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# MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

2025-2026

YEAR 2

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## CONTROL AND ROBOTICS

ELECTRIC VEHICLE PROPULSION AND  
CONTROL (E-PICO)

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PROGRAMME SUPERVISOR(S):

Malek GHANES



# YEAR 2 - Autumn Semester

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## 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

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## CORE COURSES

Course code	Title	ECTS Credits
THESIS	Master Thesis or Internship	30
THESISMOBIL	Internship / Thesis project (outgoing students)	30

# Master Programme - Control and Robotics - Electric Vehicle Propulsion and Control (E-PICO)

YEAR 2 - Autumn Semester

## 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.

### Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Industry, innovation and infrastructure / Responsible consumption and production

### Sustainable Development and Social Responsibility Positioning

This course supports sustainable development by contributing to the transition toward electric mobility and the reduction of greenhouse gas emissions. It emphasizes energy efficiency, performance optimization of AC machines, and responsible use of resources. It also raises awareness among future engineers about designing more sustainable, reliable propulsion systems aligned with current societal challenges.

### 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

# Master Programme - Control and Robotics - Electric Vehicle Propulsion and Control (E-PICO)

YEAR 2 - Autumn Semester

## 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 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.

### Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy

### 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

# Master Programme - Control and Robotics - Electric Vehicle Propulsion and Control (E-PICO)

YEAR 2 - Autumn Semester

## 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 (rectifiers, inverters and choppers)

### 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
  - 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.

## Sustainable Development Goals (SDGs) covered by this course

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Affordable and clean energy / Responsible consumption and production

## Sustainable Development and Social Responsibility Positioning

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This course focuses on the functions of power electronics and their control, which are essential for electric and hybrid vehicles, showing how they enable energy to be converted and controlled efficiently. Through the study of rectifiers, inverters, and choppers, as well as modulation and optimization strategies, energy losses can be reduced, battery life extended, and the integration of renewable energies promoted. In this way, the course contributes to sustainable mobility and social responsibility by training engineers capable of designing cleaner, more reliable, and more efficient transportation systems.

## Assessment

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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

# Master Programme - Control and Robotics - Electric Vehicle Propulsion and Control (E-PICO)

YEAR 2 - Autumn Semester

## Observation and Diagnosis for electric propulsion systems [OBSEDIA]

LEAD PROFESSOR(S): *Malek GHANES*

### Objectives

Measuring the state of a given system using physical sensors is sometimes impossible and other times possible but too costly.

This is why estimating the state of the system using software sensors (observers) is an important issue. The first part of this course examines several methods for designing observers for nonlinear systems.

In addition, faults in sensors, actuators, or process components can lead to a deterioration in the overall performance of the system and can cause serious damage.

From this perspective, the second part of the course is devoted to basic definitions and various existing diagnostic methods. Next, the diagnostic problem will be studied mainly using observers (studied in the first part) with fault estimation (simultaneous estimation of state and parameters). Finally, the problem of fault-tolerant control will be briefly addressed.

Examples and practical work will illustrate the relevance of these two parts in academic and real-world 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 (if the time permits)

- 2 lab sessions
- 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.
- Zaltni, D., & Ghanes, M. (2013). Observability Analysis and Improved ZeroSpeed Position Observer Design of Synchronous Motor with Experimental Results. Asian Journal of Control, 15(4), 957-970.
- M. Ghanes, JP. Barbot, L. Fridman and A. Levant, A novel differentiator: A compromise between super twisting and linear

algorithms, IEEE CDC, 2017.

Diagnosis:

- R. Isermann, Fault-diagnosis applications: model-based condition monitoring: actuators, drives, machinery, plants, sensors, and fault-tolerant systems. Springer Science & Business Media, 2011.

### Sustainable Development Goals (SDGs) covered by this course

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Affordable and clean energy / Responsible consumption and production

### Sustainable Development and Social Responsibility Positioning

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This course contributes to sustainable development and social responsibility by promoting an efficient approach to system observation and monitoring. The use of software sensors reduces the number of physical sensors, thereby limiting the consumption of material resources, costs, and the environmental impact of installations. Fault monitoring and diagnosis methods enhance system reliability and safety by enabling early detection of malfunctions, preventing major damage, uncontrolled shutdowns, and consequently environmental and human impacts. Finally, fault-tolerant control extends the life of systems and ensures their continued operation despite anomalies, thereby contributing to a more responsible and sustainable use of industrial technologies.

### Assessment

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Individual assessment: EVI 1 (coefficient 1.0)

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

# Master Programme - Control and Robotics - Electric Vehicle Propulsion and Control (E-PICO)

YEAR 2 - Autumn Semester

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

*LEAD PROFESSOR(S): Raphaël CHENOUIARD*

### Requirements

Matlab and Python programming language

### 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

- Numerical Optimization, Pegden, Jorge Nocedal, Stephen Wright. 2nd ed. Springer (2006).
- Introduction to Numerical Analysis, Arnold Neumaier. Cambridge University Press (2001).
- Multi-Objective Optimization Using Evolutionary Algorithms 1st edition by Deb, Kalyanmoy (2009)

### Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Industry, innovation and infrastructure

### Sustainable Development and Social Responsibility Positioning

Optimizing energy management helps avoid peaks in consumption on the electrical grid, thereby reducing primary energy requirements. Applying this to renewable energy systems also aims to reduce both the cost and environmental impact of energy production.

### 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

# Master Programme - Control and Robotics - Electric Vehicle Propulsion and Control (E-PICO)

YEAR 2 - Autumn Semester

## Project [PROJECT]

*LEAD PROFESSOR(S): 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 supervisor.

### Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Climate action / Industry, innovation and infrastructure

### Sustainable Development and Social Responsibility Positioning

The proposed projects promote a responsible approach to designing high-performance, energy-efficient systems adapted to industrial and societal challenges.

### 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

# Master Programme - Control and Robotics - Electric Vehicle Propulsion and Control (E-PICO)

YEAR 2 - Autumn Semester

## 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.

### Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy

### 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

# Master Programme - Control and Robotics - Electric Vehicle Propulsion and Control (E-PICO)

YEAR 2 - Spring Semester

## Master Thesis or Internship [THESIS]

LEAD PROFESSOR(S): Mohamed Assaad HAMIDA

### 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.

### Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy

### 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

# Master Programme - Control and Robotics - Electric Vehicle Propulsion and Control (E-PICO)

YEAR 2 - Spring Semester

## Internship / Thesis project (outgoing students) [THEISMOBIL]

LEAD PROFESSOR(S): Mohamed Assaad HAMIDA

### Objectives

- Be exposed to and adapt to an industrial or research environment
- Put in practice 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 validated 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, et Zobel Justin. How to Write a Better Thesis. 3rd edition. Carlton South, Vic: Melbourne University Press, 2011.

### Sustainable Development Goals (SDGs) covered by this course

### Assessment

Individual assessment: EVI 1 (coefficient 1)

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