

# ICT PHD

Research project for a PhD curriculum in ICT – Electronics and Telecommunication

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## **Proposed Title of the research:**

High reliability and High efficiency electric motor drives for green transportation applications

## **Keywords: (5)**

Power Converters, Reliability, Wide Bandgap, Motor drives, Green transportation,

## **Research objectives:**

In the last few years, the need for high power density and efficiency has become a central concern in the green transportation sector. To meet the challenging requirements of modern ground propulsion and transport applications, the trend has become to increase the fundamental operating frequencies of electrical machines, leading to smaller and lighter motors and generators. New power devices based on wide bandgap semiconductors (SiC and GaN) with extremely short switching times are enabling improvements in these technologies. However, higher operating frequencies also mean increased power losses in windings. In addition, faster commutation devices are also known to trigger faster degradation of coil insulation and can cause greater susceptibility to electromagnetic interference. All these concerns make the multi-physics approach the ideal candidate tool for the design of electrical machines, where the main aspects concerning the electromagnetic, thermal and structural behaviour are all considered at the same time [1]. This research aims to identify new design methodologies at component- and system-level, pursuing efficiency and reliability (as transport is a safety-critical application), as well as multidisciplinary and comprehensive approaches for converters and machines, which are usually investigated in separate processes. The research objectives include the design, numerical simulation and possible implementation of high power density, high efficiency electrical machines for electric transportation based on accurate magnetic, thermal and mechanical analyses.

## **Proposed research activity:**

Considering the overview presented above, the research project will focus on the development of novel solutions for:

- Integrated architectures (machine and drive) for high power density and reliability.
- New modelling techniques and processes for high power density designs.
- New drive architectures, based on wide bandgap devices, for fast switching commutation.
- New electrical machine solutions with reduced rare earth materials.
- Investigation on hairpin technologies, possibly in conjunction with multi-phase winding arrangements.

The objectives proposed for this research project are therefore set out as follows:

- Development and implementation of fast and accurate multi-physics analytical and/or numerical models for the design, analysis and optimisation of electric drives, which include electromagnetic, thermal and mechanical aspects comprehensively.
- The possible add-on of a lifetime estimation model aiming to enhance reliability and limit the thermal stresses on the insulations of electrical machines.
- Technical and cost-benefit analyses for each suitable solution.

- Use of the developed models to propose alternative machine and system design solutions which improve efficiency, thermal management, power density, etc.
- Assessment of the feasibility of design recommendations, prototype(s) (perhaps on a small scale), setting-up of a dedicated test rig and testing.
- Experimental validation of the developed models.

### **Supporting research projects (and Department)**

Project DORNA – “Development of high reliability motor drives for next generation propulsion applications”, GA number 872001, H2020 – MSC Research and Innovation Staff Exchange (RISE) action. This project involves 11 academic institutions and 5 industrial partners, fostering transfer of knowledge between industry and academia for the development of high reliability and efficiency motor drives for transportation applications. UniMore, with the Department Enzo Ferrari (DIEF) is in charge of the WP2 - WBG, high-frequency switching devices and power converters, with Dr. Davide Barater as local coordinator.

### **Possible connections with research groups, companies, universities.**

The research is proposed within the framework of DORNA project, in conjunction with the companies ABB, Cummins generator technologies and MMB Drives, all active in the power electronic and e-machines field. On the academic side, main involvement is with the University of Nottingham (UK). A research period at the University of Nottingham is expected during the PhD. Applicant may apply separately for Dual Degree Program with the University of Nottingham

(\*) optional

(\*\*) optional/to be completed on the second year