Regenerative Braking In Electric Vehicles Applications Using Bidirectional DC- DC Converter With Solar Energy

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Abstract- *In this paper, Regenerative braking in electric vehicles applications using bidirectional Dc-Dc converter with solaar energy, bidirectional DC/DC buck-boost converter with dual control strategy during regenerative braking is used for a two-wheeler application. Proposed system combining of two source one as PV array with MPPT and other as Battery which use to provide as input to bidirectional DC DC converter. During the normal and Good Solar Irradiation Conditions the PV array generated maximum voltage with the Help of MPPT. Therefore, it plays important role during motoring mode to supply power to motor but when Availability or less amount of solar irradiations output battery will supply power to motor. PV and battery not sufficient to provide power to motor some time. When the motor voltage less than the battery voltage proposed bidirectional converter having ability to charge the battery. using proposed control and converter parameter of motor speed, armature current, torque analysed along with battery SOC, Current, Voltage. This is done to make the system more reliable and realistic. The overall work analysed with help of MATLAB/Simulink.*

Keywords- Braking, Bidirectional Converter, Fuzzy, SOC

I. INTRODUCTION

In today's world of dwindling resources and ever-increasing prices, spending a lot on fuel has become a major part of the economic budget. The national capital spent on fuel can be minimized by reducing the fuel consumption per man.To achieve this, hybrid electric vehicles (HEV) and plug in hybrid electric vehicles (PHEV) [2] are an alternate solution. Installation of high energy battery banks and regenerative braking improves the drive range [7] of the electric vehicles as well as improving the battery life. The heavy electrical energy from the rotational mechanical energy, DC/DC converters with appropriate charging and discharging profile are required. Various technologies of DC/DC converters have been discussed here. However, regenerative braking [7], has to be carried out with the conventional frictional braking. In the braking process, there are two issues that are to be addressed. The first step is accurately applying the brakes which restrains the vehicle speed and maintains the vehicle's travelling course. And the second step is to recover the braking energy to increase the efficiency of the battery. In practical, the effectiveness of electric braking are reduced by some factors like state of charge (SOC) of batteries, speed of the vehicle and driver's brake force requirements. Thereby mechanical braking must be encompassed along with regenerative braking. Regenerative braking has various literatures and many works on regenerative braking and various algorithms, simulations for the control during the regenerative braking are proposed. The work proposed a method wherein vehicle's speed is taken into account and not the SOC. Authors in [4] have taken the SOC into account and computed the regenerative force. However, the above work does not give any methods to utilize the regenerative power to charge the battery. Works carriedout in[5] and [6] have used different topologies of bidirectional DC/DC converters to charge the battery. It is to be noted that the converters used in the works do not address the issue that arises if the terminal voltage of the machine falls below the battery voltage during low speed of the vehicle. Here we have neglected back emf when the battery voltage is greater than the terminal voltage of the machine. In this paper, propose a braking strategy where Speed of the vehicle, State of Charge (SOC) and Braking Force are taken into consideration. Safety of the vehicle is determined by speed and brake whereas the state of charge is used to prevent the battery from getting overcharged or deep discharged. This model focus on the dual (voltage and current) control method which is used to extract the maximum possible energy during the regenerative braking conditions and to ensure that the vehicle stops in an optimum time frame of process. During Regenerative Braking the bi-directional dc-dc converter either operates in the buck mode or boost mode depending on the motor terminal voltage. Here also the fuzzy logic control is used to determine the charging current of battery as its determining factors (SOC, vehicle speed and brake force requirement) have an uncertain relation with it. [1]. In this model we have PV as parallel source to the battery

