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Regenerative Braking System of Hybrid Electric Vehicle Driven By DC Motor

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ABSTRACT: Complementary features of batteries and super capacitors can be effectively used in a hybrid energy storage system (HESS). The utilization of the HESS in electric vehicles (EVs) offers many advantages, such as efficient regenerative braking, battery safety, and improved vehicle acceleration. In this paper, a new regenerative braking system (RBS) is proposed for EVs with HESS and driven by brushless DC (BLDC) motor. During regenerative braking, the BLDC acts as a generator. Hence, by using an appropriate switching algorithm, the dc-link voltage is boosted and the energy is transferred to the super capacitor or the battery through the inverter. The harvested energy can be utilized to improve the vehicle acceleration and/or keep the battery pack from deep discharging while driving uphill. To provide a reliable and smooth brake, braking force distribution is realized through an artificial neural network. To evaluate the performance of the proposed RBS, different simulations and experiments are carried out. The results confirm high capability of the proposed RBS.

KEYWORDS: Supercapacitors, Batteries, Vehicles, Switches, Topology, Inverters

I. INTRODUCTION

Recently because environmental pollution and the energy crisis are rising globally, most industrialized countries have been attempting to reduce their dependence on oil as an electric cars, electric scooters, electric bicycles, electric wheelchairs, etc. Electric vehicles (EVs) are becoming important, not only as an environmental measure against global warming but also as an industrial policy [1-2]. In order for them to be used widely, the next-generation EVs must be safe and per-form well. The propulsion force generation mechanism which strongly influence the safety and running performance of the vehicle, the faster, more efficient, less noisy and more reliable Brushless dc motors (BLDCMs) have many advantages over brushed dc motors and induction motors, such as simple structure, high efficiency, high dynamic response, higher speed range, large starting torque, noiseless operation, etc. The regenerative braking does not operate all times, e.g., when the battery is fully charged, braking needs to be effected by dissipating the energy in a resistive load.[3-5] Therefore, the mechanical brake in the EV is still needed. EVs use mechanical brake to increase the friction of wheel for the deceleration purpose. However, from the viewpoint of saving energy, the mechanical brake dissipates much energy since the EV's kinetic energy is converted into the thermal one. In view of this, this paper discusses how to convert the kinetic energy into the electrical one that can be recharged to the battery.[10-13] Thus, both the electric brake and energy regeneration are achieved A mechanical brake system is also very important for EVs' safety and other operations.

II. BACKGROUNDBLDC MOTOR AND ITS CONTROL

A.BLDC MOTORS

Brushless DC motors are inverter fed motors which perfectly suited for EVs due to their various characteristics such as high efficiency, wide speed ranges and good power densities. BLDC motor is one of the types of synchronous motor. Hence BLDC motors don't have slip i.e. the magnetic field produced by stator and rotor have same frequency.

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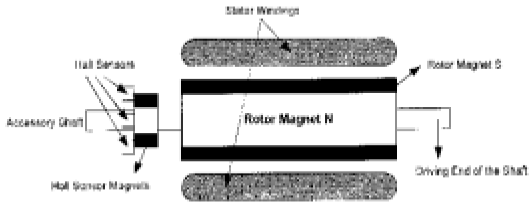

Figure 1 BLDC motor parts

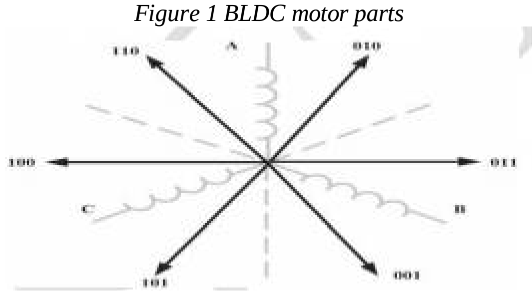

Figure 2 Six sectors of BLDC motor

B. CONTROL OF INVERTER SWITCHES FOR REGENERATIVE BRAKING MODE

During deceleration the current in the circuit of motor-battery is reversed to attain regenerative braking. Pulse Width Modulation (PWM) control is implemented for an active braking control. The back EMF of the stator winding is incapable to reach the voltage across battery when the speed of BLDC motor is low. The inductances in the stator of motor can establish a boost circuit. Through this inductor accumulator the dc bus voltage is upraised to accomplish the retrieval of brake energy. To achieve this all the switches in the higher arm of the inverter are turned off and the lower arm switches are only controlled throughout the regenerative braking mode.

