BATTERY AND SUPER CAPACITOR BASED ENERGY STORAGE SYSTEM FOR AN ELECTRIC VEHICLE

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Abstract— A configuration of Battery and super capacitor based energy storage system for an electric vehicle is presented in this work. The combination of battery and super capacitors yields better transient performance, improved battery life-span and compact sizing of ESS. The battery can supply the base power and torque to an electric vehicle and the rest of the power and torque (peak torque and peak power) can be supplied by super capacitor. The combination may reduce the size of the battery and cost of the vehicle. Two bidirectional DC-DC Converters (boost converter) are used to integrate two different energy storage systems with the dc link of dc-ac converter. The dc-dc converter connected to battery is operated in current control mode, whereas the other dc-dc converter is operated in voltage control mode. The complete system is simulated in MATLAB/SIMULINK and the results are presented to check the performance.
Key words— Super Capacitor, DC-DC Converters, ESS, Electric vehicle

I.INTRODUCTION

Now day's electric vehicles are playing major roles in India. It can be useful to reduce the pollution and usage of petrol and diesel. In electric vehicles batteries are used for energy storage purpose.The size of the battery will be decided by the rating of the vehicle. It can affect on cost of the vehicle and charging time of the battery. Here battery will supply the base torque and base power to the vehicle. Here super capacitor is used to reduce the size of the battery and it supplies the peak torque and peak power to the vehicle.

II.SUPER CAPACITOR AND BATTERY BASED ESS FOR IM DRIVE

The configuration is shown in Figure 1. The battery and supercapacitors are connected to the dc-link of the inverter through two dc-dc converters. The dc-dc converter connected to battery is operated in Voltage Control Mode (VCM) and the other dc-dc converter is operated in Current Control Mode (CCM). The Induction Motor (IM) is operated in v/f control which is put in the three phase 2-level dc-ac stage.

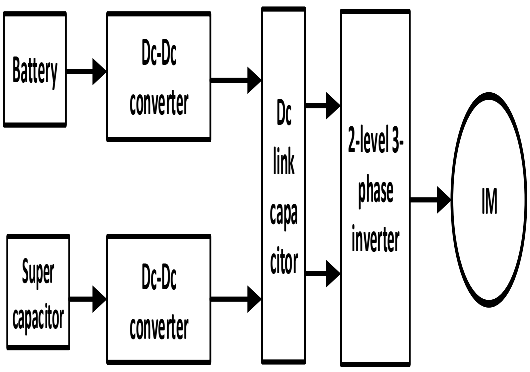


Fig.1. System under consideration

The circuit level diagram of the system is shown in configurations of the converters are shown in Figure 2.

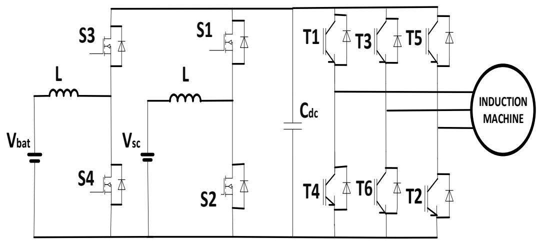


Fig.2. Circuit level diagram of the system

The ratings as shown in the above table are applicable for small three wheeler electric vehicle (TOTO vehicle). In this vehicle configuration, there are 8 number of batteries connected in series. Each of the battery unit is rated at 12 V and 28 Ah. Six numbers of super capacitors are also connected in series where each of the supercapacitor module is rated at 16V, 54 F. These batteries can supply the base power and torque during the acceleration/deceleration of the vehicle (i.e. 400 W) and reaming power and torque (i.e. peak power and peak torque) can be supplied by super capacitor (i.e. 600 W).

Fig.3. A representative diagram of TOTO vehicle

2.1 Control of dc-dc converter

The dc-dc converter connected to the super capacitor is operated under constant voltage control mode. The control block diagram is shown in Figure 3. The reference voltage is decided according to the expression of (1).

2.1.1 Super capacitor based boost converter operating in VCM

The dc-dc converter connected to supercapacitor is operated in voltage control mode. The corresponding control block diagram is given in Figure. 4.

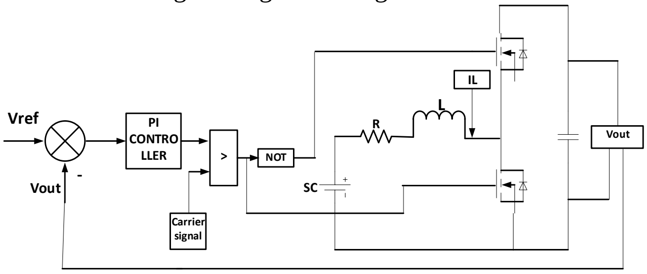


Fig.3. closed loop control of a super capacitor based boost converter which is operated in VCM

2.3 Power Segregation

The total power is supplied by the battery and supercapacitor considering the following key issues.

- Battery should supply only the base power so that its current rating can be kept at lower value.
- Supercapacitor should provide the acceleration/deceleration power
- The $\frac{di}{dt}$ of the battery should stay within the specified limit

Considering the aforesaid key issues, three algorithms are considered here for the segregation of power between battery and super capacitor.

