Structure of electrical networks, Renewable energies

Content of the subject

Chapter I: Renewable energies in electricity networks

- Description, exploitation and quality of electrical energy; - Analysis of power systems (Frequency balancing control, - Voltage control, calculation of power flows, reactive power management, etc.), - Connection to the electrical network of decentralized production;

Chapter II: Impacts of the integration of renewable resources on the distribution network

Direction of power transit; - Voltage profile (slow voltage variations, voltage surges, flicker, harmonics, disturbances of signals transmitted on the network, etc.);
- System stability; - Protection plan (Normal and exceptional regime resistance, Voltage dip resistance, Interaction with the protection plan); - Observability and Controllability of the system;
- Continuity and quality of service.

Chapter III: Impacts of the integration of renewable resources on the transport network

Uncertainty in the planning phase; - Need to strengthen the network;
- Uncertainty about the operating reserve margin; - Sensitivity linked to the management of the reagent;
- Sensitivity linked to the untimely triggering of decentralized production;

Chapter IV:Procedures for restoring the electrical system

- Islandage; Use of fast electronic power controllers (FACTS); - Design of control algorithms; - Modern telecommunications and information systems; -Automatic fault detection; etc.

Evaluation method: Continuous assessment: 40%, Examination: 60%

Bibliographic references:

1. B. Multon, “Production of Electric Energy by Renewable Sources”, Engineering Techniques, Electrical Engineering treatise, D 4, 2003.
2. L. Freris, D. Infield, 'Renewable Energies for Electricity Production', Dunod, 2013
3. D. Das, 'Electrical Power Systems', New Age International Publishers, 2006.
4. Mr.Crappe, S. Dupuis, 'stability and safeguarding of electrical networks', Hermès, 2003.
5. A. Maczulak, 'Renewable Energy: Sources and Methods',Green technology, 2010.

Semester: 3
EU Fundamental Code:UEF2.1.2

Matter :Industrial electrical networks
VHS: 45h00 (Class: 1h30, tutorial 1h30)
Credits: 4
Coefficient: 2

Teaching objectives
The subject aims to give students the necessary knowledge on industrial electrical networks (architectures, diagrams and plans), the calculation of the power balance, energy minimization, choice of electrical conduits, calculation of faults and protection.

Recommended prior knowledge:
General information on electrical networks

Content of the subject
I. Network architectures **2 weeks**
General structure of a private distribution network, The power source, HTB delivery stations, HTA delivery stations, HTA networks and HTB networks inside the site, Industrial networks with internal production.

II. Neutral regimes (RN) **3 weeks**
The different neutral regimes; The influence of RN and earth connection schemes used in LV; Indirect low voltage contact following the RN; Protection, Particularities of RCDs and breaking of the neutral conductor and phase conductors; Influence on the equipment of cutting rules and protection of conductors; Interaction between HT and LV; Comparison of different low-voltage RN-choices; RN used in high voltage.

III. Receivers and their power constraints **1 week**
Disruptions in industrial networks; Remedies to protect against flickering;
Electric motors, 4. Other receivers,

IV. Power Sources **1 week**
Power supply by RDP; Alternators (synchronous generators), asynchronous generators, Advantages and disadvantages; Uninterruptible power supplies (UPS),

V. Power assessment 1 week

V. Overvoltages and insulation coordination **1 week**
Power surges; Surge protection devices; Coordination of insulation in an industrial electrical installation,

VI. Determination of conductor sections **3 weeks**
Determination of conductor sections and choice of LV protection devices;
Determination of MV conductor sections; Calculation of the economic section

VII. Reactive energy compensation **2 weeks**
Benefits of RE compensation, Improvement of cos φ; ER compensation equipment; Location of capacitors; Determination of compensation power in relation to the energy bill; Compensation at the terminals of a transformer; Compensation of asynchronous motors; Optimal compensation; Switching on capacitor banks and protection; Presence of harmonics

Evaluation method: Continuous assessment: 40%exam 60%

Bibliographic References:
1. Denis MARQUET, Didier Mignardot, Jacques SCHONEK, "Guide to electrical installation 2010 - International CEI and French national NF standards", Schneider Electric, 2010
2. Jean Repérant, "Industrial electrical networks – Introduction", Tech. del Ing., D5020, 2001
3. Jean Repérant, "Industrial electrical networks – Engineering", Tech. del Ing., D5022, 2001
4. Dominique SERRE, "LV electrical installations - Electrical protections", Tech. del Ing., D5045, 2006
5. SOLIGNAC (G.). – Guide to electrical engineering of internal factory networks 1076 p.bibl. (30 ref.) lectra Tech & Doc Lavoisier, EDF. Paris, 1985.

