CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

2025-2026

YEAR 1

CONTROL AND ROBOTICS

DYNAMICS OF RENEWABLES-BASED POWER SYSTEMS (DREAM)

PROGRAMME SUPERVISOR(S):
Bogdan MARINESCU

YEAR 1 - Autumn Semester

CORE COURSES

Course code	Title	ECTS Credits
CONF	Conferences	-
CROSS	Control of electrical drive systems	4
DYCOS	Dynamic components of power systems	6
MIAMI	Mathematical modeling and identification	5
NASH	Nonlinear and switching dynamics	4
OPTIM	Optimization	5
POWER	Power systems dynamics	4

LANGUAGE COURSES

Course code	Title	ECTS Credits
CCE1	Cultural and Communication English	2
ESP1	Spanish Language	2
FLE1	French Language	2

Conferences [CONF]

LEAD PROFESSOR(S): Bogdan MARINESCU

Objectives

additionnal training

Course contents

Course material

Sustainable Development Goals (SDGs) covered by this course

Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

renewable energies

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	-	20 hrs	0 hrs	0 hrs	0 hrs	0 hrs

Control of electrical drive systems [CROSS]

LEAD PROFESSOR(S): Bogdan MARINESCU

Objectives

- Know how to analyse stability and structural properties of a large-scale power system
- Acquire bases for robust control for different grid objectives (control of generators, damping of grid power oscillations, ...)

Course contents

- Performances & robustness of large-scale systems ; loop-shaping and basic principles
- Multi-input/multi output systems
  - o State-space form & DAE representations
  - o Structural properties & model reduction
- Robust control techniques
  - o Methodologies (internal model principle, H2/H infinity, ...)
  - o Power systems study cases: control for mixed local and grid objectives

Course material

1. T. Kailath, Linear Systems, Prentice-Hall, 1980.
2. J. Doyle, B. Francis, A. Tannenbaum, Feedback Control Theory, MacMillan 1990. www.e-booksdirectory.com
3. M. Ilic, J. Zaborsky, Dynamics and Controls of Large Electric Power Systems, Willey 2000.

Sustainable Development Goals (SDGs) covered by this course

Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

promotion of renewables via their participation to ancillary services

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	20 hrs	6 hrs	4 hrs	0 hrs	2 hrs

Dynamic components of power systems [DYCOS]

LEAD PROFESSOR(S): Vinu THOMAS

Objectives

▪ To apply the knowledge gained on mathematical modelling of power system components and to utilize simulation software tools to develop simulation models of power system components in order to analyse the dynamic behavior of the power systems
▪ To develop the fundamental skills required to carry out research work on power system dynamics

Course contents

The students do the project in groups of 3 to 5 members. A project topic is assigned to each group. An introductory session on the topic shall be provided by the instructor and there will be interactive sessions of the group with the instructor every few weeks. The students shall be assigned specific tasks related to the project topic, to be completed before the next interactive session. During the interactive sessions, additional tasks are assigned to enable the students to complete the objectives of the project topic.
Towards the end of the semester, the students are supposed to complete all the tasks and develop a mathematical simulation model as per the topic and carry out case studies. Project assessment is done based on a final written report and oral presentations made by group members during the interactive sessions.

Course material

Perelmuter, Viktor, Renewable Energy Systems: Simulation with Simulink® and SimPowerSystems. CRC Press, 2016.
Kunjumuhammed, Linash, Stefanie Kuenzel, and Bikash C. Pal, Simulation of Power System with Renewables. Academic Press, 2019.
Kundur, P. S., Power system stability and control. McGraw-Hill Education, 1994
Yazdani, A., & Iravani, R., Voltage-sourced converters in power systems: modeling, control, and applications. John Wiley & Sons, 2010

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Climate action / Partnership s for the goals

Sustainable Development and Social Responsibility Positioning

This course helps the students to learn and implement of sustainable energy systems using group projects

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	6	10 hrs	20 hrs	0 hrs	0 hrs	2 hrs

Mathematical modeling and identification [MIAMI]

LEAD PROFESSOR(S): Vinu THOMAS

Objectives

· To mathematically model power system components.
· To take into account the model uncertainty using a probabilistic approach.
· To develop system identification and state tracking methods using a probabilistic approach.

