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Energy Regeneration System for Electric Vehicles Using DC-DC Converter with Super-capacitor

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Abstract–This research presents a hybrid energy storage system (HESS) that combines a battery with a supercapacitor for the purpose of regenerative braking in electric bikes. A suitable DC to DC converter is used in this system to connect the super-capacitor and the battery/DC web link. Its purpose is to meet the real-time high power requirements. The converter operates as a regulated power source and ensures that the voltage of the super-capacitor remains higher than the battery voltage in most urban running conditions. The battery will provide power to the system when the voltage of the super-capacitor falls below 0.5 times the voltage of the battery. In this mode, the power diode is biased in the forward direction. The braking technique of an electric bike utilizes kinetic energy to simultaneously increase the power of the battery and the range of the bike. During the deceleration phase, bicycles may convert the energy of motion into electrical energy, with the electric motor functioning as an electric generator. The electrical energy is supplied to a battery in the bike, and then converted into kinetic energy via the use of an electric motor during the following acceleration phase.

Keywords: Battery, controller, dc to dc converters, energy storage, hybrid electric bike ,super – capacitor (SC)

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INTRODUCTION

Implementing a recycling-based energy conservation strategy is a crucial approach to enhance the overall power efficiency of electric bikes (EBs). The regenerative braking system of an electric bike optimizes the consumption of battery power to enhance the bike's range. During periods of deceleration, these bicycles have the capability to recover the energy generated by their movement and then turn it into electrical power using generators. In this mode, the electrical motor serves as an electrical generator. The electrical power is supplied to the bike's battery and converted into kinetic energy by the electric motor during periods of velocity.

During the velocity process, energy must be transferred to charge the super-capacitor. Regenerative braking utilizes the primary propulsion electric motor to convert kinetic energy from the wheels, ultimately to recharge super capacitors. The waste of kinetic energy while braking in an electric bike may be recovered via the control of power electronics circuitry, allowing the electric motor to function as a generator.

Ultra-capacitors function similarly to conventional capacitors, since the energy stored in their electric field adheres to the EC = 1/2 CV2 equation, where EC represents the stored energy in Joules, C denotes the capacitance in Farads, and V represents the voltage in Volts. The integration of super-capacitors (SCs) into electric bikes is a recent advancement in the field of energy storage. The super-capacitors prevent fast battery depletion during acceleration by functioning as a generator, transferring the stored energy back into the battery. During the regenerative braking phase, superfluous power will be dissipated by the capacitor to prevent an excessive current flow.

The energy is replenished and sent by the buck-boost converter. An electric car incorporates a buck-boost converter circuit to address the issue of poor efficiency in recovering braking energy at low speeds. This circuit prevents a decrease in the efficiency of the bike's drive series.

Battery power density in battery-based energy storage systems (ESSs) must be high in order to fulfill the peak power demand. While batteries with greater power density are easily accessible, their discharge rate is often much higher than that of batteries with lower power density. The remedy to this issue is to increase the battery capacity. However, this service incurs additional costs. Furthermore, thermal monitoring poses a challenge for batteries to effectively function during periods of high power demand. During this time, the battery not only has to cool down, but also needs to heat up in low temperatures in order to reach the desired power limits.

This problem has been previously acknowledged and in this study, we propose the use of a combination of battery and super-capacitor technology in electric bikes. The fundamental concept of this bicycle is to integrate super-capacitors (SCs) with batteries in order to achieve significantly improved overall efficiency. This is because ultracapacitors (UCs) have a higher power density compared to batteries, but a lower energy density. This combo exhibits much superior performance compared to using just one of them alone.

A hybrid blend of bicycles may be categorized into two types: passive or active. The active techniques include the employment of one or more full dimension dc to dc converters to connect the power storage device to the dc web connection. In another context, the primary function of a DC to DC converter is to facilitate the unidirectional flow of energy in the storage device.

The bike battery pack is directly connected to the dc link, and a half-bridge converter is used to connect the SC bank to the dc link. However, in order to harness the full potential of the superconductor (SC), the half-bridge converter must be compatible with the power capacity of the SC. While this design successfully addresses the issue of peak power needs, the battery still faces the challenge of continuous charging and discharging processes. In order to address all of these issues, a novel Crossbreed bicycle is being suggested. Historically, electric bikes have included mechanical brakes to increase friction on the wheel during the deceleration phase. However, when it comes to energy conservation, the mechanical brake consumes a much greater amount of energy compared to the Electric bike. This text examines the process of converting kinetic energy into electrical energy and charging a battery. Thus, both the electronic brake and power regeneration have the same objectives to accomplish.

REGENERATIVEBRAKINGSYSTEM

A.WorkingPrinciple

The braking system of a car utilizes the vehicle brakes to dissipate kinetic energy, which is then turned into electrical energy via the use of a generator. During regenerative mode, the motor decelerates the automobile as it is moving downhill. When the forces are applied to the brake pedal, the vehicle decelerates and the motor operates in the opposite direction. When the vehicle is moving in the other direction, the motor functions as a generator and charges the battery, as seen in figure 2. Figure 1 depicts a vehicle operating under typical conditions, with the motor moving in the forward direction and drawing energy from the battery.

Battery ___

I.

SWITCHINGMODEOFREGENERATIVEBRAKING

Theblockdiagramofhardwareimplementationisshownbelow the figure3. In this diagram

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battery and super capacitorareconnectedinparallel.