III. MOTOR CONTROL AND MOSFET CONTROL OF REGENRATIVE

A. Motor Control:

A control of permanent-magnet BLDC motor is PWM current control. It is based on the assumption of liner relationship between the phase current and the torque, similar to that in a brushed dc motor. Therefore, by adjusting phase current, the electromagnetic torque can be controlled to meet the requirement. The general structure of a currentcontroller for a BLDC motor is instantaneous current in the motor is regulated in each phase by a hysteresis regulator, figure: 2 which maintains the current within adjustable limits. The rotor position information is sensed to enable commutationlogic, which has six outputs to control the upper and lower phase leg power switches.

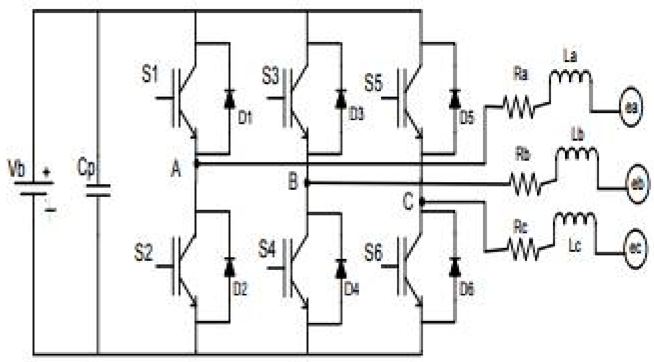

Figure 3: Equivalent circuit of an inverter driven 3-phase PM BLDC motor

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The ideal back-EMF, phase current and developed torque profiles of PM BLDC motor is a complete commutation cycle spanning 360º electrical consists of six equal intervals. The switches S1 to S6 are operated in a sequence using a control circuit based on position received from the rotor position sensors such as hall-effect sensors. To control the torque which is developed by motor, control by the inverter circuit shown in figure 3. The process of regenerative braking is shown by the arm under the IGBT Bridge whose switched movements are correspondence to the working module of motor.

VI.SIMULATION RESULTS

Using the MATLAB R2014a software the RBS of EV driven by BLDC motor using ANFIS and PID control is implemented. ANFIS in MATLAB is executed using Graphic User Interface (GUI). Both linear and non-linear braking modes are analyzed.

