III - Detailed programme by subject of the S1 semester

Semester: 1
UE Fundamental Code: UEF 1.1
Material: Advanced Electric Machines
VHS: 67h30 (lecture: 3h00, TD: 1h30)
Credits: 6
Coefficient: 3

1. Teaching objectives:

This advanced course comes in logic sequential to complete the previous courses on electric machines. It provides power-engineering students with required knowledge to understand the dynamics of electric machines for modelling and diagnosis purposes. This course is a requirement for students intending to design electric drives or renewable energy conversion systems.

2. Recommended prior knowledge:

The prerequisites for this course are differential equations, linear systems, and electric machines.

3. Material content:

Chapter 1: Review of AC Machines (3 weeks)
1- Revolving Field theory
2-Induction machine's operation principle3- Synchronous machines: types and operation principle
Chapter 2: Dynamical Modeling of AC Machines (4 weeks)
1-The Concordia/Clark and Park Transformations
2-Dq modeling of asynchronous machines3-Dq modeling of synchronous machines
Chapter 3: Identification of Electric machine parameters (4 weeks)
1-Identification of asynchronous Machine parameters.
2-Identification of synchronous Machine parameters.
3-Identification of DC machine parameters.
4-Advanced parameters estimation methods - observers
Chapter 4: Electric machine's faults and diagnosis (4 weeks)
1- Faults in Electric machines.
2- Electric machines modeling under faults.
3- Model-based fault diagnosis methods.
4- Non-model-based faults diagnosis methods.

4. Evaluation method:

Continuous assessment: 40%; Examination: 60%.

5. References:

1. Paul C. Krause,Oleg Wasynczuk, Scott D. Sudhoff, Analysis of Electric Machinery , 1986, IEEE Press.
2. Control of Electrical Drives, W. Leonard, Springer-Verlag, 1996
3. Vector control of AC machines, Peter Vas, Oxford University Press, 1990
5. Power Electronics and AC Drives, Prentice-Hall, B.K. Bose, 1986
6. Modern Power Electronics and AC Drives, B-K. Bose, Prentice-Hall International Edition, 2001.

Semester: 1
UE Fundamental Code: UEF 1.1
Material: Power Engineering Materials
VHS: 45h (Lecture: 3h00)
Credits: 3
Coefficient: 2

Teaching objectives

The main objective of this course is to teach the students the necessary knowledge about the materials used in the different power equipments for understanding well their principle of function.

Recommended Prior Knowledge

The student is supposed to have attended physics courses and Active Devices.

Content of the material:

Chapter 1: **Semi-conductor materials** (introduction, utilization, fabrication of semi-conductor, types of semiconductors) **(02 weeks)**

Chapter 2: **Semi-conductor Devices** (classification and main semi-conductor devices:SCR, GTO, PV cell**)** **(03 weeks)**

Chapter 3: **Magnetic materials** (properties, losses, types, thermal and mechanical properties, characteristics, permanent magnets, applications, etc.) **(03 weeks)**

Chapter 4: Dielectric materials (properties, losses, breakdown characteristics and performances, tests and applications) **(03 weeks)**

Chapter 5: Conduction materials (properties, losses, types, insolation techniques, tests and applications) **(02 weeks)**

Chapter 6: Superconducting materials (properties, losses, types, insolation techniques, tests and applications) **(02 weeks)**

Evaluation method:

Continuous assessment: 40%; Examination: 60%.

Bibliographical references:

A.C. Rose-Innes and E.H. Rhoderick, Introduction to Superconductivity, Pergamon Press.
Fink and Beaty, Standard Handbook for Electrical Engineers 11th Edition, pages 17–19
Kao, Kwan Chi (2004). Dielectric Phenomena in Solids. London: Elsevier Academic Press. pp. 92–93. ISBN 978-0-12-396561-5.
Cullity, B. D. & Graham, C. D. (2008). Introduction to Magnetic Materials (2 ed.). Wiley-IEEE Press. p. 103. ISBN 978-0-471-47741-9.
Saslow, Wayne M. (2002). Electricity, Magnetism, and Light (3rd ed.). Academic Press. p. 426. ISBN 978-0-12-619455-5. Archived from the original on 2014-06-27.

Semester: 1
UE Fundamental Code: UEF 1.2
Material: Digital Control System
VHS: 67h30 (Lecture: 3h00, TD 1h30)
Credits: 5
Coefficient: 3

Teaching objectives

Provide the student with basic tools for the analysis and design of discrete-time linear control systems. Furthermore, the course intends to present the basic concepts on analysis and design of sampled data, control system, and to apply these concepts to typical physical processes.

Recommended Prior Knowledge

Student should have attended the following: Linear Algebra and control system courses.

Content of the material:

Chapter 1: Introduction(Principle features of discrete time control system, Signal sampling, quantizing and coding, Data acquisition, conversion and distribution system, Reconstruction of original signal from sampled signal) **(03 weeks)**

Chapter 2: Z-transform analysis (Fundamentals of Z-transform, Important properties and theorems of the Z-transform, Z-transform from the convolution integral, Inverse Z-transform, Direct Division, Partial Fraction, Inversion Integral, Z-transform) **(03 weeks)**

Chapter 3: Design of discrete-time control systems (S-plane to Z-plane mapping and Vice-versa, Stability analysis in the Z-plane, Discrete time equivalents of LTI systems, Discrete time equivalents of analog controllers). (**03** weeks**)**

Chapter 4: Design and compensation of discrete time control system (Digital filters: structure, implementation, frequency response, applications, responses to control signals, use of root locus and frequency domain concepts, Phase lead and phase lag compensator design for discrete time system, PID controller design) **(03 weeks)**

Chapter 5: State-space methods(State space representation of discrete time systems, Discretization of the continuous time state space equation, Pulse transfer function matrix, Stability assessment from the discretized state space equations) , **(03 weeks)**

Evaluation method:

Continuous assessment: 40%; Examination: 60%.

Bibliographical references:

1. H.Ogata, Discrete-time control systems, 2nd Ed, Prentice Hall, Englewood Cliffs, New Jersey 1995.
2. G. F. Franklin, J.D. Powell, M. Workman, Digital control of dynamic systems, 3rd Ed., Pearson Educations, 2005.

3. Charles L. Phillips, "Digital Control System: Analysis and Design", Prentice Hall, Englewood Cliffs, New Jersey

Semester: 1
UE Fundamental Code: UEF 1.2
Material: Digital Signal Processing
VHS: 45h00 (Course: 3h00)
Credits: 5
Coefficient: 3

Teaching objectives:

This course will build on the knowledge acquired in the two preceding courses of signals and systems. The main objective of this course is to help students to design and implement digital filters using many different approaches. In addition to efficient algorithms for computing, the discrete-time Fourier transform.

Recommended prior knowledge:

The student is supposed to have attended continuous and discrete time linear systems courses.

Material content:

Chapter 1: Review **(1 week)**

Basic building functions, properties of syetems, Convolution derivation, Discrete-time Fourier transform, Symmetry properties of the DTFT, The Z-transform, Prpertíes of the Z-transform

Chapter 2: The sampling theorem **(1 weeks)**

The relationship between the Fourier transform of an analog signal and its discete version, Derivation of the sampling theorem of bandlimited signals, The reconstruction of signals from their samples.

Chapter 3: Finite Impulse Filters design **(2 weeks)**

Types of digital filters, The windowing method, The analysis of the filters designed by the windowing method, Types of windows, The Kaiser window, The Parks–McClellan algorithm, Examples of FIR fiters: differentiators, Hilbert filter.