Semester: 3
Fundamental EU Code: EMU2.1
Matter:High voltage techniques

VHS: 60 hours (Class: 1h30, TD 1h30, TP 1h00)
Credits: 5
Coefficient: 3

Teaching objectives

The subject aims to master electrical energies both in terms of understanding physical phenomena and in terms of the design and sizing of insulation for high voltage equipment. Also, at the end of this course, the student will be able to master insulation coordination problems in electrical networks.

Recommended prior knowledge:

Notions of fundamental physics and fundamental electrical engineering in particular:Breakdown of solid, liquid and gaseous insulators; lightning ; Insulators

<u>Content of the material:</u>

I. INTRODUCTION

Goals and methodology of HT

II. ISOLATION COORDINATION

II.1. Insulation and insulators,
II.2. Gradation of insulation,
II.3. Grading insulation levels in a network

III. CONTROL OF ELECTRIC FIELDS

III.1. Electric field and shape dependence,
III.2. Electric field control,
III.3. Electric field assessment methods
III.4Corona discharge - Impact on the electricity network

IV. IONIZATION PHENOMENA IN GASES

IV.1. Definitions,
IV.2. Discharge mechanism,
IV.3. Current-voltage characteristics of an electric discharge,
IV.4. Paschen's law,
IV.5. Crown effect

v.HIGH VOLTAGE GENERATORS

AC voltage generators - transformer, cascade transformer, resonant circuit -, DC - HV rectification, Schenkel doubler..., shock generator - Marx generator...

VI. HIGH VOLTAGE MEASUREMENT IN THE LABORATORY

VI.1. Peak value measuring devices,
VI.2. Shock voltage measuring devices,
VI.3. The sphere burster

Practical work on the subject

1.Crown discharge: "Voltage-current" characteristic in positive and negative polarity. Visualization of Trichel pulses (variable electrode radius).
2. Dielectric barrier discharge
3. Direct and alternating high voltage generators
4. Breakdown of liquid and solid insulators
5. Techniques for measuring different types of voltage: alternating voltage, direct voltage, impulse, electric field measurement

Evaluation method: Continuous control: 50%; Review: 50%.

Bibliographic References:

1. E.Kuffel, WS Zanegl, J.Kuffel "High Voltage engineering: Fundamentals", 2nd edition, Edition Newnes, 2006
2. C.Gary "Dielectric properties in air and very high voltages", Editions Eyrolles, 1984
3. M.Aguet, M.Ianovic "Treatise on electricity, Volume XIII: High Voltage", Edition GEORGI, 1982

4. P.Bergounioux “High tension”, Edition Willamblake& Co, 1997
5. J. Arrillaga, “High Voltage Direct Current Transmission”, Peter Pregrinus, London, 1983
6. K. Holtzhausen, W. Vosloo, High Voltage Engineering: Practice and Theory, Kindle Edition, 2021
7. JFAFFOLTER, High voltage, Yverdon-les-Bains, October 2000 [8] C.GARY, Corona effect on overhead electrical networks, engineering techniques, D4440 v1, 1998

Semester: 3
EU Fundamental Code:UEM2.1
Matter :TP Stability and dynamics of electrical networks
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives

The objective of the TP is to provide sufficient knowledge to enable the future electrical engineer to design and dimension the insulation of high voltage equipment and to master the insulation coordination problems in electrical networks that they would be confronted with.

Recommended prior knowledge:

Fundamental physics and electrical networks

Content of the subject

TP1: Transient analysis of 1st order and 2nd order linear circuits
TP2: Study of the transient regime of an electrical line
a) Powering up the uncompensated line when empty
b) Powering up the non-load compensated line
TP3: Series/parallel compensation of a three-phase line
TP4: Dynamic stability simulation of an infinite machine bus system

Evaluation method: Continuous control: 100%

References

1. E.Kuffel, WS Zanegl, J.Kuffel "High Voltage engineering: Fundamentals", 2nd edition, Edition Newnes, 2006
2. C.Gary "Dielectric properties in air and very high voltages", Editions Eyrolles, 1984
3. M.Aguet, M.Ianovic "Treatise on electricity, Volume XIII: High Voltage", Edition GEORGI, 1982
4. P.Bergounioux "High tension", Edition Willamblake& Co, 1997
5. J. Arrillaga, "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1983

Semester: 3
EU Fundamental Code:UEM2.1
Matter :TP Industrial electrical networks
VHS: 10:30 p.m. (TP: 1:30 a.m.)
Credits: 2
Coefficient: 1

