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Fuel Cell Hybrid Systems for Electric Vehicles

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Abstract*— This paper presents an adoptive current sharing method for fuel cell and battery fed dc drive system for electric vehicle application. Also investigation of different power management techniques suitable for fuel cell and battery hybrid power source for electric vehicle application presented. The control algorithm makes sure that total load is shared between the two sources during transients and heavy load. The controller facilitates fuel cell to operate in normal load region during transient and steady state by sharing unevenly the required load power between the two sources. The effectiveness of the proposed scheme is verified through simulation using MATLAB/Simulink software.

***Keywords*— Fuel Cell, Battery, DC-DC Converters, Simulink.**

I. INTRODUCTION

The power management scheme of the hybrid system comprising of FC and battery with its application of an electric vehicle manufactured by Global Electric Motorcars which uses dc motor drives as been demonstrated [1]. The propulsion is achieved by an array of batteries supported by a 5kW fuel cell. The block diagram of the DC drive system including the hardware and software system is shown in Fig.1. The fuel cell charges the batteries when they have low charge but it provides also power directly to the dc motor drive when it is required by the user. The main function of the fuel cell is to produce the energy required to charge the batteries. When the driver is accelerating, the dc motor drive extracts the current from the battery stack and at the same moment some current from the fuel cell system directly is sent to the dc motor drive. A low dynamic controller has been implemented in a dc-dc boost converter to function as a battery charger which consists of two loops. The inner loop is a fast response PI controller to obtain the desired current accurately on the other hand the external loop measures the dc voltage of the battery stack providing the desired current to be provided by the fuel cell system.

An power management strategy is one of the important technologies for hybrid electric vehicles due to its decisive effect on the performance of the vehicle. The power management strategy for Electric Vehicles has been a very active research field during the past decades. However, how to design a highly-efficient and adaptive control scheme is still a challenging task due to the complex structure of HEVs and the uncertain driving cycle.

The existing power management strategy methods can be generally classified into three categories such as: (a) Rule-based power management strategy, like the thermo static strategy, the load following strategy, and electric assist strategy [2]. These methods rely a lot on the results of wide experimental trials and human expertise without a prior knowledge of the driving conditions [3]. Other related control strategies employ heuristic control techniques, with the resultant strategies formalized as fuzzy rules [4,5] .

The rule-based strategies are effective which can be easily implemented but their optimal control and flexibility are significantly limited by working conditions and, consequently, are not suitable for different driving cycles. (b) Optimization-based power management strategy: some optimization methods employed in control strategy are either based on the known driving cycles or predicted future driving conditions, such as dynamic programming [7], sequential quadratic programming, genetic algorithms and many more. Usually, these algorithms can manage to determine the optimal power split among the engine and the motor for a particular driving cycle. However, the obtained optimal power-split solutions are only optimal with respect to a specific driving cycle. In general, it is neither optimal nor charge-sustaining for other cycles. It is required to predict future driving conditions during real-time operation, there is no other way to involve these control laws directly. Moreover, these methods suffer from the different types of problem, which prevents their extensive acceptance in real-time applications. Model predictive control is another type of optimization-based technique.

The optimal control problem in the restricted area is solved at each sampling instant and control actions are obtained based on online rolling optimization. This method has the advantages of good control effect and strong robustness. (c) Learning-based power management scheme, some strategies can learn from the use of previous driving data for online learning or application. Some researchers propose that traffic information and cloud computing in intelligent transportation systems and can be enhanced electric vehicle energy management since vehicles obtain real-time data via intelligent infrastructures or connected vehicles. Despite of the learning from historical data or predicted data, these power management methods also need complex control models and professional knowledge from experts. Thus, these power management methods are not end-to-end control methods. Support based learning control methods have also been used for electric vehicle power management. However, Support based learning must be able to learn from a signal that is frequently dense, noisy, and delayed. Moreover, the sequence of highly-correlated states is also a big problem of reinforcement learning, in addition to the data sharing changes, as the algorithm learns new behaviors in strengthening learning. Though these rule-based strategies are efficient and can be easily implemented [6].

