COURSE DESCRIPTION
ENERGY MANAGEMENT FOR TRANSPORTATION

SSD: CONVERTITORI, MACCHINE E AZIONAMENTI ELETTRICI (ING-IND/32)

DEGREE PROGRAMME: TRANSPORTATION ENGINEERING AND MOBILITY (P55)
ACADEMIC YEAR 2022/2023

COURSE DESCRIPTION

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GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE: NOT APPLICABLE
MODULE: NOT APPLICABLE
CHANNEL: FG A-Z
YEAR OF THE DEGREE PROGRAMME: I
PERIOD IN WHICH THE COURSE IS DELIVERED: SEMESTER I
CFU: 9

REQUIRED PRELIMINARY COURSES

None

PREREQUISITES

None

LEARNING GOALS

The course aims to provide the knowledge of the main constituents of the electric/hybrid propulsion systems of road and rail vehicles with particular regard to their principle of operation and controls. The analysis methodologies of vehicles powertrain allow the discussion to be then focused on energy management strategies, pursuing environmental sustainability goals in the incoming energy transition.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student acquires knowledge about the main components of propulsion systems, learns the principle of operation of power converter and motor, and studies how energy can be transferred by means of proper control algorithms. He gets familiar with different types of vehicle architectures, distinguishes railway propulsion from road applications, and visualizes how many power sources can interact on board a hybrid vehicle. He classifies energy storage systems and understands how different storage technology must be charged/discharged in the context of transportation systems. The student acquires analysis methodologies of energy management strategies, aiming to pursue environmental sustainability in incoming energy transition.

Applying knowledge and understanding

The student learns how to applies the acquired knowledge to characterize propulsion systems, motor drives, and storage components. He can design and carry out experimental tests to validate the proper operation of the overall system and/or to determine its parameters. He is also able to recognize possible criticism about the functioning of motor drive. Based on its characteristic, He can trace the anomalous condition to a specific subsystem of the powertrain, identifying the possible cause, and providing modification/improvements to the system architecture and/or control.

The student can exploit the acquired knowledge of energy transfer technology, solving possible subcomponent incompatibility and choosing functional equipment based on the mission profile. In this context, he can also envision energy management strategies aimed to optimize the overall transportation system efficiency, pursuing environmental sustainability goals.

COURSE CONTENT/SYLLABUS

Classification of propulsion systems. Vehicle dynamics. Vehicle energetics.

Electric road vehicles: power circuits, control systems, and on-board equipment.

Power electronics components and converters: principle of operation and modulation of Rectifiers, Chopper and Inverter. Characteristics and model of the main traction motors (Induction Motor and Permanent Magnet Synchronous Motor). Motor drives and field oriented control of AC traction motors.

Powertrain of Battery Electric Vehicles (BEV): architectures, main subsystems, and performance. Classification of hybrid configuration (series, parallel, power-split) and on-board energy management for Hybrid Electric Vehicles (HEV), and Plug-in Hybrid Electric Vehicle (PHEV). Review of technology for power converters in relation to power and voltage range. Sizing criteria of an electric vehicle and a hybrid vehicle.

Classification of energy storage system for automotive application in relation to the vehicle type (BEV, HEV, PHEV). Ion lithium batteries. Technology and model. Battery pack and battery management system (BMS). Other energy storage systems with high power density: supercapacitors and flywheel; KERS.

Charging systems for electric vehicles. Electric vehicle charging infrastructures and their integration into the electricity grid. Standards for AC and DC conductive charging of electric vehicle (EN 61851).

Electric railway propulsion: power circuits, control systems, on-board equipment. Powertrain for different types of electric traction rail vehicles (heavy-rail passenger train, light rail, urban rail transit). Integration of electric energy storage systems. Energy management considering the interaction between storage equipment on board the train and on the ground.
Application of electric drives outside of the powertrain: Heating, Ventilation and Air Conditioning (HVAC), power steering, battery cooling.
Expectations and role played by electric mobility in reducing polluting emissions and increasing the efficiency of the vehicles.

READINGS/BIBLIOGRAPHY

Mohan, Undeland, Robbins "Power Electronics: Converters, Applications and Design" J. Wiley &Sons
G Abad (Gonzalo) "Power electronics and electric drives for traction applications" John Wiley &Sons
Austin. Hughes ; Bill Drury "Electric motors and drives fundamentals, types and applications" Elsevier
Russell M. Ford editor.; Rebecca M. Burns "Energy storage technologies for power grids and electric transportation" Nova Science Publishers
Daniel. Sperling ; Mark A Delucchi; Patricia M Davis; A. F Burke (Andrew F.) "Future drive electric vehicles and sustainable transportation" Island Press
Morris Brenna, Frica Foiadelli, Dario Zaninelli "Electrical railway transportation systems" Wiley-IEEE Press
Sumedha Rajakaruna, Farhad Shahnia, Arindam Ghosh "Plug In Electric Vehicles in Smart Grids Energy Management" Springer
Sheldon S. Williamson "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles" Springer
M. Kathiresh, G. R Kanagachidambaresan, Sheldon S Williamson "E-Mobility : A New Era in Automotive Technology" Springer
Slides, lecture notes

TEACHING METHODS OF THE COURSE (OR MODULE)

Lectures, laboratory activities and exercises.

EXAMINATION/EVALUATION CRITERIA

a) Exam type

- ☐ Written
- ☑ Oral
- ☐ Project discussion
- ☐ Other

In case of a written exam, questions refer to

- ☐ Multiple choice answers

☐ Open answers

☐ Numerical exercises

b) Evaluation pattern