Teaching objectives

Recommended prior knowledge:
General information on the stability of electrical networks

Content of the subject

TP1: Calculation and choice of electrical pipes and protection using calculation software
TP2: Grounding Schemes
TP3: Technical – economic optimization of an internal industrial network

Educational visits (Visit to industrial sites)
Mini-project

Evaluation method: Continuous control: 100%

Bibliographic references

1. Denis MARQUET, Didier Mignardot, Jacques SCHONEK, "Electrical installation guide 2010 - International CEI and French national NF standards", Schneider Electric, 2010
2. Jean Repérant, "Industrial electrical networks – Introduction", Tech. del Ing., D5020, 2001
3. Jean Repérant, "Industrial electrical networks – Engineering", Tech. del Ing., D5022, 2001
4. Dominique SERRE, "LV electrical installations - Electrical protections", Tech. del Ing., D5045, 2006
5. SOLIGNAC (G.). – Guide to electrical engineering of internal factory networks 1076 p.bibl. (30 ref.) lectra. Tech.&Doc. Lavoisier, EDF. Paris, 1985.

Semester: 3
Teaching unit: UED2.1
Matter :Subject 5 to choose from
VHS: 10:30 p.m. (class: 1h30)
Credits: 2
Coefficient: 1

Semester: 3
Teaching unit: UED2.1
Matter :Subject 6 to choose from
VHS: 10:30 p.m. (class: 1h30)
Credits: 2
Coefficient: 1

Noticed:
It is possible for the specialty team to freely choose two discoveries among those offered or choose other discovered subjects according to the needs and interest of the training.

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

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

Recommended prior knowledge:
Writing methodology, Presentation methodology.

Content of the subject:

Part I-: Documentary research:

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

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

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

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

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

Part II: Memory Design

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

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

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

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

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

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

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

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

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

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

Evaluation method:

Review: 100%

Bibliographic references:

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

Proposal of some discovery materials

Semester :...
UE Discovery Code: UED....
Matter :Electromagnetic compatibility
VHS: 10:30 p.m. (Class: 1h30)
Credits:1
Coefficient: 1

Teaching objectives

The objective of the course is to apply electromagnetic field theory to problems of electromagnetic pollution of the technological environment. At the end of the course, students will be able to have a global approach to a problem of electromagnetic compatibility between the disruptor and the disturbed, to research all the potential causes of disturbances in a given environment, and to choose a technique optimal protection based on theoretical studies.

Recommended prior knowledge

Basic notions of mathematics, electromagnetism and electrical networks.

Content of the material:

1. Concept of EMC (1 week)
Terminology, context and issues. CEM actors (sources, victims and couplings).

2. Types and mode of coupling (2 weeks)
Coupling types: Conduction, radiation and ionization, (Galvanic, inductive, capacitive).
Coupling modes: differential and common
Calculation methods and measurement methods.

3. Reduction of couplings (2 weeks)
Electromagnetic effect of conductors (resistance, inductance and capacitance); Equivalent coupling circuit. Methods for reducing couplings.

4. Coupled model of transmission lines (2 weeks
Transmission line parameters, solving coupling equations in the time and frequency domains. Coupling with shielded cables.

5. Disturbances generated with power transmission lines (1 weeks)
EM radiation from busbars in LF (in permanent operating mode) and in transient mode (switching on of a line), Risk of disruption of the measuring equipment – control and command.

6. Disturbances generated by electronic circuits (1 weeks)
Transmission by conduction and radiation of transient electrical quantities.

7. Disturbances caused by electrostatic discharges (2 weeks)
Phenomenology, lightning (description of cloud-to-ground lightning, Direct and indirect effects of lightning).

8. EMC protection techniques (1 week)
Ground, shielding, arrangement of components and wiring, mass reduction effect, filtering and protection against overvoltages.

9. EMC Standards (1 week)
Current regulations

Evaluation method:100% review

Bibliographic references

1. P. DEGAUQUE and J. HAMELIN Electromagnetic compatibility - radio noise and disturbances, Dunod publisher
2. M. IANOVICI and J.-J. MORF: Presses Polytechniques Romandes
3. A. KOUYOUMDJIAN: Harmonics and electrical installations
4. R. CALVAS: Electrical disturbances in LV Technical notebook n14**1**

Semester :...
UE Discovery Code: UED....
Matter :Propagation of electrical waves on the energy network
VHS: 10:30 p.m. (Class: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives

Master the modeling of internal and external disturbances in the electrical network.

