Hybrid Regenerative Braking System for Electric Vehicles using BLDC Motor

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Abstract

The paper describes about the usage of Hybrid Regenerative Braking System (HRBS) in Electric vehicles for better efficiency in braking, fuel consumption and Improved vehicle tire traction. HRBS is proposed for Electric Vehicles and driven by Brushless DC (BLDC) motor. The design is facilitated using MATLAB-Simulink and required parameters can be determined. During regenerative braking, the Brushless DC motor acts as a generator. Hence, by using HRBS, the dc-link voltage is improved and the energy is transported to the super capacitor or the battery over the inverter. The Recaptured electric energy can be used later to drive the vehicle. We have used ANN technique for better feedback operation. Thus, results confirm HRBS is capable of best Energy retrieval among other present braking system.

Keywords: Hybrid Regenerative Braking System (HRBS), Brushless DC motor (BLDC), Artificial neutral network (ANN) and MALAB-Simulink.

1. Introduction
Deceleration of a vehicle with a customary slowing mechanism requires that the dynamic and potential vitality of the vehicle be changed over into warm vitality or warmth through the activity of rubbing. With regenerative braking on half breed electric vehicles, this vehicle dynamic vitality can be changed over once more into electrical vitality that can be put away in batteries for reuse to move the vehicle amid the driving cycle. Hence, regenerative braking can possibly monitor vitality which will enhance efficiency while decreasing emanations that add to air contamination be used in a crossover vitality stockpiling framework (HESS) [4]. In this paper, a novel structure for desirable interaction of the battery and super capacitor is proposed [1]. The presented HRBS is composed of a super capacitor module, battery pack, buck converter, and a diode. During the braking process, using an appropriate switching algorithm for the inverter, the dc-link voltage is boosted. Hence, the diode will be forward biased and the braking energy is directly harvested by the super capacitor module without employing an additional power converter. The dc-link voltage is adjusted through variation of the duty-cycle of the pulse width modulation (PWM) in the inverter. Hence, when the super capacitor is almost charged, regenerative braking can be realized by means of the battery pack. In the proposed method, the regenerative braking efficiency is improved due to the elimination of the utilized converters for this purpose [2].

2. Regenerative Braking System

A. Working Principle

Regenerative braking is a brake strategy to utilize mechanical vitality from the engine and change over motor vitality to electrical vitality and offer back to the battery. In the regenerative braking mode, the engine moderates downhill the auto. When we apply power to pedal of brake, at that point auto gets back off and engine works backward bearing. When running in nullify course engine goes about as the generator and consequently charge the battery as appeared in figure 1[9]. In this way, in figure 1 the auto which is running in typical condition where engine goes ahead and takes vitality from the battery.
When utilizing regenerative braking in electric vehicles, it decreases the cost of fuel, expanding the fuel money related framework and emanation will be brought down [9]. The regenerative slowing mechanism gives the braking power amid the speed of vehicles is low, and henceforth the activity unpredictable in this way deceleration required is less in electric vehicles.

**B. System Configuration**

Figure 3 outlines the framework design of the electric golf truck. It can be plainly observed that it contains a power collector battery pack, a half-connect three-stage voltage source converter (VoSC), a center changeless attractive brushless DC engine [6]. For the extra parts, there are two pedals, one is in charge of speeding up, the other is accountable for electric brake control, the two would include a movable voltage going from 0 V to 5 V. Corridor signals are given to give the position data of the rotor. Two sensors are received to procure the stage current of the
inverter. Task standard and mechanical structure of the braking pedal are appeared in Figure 2. From the flag yield appeared in Figure 2a, we realize that when the pedal's edge ranges from 0° to 3°, its yield voltage is shut to 0.2 V, when the brake pedal's edge changes from 5° to 18°, its relating yield voltage increment from 0.2 to 4.8 V, the yield voltage is nearly in corresponding to the braking blessed messenger. At the point when the braking heavenly attendant is more than 18°, which implies that the driver needs a new braking, mechanical slowing mechanism will work right now. Figure 2b demonstrates the outline of the mechanical structure and establishment guide of the brake pedal [1].

Fig-3. System model of EV using brushless direct-current motor.

