Design of a multicellular static converter with algorithm control based on multi-agent systems for an embedded application

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This thesis is a continuation of the work carried out on the study and development of static converters for embedded applications such as hybrid or electrical vehicles having different energy sources (fuel cells, batteries, super-capacitors,....) and the integration of multi-agent systems techniques for intelligent control in both “Energy Conversion and Control” and “Multi-Agent” research teams from the System and Transport laboratory. This one is part of the Research Institute on Transportation, Energy and Society.

Over the past years, the fuel cell has a growing interest in power generation for stationary and embedded applications. Among the existing technologies, Proton Exchange Membrane Fuel Cell (PEMFC) is one of the most promising power generation technologies in vehicle applications because of a high energy density and low operating temperature. Moreover, in vehicle applications, the fuel cell is usually associated with electrochemical storage elements such as batteries, super-capacitors in order to use each source according to their characteristics and to recover energy during braking phases.

These sources have different levels of voltages and currents complicating their interconnection thus the use of static converters is essential. Furthermore, in embedded applications, static converters have to respond to many issues such as:

- Low weight and volume,
- High energy efficiency,
- High power density,
- Low cost,
- Low electromagnetic interference.

The aim of this thesis is the study of a multicellular converter with high efficiency and high frequency with multiple inputs and single output for connecting the different energy sources while sharing different magnetic elements in order to greatly reduce the volume for an embedded application such as electric vehicle.

First, a state of the art will reference in the scientific literature the different topologies of static converters used (with or without insulation) to connect the different energy sources in electric vehicles. Moreover, the design of magnetic components and the use of new generation power switches, well known as wide band gap, based on Silicon Carbide (SiC) and Gallium Nitrite (GaN) will be studied.

Based on a configuration of a drivetrain, a multicellular converter with multiple inputs and single output will be proposed by a theoretical study in open loop using analytical calculations and
simulations to meet different objectives. A particular attention will be paid on a strategy of control system in closed-loop to optimize the operation of the converter in relation to certain criteria depending on the source and connected loads. To do this, the multi-agent systems techniques could be used in order to control the converter in both healthy and faulty operation modes to ensure continuity of service of the embedded application.

A small-scale experimental test bench will be carried out with existing resources in the laboratory (fuel cells, batteries, super-capacitors, power switches, magnetic components, DSPACE and FPGA boards,...) to validate the theoretical part.

References:


Biographies

Pr. Dr. Abdellatif Miraoui is a Full Professor of electrical engineering (Electrical Machines and Energy) at the University of Technology of Belfort-Montbéliard (UTBM) since 2000. His special interest includes Fuel Cell energy, energy management (Ultracapacitor, batteries, ...) in transportation, design and optimization of PMSM and electrical propulsion/traction. Professor A. Miraoui is a Vice President - Research Affairs of UTBM. He was Director of the Electrical Engineering department (in UTBM) from 2001 to 2009, the head of "Energy Conversion and Control" Research Team (38 researchers on 2007) and the editor of the International Journal on Electrical Engineering Transportation (IEET). He is the author of over 60 journals and 80 international conference papers. Professor A. Miraoui is Doctor Honoris Causa of Cluj-Napoca Technical University, Romania. In 2007, He received a high distinction from French Higher Education Ministry “Chevalier dans l’Ordre des Palmes Académiques”. He was also distinguished as Honorary Professor from University of Brasov-Romania.

Pr. Dr. Abderrafiaa Koukam is a Full Professor at the University of Technology of Belfort-Montbéliard (UTBM). He obtained his doctorate at the University Henri Poincare of Nancy 1, France, and his Research Direction Habilitation at the University of Burgundy. He was Director of the Systems and Transports Laboratory, Vice President of the Scientific Council of UTBM, Director of Computer Science Department and the founder of the team Multi-agent Systems and Optimization. His research focuses on multi-agent systems: modeling, simulation, verification. He assumed the coordination of two European projects (TRASCOM 2002-2004, SURE 2003-2005), several national projects (CRISTAL, ANR SafePlatoon,...), and contracts with industry in the following areas: transportation planning, mobile networks, traffic flow simulation in industrial sites, and intelligent vehicle.

Dr. Arnaud GAILLARD received the M. Sc. and Ph.D. degrees in Electrical Engineering from the University Henri Poincare of Nancy I, France in 2006 and 2010, respectively. Between 2010 and 2011, he worked as research engineer in industry, specialised in magnetic circuits for power electronics and their associated industrial applications. Since September 2011, he
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