Ultra-capacitor Application in Electric Vehicles for Regenerative Braking of DC Motor

Meenakshi S. Bawankar[1] S.K.Umathe[2] Dr.S.G. Tarnekar[3]
[1]M.Tech [2]Assistant Professor [3]Sr.Professor
[1,2,3]Department of Electrical Engineering
[1,2,3]GHRCE Nagpur

Abstract— In electric vehicle the regenerative break used to charge the battery and increase the charging range of the vehicle. Quantity of energy is depends upon the vehicle. Heavy and large vehicle can save large amount of energy. And getting a best saving of energy. Ultracapacapacitor is used to stored energy and having large capability than that of the normal capacitor.Now the latest technology used in industry with the regenerative braking is increased. The output of regenerative braking is used to improve by connecting the battery and ultracapacitor with dc-dc converter. And the controller is used to divide the amount of current and improve the efficiency of the system.Here work is done for the parallel combination of the battery and Ultracapacitor focusing on the Regenerative braking using dc motor. This recombination is used to store the energy using MATLAB simulation. During braking energy is stored into the battery and Ultracapacitor

Key words: Battery, wheel, dc-dc converter, regenerative braking, ultra-capacitor, dc motor

I. INTRODUCTION

Vehicle technology such as control technology and integrative technology has been developing rapidly. Somehow, the limitation of driving mileage still becomes a problem for the development of electric vehicles. This problem has been overcome by using regenerative braking. This technology had replaced the traditional braking systems. In this thesis, regenerative braking of Electric vehicles by using Ultracapacitor (UC) has been discussed. In regenerative braking mode, the drive-motor acts as a generator. It transforms the kinetic-energy to electrical energy for storing that into the batteries or capacitors. At the same time, the brake controller monitors the speed of the wheels & calculates the required torque plus the too much energy by the rotational force that can be converted into electricity and fed back into the batteries during regenerative mode. The application of Ultracapacitor has been increased from last decade and it's increasing every day. The advancement in Ultracapacitor technology gives more and more importance to application of Ultracapacitor. Application of UC with battery combination for electric vehicle is one of the applications. The new invention in UC technology further reduces the cost and size of it, which increase demand of UC for this particular application where cost, size and weight of machine are the important factor. Furthermore, some more technique are also used to manage ultracapacitor energy management to increase the efficiency.

Electric vehicle have a higher efficiency and lower emission compared with the engine vehicles. So the external power source such as battery, ultracapacitor is used to power the vehicle. Mostly the braking system of vehicle is based on hydraulic braking system. This braking technology causes a lot of energy wastage. Thus to compensate this disadvantages the regenerative braking system are used. We can save energy by regenerative action. When you drive an electric vehicle then energy flow from battery to the wheel via the electric motor and after applying break energy flow from wheel to the battery via the motor which works as generator. There is certain consumption of energy. As in case of electric braking generated energy is converted into the electrical energy and then it will be goes return to the source and further it is used to power on the vehicle.

II. ULTRA CAPACITOR SYSTEM

Here we discussed the regenerative braking of Electric vehicles by using ultracapacitor. In this case we applying the break then motor will behave as a generator. In this condition the back e.m.f. is greater than that of supply voltage and it return to the source. It transforms the kinetic-energy to electrical energy for storing that into the battery or ultracapacitors. At that time the brake controller monitors the speed of the wheels & calculates the torque and the extra energy from the rotational force which is converted into electricity and fed back into the battery during regenerative mode.The advancement in ultracapacitor technology gives more importance to use of ultracapacitor. The use of UC with battery for electric vehicle is one of the most useful combinations. Thus cost, weight and size are important factor to increase the demand of UC for this particular application. And the dc motor is connected in the system for better performance which has following advantages –

- It require less space as compared to other form of drive.
- It is more economical.
- It is free from pollution.
- Its operating characteristics can be easily modified.
- It can be controlled easily.
- Less maintenance.
- Easy starting.

