Optimal Energy Management Strategy for a Li-ion battery / supercapacitor hybrid energy storage system

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Laboratory: ICube (CNRS UMR 7357) & IREENA (EA 4642)
Team: SMH-ICube & IREENA
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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, luxembourgish and British researchers are involved with a network of 3 main academic partners (INSA Strasbourg, Hochschule Karlsruhe, and Hochschule Trier) and 6 associate partners (Centrale Lille (L2ep), Université Nantes, Sheffield Hallam University, CVC Südwest, IEE S.A, and CCIAE). 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:

One of the major challenges facing humanity since the end of the last century has been the development of means of energy production and transport that limit the impact on climate change and the production of air pollutants. The worrying signs on the state of our planet and demographic pressure are forcing rapid changes in our lifestyles and technologies. In recent years, the transport sector consumed nearly 70% of the world's oil production and also is responsible for 27% of global CO2 emissions. It is thus one of the main causes of global warming [1]. To reduce these emissions, many policies have been implemented to improve the energy efficiency of vehicles with an electrification partial (hybrid) or total (full electric). However, one of the obstacles to the development of these alternative solutions is related to energy storage systems. Currently, the latter do not allow both good range and powers compatible with the acceleration and braking needs of vehicles to be achieved.

Scientific objectives:

Since the 2000s, technological developments in electrical storage have made it possible to achieve sufficient mass densities of energy and power to meet automotive needs. The major disadvantage of these storage solutions is the cost of production. It represents on average one third of the final price of the vehicle. Consequently, improving the storage system is one of the main levers for reducing the overall cost of the vehicle, and the combination of several storage technologies has proven benefits [2]. These hybrid energy storage systems (HESS) are based on the combination of a type energy storage system and another type of power where the power

distribution is managed by one or more power converters [3],[4]. By adjusting the proportion of these two types of sources and developing energy management strategy, we can have solutions that are more efficient than the so-called single-source versions, whether in terms of electrical performance, compactness, service life or total cost of ownership (TCO)[5]. For that, optimal on-board energy management is becoming essential in order to effectively manage energy exchanges between the sources on board the vehicle.

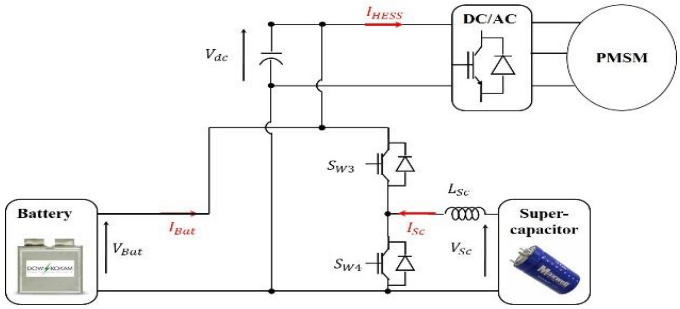

Figure. I : Li-ion battery / supercapacitor hybrid energy storage system

The aim of this internship is to develop an optimal energy management strategy for li-ion battery-supercapacitor HESS. The main focus will be on the different optimal methods providing solutions for improving the driving range, battery lifetime, volume, mass, investment cost or use of these storage systems. This can be achieved by using, for example, solutions based on new optimization techniques such as Grey Wolf Optimizer (GWO).

Work Progress

This internship will take place at the IREENA laboratory (Université de Nantes - Saint-Nazaire), in close collaboration with the ICube laboratory (INSA Strasbourg). He/she will work closely with one or more IREENA & ICube researchers, and lab technician. After performing an in-depth survey of existing optimization techniques. The next step in this internship will be the comparison of regular energy management strategies of the existing literature with the new published energy management strategies for Li-ion battery / supercapacitor HESS. As a results, this comparison will be performed in terms of sizing and RMS power of both sources. Lastly and according to the work progress, an optimal energy management strategy will be implemented by using a laboratory test bench.

Candidate's skills:

Specific knowledge: Programming in C, C++, CAN-BUS technology communicates, Matlab, PSIM and labview. Basic knowledge of advanced automatic strategies, optimization techniques and modeling.

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

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

References:

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[2] N. Allali, “Convertisseur haut rendement à dimensionnement réduit pour batterie hybridée puissance / énergie de véhicule électrique : Principe de source de courant contrôlée,” Thèse de Doctorat, ECOLE CENTRALE DE LILLE, 2016.

[3] R. Sadoun, “Intérêt d’une Source d’Energie Electrique Hybride pour véhicule électrique urbain – dimensionnement et tests de cyclage,” Thèse de Doctorat, ECOLE CENTRALE DE LILLE, 2013.

[4] C. Romaus, J. Bocker, K. Witting, A. Seifried, and O. Znamenshchykov, “Optimal energy management for a hybrid energy storage system combining batteries and double layer capacitors,” in *2009 IEEE Energy Conversion Congress and Exposition*, 2009, pp. 1640–1647.

[5] T. Mesbahi, “Influence des stratégies de gestion d’une source hybride de véhicule électrique sur son dimensionnement et sa durée de vie par intégration d’un modèle multi-physique,” 2016, 2016.