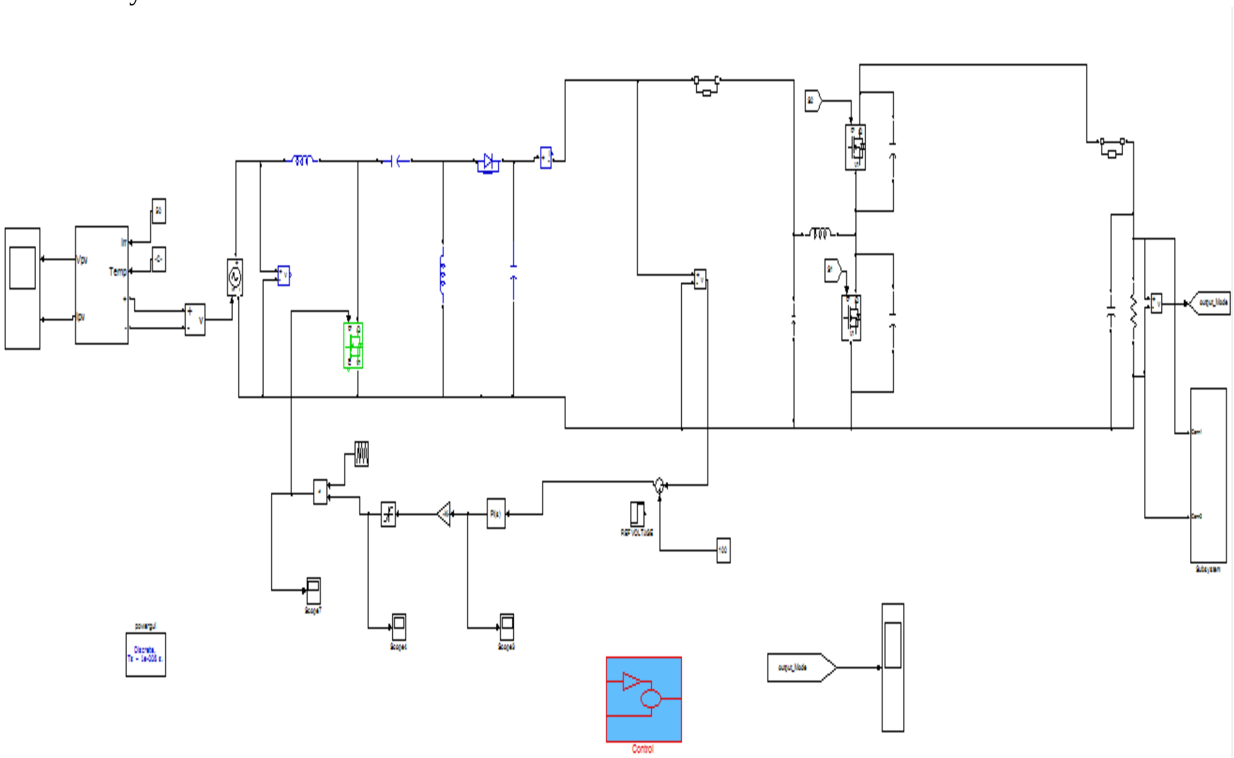

Fig 4 Simulation of normal mode

Result shows that whenever brake is pressed linearly or non-linearly the battery gets charged about 2% to 3% of its charge. Thus a 300 V battery having one charge mileage of 280 Km, driving an electrical car of maximum speed 60Km/hr.

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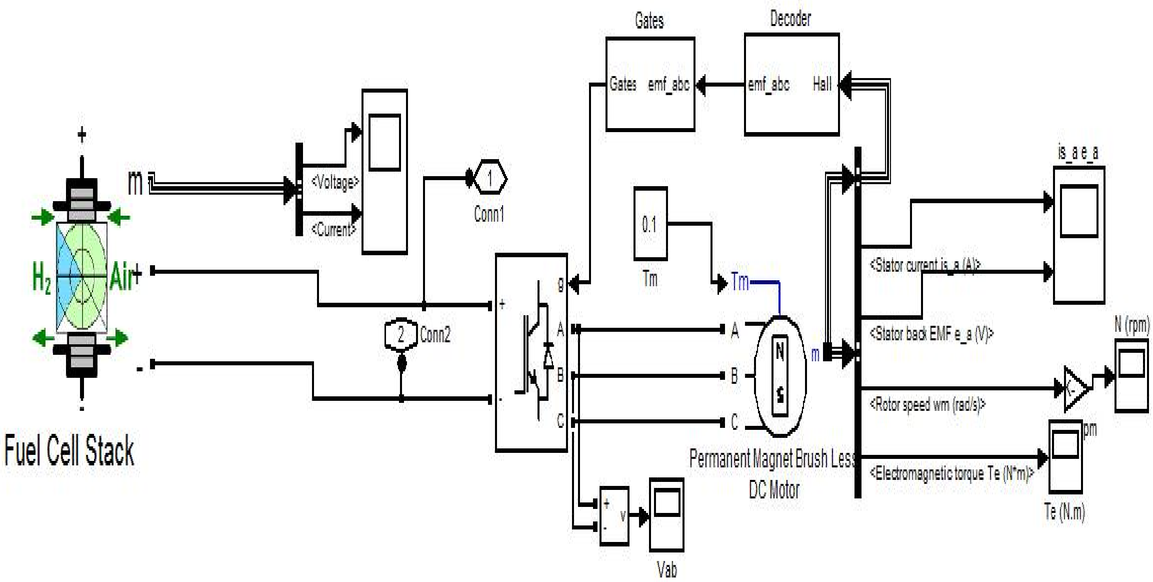

