1 General Information

Laboratory	FEMTO_ST
University	University of Technology of Belfort-Montbéliard (UTBM), Univ. Bourgogne Franche-Comte (UBFC)
Contact	**Thesis advisor :** Dr. Abdesslem Djerdir (abdesslem.djerdir@utbm.fr)

2 Thesis title and keywords

Multiple-Input Multiple-Output Power Converter for Variable DC-bus Fuel Cell Vehicles

Keywords: Fuel Cell electric vehicles (FCEV), DC-DC and DC-AC power converters, Multiple-Input Multiple-Output (MIMO) power converters, Energy management embedded devices, Interaction Fuel Cell and DC-DC power converter, Efficiency and availability of power converters.

3 Thesis subject

The use of Electric Vehicles (EV) for transportation is becoming an unavoidable solution for the environment problems caused by classical vehicles as well as for the pollution problems and the reduction of fossil energy sources. This research project focuses on the use of Fuel Cells (FC), as a main the source of energy in a vehicle and of Super-Capacitors (SCAP) to ensure the power flow reversibility on board of the vehicle. In particular, SCAPs aim to supply the motors when they either are overloaded or subject to load fluctuations, and recover the energy coming from the motor during the braking phase. The use of one or several fuel cells combined with one or several SCAP packs for supplying electrical loads, generally two at least (traction motor and onboard grid), requires the combination of power converters for conditioning the different power sources. Thus, far in the literature the researches in the power electronics area have proposed two different interfacing topologies of multiple-input DC-DC converters, non-isolated interfacing, where the multiple-input converter has inductance as energy storage and transferring element between power stages, and isolated interfacing, where the multiple-input converter combines different power sources by means of magnetic coupling. All these converters are connected to a DC- bus for which the voltage is kept constant. This DC-bus, about a few hundreds of volts, is generally, supplied by a group of step-up DC-DC converters connected to power sources whose voltage is as much as a few tens of volts. However, during the frequent starts and stops of the EV in urban driving, the sources could supply the traction motor directly without using the voltage boost converters.

The goal of this thesis is to propose a MIMO power converter structure starting from the consideration that in FCEV applications certain modes of operation require a low voltage supply, like in urban mode, so that a direct connection between the traction motor drive and the sources can be envisaged. Moreover in the configurations with a constant DC-bus, the efficiency of the system decreases as long as the level of voltage between input and output increases. This is why the proposed novel converter architecture will consider a variable DC-bus voltage level so that the voltage ratio is minimal at low speeds in urban mode and maximal at high speeds in extra-urban or highway mode. In particular, the minimum voltage to be supplied is the voltage required by the traction motor in the start-up phase. This results in increase of the source-wheel efficiency, especially in urban mode.

The new power converter has to ensure all of the possible energy exchanges between the sources (fuel cell and super-capacitors) and the electrical loads of the vehicle without the need of using a classical constant DC-bus. After proposing the overall architecture of the converter, a modeling work will be performed for simulation, design and control purposes. For the control side, a focus will be made on the one hand the interactions between the FC, the SCAP and the DC-bus and on other hand the interactions between the DC-bus and EV loads; that is the traction motor and the on-board network supplying the EV auxiliaries. These investigations will lead to propose a robust and efficient architecture regarding to both hardware and software aspects. The theoretical approach of modeling and simulation will be combined to experimental work on laboratory test benches to meet the target of this research project.

4 Expected collaborations

This work will continue the existing collaborations of the SHARPAC team with academic and private partners in the framework of the research groups (SEEDS: Electrical Engineering and HysPAC: Hydrogen and Fuel Cell systems). One goal is to apply for European projects calls within the European Interreg and H2020 programs.

5 Background

The candidate must have strong theoretical and experimental skills in power electronics and drives in order to propose a good architecture of power converter, to develop its control strategy and to build its prototype.