Recommended prior knowledge

Concepts on electrical networks, lines and cables

Content of the material:

I. General equations of coupled lines,

- solution of line equations in the phase domain, - interconnected lines
- modal analysis, - solution of line equations in the domain of modes
-representation of a line by impedance matrix, -representation of a line by admittance matrix, - notions of impedance and reflection coefficients, -representation of a line by chain matrix (F), - representation of a line by matrix S

II. Calculation of linear parameters in BF and HF,

- an overhead multi-wire line whose return is via perfect ground or finite conductivity, - an armored cable buried in perfect ground or finite conductivity,
- an aerial shielded cable above a perfect ground or of finite conductivity,

III. Modeling a multi-wire line

- frequency modeling
- temporal modeling

IV. General solutions of line equations,

- in frequency
- in finite difference time (FDTD)

V. Modeling by the topological formalism of the propagation of an electric wave in a mesh network of lines or cables taking into account the conductivity of the ground.

- in frequency (HF signals)
- in time

Evaluation mode

100% review

Bibliographic references

1. Jean-Paul VABRE, The lines, Edition Ellipses, ISBN: 2 7298 9369 51993, 1993
2. CR Paul, "Analysis of Multiconductor Transmission Lines", a wiley-interscience publication, Copyright - 1994 by John Wiley & Sons, Inc.
3. Michel Aguet, Jean-Jacques Morf, Treatise on electricity: Electric energy, Volume 12, Presses Polytechniques Romandes, 1981.
4. Michel Aguet and Michel Ianoz, High voltage, PPUR - Collection: Treatise on Electricity – 2nd edition - 11/26/2004 (TE volume XXII).
5. Fred Gardiol, Electromagnetism, Treatise on electricity, volume 3: Presses Polytechniques et Universitaires Romandes (PPUR) (May 29, 2002)

Semester :...
UE Discovery Code: UED....
Matter :Introduction to software engineering and expert systems
VHS: 10:30 p.m. (Class: 1h30)
Credits:1
Coefficient: 1

Teaching objectives

Understand the benefit of using software in the field of engineering sciences and the intervention of an expert system for real-time decision-making.

Recommended prior knowledge

Some programming concepts.

Content of the material:

I. General equations of coupled lines,
A. Software Engineering

1. definition
2. Software life cycle
3. Steps
4. Models - Methods
5. Tools
6. development and configuration
7. maintenance
8. Inadequacy of software to needs
9. Complexity
10. Operational safety
11. example of electrical network simulation software (Power World Simulator)

B. Expert system

1. Origin of Expert Systems
2. role of an expert system in industry
3. creation of an expert system.
4. evolution of expert systems.

Evaluation method:

100% review

Bibliographic references

1. Jacques Printz. : Software engineering. Presses Universitaires de France, 2002.
2. Alfred Strohmeier and Didier Buchs. Software engineering: principles, methods and techniques.
3. Laurence Negrello, ¨expert systems and artificial intelligence¨, Cahier Technique Merlin Gerin n°157.

Semester ..:
EU DiscoveryCode: UED…
Matter:Industrial Ecology and Sustainable Development
VHS:10:30 p.m.(Class: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives

Raise awareness of sustainable development, industrial ecology and recycling.

Recommended prior knowledge:

Content of the material:

- Birth and evolution of the concept of industrial ecology
- Definition and principles of industrial ecology
- Industrial ecology experiences in Algeria and around the world
- Industrial symbiosis (eco-industrial parks/networks)
- Gaseous, liquid and solid waste
- Recycling

Evaluation method:

Review: 100%.

Bibliographic references:

1. *Industrial and territorial ecology, COLEIT 2012, fromJunqua Guillaume,Brullot Sabrina*
2. *Towards an industrial ecology, how to put sustainable development into practice in a hyper-industrial society, SurenErkman 2004*
3. *Energy and its control. Montpellier Cedex 2: CRDP of Languedoc-Roussillon, 2004. . ISBN 2-86626-190-9,*
4. *Appropriations of sustainable development: emergences, diffusions, translationsB Villalba - 2009*

Semester: ..
EU Discovery Code:UED..
Matter:Industrial data
VHS: 10:30 p.m. (Class: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

This subject allows students of this master's degree to become familiar with the field of industrial computing. They will acquire the notions of communication protocols.

Recommended prior knowledge:

Combinatorial and sequential logic, µ-processors and µ-controllers, computer science.