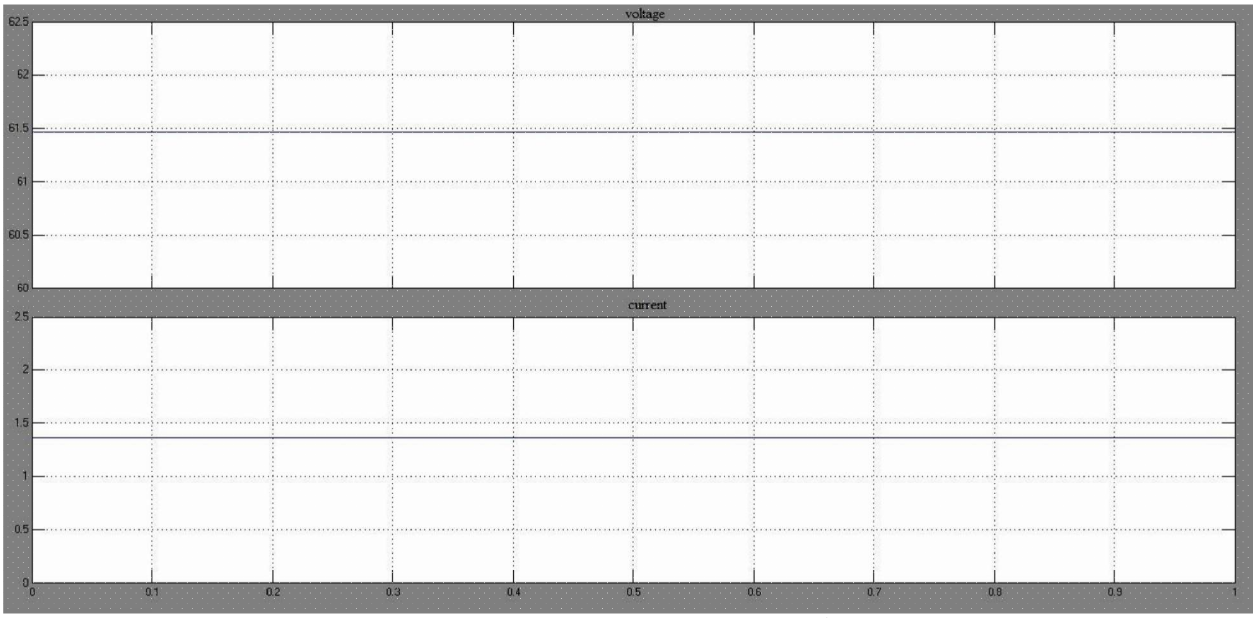

Fig 5 Input voltage and current waveform

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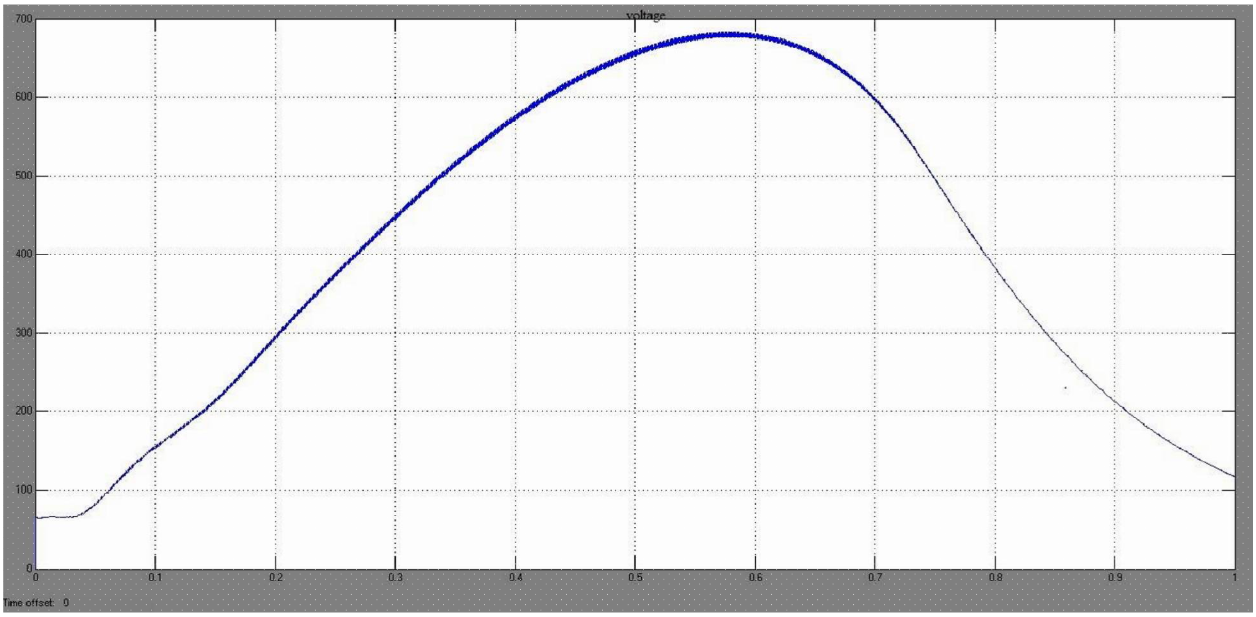

Fig 6 Output voltage from normal mode

Using the proposed RBS in this car around 30 Km distance can be prolonged. PID control is faster than fuzzy control, so the two methods combined together can realize the smooth transitions. Therefore, fig: 6 hit can be concluded that this RBS has the ability to recover energy and ensure the safety of braking in different situations.