II. PROPOSED METHODOLOG

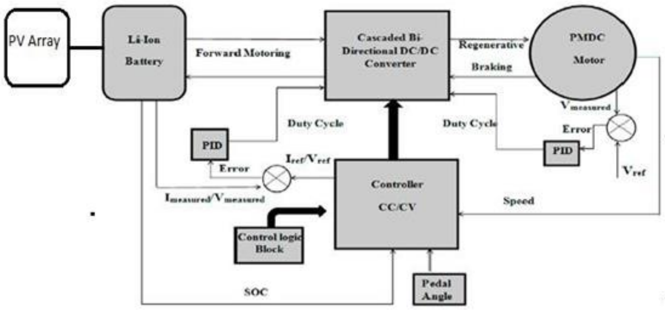

Fig-1: Block Diagram of The system

The overall configuration of the electric vehicle with the proposed control strategy is shown in Fig. 1. The system consists of PV arrays, lithium-ion battery, permanent magnet DC (PMDC) machine, bidirectional DC/DC buck-boost converter, fuzzy logic reference current generator and control logic block. Proposed system combining of two source one as PV array and other as Battery which use to provide as input to bidirectional DC DC converter. During the normal and Good Solar Irradiation Conditions the PV array generated maximum voltage therefore it plays important role during motoring mode to supply power to motor but when unavailability or less amount of solar irradiations output battery will supply power to motor The bi-directional DC/DC converter can operate in both buck and boost mode. The converter operates in boost mode during motoring operation. During regenerative braking mode, the converter can operate in boostor buck mode and the power flow is from the machine to the battery. The mode of operation during the regenerative braking depends upon the generated voltage at the terminals of the PMDC machine. If the generated voltage is less than battery voltage, the DC/DC converter operates in the boost mode and if the generated voltage is greater than the battery voltage the converter works in the buck mode. The control logic block functions during the regenerative braking mode and is responsible for shifting of control strategy from current control (CC) to voltage control (VC) mode during the braking process

III. CONTROL STRATEGY

The algorithm is used to implement the circuit on Simulink. As seen in the image below, there is a switch taking theT1 value and switching depending on positive or negative torque. Once the operating mode is chosen, values of Vmot, SOC and Ia are read depending on the mode chosen.

The ‘From’ tags bring the input parameters from the corresponding ‘Goto’ tags in the main circuit. Based on the algorithm followed, when a certain parameter is confirmed, the output‘1’is multiplied by a gain value corresponding to the Mode number plus CC/VC combination. Depending on the mode selected, switches of the converter are ON/OFF or on PWM switching mode.

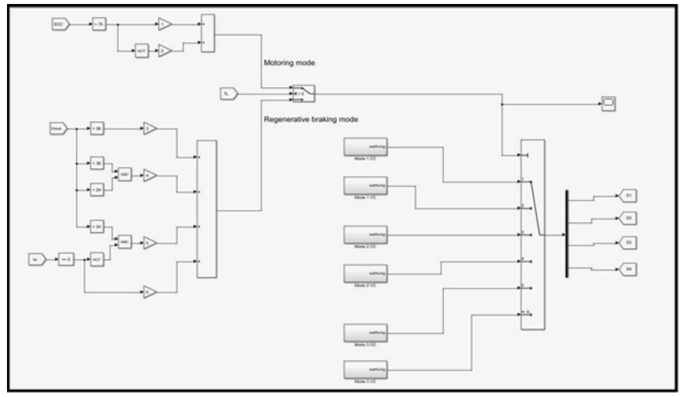

Fig 2: Simulink model of Conrol logic block

In the above fig there are blocks of subsystems representing the CC/VC blocks for each mode.

IV. SIMULATION AND RESULT

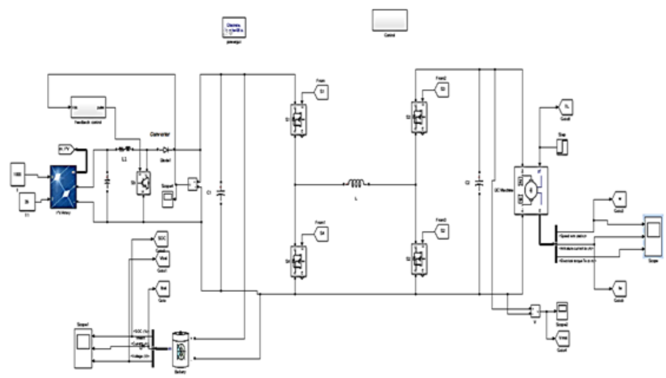

Fig 3: Simulation of main circuit

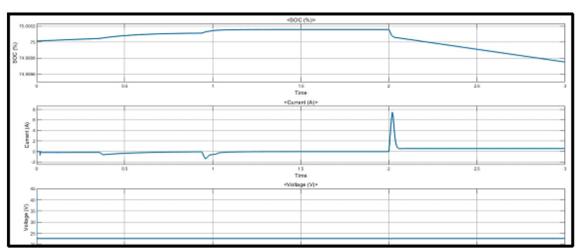

Fig 4: Battery Voltage

Fig 4 (a) shows the SOC of the battery which is initially at 75%. As the battery gets charged during the braking process the SOC of the battery rises. After t=2 the SOC starts to drop again as the motor now operates in forward motoring mode.