Course contents

Part 1

· Mathematical modelling – Types of modelling, Need for modelling
· Mathematical description of a synchronous machine, review of magnetic circuit equations and basic equations of a synchronous machine, dq transformation, per unit representation, representation of magnetic saturation
· AC Transmission: transmission line, characteristics and performance equations, two winding and three winding transformer representation, load modelling – static and dynamic, modelling of induction motors, representation in stability studies, synchronous motor models- acquisition of load model parameters
· Modelling of excitation systems: modelling of excitation components and complete excitation systems, Prime movers and electricity supply systems –hydraulic, steam, thermal and wind turbines and governing systems
· Voltage source converter modelling – averaged model, model in beta and dq frame

Part 2
· Probability theory: random vectors, density, mean, variance.
· Time analysis, frequency analysis: random signals, autocorrelation, power spectral density.
· Classical estimation Theory, Bayesian estimation: maximum likelihood (ML) estimation, minimum mean square error (MMSE) estimator, maximum a posteriori (MAP) estimator, linear minimum mean square error (LMMSE).
· Markov chains, Markov processes, Statistical filtering: Kalman

Course material

Lecture notes at Centrale Nantes (provided document)
Kundur, P. S., Power system stability and control. McGraw-Hill Education, 1994
Yazdani, A., & Iravani, R., Voltage-sourced converters in power systems: modeling, control, and applications. John Wiley & Sons, 2010

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Climate action

Sustainable Development and Social Responsibility Positioning

This course provides the basics of mathematical modelling of power system components to provide sustainable and clean energy

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	22 hrs	4 hrs	4 hrs	0 hrs	2 hrs

Nonlinear and switching dynamics [NASH]

LEAD PROFESSOR(S): Bogdan MARINESCU

Objectives

- Have an introduction to nonlinear systems
- How to analyze the stability and performance properties of nonlinear systems
- Have an introduction to hybrid and switched systems and familiarize with their main behaviors
- Acquire the main tools to analyze the stability of switched systems and provide main tools for their stabilization.
- The obtained skills will be based on both extensions of linear tools as well as electrical applications and power converters.

Course contents

- Introduction to nonlinear dynamics and associated definitions
- Stability of nonlinear systems with Lyapunov function theory
- Introduction to a specific class of nonlinear systems: hybrid and switched systems.
- Stability of switched systems.
- Control design for switched systems.

Course material

1. R. Goebel, R. G. Sanfelice, A. R. Teel. Hybrid Dynamical Systems: Modeling, Stability and Robustness. Princeton University Press.
2. H. K. Khalil. Nonlinear Systems. Second Edition. Prentice Hall, Upper Saddle River. 1996.
3. D. Liberzon. Switching in Systems and Control. Birkhäuser, 2003.
4. Z. Sun, S. S. Ge. Stability Theory of Switched Dynamical Systems. Springer London. 2011.
5. M. Vidyasagar. Nonlinear Systems Analysis. Second Edition. Prentice-Hall International Editions. 1993.

Sustainable Development Goals (SDGs) covered by this course

Industry, innovation and infrastructure / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

renewable energy

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	14 hrs	4 hrs	12 hrs	0 hrs	2 hrs

Optimization [OPTIM]

LEAD PROFESSOR(S): Ina TARALOVA

Objectives

Optimisation is transversal to all engineering fields, and beyond.
The aim of the course is to get acquainted with iterative optimization methods in one dimensional and multidimensional case, linear or nonlinear, with or without constraints.

Students will be given further analytical tools for the formulation and solution of PF and OPF problems, with numerical applications to benchmark problems in power systems such as congestion management in RTE.

Course contents

1. Introduction to optimization problems : Examples, definitions. Convex sets and convex functions.
2. Unconstrained optimization. Definition of convergence rate, complexity of the algorithm
2.0. Unconstraint optimization. Linear problem, Simplex method
2.1. Unidimensional problems
2.1.1 Derivative-based optimization methods (DBO) : Newton's method, Secant method
2.1.2. Derivative-free optimization methods (DFO) : Mini-Max problems, Dichotomy, Fibonacci, Golden section, Brent's method, "Economic" methods
2.2. Multidimensional problems
2.2.1 Direct search heuristic methods : Hooke and Jeeves, Nelder – Mead simplex method
2.2.2 Gradient-based method: Gradient, steepest descent, conjugate gradients, quasi-newton
3. Constrained optimization. Examples of constrains in Control.
3.1. Dual methods : Lagrange multipliers
3.2. Primary methods: Interior and exterior points