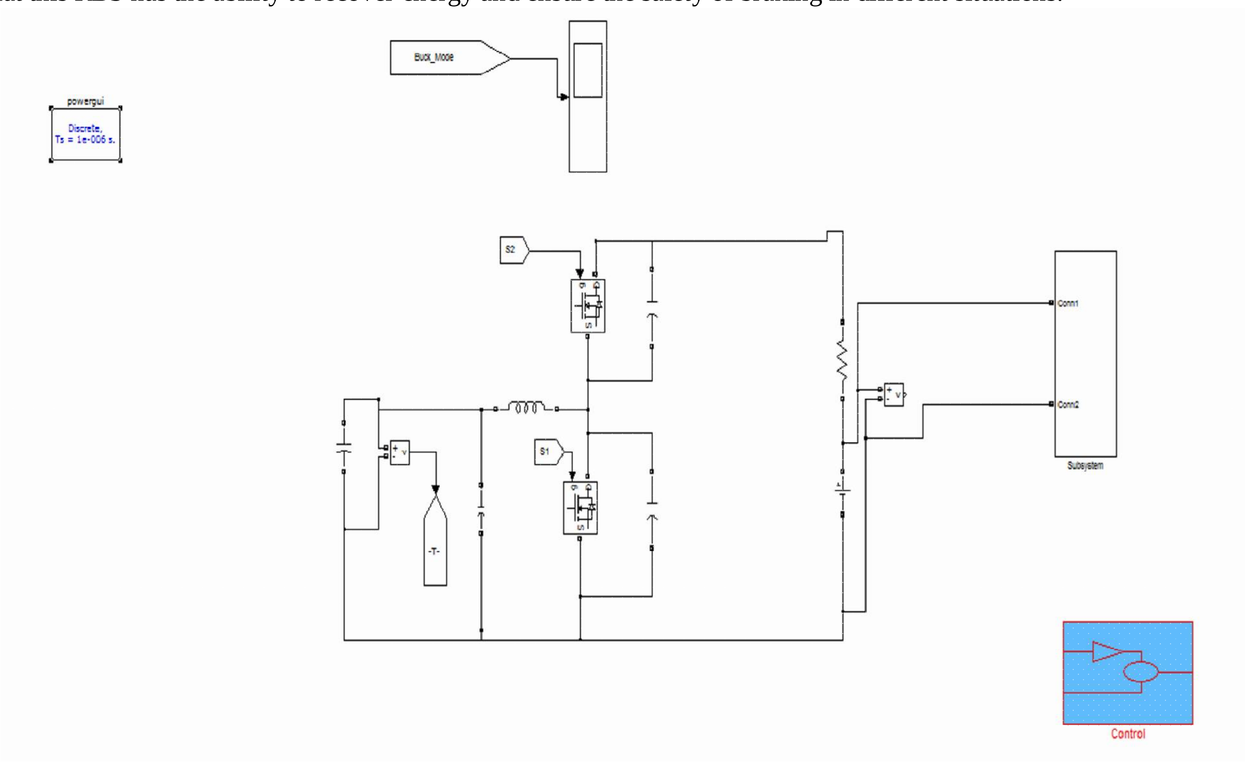

Fig 7 Regenerative mode simulation

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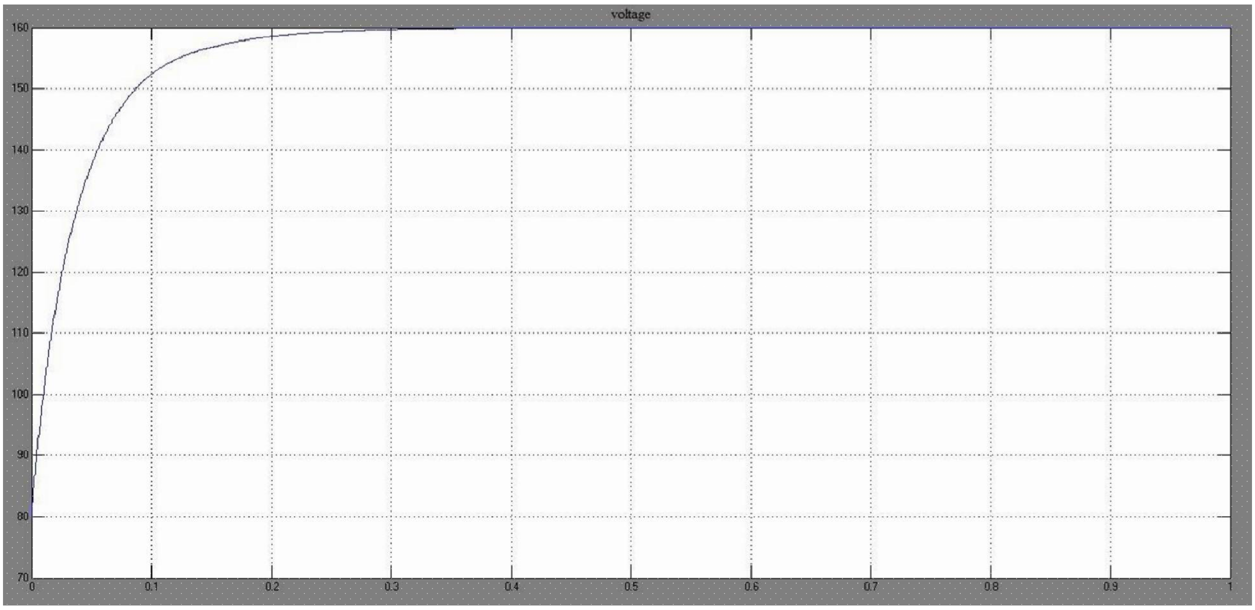

Fig 8 Regenerative output voltage waveform

V. APPLICATION

This RBS can be implemented using ATMEGA64 microcontroller. The programs are implanted into the controller. Force sensor and Gate driver circuit is used to generate the gate pulses.

VI. CONCLUSION

This paper presented the advanced RBS of an electric vehicle driven by Brushless DC motor. The proposed scheme is implemented using MATLAB and the results are illustrated. PID control and ANFIS both are refined methods which are adapted in our scheme to have a fine transition between mechanical and electrical barking. ANFIS takes the input variables as State of charge, braking force and the speed of motor. The PWM technique is implemented to the inverter using PID control to maintain the constant braking torque. Thus it is proved that it is possible of recovering energy using our recommended RBS. By using the submitted RBS the safety of the vehicle is also ensured.

REFERENCES

[1] P. J. Grbovic, P. Delarue, P. Le Moigne, and P. Bartholomeus, “A bidirectional three-level dc-dc converter for the ultra-capacitor applications,”IEEE Trans. Ind. Electron., vol. 57, no. 10, pp. 3415–3430,Oct. 2010.