II. DIFFERENT DRIVE SYSTEMS

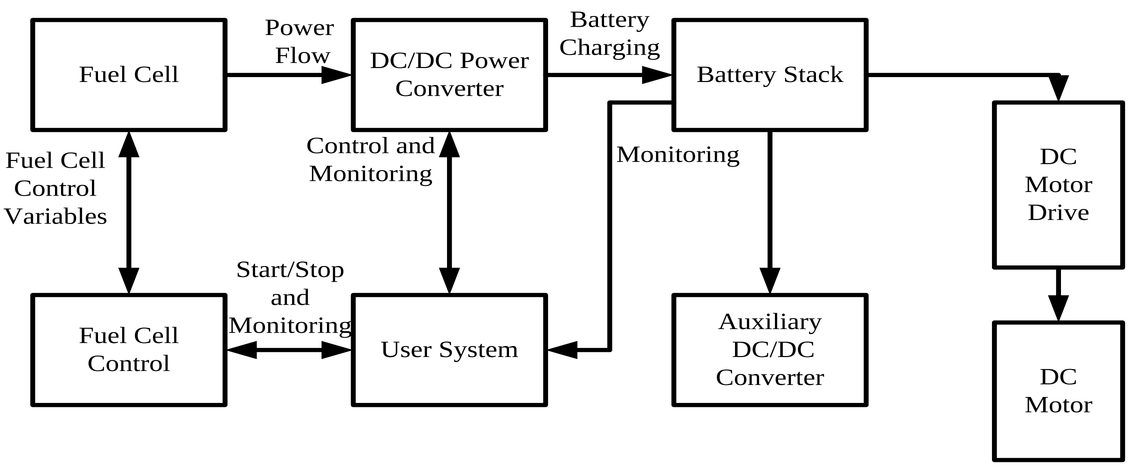

Fig.1 Block diagram of the DC drive system.

A compact digitally controlled fuel cell battery hybrid source was presented [2]. Digital technology is applied in the control of power electronics due to the advantages over analog technology such as programmability, less susceptibility to environmental variations, and low parts count. The user can set the fuel cell current limit, battery current limit, and battery voltage limit in the digital controller. The digital controller comprises a synchronous buck converter that is controlled by a micro controller, current and voltage sensors and a voltage regulator. The control software runs on microcontroller. The block diagram representation of the hybrid system along with the control system is shown in the Fig.2.

