Multi-physical modeling and intelligent power management of a Li-ion battery / supercapacitor hybrid energy storage system for electric vehicle applications

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VEHICLE project in a few words:

The VEHICLE project (AdVanced li-ion battEry/supercapacitor HybrId energy storage system with synchronous reluctance maChine for electric vehicle applications) aims to develop adapted solutions to on-board energy storage systems through the hybridization of energy sources and the use of innovative machines for electric vehicles. The Upper Rhine region is home to leading-edge laboratories in the field of electric traction. VEHICLE is built to combine existing complementary expertise and create synergies to lead to the development of innovations, and establish a new research consortium in the Upper Rhine region. French, German and British scientists are involved with a network of 3 main academic partners and 6 associate partners. The VEHICLE project is developed as part of the INTERREG V Upper Rhine program and the Offensive Science initiative. It is co-financed in the context of this initiative by the Grand Est Region in France, the Baden-Württemberg and Rhineland-Palatinate Länder in Germany.

Worldwide energy context:

The energy challenge is one of the main issues to the development of efficient, less polluting and economically viable means of transport with a rational use of the world's natural resources. In this context, vehicle manufacturers in the world are undergoing unprecedented technological change [1]. In the field of the traction and transport, the voices of progress are linked, among other things, to the electrification (partial or total) of vehicles [2].

Scientific objectives:

In the traction field, the energy storage system used in electric or hybrid vehicles remains the weak link: very expensive, limited in driving range, slow to recharge, etc. Today, the main axis of progress is undoubtedly based on the development of on-board energy storage systems providing solutions for improving the driving range, battery lifetime, volume, mass, total cost of ownership (TCO), or use of these storage systems [3]. One of the solutions proposed by vehicle industrial interests in the past few years is the hybridization of sources [4]. In this context, the hybridization of batteries with supercapacitors offers good performance in terms of driving range, available power and service continuity [5]. This hybridization results in an electrical storage system with a high power density and a high energy density. In such systems, intelligent on-board energy management is becoming essential in order to effectively manage energy exchanges between the sources on board the vehicle [6].

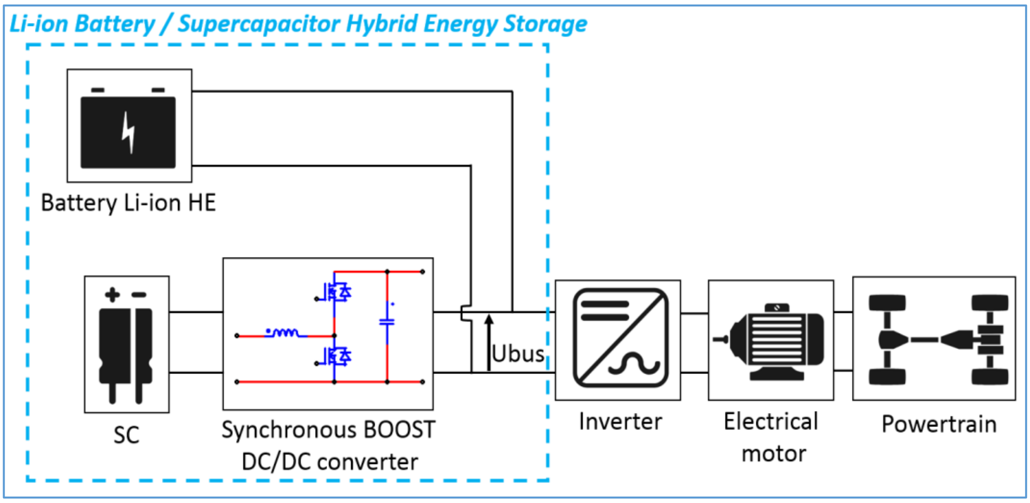

Figure. I : Li-ion battery / supercapacitor hybrid energy storage system

T. Mesbahi [2] has shown that the use of two hybrid storage sources combined with improved energy management methods can significantly increase the energy performance and lifetime of on-board hybrid sources. Based on the perspectives of this work, the thesis would concern an application of electric vehicle with two energy sources (battery and supercapacitors). To optimize the energy consumed for a typical driving cycle, we would first like to use advanced automatic strategies based on artificial intelligence, such as fuzzy logic and neural networks approach. A multi-physical model including electrical, thermal and ageing aspects will be developed and coupled to the energy management strategy to evaluate the progressive degradation of system performance during driving cycles. This would then make it possible to evaluate and optimize the total cost of ownership (TCO) of a vehicle.

Candidate's skills:

Specific knowledge: Programming in C, C++, CAN-BUS technology communicates, matlab, PSIM and labview. Basic knowledge of advanced automatic strategies and multi-physical modeling.

Desired education: Master or Engineer (Bac + 5) with a specialization in Electrical Engineering, Computer Engineering, or Electronics and Automatics Engineering.

Desired personal skills: High motivation for innovation and the search for operational solutions in an industrial context. Motivation for the combination of simulation and experimentation.

References:

[1] E. Magdalinski and T. Pellerin-Carlin, “La voiture électrique, un moteur de la transition énergétique en Europe,” Tribune, Institut Jacques Delors, 2017.

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[3] L. Kouchachvili, W. Yaïci, and E. Entchev, “Hybrid battery/supercapacitor energy storage system for the electric vehicles,” *J. Power Sources*, vol. 374, pp. 237–248, Jan. 2018.

[4] M. Ehsani, Y. Gao, S. E. Gay, and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design,” 2005.

[5] P. Garcia, J. P. Torreglosa, L. M. Fernandez, and F. Jurado, “Control strategies for high-power electric vehicles powered by hydrogen fuel cell, battery and supercapacitor,” *Expert Syst. Appl.*, vol. 40, no. 12, 2013.

[6] T. Mesbahi, F. Khenfri, N. Rizoug, P. Bartholomeus, and P. Le moigne, “Combined Optimal Sizing and Control of Li-Ion Battery/Supercapacitor Embedded Power Supply Using Hybrid Particle Swarm-Nelder-Mead Algorithm,” *IEEE Trans. Sustain. Energy*, vol. 3029, no. c, pp. 1–1, 2016.