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## RESEARCH TOPICS

- Wireless power transfer for automotive applications
- Improve energy efficiency of railway system
- Microgrids: stability analysis and synthetic inertia
- Modular PMSG Drives for Multi-MW WECSs
- MMC for traction drives
- Dynamic and aging battery model

## WIRELESS POWER TRANSFER FOR AUTOMOTIVE APPLICATIONS

*Keywords: battery powered vehicles. electric vehicle charging, inductive power transmission.*

Inductive power transfer is a near-field technology for the transmission of electric energy via oscillating magnetic fields by inductive coupling between coils. The main issues related to this technology are the large air gap between coils and the lack of any ferromagnetic core, resulting in a weak coupling between transmitter and receiver coils and large leakage flux. In this research, an inductive power transfer system for automotive applications has been designed and tested.

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## IMPROVE ENERGY EFFICIENCY OF RAILWAY SYSTEMS

*Keywords: Energy savings, energy storage systems (ESS), multiport, power electronic transformers (PET), railway.*

This research is held in collaboration with the JRC on railway systems. In particular the research will be study how to improve the railway substation adding a regenerative converter and how to improve the efficiency of train with optimal driving strategies.

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## MICROGRIDS: STABILITY ANALYSIS AND SYNTHETIC INERTIA

*Keywords: inverter, system stability, virtual impedance, parameter identification, droop control*

The topic deals with a microgrid supplied by static converters. some criteria to design the parameters, above all in a droop control operation, are developed to assess the stability. Then the provision of fast-response synthetic inertia services from a grid-connected converter is analysed.

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## MODULAR PMSG DRIVES FOR MULTI-MW WECS

*Keywords: Multi Modular converters, multi-modular electrical machines, dc current ripple mitigation, converter sequential command.*

The studied system includes modular axial-flux PM synchronous generators for multi-MW wind turbines and multi inverter converters. The machine modules are aligned with one another and driven by the same shaft. Each module is connected to its own two-level converter; the converters are paralleled at the DC side.
The research regards: control strategy of the inverters, in order to limit the global dc current and torque ripples; sizing and model aspects of multi-winding transformer for the mains interface; analysis and mitigation of torsional vibrations.

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## MMC FOR TRACTION DRIVES

*Keywords: Traction drives, BMS, MMC*

The activity consists in the design, realization and control of an innovative traction drive built using a modular structure similar to those of MMC converters. The battery cells onboard are integrated directly in the power converter that can implement three functions: traction drive, battery management system and charger onboard. All these functions have been proved by means of numerical simulations and preliminary tests have been performed on a prototype realized at the University of Birmingham. A large prototype is under development and studies to improve the modulation technique are in progress at POLIMI.

### *References*

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## DYNAMIC AND AGING BATTERY MODEL

*Keywords: Lithium ion batteries, aging, dynamic model*

Several dynamic models for lithium batteries and lithium capacitors have been studied and proposed. The test campaign is now focused in understanding the aging phenomena trying to decouple the effects due to different factors (i.e. cycling, current, temperature, voltage, frequency)

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