Chapter 4: Infinite Impulse Filters design **(3 weeks)**

Difference between FIR and IIR design, Constraints on the IIR design methods, Mapping method, Impulse invariance method, Bilinear transformation method, Prototype analog filters, Butterworth filter, Chebyshev filter, Elliptic filter.

Chapter 5: The Discrete Fourier Transform (DFT) **(3 weeks)**

Definition, the derivation of the DFT, Properties of the DFT, Matrix form of the DFT, Circular convolution, Linear convolution vs Circular convolution,

Chapter 6: The Fast Fourier Transform (FFT) **(2 weeks)**

Definition, Divide-and-conquer algorithm, Radix-2 FFT, Decimation-in-time, Decimation-in-frequency.

Chapter 7: Signal Flow graph and implementation **(3 weeks)**

Definition, basic elements of a signal flow graph, structures for IIR filters, cascade and parallel structures for IIR filters, structures for FIR filters, Quantization errors in IIR filters, second-order structures for IIR filters .

Evaluation method:

Continuous assessment: 40%; Examination: 60%.

Bibliographical references:

1. J. G. Proakis, and D. G. Manolakis, "Digital Signal Processing, principles, algorithms, and applications" Prentice-Hall, 3rd edition 1996.
2. A. V. Oppenheim, and R. W. Schafer, " Discrete-time Signal Processing " Prentice Hall; 3rd edition, 2009.

Semester: 1
UE Fundamental Code: UEF 1.2
Material: Optimization
VHS: 60h (Lecture: 3h00, TD 1h00)
Credits: 5
Coefficient: 3

Teaching objectives:

The objective of this course is to equip students with the fundamental principles and techniques necessary for solving complex decision-making problems efficiently. Through this course, students will develop a solid understanding of optimization models, algorithms, and their applications in power engineering. By the end of the course, students should be able to formulate optimization problems, select appropriate solution methods, and interpret the results effectively.

Recommended prior knowledge:
Student must attend all math courses, Electric Circuits and Linear System courses.

Material content:

Chapter I: Introduction to numerical methods (2 weeks)
- Numerical methods to solve linear systems
- Numerical, integral and differential
- Numerical methods for Ordinary differential Equations, EDOs: Euler method, Runge-Kutta method, Adams method, etc.
- Solving system of ODEs

Chapter II: Partial Differential Equation (PDEs) (1 weeks)
- Introduction and classifications of PDEs based problems (Elliptic, Parabolic, Hyperbolic PDES)
- Methods to solve PDEs, PDETOOL.

Chapter III: Optimization Techniques (13 weeks)
- Generic formulation of optimization problems.
- Exposure to classes of optimization problems: Linear-nonlinear, continuous, constrained-
- Unconstrained, single-multiple variables
- Linear programming
- Nonlinear programming with constraints and no constraints
- Optimization of practical problems using Metaheuristics
- Matlab optimization toolbox

Evaluation method:
Continuous assessment: 40%; Examination: 60%.

Bibliographical references:

1. Douglas West, Introduction to Graph Theory, second edition. Prentice Hall, 2001
2. Singiresu S. R, Enginering optimization: theory and practice, John Wiley & Sons, 2009

3. Won Y. Yang, Wenwu Cao, Tae S. Chung, John Morris Applied numerical methods using MATLAB, John Wiley & Sons, 2005.

Semester: 1
UE Methodological Code: EMU 1.1
Material: Advanced Electric Machines Lab
VHS:45h00 (TP: 3h00,)
Credits: 2
Coefficient: 1

Teaching objectives:

Teaching objectives:

1. Construct dynamic models of DC and AC machines
2. Handle all the required test to identify electric machines
3. Analyze the dynamic and steady state response of DC and AC machines

Prior knowledge the prerequisites for this course courses are differential equations, linear systems, DC and AC circuits and electric machine I & II.

Content of the material:

Lab n° 1 : simulation of DC machines (with and without power converters) **(01 Weeks)**

TP n° 2: simulation of asynchronous machines (with and without power converters).**(02 weeks)**

TP n° 3: simulation of synchronous machines (with and without power converters).**(02 weeks)**

TP n° 4: simulation of brushless DC machines. **(02 weeks)**

Lab n° 5 : identification of AC machine parameters **(02 Weeks)**

TP n° 6 : Simulation of AC machines under faults . **(02 weeks)**

Lab n° 7: Diagnosis of induction motor faults **(02 Weeks)**

Method of evaluation:
Continuous assessment: 100 %;

References

1. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, Analysis of Electric Machinery, 1986, IEEE Press.
2. Ion Boldea and Lucian Tutelea, Electric machines: steady state, transients, and design with MATLAB, Taylor & Francis, CRC Press, 2010.
3. Marian P. Kazmierkowski, R. Krishnan, Frede Blaabjerg, Control in Power Electronics: Selected Problems, Academic Press, Elsevier, 2002.
4. CHEE-MUN Ong, Dynamic simulation of Electric Machinery using Matlab/Simulink, Prentice Hall PTR, 1998

Semester: 1
UE Methodological Code: EMU 1.1
Material: Optimization Lab
VHS: 22h30 (TP: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

Many problems in science, technology, economy etc. can be modeled as an optimization problem whose solutions can be approximately computed using iterative techniques. In these cases, a set of techniques, can be applied to linear or nonlinear optimization problems. Numerical Methods then are used to produce efficiently approximate solutions when analytical solutions are not possible.

Recommended prior knowledge:

The student should attended Calculus I, II, and III, and IV.

Material content:

Lab N°1: Compute the integral using Simpson and trapeze methods **(02 weeks)**

Lab N°2: Solving system of ODEs using Taylor's methods, Runge-Kutta's methods **(02 weeks)**

Lab N°3: Solving linear and nonlinear systems (using GS, NR, etc) **(03 weeks)**

Lab N°4: Solving PDEs using different techniques **(1 week)**

Lab N°5: Minimization of single variable function with without constraints **(1 weeks)**

Lab N°6: Minimization of multi-variable function with constraints (equalities and inequaities) **(4 weeks)**

Lab N°7: Optimization using Matlab Toolbox **(2 weeks)**

Evaluation method:

Continuous Assessment: 100%

References:

1- Steven C. Charpa, Raymond Canale, Numerical methods for engineers, McGraw Hill; 7th edition (January 24, 2014).
2- H.M. Antia Numerical methods for scientists and engineers, McGraw Hill, 1995.
3- W.Dos Passos, Numerical Methods, Algorithms and Tools, Taylor and Francis Group , 2010
4- Steven C. Charpa, Applied Numerical methods with Matlab for engineersand scientists, 4th edition, McGraw Hill, 2017.

Semester: 1
UE Methodological Code: EMU 1.1
Material: Digital Control System Lab
VHS: 22H30 (TP: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

The aim of this course is to provide the student with basic tools for the analysis and design of discrete-time linear control systems. Furthermore, the lab intends to present the basic concepts on analysis and design of sampled data control system and to apply these concepts to typical physical processes.

Recommended prior knowledge:

The student should attended linear control system.

