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HYBRID FUEL CELL POWERED CHARGING STATION FOR URBAN SUPERCAPACITOR BUSES

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Abstract

The paper deals with design, development and construction of fast charging station prototype for supercapacitor propelled (supercapacitor pack is the main energy source) city buses. The concept behind operation of such bus fleet is as follows: since supercapacitor possess extremely high power density while suffering from low energy density, charging the pack at the beginning and then at the end of the route (as in case of battery-powered vehicles) is impossible. The reason is that the amount of supercapacitor required to sustain a long route without charging is non-feasible. On the other hand, it is possible to keep the energy pack small by storing enough energy to advance from a station to the adjacent one only (around 1km route). Therefore the proposed concept is to recharge the energy pack each time the bus enters a station to pick up passengers. The charging time should be enough to fully recharge the pack in order to allow the bus to reach the next station, but not too long to maintain the passengers comfort. The main advantages of supercapacitor storage over electrochemical batteries - much longer cycle life (two-three orders of magnitude), non-frequent maintenance and wider temperature range operation – turn the proposed concept into a very attractive one in case the supercapacitor prices are reasonable. In order to perform fast charging of a bus, entering the station, the charger is required to deliver (as an example) around 2.2kWh of energy in 60-90 seconds. This energy will be split into propulsion and service (air conditioning etc.) components. Assuming 95% charging efficiency, the required average charging power is around 140kW. Obviously, both charging hardware and grid connection must be able to sustain this charging rate and must be designed accordingly. Nevertheless, it must be noted that the frequency of bus arrival is estimated (again, as an illustrative example) as once in 6 minutes, i.e. after 90 seconds charging come 270 seconds of rest, i.e. the average charging period grid power is 1/4 of the charging power. Noting that the energy is delivered by the average power only and the dynamic component (charging minus average) energy in one charging period is zero one may conclude that it is possible to reduce the rating of the energy source (fuel cell is utilized here) by appropriate hybridization of the charger with additional supercapacitor energy storage. It is straightforward that the minimum fuel cell rating is determined by the average charging period power; designing such a connection will probably require large energy storage. Therefore a careful optimization must be performed in order to determine the correct component sizing based on price/efficiency/size etc. Simulation and experimental results of a small-scale prototype are given to illustrate the proposed concept. Sample experimental results are given in Fig. 1.

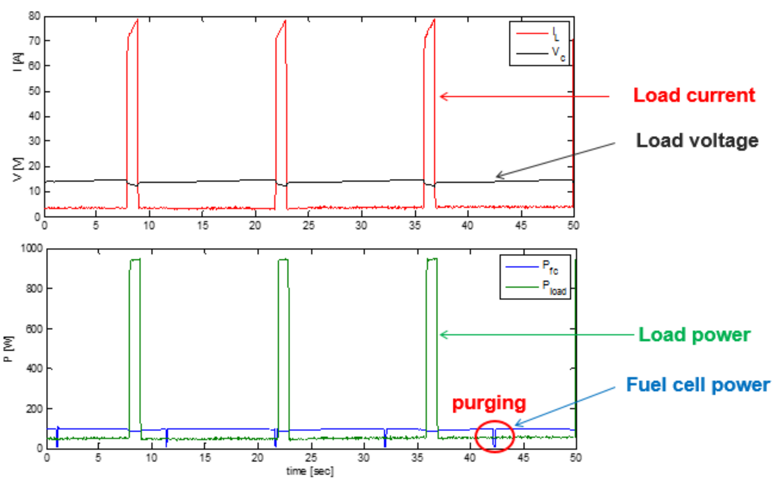

Figure 1: Sample experimental results. Top: load current and voltage; Bottom: load and fuel cell powers

REFERENCES (SELECTION)

[1] A. Kuperman, U. Levy, J. Goren, A. Zafransky and A. Savernin, "Battery charger for electric vehicle traction battery switch station," *IEEE Transactions on Industrial Electronics*, vol. 60, no. 12, pp. 5391 – 5399, Dec. 2013.

[2] A. Kuperman, M. Mellincovsky, C. Lerman, I. Aharon, N. Reichbach, G. Geula and R. Nakash, "Supercapacitor sizing based on desired power and energy performance," *IEEE Transactions on Power Electronics*, vo. 29, no. 10, pp. 5399 – 5405, Oct. 2014.