Material content:

Chapter 1 : Introduction to industrial computing; **(02 weeks)**

Chapter 2 : Connecting the hardware to a µP; **(02 weeks)**

Chapter 3: Peripherals and interfaces (Ports, Timers, etc.); **(04 weeks)**

Chapter 4: Serial communication bus (RS-232, DHCP, MODBUS, I2C); **(05 weeks)**

Chapter 5: Data acquisition: CAN and CNA peripherals; **(02 weeks)**

Evaluation method:

Review: 100%

Bibliographic references:

1. Baudoin, Geneviève & Virolleau, Férial, "The DSP family, TMS 320C54X [printed text]: application development", Paris: Francis Lefebvre, 2000, ISBN: 2100046462.
2. Pinard, Michel, "DSPs, ADSP218x family [printed text]: principles and applications", Paris: Francis Lefebvre, 2000, ISBN: 2100043439;
3. Tavernier, Ch., "PIC microcontrollers: applications", Paris: Francis Lefebvre, 2000, ISBN: 2100059572;
4. Tavernier, Ch., "PIC microcontrollers: description and implementation", Paris: Francis Lefebvre, 2004, ISBN: 2100067222;
5. Cazaubon, Christian, "HC11 microcontrollers and their programming", Paris: Masson, [sd], ISBN: 2225855277;
6. Tavernier, Christian, "AVR microcontrollers: description and implementation", Paris: Francis Lefebvre, 2001, ISBN: 2100055798;
7. Dumas, Patrick, "Industrial computing: 28 practical problems with course reminder", Paris: Francis Lefebvre, 2004, ISBN: 2100077074.

Semester: ..
UE Discovery Code: UED ..
Matter:Electrical engineering materials
VHS: 10:30 p.m. (Class: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

The objective of this course is to provide the basic knowledge necessary to understand the physical phenomena occurring in materials and to make an appropriate choice for the design of electrical components and systems. The fundamental characteristics of different types of materials as well as their behavior in the presence of electric and magnetic fields are covered.

Recommended prior knowledge:

Fundamental physics and applied mathematics.

Material content:

I. Know and understand the operation, constitution, technology and specification of electrical equipment used in electrical networks.

II. Magnetic materials: properties, losses, types, thermal and mechanical properties, characterization, magnets, applications.

III. Conductive materials: properties, losses, insulation, testing and applications.

IV. Dielectric materials: properties, losses, breakdown and performance, constraints, tests and applications.

Method of evaluation;
Continuous control: 40%; Exam: 60%.

Bibliographic references:

1. AC Rose-Innes and EH Rhoderick, Introduction to Superconductivity, Pergamon Press.
2. P. Tixador, Superconductors, Editions Hermès, Materials Collection, 1995.
3. P. Brissonneau, Magnetism and Magnetic Materials Editions Hermès.
4. P. Robert, Electrotechnical Materials, Volume II, Treatise on Electricity, Electronics and Electrotechnics of the Ecole Polytechnique Fédérale de Lausanne, Edition Dunod.
5. Engineering Techniques.
6. R. Coelho and B. Aladenize, Dielectrics, Treatise on New Technologies, Materials series, Editions Hermès, 1993.
7. M. Aguet and M. Ianoz, High Voltage, Volume XXII, Treatise on Electricity, Electronics and Electrotechnics of the Ecole Polytechnique Fédérale de Lausanne, Edition Dunod.
8. C. Gary et al, The dielectric properties of air and very high voltages, Collection of the Department of Electricity Studies and Research of France, Edition Eyrolles, 1984.
9. Dielectric Materials for Electrical Engineering, Volume 1 & 2, HERMES LAVOISIER, 2007.

Semester: ..

EU DiscoveryCode: UED..
Matter:**Maintenance and operational safety**
VHS:10:30 p.m.(Class: 1h30)
Credits: 1
Coefficient: 1

Content of the material:

I-History, context and definitions of SdF

II-Analysissystems with independent components (-Modeling of the malfunction logic by fault trees, -Qualitative and quantitative Boolean exploitation, -Limits of the method)

III- Analysis of systems taking into account certain dependencies (-Modeling of systems, -Markovian by state graphs, -Quantitative exploitation of the model, -Limit of the method)

IV- Analysis of systems with generalized consideration of dependencies (-Modeling using petrie networks (RdP), - Quantitative exploitation of the model: RdP: stochastic)

V- Application of operational safety methodologies (- reliability, - maintainability, - Availability, -security)

VI- Reliability forecast methodology (-Forecast calculation of reliability, - Analysis of failure modes, - fault diagnosis and maintenance techniques)

Evaluation method: Continuous monitoring*40%, exam: 60%*

Bibliographic references:

1. Patrick Lyonnet, "Reliability engineering, Edition TEC & DOC, Lavoisier, 2006.
2. Roger Serra, "Reliability and industrial maintenance", Course, ETS Higher Technology School, University of Quebec, 2013.
3. David Smith, Reliability, maintenance and risk, DUNOD, Paris 2006.