Content of the material:

Lab N°1: Discrete-time simulation with Simulink **(2 weeks)**
Lab N°2: Design by Simulation **(2 weeks)**
Time-domain controller emulation. Frequency-domain controller emulation
Lab n°3: Digital Effects **(2 weeks)**
Sampling, aliasing, zero-order hold. Discrete-time plant modeling. Filter structure and finite-precision effects.
Lab N°4: Transfer Function Controller Design **(2 weeks)**
Frequency-response controller design. Numeric optimal PID controller design. Ragazzini's direct control design method.
Lab N°5: State-Space Controller Design **(2 weeks)**
State-feedback controller design. State estimation and control design

Evaluation method:
Continuous Assessment: 100%

References:

1- H.Ogata, Discrete-time control systems, 2nd Ed, Prentice Hall, Englewood Cliffs, New Jersey 1995.
2- G. F. Franklin, J.D. Powell, M. Workman, Digital control of dynamic systems, 3rd Ed., Pearson Educations, 2005.

3- Charles L. Phillips, "Digital Control System: Analysis and Design", Prentice Hall, Englewood Cliffs, New Jersey

Semester: 1
Teaching unit: UED 1.2
Subject: Subject 1 of your choice (Elective course)
VHS: 22h30 (lecture: 1h30)
Credits: 1
Coefficient: 1

Remark

Members of power engineering's curriculum committee are requested to select a course from the list proposed in this document. Selection of one course or another depends on the need and priority.

IV - Detailed programme by subject of the S2 semester

Semester: 2
Teaching unit: UEF 2.1
Material: Advanced Power Electronics
VHS: 45h00 (Lecture: 3h00)
Credits: 5
Coefficient: 3

Teaching objectives:

This course presents the principle of operation, and design of drivers of different power switches. Students will be introduced to modern and industrial power electronics converters; their topologies, control techniques, and quality of current and voltage being generated.

Recommended prior knowledge:

The prerequisite courses are: Calculus I & II, DC and AC circuits, and first course of power electronics.

Material content:

Chapter 1: Power Devices (Power diodes, SCR, BJT, MOSFET, IGBT, GTO,) **(1 week)**

Chapter 2: Power Devices gate driver (MOSFET and IGBT Gate drive circuits, gate drive design procedure, SCR gate drive circuits, light dimer) **(2 weeks)**

Chapter 3: Devices and converters protection (RC snubber circuits, soft voltage clamp, snubber for bridge circuits) **(2 weeks)**

Chapter 4: Advanced DC/DC converters (first quadrant dc chopper, second quadrant dc chopper, four quadrant dc chopper **(2 weeks)**

Chapter 5: DC/AC converters (single phase H-bridge, 180° conduction, 120° conduction, PWM, three-phase inverter) **(2 weeks)**

Chapter 6: Facts devices and custom controllers (series reactive power compensation, series reactive power compensation, self-commutating Fact devices (DVR, STATCOM, UPFC,) Active filters) **(2 weeks)**

Chapter 7: Multilevel converters(diode clamped multilevel inverter, flying capacitor multilevel inverter, cascaded H-bridge multilevel inverter, capacitor clamped multilevel inverter, PWM for Multilevel inverters) **(2 weeks)**

Chapter 8: AC/AC converters (indirect and direct matrix converter). **(2 weeks)**

Evaluation method:

Continuous assessment: 40%; Examination: 60%.

References:

1. "Power Electronics: Circuits, Devices, and Applications" M. H. Rashid, Prentice Hall, 4THedition.

2. Power Electronics, Converters, Applications, and Design", N. Mohan, T. M. Undeland, and W. Robbins, John Wiley.
3. Power Electronics and AC Drives, Prentice-Hall, B.K. Bose, 1986
4. Modern Power Electronics and AC Drives, B-K. Bose, Prentice-Hall International Edition, 2001.
5. Barry W Williams, P rinciples and E lements of Power Electronics: Devices, Drivers, Applications, and Passive components, ISBN 978-0-9553384-0-3 , © Barry W Williams, 2006.

Semester: 2
Teaching unit: UEF 2.1
Material: Machines & Drives
VHS: 45h00 (Course: 3h00)
Credits: 5
Coefficient: 3

Teaching objectives

Acquire the ability to analyze variable speed DC and AC motor drive systems and predict their performance in steady state as well as in dynamic state. The knowledge acquired must allow the student to develop design skills in term of control selection and controller computation for electric machines.

Recommended Prior Knowledge

The student should have attended the following courses: Power electronics – Electric machines – Dc and AC circuits, and Differential equations.

Material content

Chapter 1: Introduction to Electric Drive (definition, components, aims, examples..) **(01 week)**

Chapter 2: Modeling of SE-DC motors (equivalent circuit, principle of operation, dynamic modelling, transfer function, poles, etc.) **(01 week)**

Chapter 3: Rectifier and chopper supplied DC drives (single phase rectifier, bridge, three-phase rectifier, transfer function, four quadrant operation of rectifier, buck chopper, boost chopper, transfer function, four-quadrant operation) **(01 week)**

Chapter 4: Closed loop DC drives (simplified transfer function, current control design, speed loop design, speed reversal scheme) **(02 weeks)**

Chapter 5: Induction motor-Steady state analysis (principle of operation, equivalent circuit, analysis of motor paramters, classes of IMs). **(01 week)**

Chapter 6: Scalar control of IM (derivation of scalar control, V/f controller, constant slip control, constant air-gap flux control) **(02 weeks)**

Chapter 7: DQ-model of IM (objectives, 3-to-2 transformation, dq-transformation, abc –model, alfa-beta and dq model of IM, selection of rotating reference frame) **(02 weeks)**

Chapter 8: Vector control of IM (equation of torque, principle of FOC, FOC schemes (rotor, stator and air-gap), application of RFOC, direct and indirect FOC). **(02 weeks)**

Chapter 9: Direct Torque Control (DTC) of IM (model of IM, model of inverter, space vector voltage, derivation of DTC, derivation of control tables) **(02 weeks)**

Chapter 10: PMSM 's modelling and vector control (abc model of PMSM, 3-to-2 and dq transformation, model of PMSM in rotating rotor reference frame, FOC principle, derivation of FOC equations) **(01 week)**

Evaluation method

Continuous assessment: 40%; Review: 60%.

References

1. Muhammad H. Rashid., Power Electronics, Circuits Devices and Applications, 3rd edition, 2004, Pearson Prentice Hall.
2. B. K. BOSE, "Power Electronics and AC Drives", Prentice-Hall, 1986.
3. Krishnan, R., Electric Motor Drives: Modelling, Analysis and Control, Prentice-Hall, New Jersey, 2001.
4. Ion Boldea and Lucian Tutelea, Electric machines: steady state, transients, and design with MATLAB, Taylor & Francis, CRC Press, 2010.
5. Marian P. Kazmierkowski, R. Krishnan, Frede Blaabjerg, Control in Power Electronics: Selected Problems, Academic Press, Elsevier, 2002.
6. CHEE-MUN Ong, Dynamic simulation of Electric Machinery using Matlab/Simulink, Prentice Hall PTR, 1998.

Semester: 2
Teaching unit: UEF 2.2
Material: Power system Analysis
VHS: 67h30 (Lecture: 3h00, TD 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:

The course is intended to provide power engineering student with a good perspective of the most important power system components and an active knowledge required to analyze a large interconnected power system under normal and abnormal conditions (symmetrical system case only).

Recommended prior knowledge:

The prerequisite courses are : Calculus I & II, DC and AC circuits, first course of Electric Machines and numerical methods.