- Algorithm 1: power segregation under hard limit condition
- Algorithm 2: power segregation using a low pass filter
- Algorithm 3: power segregation using di/dt limiter

- ***Algorithm-1: Power segregation under hard limit condition***

In this case, the power above a certain level is supplied by supercapacitor and the power below that level is provided by battery. The algorithm is pictorially shown in the figure below.

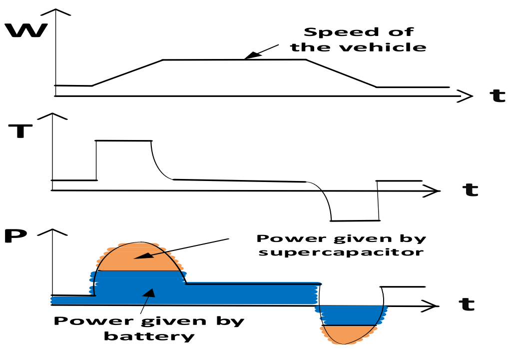
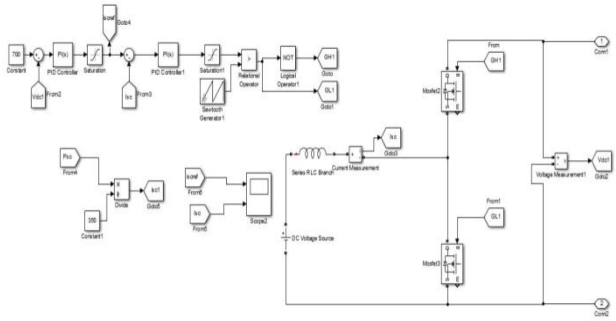


Fig.4. Power segregation using algorithm-1

III. Results

3.1.1 Simulink schematic of a closed loop control of dc-dc boost converter operating in VCM

Figure 3.1.8: Simulink schematic of dc-dc boost converter (VCM)



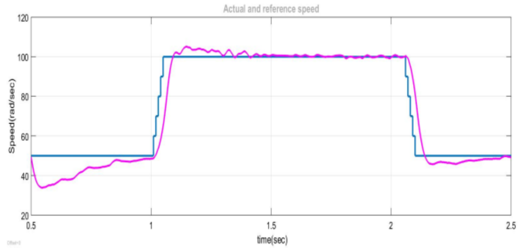


Fig.5. Reference and actual rotor speed

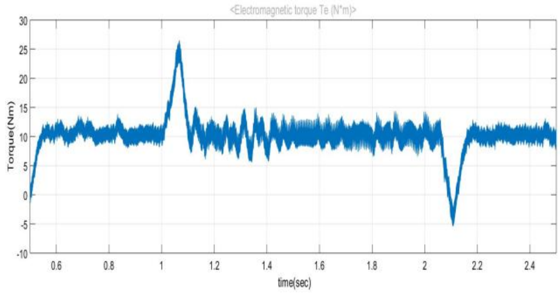


Fig.6. Electromagnetic torque

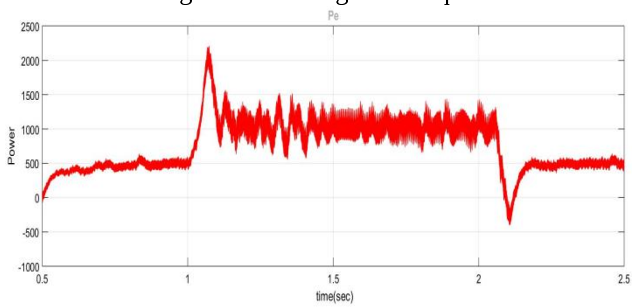


Fig.7. Power drawn by the motor

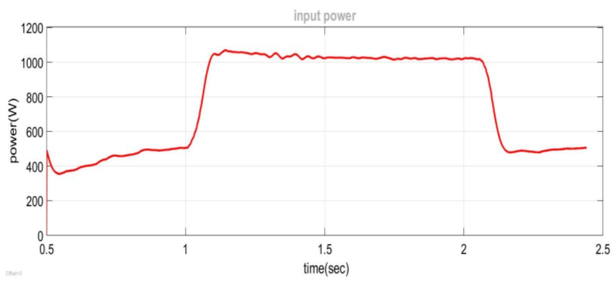


Fig.7. Input power of an Induction motor

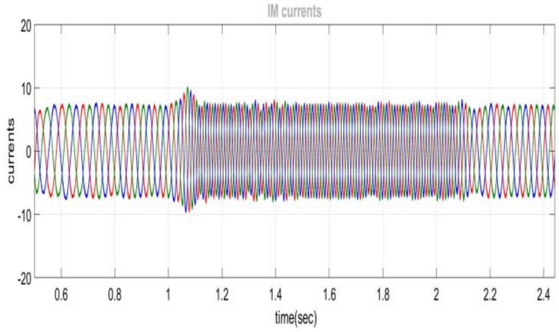


Fig.8. Stator currents of an IM

VI. CONCLUSION

A battery and super capacitor based energy storage system is presented in this work. The battery is supplying the base power and the supercapacitor is providing the peak power. This eventually reduces the size of the battery and increases life-span. The transient performance is also expected to be improved. The closed loop control of dc-dc converters and v/f control of IM are tested through simulation. A hardware prototype is developed in the laboratory to demonstrate the work.

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