Here only the required energy is going to the battery and remaining will be stored in to the Ultracapacitor. Ultracapacitor deliver energy during overload. The Ultracapacitor (also known as the super capacitor or electrical double layer capacitor) is a different from the normal capacitor. It has very high capacitance and high energy density. The capacitor stored energy by means of static charge. Applying the voltage with proper polarity, on the positive and negative plates charges the capacitor. Compared with a conventional capacitor, so called super capacitors offer much more charge to be stored per unit volume. This is achieved through increased effective electrode surface and the additional electrolyte. Most super capacitors on the market today use activated carbon as the electrode material. The charge is stored via charge separation and alignment of the dipoles in the electrical double layer. The thinness of this layer along with its large electrode surface area allows the

supersized capacity of super capacitors compared to conventional capacitors.

III. REGENERATIVE BRAKING CONCEPT

In Regenerative braking generated energy is supplied to the source, for this condition should satisfy that V < Ea & Ia should be negative. Ea is decided mainly by the speed if it is a Plane DC motor. Ea can also be controlled by field current.

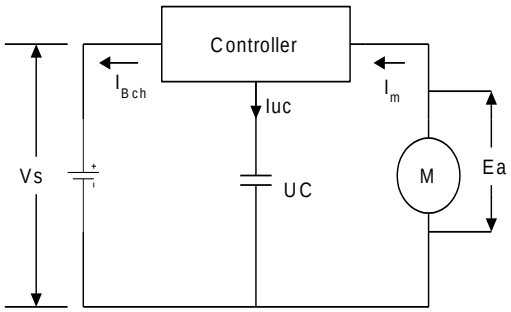

Fig. 1: Circuit diagram using Regenerative Braking

IV. SYSTEM ANALYSIS

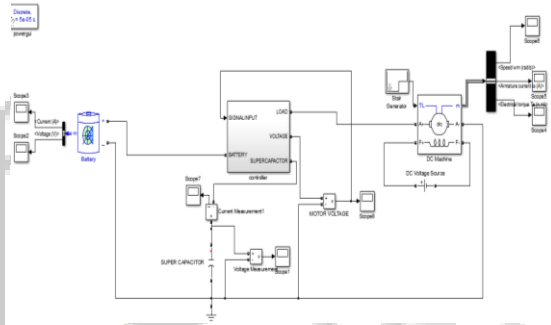

Fig. 2: Regenerative Braking Model

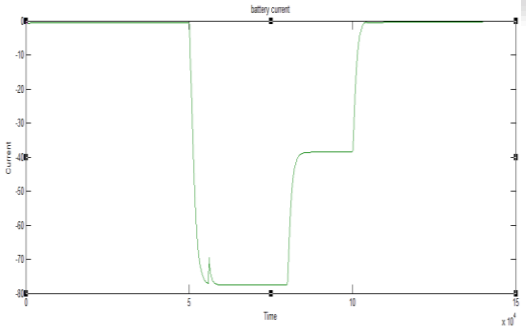

Fig. 3: Battery Current at starting

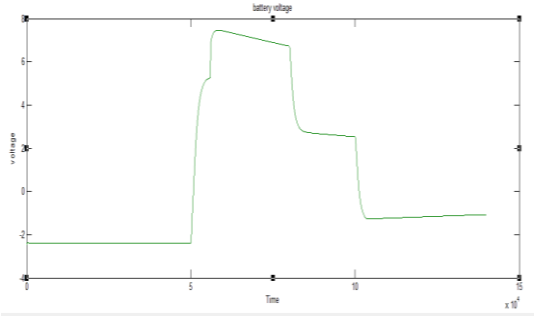

Fig. 4: Battery Voltage at starting

