CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

2022-2023

YEAR 2

CONTROL AND ROBOTICS

ELECTRIC VEHICLE PROPULSION AND CONTROL (E-PICO)

PROGRAMME SUPERVISOR(S):
Mohamed Assaad HAMIDA

YEAR 2 - Autumn Semester

CORE COURSES

Course code	Title	ECTS Credits
ACEV	Advanced control of electric propulsion systems	5
CAPEV	Case study application dedicated to electric vehicle topology	5
COPCEV	Control of power converters for electric propulsion system	5
OBSEDIA	Observation and Diagnosis for electric propulsion systems	5
OPTEV	Optimization, application to energy management of electric vehicle charging	5
PROJECT	Project	5
SEMEV	Seminars	-

YEAR 2 - Spring Semester

CORE COURSES

Course code	Title	ECTS Credits
THESIS	Internship / Thesis project	30

Advanced control of electric propulsion systems [ACEV]

LEAD PROFESSOR(S): Mohamed Assaad HAMIDA

Objectives

After having followed the course, the candidate shall have obtained thorough insight in and understanding of:
- Analysis and modelling of electric machine used in electric vehicle
- Control of electric machine

Course contents

This course introduces the concept of control of electric motors for electric vehicle application. Initially, the dynamic models of the ac motors are developed that will be useful in understanding the dynamic control. Advanced control techniques are applied to optimize the performance of ac motor drives.

- Application-Specific Selection of Machine-and-Drive Systems
- High-Speed Electric Machines
- Control principles for electrical motor drives
- Performances improvement of AC machines control
- Sensorless control of AC machines

Course material

1. P. Vas," Sensorless vector and direct torque control", Oxford science publications, 1998.
2. A. Glumineau and J. De Leon "Sensorless AC Electric Motor Control", Springer, 2015.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	16 hrs	6 hrs	8 hrs	0 hrs	2 hrs

Case study application dedicated to electric vehicle topology [CAPEV]

LEAD PROFESSOR(S): Mohamed Assaad HAMIDA

Objectives

Objectives of this course are to study the following three case studies:

- Electric fault tolerant control and safety of electric propulsion
- Sensorless control to render electric vehicles more affordable
- Battery management system and interaction between the battery charger and the renewable energy sources

Course contents

Course material

1. A. Silveira, R. Araújo and R. de Castro," Survey on Fault-Tolerant Diagnosis and Control Systems Applied to Multi-motor Electric Vehicles", Springer, 2011.
2. R. Sumedha, S. Farhad, G. Arindam, "Plug In Electric Vehicles in Smart Grids", Springer, 2015.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	18 hrs	6 hrs	8 hrs	0 hrs	0 hrs

Control of power converters for electric propulsion system [COPCEV]

LEAD PROFESSOR(S): Malek GHANES

Objectives

The course covers:

- Analysis of power converters used in electric vehicles
- Power converter design
- Power converter modelling and control

Course contents

1. Brief reminder on Power Electronic Functions
2. Brief reminder on Power Electronic Components
3. Non Controlled 3-Phase Rectifiers, EV/HEV applications
4. Controlled 3-Phase Rectifiers, EV/HEV applications
5. Inverters and their Control, EV/HEV applications
   - Inverter presentation
   - How an inverter works
   - Pulse Width Modulation (PWM)
   - Advanced PWM
   - Optimization
6. Choppers and their Control, EV/HEV applications
   - Chopper presentation
   - DC-DC converter topologies
   - Modulation strategies 25
   - DC-DC LLC resonant converters

Course material

1- Al Attar, H., Hamida, M. A., Ghanes, M., & Taleb, M. (2022). LLC DC-DC Converter Performances Improvement for Bidirectional Electric Vehicle Charger Application. World Electric Vehicle Journal, 13(1), 2.
2- W. G. Gerekial, Bi-directional power converters for smart grids, en, Norwegian University of Science and Technology, Tech. Rep., Jun. 2014, p. 108.
3- Bourgeade Adrien, Malek Ghanes, Fadel Maurice, Bouarfa Abdelkader, and Barbot Jean-Pierre. Off-line pwm control with a three phases relaxed symmetry applied to a two-level inverter. In 2021 IEEE Conference on Control Technology and Applications (CCTA), pages595–600, 2021.
4- J. Holtz. Pulsewidth modulation for electronic power conversion. Proceedings of the IEEE, 82(8):1194–1214, 1994.
5- J. Holtz. Advanced pwm and predictive control - an overview. IEEE Transactions On Industrial Electronics, 63(6):3837–3844, June 2016.
6- A. Bouarfa, M. Bodson, and M. Fadel. An optimization formulation of converter control and its general solution for the four-leg two-level inverter. IEEE Transactions on Control Systems Technology, 26(5):1901–1908, 2018.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	14 hrs	6 hrs	10 hrs	0 hrs	2 hrs

Observation and Diagnosis for electric propulsion systems [OBSEDIA]

LEAD PROFESSOR(S): Malek GHANES

Objectives

Measuring the state of a given system with physical sensors is sometimes impossible and sometimes possible, but too costly. That is why estimating the state of a system by means of software sensors (observers) is an important issue. The first part of this course investigates several methods of observer design for non-linear systems.