Material content:

Chapter 1 : An overview of modern power system (1 week)

- History of Power Systems, Modern power system main components , Generation Transmission, Distribution, Loads, Power System interconnection, Power system control, Power system protection

Chapter 2: Basic concepts (2 weeks)

- Power in single phase AC circuits, Complex power, Conservation of power , Power factor correction , Complex power flow, Three phase circuits, Δ-Y transformations, Per-phase analysis

Chapter 3: Generators and Transformers (2 weeks)

- Introduction, Synchronous generators, Steady state characteristics , cylindrical rotor SM, Salient-pole synchronous generators,
- Power transformer, Equivalent circuit of a transformer, Three phase transformers, Autotransformers, Three winding transformers, Voltage control of transformers

Chapter 4: Transmission lines (4week)

- Introduction, Types of TLs conductors , Resistance of TLs
- Inductance of TLs, Inductance of a single conductor , Inductance of a single-phase and three-phase line , Inductance of a non-symmetrical TLs , Bundled conductors , Parallel-circuit three phase transmission lines
- Capacitance of TLs, Potential difference between two points due to a charge , Multi-conductors case, Capacitance of a single-phase and three-phase lines, Capacitance of a non-symmetrical TLs , Bundled conductors , Parallel-circuit transmission lines, Effect of earth.
- Assessment of transmission lines performances : Introduction , Short line model, Medium line model, Long transmission lines, Voltage and current waves, Lossless line, Surge impedance loading

Chapter 5: Power system representation and solutions (1 week)

- Single line diagram, Single line diagram symbols, Equivalent Impedance and reactance diagram

- Per-unit representation, Node elimination, Nodal analysis, Construction of bus admittance

Chapter 6: Load flow analysis (3 weeks)

- Introduction, Power flow problem, Classification of busbars, Solution of power flow problem, Solution using Gauss-Seidal , Solution using Gauss-Seidal accelerated , Inclusion of PV buses in Gauss-Seidal

Chapter 7: Balanced faults (2 weeks)

- Introduction, Balanced three phase faults, Short-circuit capacity , Systematic fault analysis, Formation of the bus impedance matrix.

Evaluation method:

Continuous assessment: 40%; Examination: 60%.

References:

1. Elements of power system analysis, D. W. Stevenson, 1985, third edition, Library code: TK3001. S85
2. Electric power systems, B.M. Weedy, B. J. Cory, 1998, 4th edition, John Wily & Sons, TK1001. W4
3. Power System Analysis, Hadi Saadat, 2004, 2nd edition, MC Graw Hill, TK1001. S23

Semester: 2
Teaching unit: UEF 2.2
Material: Reliability, Availability, Maintainability, and Safety (RAMS)
VHS: 60h00 (lecture3h00 TD 1h00)
Credits: 4
Coefficient: 3

Teaching objectives:

The objective of this course is to provide students skill so that he can:1. identify and analyze the concepts of reliability, availability, maintainability and safety (RAMS) in engineering problems;2. apply appropriate techniques and tools to evaluate and improve the RAMS in engineering systems;3. Identify quality, safety and compatibility standards in different engineering disciplines and develop a safety case.

Recommended prior knowledge:

The prerequisite of this course is calculus and knowledge of probabilities and statistics

Material content:

Chapter 1- Introduction (Definition and concepts, Review of Reliability Engineering, Relationship with Lean Manufacturing, Roles in Supply Chain Management **(1 week)**

Chapter 2- Basics (Lifetime distributions; Failure rate and bathtub curve; Reliability models; Computation software; Calculation of reliability). **(2 weeks)**

Chapter 3- Reliability (Reliability block diagram and Structure function, Series system; Parallel system; Series-Parallel systems, Computation of system reliability) **(03 weeks)**

Chapter 4- System analysis techniques (Fault tree analysis, Failure mode and effect analysis, Probabilistic risk analysis, System safety, Reliability prediction and allocation, Reliability design and management) **(03 weeks)**

Chapter 5- Reliability testing and data analysis(Types of reliability testing; Graphical techniques in reliability; Model selection; Reliability estimate) **(03 weeks)**

Chapter 6- Maintainability (Maintainability requirements; Cost and maintainability; Availability; Maintenance strategies; Design guideline for maintainability **(03 weeks)**

Evaluation method:

Continuous assessment: 40%; Examination: 60%.

References:

1. Marvin Rausand, Arnljot Høyland, System Reliability Theory: Models, Statistical Methods, and Applications. John Wiley & Sons, 2003.

2. Alain Villemeur, Reliability, Availability, Maintainability and Safety Assessment. Volume 1, Methods and Techniques., 1992.
3. David Smith, Reliability, Maintainability and Risk., Butterworth-Heinemann 2011

Semester: 2
Teaching unit: EMU 2.1
Material: Machines & Drives Lab
VHS: 45h00 (TP: 3h00)
Credits: 3
Coefficient: 1

Teaching objectives:

- Get familiar with the use a DSP board
- Apply and master methods of electric machine identification
- Design electronic circuit to acquire speed, current and voltage signals
- Implement control algorithms on DSP board.

Recommended prior knowledge:

The prerequisite courses are: power electronics, digital systems, and electric machines

Material content:

TP N1: DSP programming using Simulink (**2 weeks**)

TP N2: DC Motor identification (**1 week**)

Lab N 3: Dc motor open loop control (**2 weeks**)

TP N 4: Dc motor closed loop control (**2 weeks**)

TP N5: Induction motor parameters identification (**2 weeks**)

TP N6: Implementing induction motor Scalar controller, V/f (**2 weeks**)

TP N7: Implementing induction motor Vector controller, FOC (**2 weeks**)

TP N8: Implementing induction motor Direct Torque Controller, DTC (**2 weeks**)

Evaluation method:

Continuous assessment: 100%.

References:

1. Muhammad H. Rashid., Power Electronics, Circuits Devices and Applications, 3rd edition, 2004, Pearson Prentice Hall.
2. B. K. BOSE, "Power Electronics and AC Drives", Prentice-Hall, 1986.
3. Krishnan, R., Electric Motor Drives: Modelling, Analysis and Control, Prentice-Hall, New Jersey, 2001.
4. Marian P. Kazmierkowski, R. Krishnan, Frede Blaabjerg, Control in Power Electronics: Selected Problems, Academic Press, Elsevier, 2002.
5. CHEE-MUN Ong, Dynamic simulation of Electric Machinery using Matlab/Simulink, Prentice Hall PTR, 1998.

Semester: 2
Teaching unit: EMU 2.1
Material: Power system Lab
VHS:22h30 (TP: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

- Practice the different measurement in single and three phase circuits
- Understand the behavior and effect of transmission lines
- Master the control of voltage and power factor
- Understand the power transfer capability and stability

Recommended prior knowledge:

The prerequisite of this lab are DC and AC circuits lab, machines Lab .

Material content:

Lab N°1: Familiarization with power system equipment (**01 weeks)**

TP N°2: Identification of power system phase sequence **(02 weeks)**

Lab N°3: Measurement of real and reactive power **(02 weeks)**

Lab N°4: Active and reactive power flow and voltage regulation **(02 weeks)**

Lab N°5: Phase angle and voltage drop between sender and receiver **(02 weeks)**

TP N°6: Parallel transmission line and power transfer capability **(02 weeks)**

Lab N°7: The synchronous motor under load **(02 weeks)**

Lab N°8: Stability of power system **(02 weeks)**

Evaluation method:

Continuous Assessment: 100%

References:

1. Electric Power Transmission lines, Thoedore Wildi, LabVolt, Laboratory Experiments,
2. Elements of power system analysis, D. W. Stevenson, 1985, third edition, Library code: TK3001. S85
3. Electric power systems, B.M. Weedy, B. J. Cory, 1998, 4th edition, John Wily & Sons, TK1001. W4
4. Power System Analysis, Hadi Saadat, 2004, 2nd edition, MC Graw Hill, TK1001. S23

Semester: 2
Teaching unit: EMU 2.1
Material: Advanced Power Electronics Lab
VHS: 45h00 (TP: 3h00)
Credits: 3
Coefficient: 1

Teaching objectives:

The student will learn how to:

- design driver and protection circuits for power devices
- Design Choppers
- apply classical and modern control techniques for inverters
- Get familiar with advanced configuration of DC-to-AC converters

Recommended prior knowledge:

The prerequisite courses are: active devices, digital systems, and first course of power electronics.