Semester: ..
EU Discovery Code:UED…
Matter:Maintenance of electrical networks
VHS: 10:30 p.m. (class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives

This subject aims to organize maintenance tasks and define the objectives of this discipline in the field of electrical network operation.

Recommended prior knowledge:

General information on theOperational safetyelectrical networks

Content of the subject

I. General information on the concept of maintenance

I-1 Origin of maintenance, transition from upkeep to maintenance, I-2 Definition of the different types of maintenance, I-3 Transition to maintenance of electrical systems,

II. Preventive maintenance

II-1 Systematic maintenance, II-2 Conditional maintenance, a) According to age, b) According to conditions

III. Reliability Based Maintenance

III-1 Basic notion of calculating the reliability of an electrical system, III -2 Modeling, State spaces, Fault trees, III -2 Case of multi-component systems, III -3 cases of multi degraded systems

IV. Analysis of failure modes, their effects and their criticality (FMEA)

IV-1 Functional analysis and expertise, IV-2 Assessment of frequency of occurrence, severity and criticality, IV-3 Applicability of maintenance actions, IV-4 Maintenance plans

V. Maintenance of systems associated with multiple degradation processes

VI. Evaluation of maintenance costs

VII. Applications to electrical network equipment

Evaluation method:100% review

Bibliographic references:

1. IEEE/PES Task Force on Impact of MaintenanceStrategy on Reliability. The present status of maintenance strategies and the impact of maintenance on reliability. IEEE Trans. Pwr Syst., 2001, 16(4), 638–646.
2. Tsai, YT, Wang, KS, and Tsai, LC A study of availability centered preventive maintenance for multicomponent systems. Reliability Engng Syst. Saf., 2004,84, 261–269.
3. Chan, GK and Asgarpoor, S. Optimum maintenance policy with Markov process. Elect. Pwr Syst. Res., 2006,76, 452–456.
4. FairouzIberraken, RafikMedjoudj, RabahMedjoudj and DjamilAissani:Combining reliability attributes to maintenance policies to improve high-voltage oil circuit breaker performances in the case of competing risks. Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability 1748006X15578572, first published on April 2, 2015 as doi:10.1177/1748006X15578572
5. FairouzIberraken, RafikMedjoudj, RabahMedjoudj, DjamilAissaniet Klaus Dieter Haim: Reliability based preventive maintenance of oil circuit breaker subject to competing failure processes, International Journal of Performability Engineering Vol. 9, No. 5, September 2013, p.495-504. © RAMS Consultants
6. RabahMedjoudj, DjamilAissani, Ahmed Boubakeur and Klaus Dieter Haim, Interruption modeling in electrical power distribution systems using Weibull-Markov model, Proceedings of the Institution of Mechanical Engineers (IMEchE), Part O: Journal of Risk and Reliability June 1, 2009 223: 145 -157, doi:10.1243/1748006XJRR215.

Semester: ..
EU Discovery Code:UED…
Matter: High voltage electrical equipment
VHS: 10:30 p.m. (class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objective:

This subject allows the student to have an idea of the electrical equipment used in high voltage (HTA and HV) and more particularly HV circuit breakers because they play an important role in the protection of electrical transport and distribution networks.

Content of the subject

Chapter I: General information on HV electrical equipment (4 weeks)

The different types of HV equipment, symbols, classification of the HV electrical equipment (according to the destination, according to the voltage, according to the installation, according to the operating temperature), the rated characteristics of the HV electrical equipment, The disconnector HT (head of line disconnector, pantograph disconnector, MALT disconnector), switches, contactors, fuse circuit breakers, circuit breakers, surge arresters.

Chapter II: Establishing and breaking short-circuit currents (4 weeks)

Establishment and breaking of short-circuit currents, Process of breaking a short-circuit current, Cutting by electric arc, Extinguishing peak, transient recovery voltage, post-arc current, Terminal fault (single-phase and three-phase), First pole factor, Representation of normalized TTR waves, Near-line fault, Determination of the shape of the line-side TTR, Calculation of the line-side TTR parameters, Critical length of the line, modeling of the electric arc in an HV circuit breaker

Chapter III: Circuit breakers (4 weeks)

Definition, Classification according to the breaking medium, General operating principle of an HV circuit breaker, oil circuit breakers, compressed air circuit breakers, vacuum circuit breakers, SF6 circuit breakers, classification of circuit breakers according to use (line circuit breaker, reactance circuit breaker, generator circuit breaker), classification according to installation (outdoor, indoor), operating temperature, rated characteristics of an HV circuit breaker (rated voltage, rated frequency, rated current admissible short duration, short-circuit breaking capacity, transient recovery voltage, rated closing capacity, assigned breaking duration, assigned operating sequence), the contact system.

