Summary of PhD Thesis:

Supercapacitor energy storage systems and power converters for the reduction of energy consumption in public transportation systems

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Fossil fuels based transportation sector presents a threat to environment due to the emissions that provoke global warming and other hazardous effects. In addition, the need to import oil from foreign countries to meet the transport demand in society makes the economies very dependant on the fluctuations of these oil prices. Electric and hybrid vehicles can reduce the bill on fossil fuel imports and, thus, reduce their associated emissions, contributing to a cleaner and more robust economy.

This PhD thesis is divided in two blocks closely related. The first block presents a theoretical study, based on simulations, that evaluates the potential energy savings that could be achieved in the public transport sector by using supercapacitor based energy storage systems (ESS). To achieve the results, two simulators have been developed. First, a vehicle simulator is used to calculate the benefits of hybridization in city buses and determine their energy consumption. In a next step, this model has been extended to form a multi-train simulator that assesses the energy flow in tram and metro lines and compares the energy consumption of a conventional line with that of a tram/metro line benefiting from supercapacitors (or other ESS technologies). The tool determines the energy exchange between vehicles and line current and voltages under different traffic conditions. It can be used to determine what the energy savings would be when installing wayside and onboard ESS. It can be used in two ways: it can assess the benefits of a specific ESS, from a given manufacturer, when installed in a particular line or it can be used to design and optimize the ESS in a metro/tram line. This simulator can be very helpful for public transport operators who envisage a cleaner transport fleet.

The second part of the thesis focuses on the design of a power converter for the supercapacitor based EES. The power converter has the mission of controlling the power flow between the supercapacitors and the load and to adapt the supercapacitors varying voltage to a stable voltage on the load side. Different converter topologies already exist for this purpose; however, this thesis, will study the use of the Series Resonant Converter and its potential implementation for hybrid electric vehicles (HEV), where efficiency, size and EMI are important constraints. This converter is reported to have high efficiency due to soft switching techniques, but it has been tested only for low power levels compared to those needed in HEV. This study will show the advantages and drawbacks of this converter topology, for HEV usage. Thus, it will add to the state of the art of HEVs development.

In conclusion, the implementation of supercapacitor based EES and efficient power converters can improve the efficiency of the public transportation system and can reduce the overall operating cost and energetic bill.