**C. EV Modeling**

The demonstrating of the EV has been done in MATLAB/Simulink. The driver square influences a torque to ask for which proliferates through different powertrain framework part and acknowledges vehicle movement. Framework level test systems have been displayed by utilizing observational information that depend on estimations provided by segment producers or reached out from estimations got from writing sources. These are demonstrated in
Simulink as look-into tables. Other segment models are physical or diagnostic in nature and are demonstrated by numerical conditions [10]. The electric engine picked is a BLDC engine with a pinnacle energy of 40 kW. The battery pack is a Li-Ion battery. It has an ostensible voltage of 72 V, with vitality substance of 1.2 kWh and weight around 20 kg. Once the brake pedal is discouraged, as per the situation of the brake pedal, a relating extent of brake torque is connected [8]. At that point, the brake torque because of the regenerative brake control methodology is separated into regenerative braking and contact braking [6]. The measure of mechanical vitality devoured by a vehicle when driving a prespecified driving example chiefly relies upon three factors: the streamlined grating misfortunes, the moving erosion misfortunes, and the vitality dispersed in the brakes.

Fig. 4. Equivalent circuit of the voltage source inverter, BLDC motor, and the proposed HESS.

The perfect back-EMF, stage present and created torque profiles of PM BLDC engine is an entire recompense cycle spreading over 360° electrical comprises of six equivalent interims. The changes S1 to S6 are worked in a succession utilizing a control circuit in view of position got from the rotor position sensors, for example, corridor impact sensors. To control the torque which is created by engine, control by the inverter circuit appeared in figure 5. The procedure of regenerative braking is appeared by the arm under the IGBT connect whose exchanged developments are correspondence to the working module of engine [6].

3. Analysis of The Proposed RBS
The Figure 4 demonstrates the comparable circuit of the inverter, the BLDC engine, and the proposed HESS. In Fig. 4, \( r_s \) and \( L_s \) are the protection and inductance of the armature, individually. \( EMFA \), \( EMFB \), and \( EMFC \) are the armature back electromotive powers (EMF) of stages a, b, and c, separately. Since the DC–DC converter is generally sit amid braking, it isn't appeared in Fig. 4. Amid regenerative braking, the BLDC machine goes about as a generator, and the motor vitality of the vehicle can be put away in the HESS by the inversion of the present stream. To accomplish this capacity, the dc-interface voltage should be supported so D1 or potentially D2 are/is forward-one-sided and the vitality is exchanged to the HESS. A similar power circuit of Fig. could be used with a proper exchanging format. In ordinary conditions, each of the six switches in the inverter are com-changed by the rotor position, acquired by the lobby impact sensors. In the regenerative braking, the switches on the high side of the half scaffold are altogether killed and the low-side MOSFETS are controlled by the PWM with a proper exchanging technique. The three-stage back EMFs, three-stage ar-develop streams, lobby impact signals, and the pertinent exchanging designs are appeared in Fig. 6. In the regenerative braking mode, there are six recompense interim, and just a single of the inverter switches is turned ON and OFF amid every interim.
A. Road Load and Traction Forces of the EV

In this paper, a simplified model of the road vehicle kinematics is used for estimation of the dynamic tractive requirements of the EV powertrain. This model represents the driving forces of the vehicle, as shown in Fig. 7.
4. Conclusion

In this paper, another RBS in light of usage of HESS is proposed for EVs driven by BLDC engine. Amid regenerative braking as well as vitality recovery, the active vitality of the vehicle is gathered by the supercapacitor utilizing the fitting exchanging format of the inverter. Subsequently, the requirement for extra power hardware interfaces is disposed of. In the interim, the MLP-ANN controller is used to control the braking power dissemination amongst back and front wheels of the EV. Also, the PI controller is utilized to control the obligation cycle of the PWM in the inverter to acknowledge consistent torque braking. In correlation with other comparative sorts of the regenerative braking plans, the proposed strategy has the superiorities of being basic and high effective. The EV is mimicked in WVU 5-top drive cycle, and it is demonstrated that in examination with the regenerative braking with ESS, the effectiveness of the recovery is enhanced by around 20%. In addition, it is demonstrated that the drive scope of the EV is expanded by around five cycles. It can be presumed that the exhibited conspire can catch the braking vitality with proper productivity and guarantees the protected deceleration of the EV.

References