Chapter IV: Tests of HV electrical equipment (3 weeks)

Standards associated with HV electrical equipment, testing of HV electrical equipment, testing of HV circuit breakers in an electrical network, testing of HV circuit breakers in a high power laboratory, direct testing, synthetic testing, fault testing at the terminals, Near-line fault test,

Bibliographic references:

1. D. Dufournet, "Electrical HV interruption equipment. Part 1", Engineering Technology, D 4-690, 2001;
2. S. Theoleyre, "Cutting techniques in MT", Schneider technical notebook No. 193, 1998;
3.www.siemens.com/High-Voltage Circuit Breakers from 72.5kV to up 800kV;
4. B. de Metz-Noblat, F. Dumas, G. Thomasset,"Calculation of short-circuit currents", Schneider technical notebook No. 158, 2000;
5. L. Van der Sluis, "Transients in Power Systems", John Wiley & Sons, 2001;
6. D. Dufournet, "Electrical HV interruption equipment. Appendices", Engineering technology, D4-696, 2001;
7. RWAlexander, D. Dufournet ,"Transient Recovery Voltage (TRVs) for High-Voltage Circuit Breakers";
8. AC High voltage circuit breakers, IEEE Switchgear Committee Denis Dufournet; Portland (Maine, USA), October 2017.

Semester:..
EU Discovery Code:UED…
Matter:Electrical energy and building
VHS: 10:30 p.m. (class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

Become familiar with the different sources of renewable energy and allow the student to have all the necessary tools to manage, design and exploit these energy resources, particularly in buildings.

Recommended prior knowledge:

Fundamental notions of electricity, basic knowledge of static converters, renewable energy sources, electrical energy networks, measuring and protection equipment.

Material content:

Chapter I: The energy-producing building(3 weeks)
Concept of positive energy building BEPOS, structure of so-called passive buildings, namely their roofs, walls, windows, waterproofing, etc. with the aim of accumulating and releasing heat or producing electricity;

Chapter II Energy storage techniques(3 weeks)
Definition of the different storage techniques used in buildings, particularly those on a small scale (hydraulic "reservoir" storage, electrochemical "battery" storage, etc.).

Chapter III: Optimization and maximization of power(3 weeks)
Classic and intelligent: The P&O technique, incremental technique, neural networks and fuzzy logic…etc. ;

Chapter IV: Power management (4weeks)

- Analysis of the operating modes of optimization and power management algorithms, energy efficiency (calculation).
- Evaluate the energy needs of the building and know how to propose an adequate organization chart for the proper power management of the building;
- Define the different concepts of management strategy: based on rules, based on deterministic optimization methods and based on stochastic optimization methods.

Chapter V: The intelligent building: definition and design(2 weeks)
Give students an overview of the design and implementation of power management techniques in smart buildings (real-time acquisition and implementation map), technical-economic data.

Bibliographic references

1. A. Garnier, "The positive energy building",Eyrolles edition, 2012;
2. K. Beddiar, J. Lemale, "Smart Building and energy efficiency", Dunod edition, 2016;
3. DL Ha, "An advanced energy management system in buildings to coordinate production and consumption", Doctoral thesis, University of Grenoble, 2008;
4. RM Badreddine, "Optimized Energy Management for a multi-source, multi-load intelligent building: different validation principles", Doctoral thesis, University of Grenoble, 2012;
5. RM Noel, "Management of electrical energy in a tertiary sector", éeditionsEuropean academics, 2018.

Semester:..
EU Discovery Code:UED…
Matter:Embedded electrical networks
VHS: 10:30 p.m. (class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objective:

An on-board electrical network (in the case of automobiles, aviation, trains, tramways, ships, etc.), as opposed to the public distribution network, is differentiated by a low short-circuit power and a power supply of isolated systems. Even ifenergy management in these systems is similar to that of large interconnected systems, their sizes and masses require more adapted management (choice of power supply type (alternating or direct), voltage level to apply, protection rules, architecture guaranteeing optimal supply to the loads). This subject will allow students to evaluate the similarities and differences between these areas of mobility.

Recommended prior knowledge:

Knowledge of different energy sources, storage systems,AC and DC electrical networks, electromagnetic compatibility.