Second part taught by RTE lecturers

4.1Optimisation in power systems
4.2 Optimisation in electrical grids based on linear models (N-1 rule, Security Constrained Optimal Power Flow)
4.3 ACOPF : Alternative Current Optimal Power Flow
4.4 Real-time optimization for congestion management in RTE

Course material

1. (2016), D.Bertsekas, Nonlinear Programming, Athena Scientific.
2. (2004) S.Boyd, L. Vandenberghe, Convex Optimization, Cambridge University Press,

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Quality education / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

minimisation of optimisation criteria on energy and other resorces Stock optimisation

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	20 hrs	2 hrs	8 hrs	0 hrs	2 hrs

Power systems dynamics [POWER]

LEAD PROFESSOR(S): Vinu THOMAS

Objectives

Acquire the bases of the dynamic operation of power grids. After completing this module, students will be able to:
- Understand and analyze the main dynamic phenomena of interconnected power systems
- Know the basic and classic regulations of power grids
- Use grid dedicated simulation softwares
- knowledge of the electricity sector (fields of activity of companies like RTE, EDF or equipment manufacturer such as, for example, Alstom, Siemens, ABB)

Course contents

- Electricity production and grid management (general notions)
- Load flow
- Basic dynamics (frequency/voltage) of a power grid; generation/consumption balance
- Stability (voltage, frequency/transient, small-signal/oscillatory)
- Primary/secondary/tertiary regulations;
- Voltage & frequency system services
- Zoom on the French and European grids

Course material

P. Kundur, Power System Stability and Control, McGraw-Hill, 1994.
G. Rogers, Power System Oscillations, Kluwer Academic, 2000.
M. Ilic, J. Zaborsky, Dynamics and Control of Large Electric Power Systems, Wiley, 2000.
P.W. Sauer, M.A. Pai, Power Systems Dynamics and Stability, Prentice Hall, 1998.

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Climate action

Sustainable Development and Social Responsibility Positioning

This course aligns the students to learn and apply new methods for clean energy integration to the grid

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	18 hrs	4 hrs	8 hrs	0 hrs	2 hrs

Cultural and Communication English [CCE1]

LEAD PROFESSOR(S): David TROYA

Objectives

This course aims at improving your critical thinking and persuasion skills in English. Using documentaries, we will explore, discuss and debate a range of cultural, political, social, and environmental issues relevant to current world events.

Speaking and understanding English as a second or third language is a great achievement, but does it mean you are an effective communicator? The next step involves, among other things, critical thinking and persuasive skills, both of crucial importance in the modern professional environment. We will address these issues by analyzing documentaries that will lead to formal debates.

Several competencies will be developed through class exercises. Oral presentations will be an opportunity put your verbal as well as your non-verbal communication skills into practice. During debate, you will be able to sharpen your analytical skills, provide constructive feedback, defend an argument, and prove a point.

Course objectives

- Improving your communication skills

- Becoming an active listener

- Enhancing your non-verbal communication skills

- Developing critical thinking toward media

- Boosting leadership skills through moderating

- Organizing evidence and arguments

Course contents

Each session will be dedicated to a particular cultural, political, social or environmental topic of relevance in the wider anglophone world. Each topic will include multimedia material in the form of a short documentary or documentary excerpt. During class, students will lead a primer presentation, a moderated discussion and a formal debate.

Primer Presentation:

In pairs, you will hold a short talk to prime us on the topic of that week's documentary: you will introduce us to the topic by setting it in a wider context and establishing what's at stake.

Moderated Discussion :

In pairs, you will moderate a discussion related to the themes explored by the documentary. Moderators will come prepared with open-ended questions pertaining to the strengths and weakness of the documentary. They will distinguish between content and form and encourage critical, constructive opinions.

Formal Debate:

What's the difference between an opinion and an argument? You will soon find out. After the moderated discussion, we will brainstorm potential topics for debate, and follow the British Parliamentary model to sharpen your research, critical thinking, and persuasive skills.

During the debate, each speaker will be assigned an audience member who evaluates their individual performance and provides a short debrief. A panel of two judges will determine which side wins.

Course material

Written and televised press, information and digital tools, general documents, business environment and company strategies. Internet conferences (Ted Talks, etc.), our own educational materials on Hippocampus (Moodle).