Fig 4 (b) shows the battery current. When the brakes are applied the motor acts as a generator (reverse motoring mode) and the current flows from the motor to the battery.

Fig4(c) shows the battery voltage which remains more or less constant throughout.

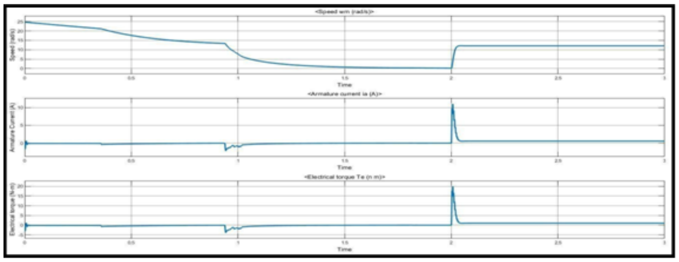

Fig 5: Motor Outpot

Fig 5 (a) shows the speed of the vehicle which is 25 m/s initially at the instant when the brakes are applied and reduces to zero when the vehicle comes to halt at t=2. After that the vehicle speed rises again.

Fig 5 (b) shows the armature current which has a negative value indicating flow of current from motor to battery until it becomes zero at t=2. The current magnitude becomes positive after t=2 as the motor transitions to forward motoring mode.

Fig5(c) shows the motor electrical torque. As the torque is proportional to armature current the torque curve follows the armature current curve, only differing in magnitude.

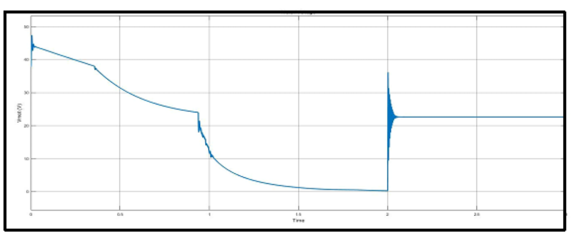

Fig 6: Motor Terminal Voltage

Fig 6 shows the motor terminal voltage. .

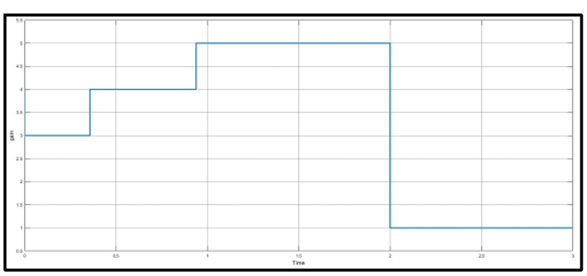

Fig 7 :Mode Output

Fig7 shows the modes of operation of the cascaded bi-directional buck-boost converter.

V. CONCLUSION

Regenerative Braking in Electric Vehicles Applications using Bidirectional Converter with Solar Energy" suggests, through this paper.

1. Understanding the concept of regenerative braking in electric vehicles and why this is particularly useful but difficult for two-wheeler EVs.
2. Understanding how the dual control strategy as well as our chosen components can help extract maximum energy and stop the vehicle safely in a limited timeframe, irrespective of speed.
3. Developing a compact Simulink model combining the different components and subsystems as it would be in a realistic system.
4. Developed a control logic algorithm for operating the circuit in different modes according to the speed of the vehicle and whether it is in motoring or regenerative braking mode.
5. Studying outputs obtained for executing the braking system in a limited time frame and understanding the transition from motoring to regenerative braking with current control and voltage control performed accordingly.
6. Userenewablesourceofenergy(PV)inparallelwithbatterywhichhelptomaintaincontinuityofsupply.
7. Overall parameter of battery ad motor observed and analyzed using MATLAB which will be better using Proposed Methodology.

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