Material content:

Chapter I: Embedded electrical networks and their evolution: (4 weeks)

- Specific case studies: Cars, planes, ships, tramways, industrial or island networks;
- Energy needs, evolution of on-board power, evolution towards more electrical systems, etc.

Chapter II: Architecture and management of energy sources of different nature: (4 weeks)

Structure and sizing of the electrical installation (power requirements, cable lengths, etc.), methods of distributing electrical power, energy backup systems (storage), etc.

Chapter III: Design of on-board electrical networks: (5 weeks)

Issues linked to the use of HVDC and HVAC networks, Coupling between equipment and the risk of stability, protection against faults (choice of neutral system and associated protections, selectivity of protections), voltage quality , management of transitional regimes)

Chapter IV: Standard quality standards for on-board electrical networks: (2 weeks)

Electricity quality, harmonics problem.

Bibliographic references:

1. F. Barruel, "Analysis and design of on-board electrical systems. Application to aircraft on-board networks", Doctoral thesis, Joseph Fourier University, 2005;
2. C. Baumann: "Architecture and management of a high-voltage continuous mesh network for aeronautics", Doctoral thesis, University of Toulouse, 2009;
3. G. Filliau, A. Bond, L. Maodier, "the all-electric ship: Propulsion and energy production", Engineering technique, treatise Electrical engineering, D5-610, 2008;
4. K. Maalej, "Energy management methods for a hybrid electric vehicle and a battery electric vehicle using online mass estimation", thesis at the University of Quebec at Trois-Rivières, 2014;
5. M. Pacault, A. Bondu and, P. Letellier, "Electric ship - Propulsion, electrical distribution and energy production", Engineering Technique, D5610, 2016.

Semester:..
EU Discovery Code:UED…
Matter:Renewable Energies
VHS: 10:30 p.m. (class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives:

Allow students to acquire theoretical knowledge about renewable energy: sources of renewable energy, types of renewable energy conversion systems, and energy conversion for each renewable energy conversion system.

Recommended prior knowledge:

- The principles of thermodynamics,
- The modes of heat transfer,
- The principles of fluid mechanics.

Content of the material:

Chapter I: General information on renewable energies.

- Sources of renewable energies,
- Types of renewable energies.

Chapter II: Wind conversion systems.

- Introduction to wind power,
- Architecture of wind conversion systems,
- Potential and energy conversion.

Chapter III: Photovoltaic conversion systems.

- Introduction to the solar field.
- Principle of photovoltaic conversion (photovoltaic effect)
- Type of photovoltaic conversion systems.

Chapter IV: Thermal conversion systems.

- Solar thermal collectors.
- Solar thermal energy conversion.

Chapter V: Storage, fuel cells and hydrogen

Chapter VI: Applications.

Evaluation method: Review: 100%.

Bibliographic references:

1. *Sabonnadière Jean Claude. New energy technologies 1: Renewable energies, Ed. Hermès.*
2. *Gide Paul. The great book of wind power, Ed. Moniteur.*
3. *A. Labouret. Photovoltaic Solar Energy, Ed. Dunod.*
4. *Viollet Pierre Louis. History of hydraulic energy, Ed. Press ENP Chaussée.*
5. *Weigh Felix A. Solar thermal installations: design and implementation, Ed. Monitor.*
6. BentSorensen. Renewable Energy. Elsevier, UK, 2004.
7. Multon et al, Electric wind generators", Engineering Techniques, Electrical Engineering Treatises, 2004
8. Hau, Wind-Turbines, Springer, 2000
9. J.F. Manwell, J.G. McGowan and A,L. Rogers, Wind energy explained theory, design and application, University of Massachusetts, Amherst, USA

10. Gary L. Johnson, Wind energy systems, 2006
11. R. Patel Mukund, Wind and solar power systems, Taylor & Francis, 2006.
12. Anne Labouret, Michel Villoz, Photovoltaic solar energy, Dunod edition, 2005.
13. T. Markvart and L. Caslaner. Practical hand book of photovoltaics: fundamentals and applications. Elsevier, UK, 2003
14. Luis Castaner and Tom Markvart, Practical Handbook of Photovoltaics: Fundamentals and Applications, , Edition: Elsevier Science Ltd, 2003
15. M. Tissot, "The guide to solar and photovoltaic energy", Eyrolles, 2008.
16. *Beckman, WA, Klein, SA, Duffie, JA, 1977, Solar Heating Design by the f-Chart Method, Wiley Interscience, NY*
17. *Duffie, JA Beckman, WA, 2006, Solar Engineering and Thermal Process, John Wiley & Sons, third Ed., NY*