Material content:

TP N1: Semiconductor devices and losses in operation **(1 week)**

TP N2: IGBT gate drive design **(2 weeks)**

TP N 3: DC/DC Converter: buck/boost design **(2 weeks)**

TP N 4: Single phase DC/AC conversion: Square+ PWM **(2 weeks)**

TP N5: Three phase DC/AC conversion: 6Step + PWM **(2 weeks)**

TP N6: Three phase DC/AC conversion: SVM **(2 weeks)**

TP N7: 3Level inverter demonstration **(2 weeks)**

TP N8: Three phase AC/AC conversion demonstration **(2 weeks)**

Evaluation method:

Continuous assessment: 100%.

References:

1. "Power Electronics: Circuits, Devices, and Applications" M. H. Rashid, Prentice Hall, 4THedition.
2. Power Electronics, Converters, Applications, and Design", N. Mohan, T. M. Undeland, and W. Robbins, John Wiley.
3. Power Electronics and AC Drives, Prentice-Hall, B.K. Bose, 1986
4. Modern Power Electronics and AC Drives, B-K. Bose, Prentice-Hall International Edition, 2001.

Semester: 2
Teaching unit: UET 2.1
Subject: Standards and Rules of Ethics and Integrity
VHS: 22h30 (lecture: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:
Develop student awareness regarding ethics and rules that govern life at both university and in the professional world. The course presents the risks and consequences of corruption that are raised by new technologies and sustainable development and eventually how to fight them.

Recommended prior knowledge:
Ethics & Integrity(**basics**)

Content of the material:

A. Compliance with the rules of ethics and integrity, (06 weeks)
1. Reminder of Ethics and Deontology of the MESRS: Integrity and Honesty. Academic freedom, objectivity and critical thinking. Equity. Rights and obligations of the student, teacher, and other staff,
2. Honest and responsible research
- Respect for the principles of ethics in teaching and research
- Responsibilities in teamwork: Professional equality of treatment. Conduct against discrimination.
- Plagiarism (definition of plagiarism, different forms of plagiarism, procedures to avoid unintentional plagiarism, etc.
3. Ethics and deontology in the professional life:
Legal confidentiality in business. Loyalty to the company. Responsibility within the company, Conflicts of interest.
B- Intellectual Property (04 weeks)
I- Fundamentals of intellectual property
II- Copyright
III- Protection and enhancement of intellectual property
C. Ethics, sustainable development and new technologies (05 weeks)
Link between ethics and sustainable development, energy saving, bioethics and new technologies (artificial intelligence, scientific progress, humanoids, robots, drones

Method of evaluation:
Review: 100%

Bibliographical references:

1. *Consult the two links* www.wipo.int, 2) http://www.app.asso.fr/
2. Orders No. 933 of 28 July 2016 laying down the rules relating to the prevention and fight against plagiarism
3. Carr, D. Professionalism and Ethics in Teaching. New York, NY Routledge. 2000.

V - Detailed programme by subject of the S3 semester

Semester: 3
Teaching unit: UEF 3.1
Material: Power system: operation & control
VHS: 45h00h (Course: 3h)
Credits: 5
Coefficient: 3

Teaching objectives:

This advanced course comes in logic sequential to complete the first semester course that's power system I. It provides students with a deep understanding of methods and tools used to make large interconnected power systems efficient, stable and secure.

Recommended prior knowledge:

The prerequisites for this course courses are Calculus I & II, DC and AC circuits, Electric Machines, numerical methods and power system I.

Material content:

Chapter 1: Introduction (01 week)

Chapter 2: Load flow analysis (02 weeks)

- Introduction , Standard format of data, Tap changing transformers , Fast-decoupled power flow solution, Line flows and losses, Standard format of output data

Chapter 3: Symmetrical components and unbalanced faults (02 weeks)

- Introduction, Fundamentals of symmetrical components, Sequence impedances
- Sequence networks of a loaded generator, Single line-to-ground fault, Line-to-line fault, Double line-to-ground fault, Unbalanced fault analysis

Chapter 4: Economic dispatch problem (03 weeks)

- Introduction , Nonlinear function optimization (Constrained equality optimization, Constrained inequality optimization) , Operating cost of a thermal plant, ED neglecting losses and generator limits , ED neglecting losses and including generator limits , ED including losses, Derivation of loss formula

Chapter 5: Stability analysis (03 weeks)

- Introduction, Swing equation, Model of synchronous machine for stability studies
- Steady state stability , Transient stability , Numerical solution , Multimachine systems

Chapter 6 : Review of system control (01 week)

- The control problem, Stability, Steady state error , Step response, Root-locus design of controllers, Frequency response

Chapter 7: Power System Control (03 weeks)

- Introduction, Basic generator control loops, Frequency control (Load frequency control, Automatic generation model, AGC with optimal dispatch of generation)

- Reactive power and voltage control (Amplifier Model, Exciter model, Generator model, Sensor model, Excitation model, AGC including excitation system, Introductory modern control application

Evaluation method:

Continuous assessment: 40%; Review: 60%.

Bibliographical references:

1. Elements of power system analysis, D. W. Stevenson, 1985, third edition, Library code: TK3001. S85
2. Power generation: operation and control, Allen J. Wood, Bruce F. Wollenberg, J. Wiley and Sons, New York, second edition, 1996.

Semester: 3
UE Fundamental Code: UEF 3.1
Material: Protective systems
VHS: 60h (Lecture: 3h00 TD: 1h00)
Credits: 5
Coefficient: 3

Teaching objectives:

The course is intended to provide power engineering students with a good understanding of the most important protection techniques and an active knowledge required to design and implement any protective systems.

Recommended prior knowledge:

The prerequisite courses are : Power System, AC circuits, Electric Machines and DSP.

Content of the material:

Chapter 1:Introduction **(01week)**

Chapter 2 : Fault Analysis : review of balanced and unbalanced faults, fault analysis with protection design **(01 week)**

Chapter 3 : Protective Devices: Fuses, Varistance, Surge arrester, circuit-breaker **(02 weeks)**

Chapter 4: Instrument Transformers: Current transformer (CT) and Potential transformer (PT) **(1 week)**

Chapter 4: Protective Relays: types of protective relays, construction and principle of operation, characteristics and performances of relays **(03 week)**

Chapter 5: Protection Systems and Schemes: Design requirements, types of protection, selectivity techniques, implementation **(02 weeks)**

Chapter 6: Applications: Electrical Machines Protection, Transformer Protection, transmission lines and nozzles Protection **(03 weeks)**

Chapter 7: Digital Protection : required instrumentation, numerical relay, implementation of different protection functions **(02 week)**

Method of evaluation:

Continuous assessment: 40%; Examination: 60%.

Bibliographical references:

1. Protective Relaying: Principles and Applications, Third edition, J Lewis Blackburn and Thomas J. Domin, CRC Press, 2007.
2. P.M. Anderson, Power System Protection, IEEE Press, NY, 1999.
3. P. Rush, Network Protection and Automation Guide, 1st Ed., Library of Cayfosa, Barcelona, 2002.