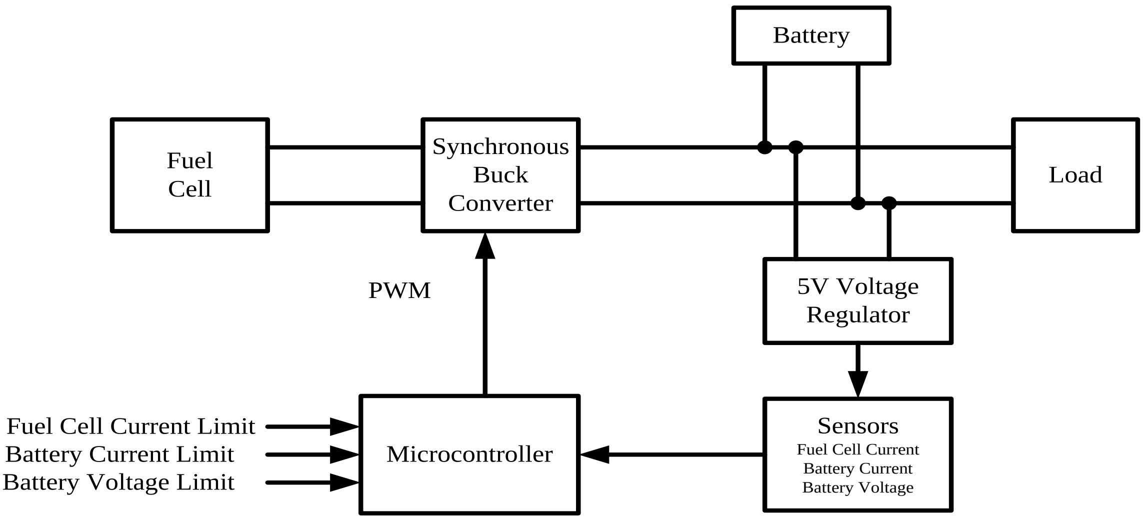

Fig.2 Block diagram of the compact digitally controlled hybrid system.

A hybrid power system combining a 2 kW air-blowing PEMFC stack and a lead–acid battery pack for a lightweight electric vehicle has been developed. The key components of the hybrid system include a fuel cell, a lead acid battery pack, a main dc-dc converter and a central controller as shown in Fig 3. The stack current and voltage respond transiently to the load variations when the fuel cell system itself is able to satisfy the power demand. When the external load is beyond the range of the fuel cell system, the battery begins to provide power assistance by increasing current output. The battery current exhibits satisfactory transient response to the load changes especially during the accelerating and climbing periods.

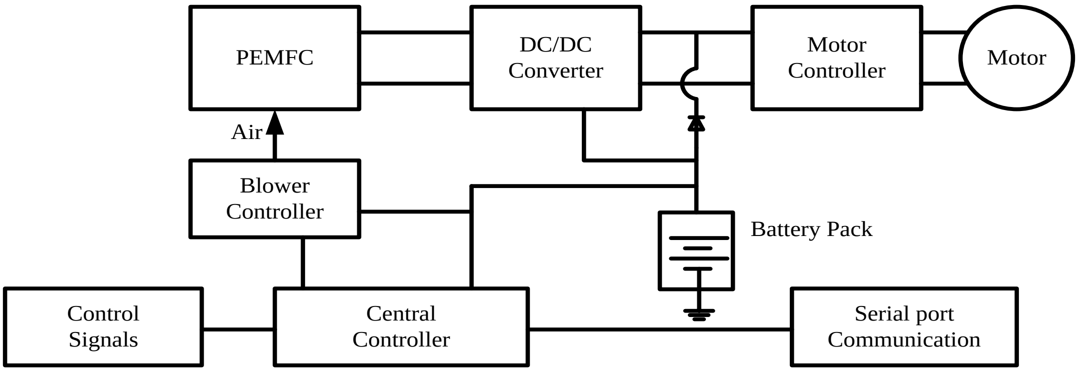

Fig.3 A schematic diagram of the system configuration.

A complete drive system has been realized to verify the feasibility of the proposed control system of the fuel cell battery hybrid source. As the DC motor drive is fed from a hybrid power source, the motor takes power always from fuel cell and only during transient period battery delivers power to the load under heavy load condition. The proposed controller works satisfactorily under light load, heavy load condition and regenerative condition as well. Simulations of the entire drive system are presented in this section. The designed values of the components of the drive system are shown in Table-1. The simulation is carried out using MATLAB/Simulink. Fig 4 demonstrates the simulation result of power sharing technique and verifies the feasibility of the control system.

TABLE-1

SI.No	Components	values
1	Fuel cell (PEMFC)	5 kW.
2	Li-Ion Battery	48V
3	Motor (DC)	5HP
4	Converter Switch	IGBT
5	Switching Frequency	12KHz
6	Boost Inductor	2mH
7	Filter Capacitor	1400µF