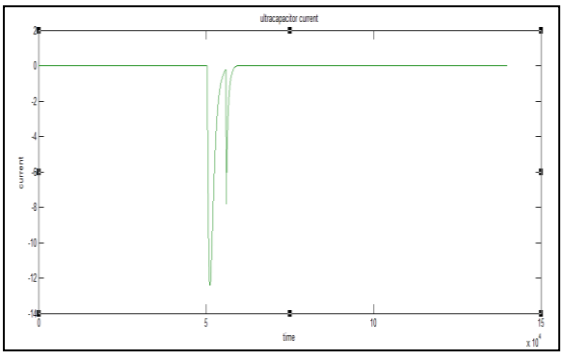

Fig. 5: Ultra capacitor Current

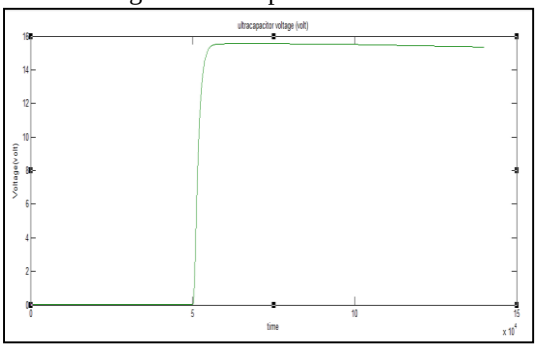

Fig. 6: Ultra capacitor voltage

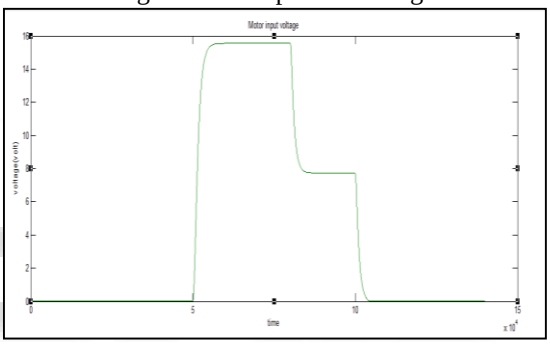

Fig. 7: Motor Input Voltage

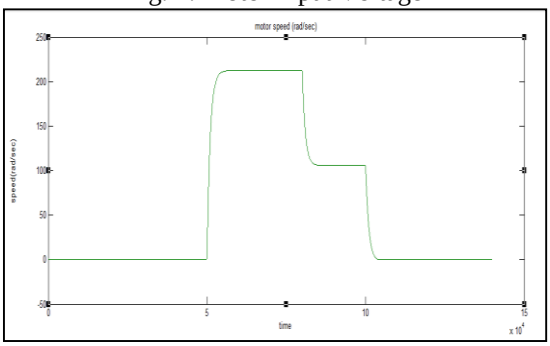

Fig. 8: Motor Speed

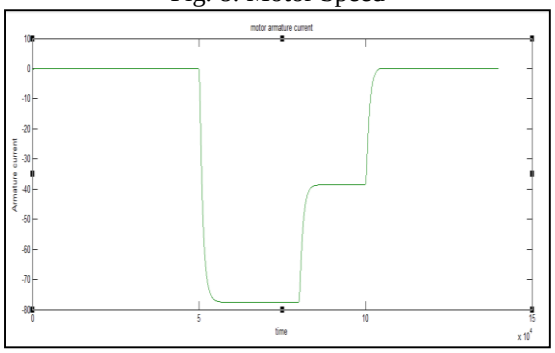

Fig. 9: Motor Armature Current

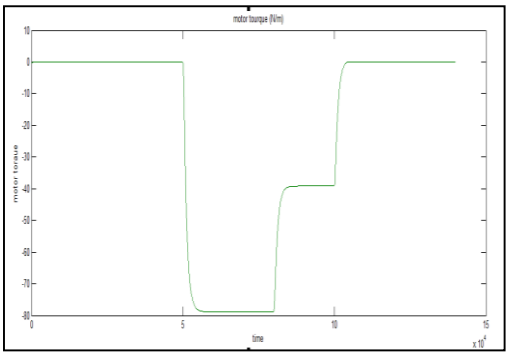

Fig. 10: Motor Speed

V. CONCLUSION

Ultracapacitor connected in parallel with the battery reduces burden on battery during starting of motor and again parallel combination of Ultracapacitor provides maximum utilization and faster exchange of energy. Here Ultracapacitor is conned in Parallel with battery to store the excessive energy during braking which is used to power on the vehicle again. Comparison of various system schemes is based on time for which Ultracapacitor is connected in the system.

In first simulation battery is connected to the motor and the current in the battery is negative which is depending on the direction of switches. During braking Energy is calculated by the method of area under the graph which is found to be 195.12 J. In second simulation the battery voltage is positive and it is increased after 2.5 sec during starting. In third & fourth simulation ultracapacitor current & voltage is given with respect to time. Again current is negative & voltage is positive. In next simulation input voltage given to the motor is positive and brake applying the supply of the motor is disconnected and it work like generator and rotate in reverse direction. So the torque is negative and also the armature current is negative. Thus kinetic energy is return to the supply.