Semester: 3
UE Core Code: UEF 3.2
Material: Microcontrollers & Instrumentation
VHS: 45:00 (Lecture: 3h00)
Credits: 5
Coefficient: 2

Teaching objectives:

The course presents the use of instrumentation and modern digital microcontrollers in power engineering systems. Modern industrial system requires accurate instruments and fast controllers for the implementation of the control, diagnosis or the monitoring of its functioning. This course aims to arm power-engineering student with powerful tools that will help him implementing modern control techniques, particularly in power electronics and electric drives.

Recommended prior knowledge:

The student is supposed to have attended DSP and Electronic courses.

Content of the material:

1. **Chapter 1:** Introduction. **(01 week)**
2. **Chapter 2:** Measurement and instrumentation principles. **(02 weeks)**
3. **Chapter 3:** Signal processing and Measurement systems. **(02 weeks)**
4. **Chapter 4:** CPU architecture. **(02 weeks)**
5. **Chapter 5:** Programming Tools . **(02 weeks)**
6. **Chapter 6:** Digital interfaces and analog interfaces. **(02 weeks)**
7. **Chapter 7:** TIMER, PWM generation and Interrupts **(02 weeks)**
8. **Chapter 8:** Communication protocols UART, SPI, I2C, CAN... **(02 weeks)**

Method of evaluation:

Continuous assessment: 40%; Exam: 60**%.**

Bibliographical references:

1. Computer Architecture, Carter Nicholas, Mc Graw Hill, 2008.
2. Fundamentals of Digital Logic with VHDL. By S. Brown & Z. Vranesic
3. Digital Design with CPLD Applications & VHDL By R. K. Dueck
4. Computer System Architecture, M. Morris Mano, Mc Graw Hill, 2008.

Semester: 3
Teaching unit: UEF 3.2
Material: Industrial Power network with PLC
VHS:45h00 (Course: 3h00)
Credits: 5
Coefficient: 3

Teaching objectives:

The main objective of this course is to teach the students the necessary knowledge about the Industrial Power Network's components and the use of PLCs in designing their control.

Recommended prior knowledge:

The student is supposed to have attended power system and Electric Machines courses.

Material content:

Chapter 1: Introduction **(01 week)**

Chapter 2: Connecting Components (power lines, connectors, bus bars)**(02 weeks)**

Chapter 3: Interrupting devices (Switches, contactors, circuit breakers)**(02 weeks)**

Chapter 4: Regulating devices (starters, pf compensators, braking systems, speed controllers. **(02 weeks)**

Chapter 5: PLC Hardware and programming **(03 weeks)**

Chapter 6: Design of industrial network control using PLC **(02 weeks)**

Chapter 7: Dedicated applications **(03 weeks)**

Evaluation method:

Continuous assessment: 40%; Examination: 60%.

References:

1. Protective Relaying: Principles and Applications, Third edition, J Lewis Blackburn and Thomas J. Domin, CRC Press, 2007.
2. P. Rush, Network Protection and Automation Guide, 1st Ed., Library of Cayfosa, Barcelona, 2002.
3. W. Bolton. "Programmable Logic Controllers". Newnes, 5th Ed, 2009.
4. Mr. Rabiee. "Programmable Logic Controllers: Hardware and Programming". Goodheart-Willcox, 3rd Ed, 2012.

Semester: 3
Teaching unit: EMU 3.1
Material: Power system: operation & control Lab
VHS: 22h30 (TP: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

- Practice the different algorithms of load flow analysis
- Analyze power system under normal and faulty situations
- Solve the Economic dispatch problems
- Apply iterative methods for the analysis of power system stability
- Design controllers for the control of voltage and frequency of interconnected power systems

Recommended prior knowledge:

The prerequisite of this lab are DC and AC circuits lab, machines Lab .

Material content:

TP N°1: construction of power system admittance matrix (**01 weeks)**

TP N°2: load flow solution using Gauss-Saidal Method **(02 weeks)**

Lab N°3: load flow solution using Newton-Raphson Method **(02 weeks)**

Lab N°4: load flow solution using Fast decoupled technique (**02 weeks)**

Lab N°5: balanced and unbalanced fault analysis of PS (**02 weeks)**

TP N°6: Economic dispatch problem with and without constraints **(02 weeks)**

Lab N°7: Stability analysis of Single machine infinite bus (SMIB) **(02 weeks)**

TP N°8: AGC with Economic Generation Dispatch **(02 weeks)**

Evaluation method:

Continuous Assessment: 100%

References:

1. Power generation: operation and control, Allen J. Wood, Bruce F. Wollenberg, J. Wiley and Sons, New York, second edition, 1996.
2. Elements of power system analysis, D. W. Stevenson, 1985, third edition, Library code: TK3001. S85
3. Electric power systems, B.M. Weedy, B. J. Cory, 1998, 4th edition, John Wily & Sons, TK1001. W4
4. Power System Analysis, Hadi Saadat, 2004, 2nd edition, MC Graw Hill, TK1001. S23

Semester:3
Teaching unit: EMU 3.1
Subject: Microcontrollers & Instrumentation Lab
VHS: 45h00 (TP: 3h00)
Credits: 2
Coefficient: 1

Teaching objectives:

This lab is intended to arm power engineering student with this powerful too that will help him designing microcontroller based system then implementing algorithms on µcontrollers. This skill is crucial for modern control techniques, particularly in power electronics and electric drives.

Recommended prior knowledge:

The prerequisite courses are: Active devices and digital systems.

Material content:

TP N1: Operational amplifier circuits for instrumentation **(1 week)**

Lab N2: Instrumentation transformers **(2 weeks)**

Lab N 3: Hall effect sensors **(2 weeks)**

Lab N 4: Microcontroller programming tools **(2 weeks)**

TP N5: Microcontroller Digital interfaces **(2 weeks)**

TP N6: Microcontroller Analog interfaces **(2 weeks)**

TP N7: Microcontroller Timer and PWM generation **(2 weeks)**

TP N8: Microcontroller communication modules **(2 weeks)**

Evaluation method:

Continuous assessment: 100%.

References:

1. Computer Architecture, Carter Nicholas, Mc Graw Hill, 2008.
2. Fundamentals of Digital Logic with VHDL. By S. Brown & Z. Vranesic
3. Digital Design with CPLD Applications & VHDL By R. K. Dueck
4. Computer System Architecture, M. Morris Mano, Mc Graw Hill, 2008.

Semester: 3
Teaching unit: EMU 3.1
Material: Industrial Power Network with PLC Lab
VHS: 45h00 (TP: 3h00)
Credits: 2
Coefficient: 1

Teaching objectives:

1. The student will learn implementing industrial motor systems
2. The student will learn all methods of industrial motor control
3. The student will learn the use of PLC in to implement industrial motor control

Recommended prior knowledge:

The prerequisite courses are: Active devices, digital systems, and electric machines

Material content:

TP N1: Electrical Installation (Two way switching, ect..) **(1 week)**

TP N2: Two direction control of Electric motor **(1 week)**

TP N 3: Two level speed control of Electric motor **(1 week)**

TP N 4: Ywe-Delta starter for Induction motor **(1 week)**

TP N5: Rotor resistance starter for Induction motor **(1 week)**

TP N6: Starter of DC motor **(1 week)**

TP N7: Electric Braking System for Induction motor **(1 week)**

TP N8: Implementation of the above experiments using PLC **(8 weeks)**

Evaluation method:

Continuous assessment: 100%.