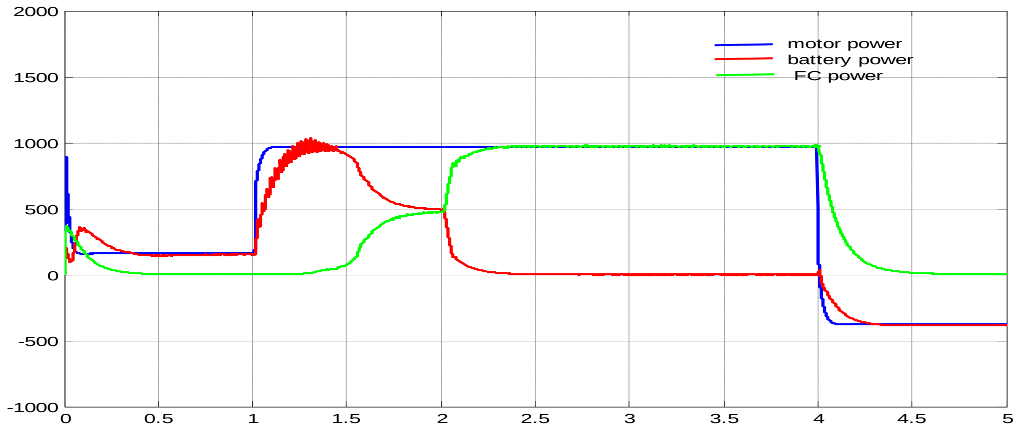

Fig.4. Simulation of Power Sharing technique between FC & Battery.

III. CONCLUSIONS

Reliability and low operational cost for electric power using dual power sources of different nature is to enhance the reliability of power source, therefore power management and current sharing has been demonstrated in this paper. The simulation was carried out on the basis of power demand by the load keeping the battery SOC within the limit and fuel cell status. When power demanded by the drive is less at low speed, the low power is supplied by battery only minimizing the hydrogen consumption by the fuel cell. When the power demand is high at higher speed, both fuel cell and battery supplies power to meet the load demand. The robustness of the controller has been proved by observing that the strategy works very well for different driving cycle.

REFERENCES

[1] Da Huo, Simon Le Blond, Chenghong Gu, Wei Wei, Dongmin Yu, "Optimal operation of interconnected energy hubs by using decomposed hybrid particle swarm and interior-point approach," International Journal of Electrical Power Energy Systems, Volume 95, Pages 36-46 February 2018.

[2] Rupendra Kumar Pachauri, Yogesh K. Chauhan, "**Various** control schemes of power management for phosphoric acid fuel cell system," International Journal of Electrical Power & Energy Systems, Volume 74, Pages 49-57, January 2016.

[3] Jennifer Bauman, Mehrdad Kazerani, "A Comparative study of Fuel Cell Battery, Fuel Cell Ultracapacitor, and Fuel Cell Battery Ultracapacitor vehicles," IEEE Transaction on vehicular technology, vol 57, no 2, pp. 760-769, March. 2008.

[4] Wei Jiang, Babak Fahimi, "Active Current Sharing and Source management in Fuel Cell–Battery Hybrid Power System," IEEE Transaction on Industrial Electronics, vol 57, no 2, pp. 752-761, Feb. 2010.

[5] J. Wang, F. Z. Peng, J. Anderson, A. Joseph, and R. Buffenbarger, "Low cost fuel cell converter system for residential power generation," *IEEE Trans. Power Electron.*, vol. 19, no. 5, pp. 1315–1322, Sep. 2004.

[6] L. Solero, A. Lidozzi, and J. A. Pomilio, "Design of multiple-input power converter to hybrid vehicles," *IEEE Trans. Power Electron.*, vol. 20, no. 5,pp. 1007–1016, Sep. 2005.

[7] Wirasingha, S.G.; Emadi, A. Classification and review of control strategies for plug-in hybrid electric vehicles. IEEE Trans. Veh. Technol. **2011**, 60, 111–122.

[8] Gokce, K.; Ozdemir, A. An instantaneous optimization strategy based on efficiency maps for internal combustion engine/battery hybrid vehicles. Energy Conversion and Management. **2014**, 81, 255–269