PhD in Mechanical Engineering

Research Title: Electric powertrain control integration for automotive applications

Funded by	SILK - FAW

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Context of the research activity	Nowadays, it is mainstream for automotive companies to invest in electric and hybrid systems due to an increasing awareness about environmental issues such as global warming, greenhouse gas emissions, and depletion of fossil fuels. At this scope, electric and hybrid vehicles requires a completely new powertrain design comprising electric motors, inverter and battery pack for optimized fuel economy and enhanced vehicle performance. A multidisciplinary approach is required for subsystems integration that ranges from mechanical and thermal design of components first of all form control point of view. In particular, the research activity will focus on the creation and implementation of real-time algorithms and control strategies, at both high and low levels, for the enhancement of the vehicle performances. The battery pack and the electric motor are the core of the system since it provides energy to all vehicle components. Indeed, a preliminary and deep knowledge about electrical and thermal characterization of batteries, but also about electric motor and the control strategies are essential to achieve the activity targets. Moreover, deep knowledge in automotive sector and interest in research and innovation are required, since testing activities will be done to guarantee the correlation between numerical simulation and experimental results. The PhD student will be inserted in the Research Group IEHV (Innovative Electric and Hybrid Vehicles) of the ing M. Carello.

Objectives	Research activity has the intents of increasing the vehicle performance and evaluate the effect on performance of different level of integration and control strategies of battery and EM ECU and inverter. It include: drive systems powered by electric motors, inverter, battery and BMS modelling and control, complete electric and hybrid vehicle energetic modelling, control algorithm development for an effective TMS design. The tests in laboratory, using instrumented test bench and sensors, allows obtaining the parameters for the models but also validating a global model of an electric powertrain. The main PhD development points and targets are: • Evaluations of the actual state of art of technologies electric motors, inverters for an integration in an electric powertrain. • Development of single component model (electric motor + inverter + battery pack) • Full powertrain (electric motor + inverter + batter pack) modelling for real-time control and onboard performance evaluation. • Investigation of powertrain behaviour in critical operative conditions for performances improvement, modifying for example the battery characteristics (discharge C-rate, fast-charge applications, and extreme temperatures) and inverter control strategies. • Development of control logics and algorithms at component-level, take into account BMS characteristics, regenerative braking. The main Methodologies to reach the targets could be: - High level engineering with CAD/CAE tool to create accurate thermal and magnetic analysis for powertrain design. - Performing test bench for experimental and numerical results correlation.

Skills and competencies for the development of the activity	• CAD software – ability to analyse, create and edit 3D models and technical drawings. • CAE software (i.e. Hyperworks) – ability to perform linear and modal FEM simulations with different element types (1D, 2D and 3D) also to perform magnetic simulations. • CFD software (i.e. Star CCM+, Acusolve, Fluidyna, Comsol) – ability to execute coupled thermal simulations • Math modelling competence (MATLAB/Simulink) – ability to analyse and create co-simulations, control systems and models, perform data analysis. • C/C++ programming software – ability to develop algorithms and control logics for electric powertrain • Software to develop powertrain real time control (i.e. uVision)

	• Manual skills for testing, testbench assembly and testing plan definition; • Good analytical skills and broad knowledge of the automotive sector.