Sustainable Development Goals (SDGs) covered by this course

Climate action / Industry, innovation and infrastructure / Partnership s for the goals / Quality education / Reduced inequalities

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

Spanish Language [ESP1]

LEAD PROFESSOR(S): Marta HERRERA

Objectives

For beginners:
Practice and reinforcement of the five skills (oral and written expression and comprehension as well as interaction)
Acquisition of vocabulary and linguistic structures
Be able to talk about yourself and those around you
Be able to express oneself during daily activities
Know how to give your opinion

For advanced students:
Practice and reinforcement of the five skills (oral and written expression and comprehension as well as interaction)
Acquisition of specialised vocabulary
Be able to understand the essential content of concrete or abstract subjects including a technical discussion
Be able to communicate spontaneously and fluently
Be able to express oneself in a clear and detailed manner, to express an opinion on a topical subject

Course contents

For beginners:
Personal environment (introduce yourself, express yourself, your tastes, your character, your hobbies, etc.), your surroundings (friends, family, location, climate), your interests (sports, leisure)
Present tense (regular and irregular)
Language patterns to express habit, obligation, "gustar" and its equivalents,
Possessive adjectives
Differences between "es", "está", "hay"
Use of "por" and "para"
Adverbs and frequency patterns
Numeral adjectives

For advanced students:
Knowledge of the Hispanic world (economic, technical, cultural and social environment)
Present tense (regular and irregular)
Imperative
Past tenses
Direct / indirect style
Future tense
Conditional tense
Present and past subjunctive moods

Course material

Preparation manuals, our own tailor-made documents, written and internet press, general civilization documents, digital tools

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Climate action / Decent work and economic growth / Gender equality / Goo health and well-being / Industry, innovation and infrastructure / No poverty / Partnership s for the goals / Peace, justice and strong institutions / Quality education / Reduced inequalities / Responsible consumption and production / Sustainable cities and communities / Zero hunger

Sustainable Development and Social Responsibility Positioning

Key competencies for sustainability Collaboration: the abilities to learn, to understand and respect others; to deal with conflicts in a group; and to facilitate collaborative and participatory problem solving. Critical thinking: the ability to reflect on one's own values, perceptions and actions. Self-awareness: the ability to reflect on one's own role in a group; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
Spanish	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

French Language [FLE1]

LEAD PROFESSOR(S): Silvia ERTL

Requirements

N/A

Objectives

The objective is to familiarize the learner with the French language and French culture through an entertaining task-based communicative language teaching, focused on speaking combined with:

- Phonetics
- Self-correcting exercises on our learning platform
- Learning Lab activities
- Project work
- Tutoring

Course objectives include the acquisition and reinforcement of vocabulary, syntax, and pronunciation by both traditional means and through the use of digital resources.
Students will learn general French, develop language skills of oral and written comprehension and expression.

After completing this course (32 hours + personal work), the students will be able to communicate in spoken and written French, in a simple, but clear manner, on familiar topics in the context of study, hobbies etc. Another important goal of this course is to introduce the student to French culture. At the end of the course (2 semesters), complete beginners can achieve an A1 level and some aspects of the A2 of The Common European Framework of Reference for Languages. More advanced students may aim for B1/B2 levels.

Course contents

Full range of practical communication language exercises: reading comprehension, listening comprehension, written expression, oral expression.

Learners will be able to use the foreign language in a simple way for the following purposes:

1. Gving and obtaining factual information:
- personal information (e.g. name, address, place of origin, date of birth, education, occupation)
- non-personal information (e.g. about places and how to get there, time of day, various facilities and services, rules and regulations, opening hours, where and what to eat, etc.)

2. Establishing and maintaining social and professional contacts, particularly:
- meeting people and making acquaintances
- extending invitations and reacting to being invited
- proposing/arranging a course of action
- exchanging information, views, feelings, wishes, concerning matters of common interest, particularly those relating to personal life and circumstances, living conditions and environment, educational/occupational activities and interests, leisure activities and social life

3. Carrying out certain transactions:
- making arrangements (planning, tickets, reservations, etc.) for travel, accommodation, appointments, leisure activities
- making purchases

- ordering food and drink

Course material

Preparation manuals, our own tailor-made documents, written and televised press, internet, general civilization documents, digital tools, our own educational materials on Hippocampus (Moodle).

Sustainable Development Goals (SDGs) covered by this course

Quality education

Sustainable Development and Social Responsibility Positioning

Targeted competencies extracted from: Education for sustainable development goals, learning objectives (UNESCO) https: //unesdoc.unesco.org/ark:/48223/pf0000247507 https://www.coe.int/fr/web/common-european-framework-reference-languages/official-translations-of-the-cefr-global-scale

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	2	0 hrs	48 hrs	0 hrs	0 hrs	0 hrs