References:

1. Lab Volt Laboratory Manual

Semester: 3
Teaching unit: EMU 3.1
Material: Protective System Lab
VHS: 22h30 (TP: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

4. The student will learn to implement Protective schemes
5. The student will learn the different industrial software related to protection
6. The student will learn the use Computer to modify numerical relay settings

Recommended prior knowledge:

The prerequisite courses are: Power systems and electric machines

Material content:

TP N1: simulation of Power systems using ETAP- load flowanalysis **(1 week)**

TP N2: simulation of Power systems using ETAP- fault analyses **(1 week)**

TP N 3: simulation of different protection schemes using ETAP **(1 week)**

Lab N 4: Selectivity design **(1 week)**

TP N5: Transforming Protection **(1 week)**

TP N6: Transmission line protection **(1 week)**

TP N7: Motor/Generator protection **(1 week)**

TP N8: Numerical relay settings configuration **(2 weeks)**

Evaluation method:

Continuous assessment: 100%.

References:

1. Protective Relaying: Principles and Applications, Third edition, J Lewis Blackburn and Thomas J. Domin, CRC Press, 2007.
2. P.M. Anderson, Power System Protection, IEEE Press, NY, 1999.
3. P. Rush, Network Protection and Automation Guide, 1st Ed., Library of Cayfosa, Barcelona, 2002.

Semester: 3
Transversal UE: UET 3.1
Subject: Communication skills
VHS: 22h30 (lecture: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

This is a 'service English' communication course intended to prepare the students to communicate and function in English (Lab reports, Industrial experience reports and end of study cycle project reports). The course outline presented in this document is divided into two parts: a first part (first five units) which is considered as a link between the students' previous work in the first two semesters; and a second part consisting of eleven units which will present the students with discourse behaviours and discourse means to communicate and function in English. Other items are treated throughout the programme: mechanics of writing (punctuation, numbering of chapters and sub-chapters, labelling of visuals, quotations...).

Recommended prior knowledge:

Student must attend all English courses

Content of the material:

a) **Part One (06 weeks)**

1. Transition from sentence production to the development of continuous prose,
2. Devices for linking ideas and sentences: logical, grammatical and lexical connectors,
3. Concepts of reference, 4. Paragraph Development: Producing pieces of coherent discourse, 5. Different types of paragraphs (analysis, description, comparison/contrast, analogy, definition ...)

b) **Part Two (09 weeks)**

1. Definition: Explaining what something is, 2. Instructions and Process: Explaining how to do something, 3. Description of a Mechanism: Explaining how something works,
4. Analysis through Classification and Partition: Putting things in order, 5. Analysis through Effect and Cause: Answering Why, 6. The Summary: Abstracting and Getting to the heart of the matter, 7. Using the Library: Getting acquainted with resource materials, 8. Visuals: Seeing is convincing, 9. Report Writing: Telling it like it is, 10. Oral Communication: Saying it clearly, 11. Business Letters: Sending a Message through the mail

Method of evaluation:
Review: 100%

Bibliographical references:

5. Rob Biesenbach, Unleash the Power of Storytelling: Win Hearts, Change Minds, Get Results, Eastlawn Media (February 13, 2018).
6. Carmine Gall, Five Stars: The Communication Secrets to Get from Good to Great Hardcover, St. Martin's Press (June 5, 2018)

7. Mark Goulston , Just Listen: Discover the Secret to Getting Through to Absolutely Anyone, AMACOM; Reprint edition (March 4, 2015)
8. Celeste Headlee We Need to Talk: How to Have Conversations That Matter, Harper Wave (September 19, 2017).
9.
10. Jerold Panas and Andrew Sobel (Author), Power Questions: Build Relationships, Win New Business, and Influence Others,Wiley; 1st edition (February 7, 2012)

Semester: 3
Teaching unit: UET 3.1
Subject: Project Management
VHS: 22h30 (lecture: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

1. Understand and apply the sequential steps of the project management framework.
2. Understand the importance and function of project management and apply the project process of initiating, planning, executing, controlling and closing the project.

Recommended prior knowledge:

Ethics & Integrity (basics)

Content of the material:

Chapter 1. Initiating a project **(02 weeks)**

Chapter 2. Planing of project activities **(02 weeks)**

Chapter 3. Project execution activities **(03 weeks)**

Chapter 4. Closing down the project activities **(03 weeks)**

Chapter 5. Application and case studies :

- Representing and scheduling project steps activities **(02 weeks)**
- Use of software program : Primavera activities **(03 weeks)**

Method of evaluation:

Review: 100%

Bibliographical references:

1. P. Lewis, Fundamentals of Project Management, James, ISBN: 9780814408797
2. Harold, Ph.D. Kerzner Project Management: A Systems Approach to Planning, Scheduling, and Controlling, (ISBN-10: 0471741876/ISBN-13: 978-0471741879).

Proposal of some discovery materials

(*One course must be selected from this list*)

Semester: 2
Teaching unit: UED 1.2
Subject: Introduction to Advanced Control Techniques
VHS: 22h30 (lecture: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

This course is intended to familiarize students with advanced and modern control techniques. The most used techniques in power engineering field namely: input - output linearization techniques, sliding mode control. The course presents the Lyapunov theorem that is used for the nonlinear control design.

Recommended prior knowledge:

The prerequisite of this course are probability, calculus, and introduction to optimization.

Content of the material:

Chapter 1. Nonlinear systems (05 weeks)

1.1. General information on nonlinear systems, usual nonlinearities and modeling in the state space of nonlinear systems

1.2. Interconnected complex nonlinear systems, singular perturbations.

1.3. Piece-wiselinearsystems and multi-models

Chapter 2. Stability and control of nonlinear systems (05 weeks)

2.1. Stability, Lyapunov based Stability

2.2. Input-output linearization control of nonlinear systems

Chapter 3. Other advanced control techniques (05 weeks)

5.1. Sliding mode control

5.2. Backstepping control

5.3. Model Predictive Control

5.4. Passivity-based control.

Method of evaluation:

Review: 100%

Bibliographical references:

1. A. Isidori, Nonlinear control systems (I and II), Springer-Verlag
2. H. K. Khalil, Nonlinear Systems, Prentice Hall
3. H. Nijmeijer, Nonlinear dynamical control systems
4. M. Vidyasagar, Nonlinear system analysis, Prentice Hall

Semester: 2
Discovery UE: UED 1.2
Subject: Introduction to Artificial Intelligence Techniques
VHS: 22h30 (lecture: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

This course is intended to familiarize students with most employed methods of artificial intelligence. The course also intends to present the different application of AI in power engineering filed and particularly control of electro-energetic systems.

Recommended prior knowledge:

The prerequisite of this course are probability, calculus, and introduction to optimization.

Content of the material:

Chapter 1: Fuzzy logic **(02 weeks)**

Fuzzy sets. Fuzzy values. Membershipfunctions. Operations in fuzzy logic. Structure of fuzzy controller. Fuzzyfication. Inference system. Defezzification.

Chapter 2: Artificial Neural Network **(03 weeks)**

ANN topologies. Multilayer ANN. Static ANN. Dynamic ANN. Tryninig of ANNs. Supervised and unsuprvised training.