Moreover, faults in sensors, actuators or process components may deteriorate overall system performance and could cause serious damage.
From this point of view, the second part of this course will provide some basic definitions and different existing methods of diagnosis. Then, the diagnostic problem will be mainly investigated by using observers (studied in the first part) with fault estimation (simultaneous state and parameter estimation). Finally, fault tolerant control problem is briefly studied.

Examples and labs will illustrate the validity of these two parts in the framework of academic and real applications.

Course contents

I. Observation

1. Introduction to Observation
2. Observation of linear systems
3. Observation for nonlinear systems

II. Diagnosis

1. Introduction to Diagnosis (FDI)
2. Diagnosis with UIO (Unknown Input Observer)
3. Diagnosis with Parity Space

- 2 or 3 practice labs
- 2-hour exam

Course material

Observation:

▪ R. Hermann and A.J. Krener, Nonlinear controllability and observability, IEEE Trans. Automatic Control, 22:728-740, 1977.
▪ R.E. Kalman and R.S. Bucy. New results in linear filtering and prediction, theory. J. Basic Eng., 83:95-108, 1961.
▪ G. Besançon (Ed.). Nonlinear Observers and Applications. LNCIS, Vol. 363. Berlin, Springer-Verlag, 2007.
▪ M. Ghanes, JP. Barbot, L. Fridman and A. Levant, A novel differentiator: A compromise between super twisting and linear algorithms, IEEE CDC, 2017.
▪ Zaltni, D., & Ghanes, M. (2013). Observability Analysis and Improved Zero-Speed Position Observer Design of Synchronous Motor with Experimental Results. Asian Journal of Control, 15(4), 957-970.
▪ Taherzadeh, M., Hamida, M. A., Ghanes, M., & Koteich, M. (2020). A New Torque Observation Technique for a PMSM Considering Unknown magnetic Conditions. IEEE Transactions on Industrial Electronics, 68(3), 1961-1971.

Diagnosis:

▪ R. Isermann, Fault-diagnosis applications: model-based condition monitoring: actuators, drives, machinery, plants, sensors, and fault-tolerant systems. Springer Science & Business Media, 2011.
▪ Taherzadeh, M., Hamida, M. A., Ghanes, M., & Maloum, A. (2021). Torque estimation of permanent magnet synchronous machine using improved voltage model flux estimator. IET Electric Power Applications, 15(6), 742-753.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	18 hrs	4 hrs	8 hrs	0 hrs	2 hrs

Optimization, application to energy management of electric vehicle charging [OPTEV]

LEAD PROFESSOR(S): Raphaël CHENOUARD

Objectives

Understand a problem and formalize it mathematically as an optimization problem.
Introduction to common optimization methods
Application on a concrete electric vehicle charging problem

Course contents

- Introduction to mathematical optimization
- Common numerical methods (gradient-based)
- Introduction to global optimization methods
- Introduction to metaheuristics
- Application to an electrical vehicle charging problem

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	14 hrs	8 hrs	8 hrs	0 hrs	2 hrs

Project [PROJECT]

LEAD PROFESSOR(S): Malek GHANES / Mohamed Assaad HAMIDA

Objectives

The objectives of the project are to study the following topics:

- Observation in electric propulsion
- Electric fault tolerant control and safety of electric propulsion
- Sensorless control to render electric vehicles more affordable
- Battery management system and interaction between the battery charger and renewable energy sources

A report has to be written by the student at the end of the project.
1 meeting per week to discuss progress with the project superviser.

Course contents

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	0 hrs	0 hrs	0 hrs	32 hrs	0 hrs

Seminars [SEMEV]

LEAD PROFESSOR(S): Mohamed Assaad HAMIDA

Objectives

The course comprises talks and project supervision in the field of EV/HEV topics. Speakers from industry and researchers in the field are invited to give the talks and supervise the projects.

Course contents

1- Talks will be given by external speakers in the EV/HEV field.
2- Students will work on oral presentations related to EV and HEV systems.

Course material

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

Internship / Thesis project [THESIS]

LEAD PROFESSOR(S): Malek GHANES

Objectives

- Be exposed to and adapt to an industrial or research environment
- Apply the scientific and technical skills acquired in the previous semesters
- Strengthen interpersonal and communication skills
- Be part of or manage a project
- Organize tasks, analyze results and build deliverables

Course contents

Students should be pro-active and career-oriented in the search for their thesis/internship. The topics are approved by the program supervisor to ensure an adequate Master level. The thesis/internship is evaluated through the submission of a written report and an oral defense.

Course material

- Turabian Kate Larimore, Booth Wayne Clayton, Colomb Gregory G., Williams Joseph M., & University of Chicago press. (2013). A manual for writers of research papers, theses, and dissertations: Chicago style for students and researchers (8th edition.). Chicago (Ill.) London: University of Chicago Press.
- Bui Yvonne N. How to Write a Master's Thesis. 2nd ed. Thousand Oaks, Calif: Sage, 2014.
- Evans David G., Gruba Paul, Zobel Justin. How to Write a Better Thesis. 3rd edition. Carlton South, Vic: Melbourne University Press, 2011.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	30	0 hrs	0 hrs	0 hrs	0 hrs	0 hrs