[2] F. Wang, X. Yin, H. Luo, and Y. Huang, “A series regenerative braking control strategy based on hybrid-power,” in Proc. Int. Conf. CDCIEM, 2012, pp. 65–69.
[3] N. Mutoh and Y. Nakano, “Dynamics of front-and-rear-wheel independent-drive-type electric vehicles at the time of failure,” IEEE Trans. Ind. Electron., vol. 59, no. 3, pp. 1488–1499, Mar. 2012.
[4] M. Cheng, W. Hua, J. Zhang, and W. Zhao, “Overview of stator permanent magnet brushless machines,” IEEE Trans. Ind. Electron., vol. 58, no. 11, pp. 5087–5101, Nov. 2011.
[5] Y.Wang and Z. Deng, “Hybrid excitation topologies and control strategies of stator permanent magnet machines for dc power system,” IEEE Trans.Ind. Electron. vol. 59, no. 12, pp. 4601–4616, Dec. 2012.
[6] C. SheebaJoice, S. R. Paranjothi, and V. J. Senthil Kumar, “Digital control strategy for four quadrant operation of three phase BLDC motor withload variations,” IEEE Trans. Ind. Informat., vol. 9, no. 2, pp. 974–982, May 2013.
[7] A. Sathyan, N. Milivojevic, Y.-J. Lee, M. Krishnamurthy, and A. Emadi, “An FPGA-based novel digital PWM control scheme for BLDC motor drives,” IEEE Trans. Ind. Electron., vol. 56, no. 8, pp. 3040–3049,Aug. 2009.
[8] N. Keskar, M. Batello, A. Guerra, and A. Gorgerino, “Power Loss Estimation in BLDC Motor Drives Using iCalc,” International Rectifier, ElSegundo, CA, USA, Rep. AN-1048, Feb. 2010.