Hence maximum utilization of Ultracapacitor to stored the excessive energy during regenerative braking is possible.

REFERENCES

[1] M.K Yoong*, Y.H Gan, G.D Gan, C.K Leong, Z.Y Phuan, B.K Cheah. K.W Chew, "Studies of Regenerative Braking in Electric Vehicle," Proceedings of the 2010 IEEE Conference on Sustainable Utilization and Development in Engineering and Technology Universiti Tunku Abdul Rahman 20 & 21 November 2010, Faculty of Engineering, Kuala Lumpur, Malaysia.

[2] Ming-Ji Yang, Hong-Lin Jhou, Bin-Yen Ma, and Kuo-Kai Shyu, "A Cost-Effective Method of Electric Brake With Energy Regeneration for Electric Vehicles," IEEE Trans. Industrial Electronics., vol. 56, no. 6, pp. 2203–2212, June 2009

[3] Petar J. Grbovi´c, Philippe Delarue, Philippe Le Moigne, and Patrick Bartholomeus, "The Ultracapacitor-Based Regenerative Controlled Electric Drives With Power-Smoothing Capability," IEEE Transactions On Industrial Electronics, Vol. 59, No. 12, December 2012

[4] Furkan Akar, and Bulent Vural, "BatterylUC Hybridization for Electric Vehicles via a Novel Double Input DC/DC Power Converter," 2013 3rd International Conference on Electric Power and Energy Conversion Systems, Yildiz Technical University, Istanbul, Turkey, October 2-4, 2013

[5] Mohamed Hedi Chabchoub, Hafedh Trabelsi "Consolidation Of The Electric Vehicle Battery By An Ulracapacitor For Performance Improvement" 10th International Multi-conference On Systems, Signals & Devices (Ssd), Hammamet, Tunisia, page no.1-5, INSPEC Accession Number: 13709273, March 18-21, 2013

[6] A.S. Samosir ,A. H. M. Yatim," Dynamic Evolution Control of Bidirectional DC-DC Converter for Interfacing Ultracapacitor Energy Storage to Fuel Cell Electric Vehicle System" Australasian Universities Power Engineering Conference (AUPEC'08), Paper P-113 Page 1-7,2008

[7] A. H. Eghbali , B. Asaei and P. Nader "Fuel efficient control strategy, based on battery-ultracapacitor energy storage system, in parallel hybrid electric vehicles", Proc. IEEE Veh. Power Propulsion Conf. (VPPC), pp.1 -5 2010

[8] Juan W. Dixon & Micah E. Ortlizar " Ultracapacitor + DC-DC Converters in Regenerative Braking System" in IEEE AESS System Catholic University of Chile, Maguzinr, August 2002.

[9] Shane Colton "A Simple Series Battery/Ultracapacitor Drive System For Light Vehicles And Educational Demonstration" In Edgerton Center Summer Engineering Workshop Massachusetts Institute Of Technology, Cambridge, Massachusetts, United States Of America,March-2009.

[10] P.R.Sawarkar, Dr S.G.Tarnekar, Dr.S.B.Bodkhe "Improvement In Energy Transactions In Ultra Capacitor Banks By Series/Parallel Re-combination"—an Indian patent filed by GHRLABS, in 2012.

[11] Destiny Loukakou, Patrice Chetangny, and Vincent Soussou Houndedako, "Regenerative braking in a small low cost plug-in hybrid electric vehicle for urban use," 2013 Eighth International Conference and Exhibition on Ecological Vehicles and Renewable Energies (EVER).

[12] Zhifeng Bail, Yaojiie Sun, ' Yandan Lin, "Research On Ultracapacitor-battery Hybrid Power System" In Institute For Electric Light Sources, Fudan University Engineering Research Center Of Advanced Lighting Technology Of Ministry Of Education, Departments Of Materials Science, Fudan University Shanghai, China,2011

[13] S.PAY, Member, IEEE, And Y.BAGHZOUZ, Senior Member, IEEE "Effectiveness Of Battery-Supercapacitor Combination In Electrical Vehicles" In IEEE Bologna Power Tech Conference, June 23th-26th , Bologna,italy,2003