Chapter 3: Adaptive Neural Fuzzy Inference System **(02 weeks)**
Chapter 4: Genetic Algorithms **(02 weeks)**
Chapter 5: Particle Swarm Optimization Algorithm **(02 weeks)**
Chapter 6: Expert systems **(02 weeks)**
Chapter 7: Probability and probabilistic reasoning **(02 weeks)**

Method of evaluation:
Review: 100%

Bibliographical references:

1. D. R. Hush & B.G. Horne, "Progress in Supervised Learning Neural Networks," IEEE signal proc. magazine, Vol.10, No.1, pp.8-39-, Jan. 1993.
2. B. Kosko, " Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence," Englewood Cliffs, Nj: Prentice-Hall, 1992.
3. L.X.Wang, "Adaptive Fuzzy Systems & Control: Design & Stability Analysis": Prentice-Hall, 1994.
4. Hung T. NguyenNadipuram R. Prasad, Carol L. Walker • Elbert A. Walker, "A First Course in Fuzzy and Neural Control"
5. FAKHREDDINE O. KARRAY, CLARENCE DE SILVA, "Soft computing and intelligent systems design. Theory, tools and applications »

Semester: 3
Discovery UE: UED 1.2
Material: Renewable Energy
VHS: 22h30 (lecture: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

The content of this course is present some important renewable energy sources, their principal of operation, standalone operation and integration to grid utilities.

Recommended prior knowledge:

The prerequisite courses are : Electric machines ; power electronics.

Content of the material:

Chapter 1. Solar radiation (solar Spectrum, solar declination, altitude angle, solar position, direct beam radiation) **(02 weeks)**

Chapter 2. Solar Cells **(**Introduction, Semiconductor physics , Solar cells Operation, The solar cell equivalent circuit, Power losses in solar cells , Temperature and irradiance effects **) (02 weeks)**

Chapter 3. Photovoltaic (PV) System Engineering (Structure of a PV system, The PV Generator , Electrical characteristics of PVG, Power Conditioning and control (MPPT), Perturb & Observe (P&O), Incremental Conductance **)** **(03 weeks)**

Chapter 4. Application and sizing (introduction, storage system, sizing procedure, examples) **(02 weeks)**

Chapter 5. Wind energy source (introduction, wind energy in Algeria, source of wind energy, principle of wind turbine, wind power production, MPPT) **(01 weeks)**

Chapter 6. Wind energy conversion systems (Types of will wind energy conversion systems, Major components of WECS, Wind turbine aerodynamics, Conventional MPPT techniques, Modeling and Operation analysis of WECS based on - Induction generators, - Permanent magnet synchronous generators) **(03 weeks)**

Chapter 7. Other renewable energy sources (Geothermal, tidal, Fuel cell, etc.) **(02 weeks)**

Method of evaluation:
Review: 100%

Bibliographical references:

1. R. A. Messenger, J. Ventre, Photovotaic Systems Engineering, CRC Press, 2nd edition, 2004
2. S. N. Bhadra, et al. Wind electrical system, Oxford University Press, 2013
3. M. El-Sharkawi, Electric Energy: an introduction, 3rd edition, CRC Press, Taylor & Francis Group, 2013.
4. Henrik Lund , Renewable Energy Systems, 2nd edition, Elsevier, 2014.
5. Vaughn Nelson, Electric Energy: an introduction, CRC Press, Taylor & Francis Group, 2011.

Semester: 2
UE Discovery Code: UED 1.2
Material: Introduction to Power Quality
VHS: 22h30 (Lecture: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

This course outlines the following:

- Origins of phenomena that alter the electric power quality and their origins in the power system. Their effects on the system voltage or current
- Explain the relationship between nonlinear loads and power quality and the different solutions to remedy the above problems.

Recommended prior knowledge:

Student should have attended : power system, AC circuits, and power electronics.

Material content:

Chapter 1: Introduction to power quality **(03 weeks)**
Introduction, definition and terminology of power quality, power quality measurments.

Chapter 2: Power quality deterioration **(05 weeks)**
Most common power quality problems and their effects on the load and process.

- Voltage swell , flicker and interruptions, their origins, their effects on the receiver,
- Harmonics and sub-harmonics:Origins of harmonics and sub-harmonics, Types of nonlinear load, impacts of harmonics in power system and consumers.
- Voltage fluctuation: origin and consequences on power generation and equipment
- Transient phenomena: definition, electromagnetic compatibility, lightning impacts, lightning protection,
- Unbalance

Chapter 3: Power quality standards **(03 weeks)**
Voltage characteristic, terminology, measurement of voltage parameters, Power quality analyzer.

Chapter 4: Solution to enhance power quality **(04 weeks)**

- Use of static compensators
- Passive and active filters
- Use of LC loads
- Use balanced loads
- Use of soft starters for large induction motors
- Increase size of transformers and feeder cables

Evaluation method:

Review: 100%

References:

6. Guide to Quality of Electrical Supply for Industrial Installations Part 2: Voltage Dips and Short Interruptions Working Group UIE Power Quality 1996.

7. G.J. Wakileh, Power system harmonics-Fundamental Analysis and Filter Design, Springer-Verlag, 2001.

8. A. Kusko, M-T. Thompson, Power Quality in Electrical Systems, Mc Graw Hill, 2007.

9. F. Ewald Fuchs, M.A.S. Masoum, Power Quality in Power Systems and Electrical Machines, Elsevier Academic Press, 2008.

10. R.C. Dugan, Mark F. Granaghan, Electrical Power System Quality, McGraw Hill, 2001.

11. Scheider Technical Specifications Nos. CT199, CT152, CT159, CT160 and CT1.

12. A. Robert, Supply Quality Issues at the Interphase between Power System and Industrial Consumers, PQA 1998.

UE Discovery Code: UED 1.2
Subject: Introduction to Smart Grid
VHS: 22h30 pm (Lecture: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

The technologies and operation problems of smart grid will be introduced in this course. Furthermore, the relationship of the electricity market and smart grid will be discussed, and then one issue of how to integrate distributed energy resources will be analyzed and discussed.

Recommended prior knowledge:

Student should have attended: power system, AC circuits, and power electronics.

Material content:

Chapter 1: Overview of Smart Grid **(02 weeks)**

History Development of Power System, Overview of Smart Grid in the United States, Overview of Smart Grid in the European Union, Overview of Smart Grid in other countries, Overview of Smart Grid in China.

Chapter 2: Definition and Framework of Smart Grid **(02 weeks)**

- Research Institutions and Standards of Smart Grid
- Performance Characteristics of Smart Grid
- Typical Structure of Smart Grid

Chapter 3: Smart Grid Technologies **(03 weeks)**

- Measurement Technology of Smart Grid
- Communication Technology of Smart Grid
- Control Technology of Smart Grid
- Related Equipment of Smart Grid

. Chapter 4: Related Issues in Operation of Smart Grid **(04 weeks)**

- Energy Saving, Emission Reduction and Smart Grid
- Economic Operation of Smart Grid
- Smart Grid Management
- Smart Grid and Marketing Operation
- Smart Grid and Microgird

Chapter 5 Distributed Generations in Smart Grid **(04 weeks)**

- Micro Turbines
- Wind Generation in Smart Grid
- Impact of Large Scale Wind Generation in Power System
- Photovoltaic System
- Energy Storage Device

Evaluation method:

Review: 100%

References:

1. Qing-Chang Zhong, Tomas Hornik, CONTROL OF POWER INVERTERS IN RENEWABLE ENERGY AND SMART GRID INTEGRATION, Wiley & IEEE Press, 2013.

2. James A. Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley-IEEE Press; 1st edition (March 6, 2012)

3. Radian Belu, Smart Grid Fundamentals: Energy Generation, Transmission and Distribution, CRC Press 2022.
4. Janaka B. Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, Smart Grid: Technology and Applications, Wiley 2012