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Fig.1Normaldrivingcondition

Direction of Motion Wheel Torque Developed

Direction of Power Flow

Two Power MOSFETs (IRF 460) are attached in two quadrant arrangement. The diode is linked in between Battery (12V) and Ultra Capacitor (16V). An External Inductor is linked between armatures of DC electric motor and joining point of series linked MOSFETs.

When regenerative stopping using in electric automobiles, it reduces the expense of fuel, boosting the performance of the lorry and exhaust will be lowered. The regenerative braking offers the braking force throughout the speed of the lorry is low and hence the traffic quits and goes therefore slowdown needed is less in electrical lorry. If we apply the break in lorries after that power generated mosts likely to the battery and remaining power goes to super-capacitor. Hence, in this procedure the lifetime of battery likewise enhances and this stopping mode of lorry is received number 2. Battery

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Directionof

Mode I.

Originally top power MOSFET S1 is fed with PWM pulses with variable responsibility proportion to run the motor at any kind of wanted speed. The speed of the motor is manageable by differing task proportion of PWM entrance pulses. The carrier frequency of PWM pulses is kept around 10 KHz to 15 KHz. The electric motor is attached to the load with flywheel to keep the kinetic energy during motoring operation.

Setting II.

The lower Power MOSFET S2 is then fed with same PWM pulses from control circuit in order to obtain regenerative stopping. Throughout this mode the electric motor back emf give rise to armature present in reverse instructions as compared to what it.

Power Flow.

was throughout motoring. When the reduced MOSFET is turned off throughout Toff, the current from electric motor armatures flows via inductor into the Super-capacitor. The Super-capacitor In electrical vehicle, the brakes function so efficiently in driving such that atmosphere drops in cities. The stopping system and controller is the almost all of cars because it manages the whole part of the automobile of motor. The brake controllers are the feature as monitor the speed of the wheel and compute the torque of car.

A.Mode of Procedure in Electric Car.

In the regenerative stopping operation, there are two modes as shown listed below.

Motoring Setting:.

I.Conducting Setting.

Throughout this mode, existing circulations from battery to switch s1, to inductor to electric motor armature and back to the battery.

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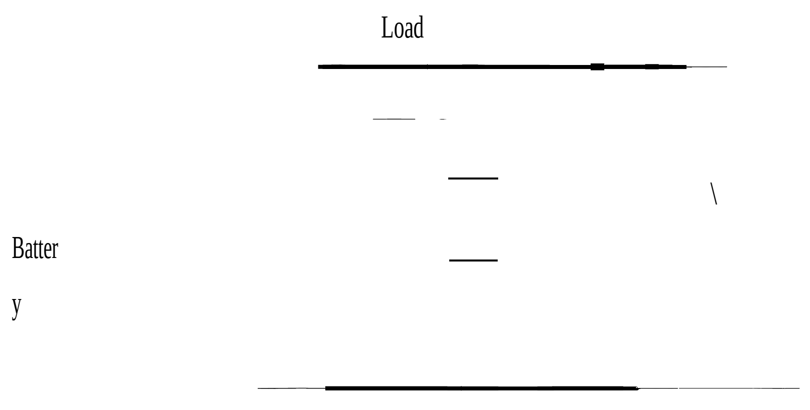

Fig.4ConductingMode

I. FreewheelingMode

Duringthismode,armaturecurrentcirculatesthroughdioded2andexternalinductorasshowninfigure5.

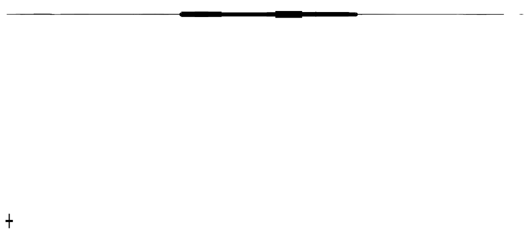

Fig.7RegenerativeMode

The motoring setting refers to the regenerative braking setting in a vehicle.

In this configuration, power will be extracted from an ultra-capacitor (SC) and returned to the electric motor armature using switch s1 and inductor L. In this scenario, the current flow from the battery will be prevented due to the reverse biasing of the series diode between the battery and the supercapacitor. The current will only flow out of the battery when the voltage across the short circuit drops below the battery voltage by 0.7 volts. Afterwards, the motor transitions to the automobile mode.

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Regenerative Mode:. I. Conducting Mode.

In this mode, the armature current flows in the opposite direction compared to the driving mode, via button s2 and inductor L.

Fig.6ConductingMode

I. RegenerativeMode

In this particular configuration, the armature current of the electric motor flows from the motor armature to the super-capacitor C through the external inductor L, as depicted in figure 7. The capacitor is charged to a higher voltage and stores the electrical power generated by the motor during speed braking. This operating mode functions as a boost converter, efficiently transferring energy from a low voltage source to a high voltage source.

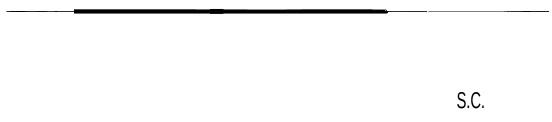

Fig.8PostRegenerativeMode

In this configuration, a battery and a high-capacity capacitor are linked to the controller in order to provide a consistent power supply to the controller, thereby ensuring efficient operation of the electric motor. During the regrowth process, the electric motor functions as a generator, converting kinetic energy into electric energy. This electric energy is then sent back to the controller, which in turn charges the battery. If the battery is fully charged, the controller decides to direct the energy to the SC. The direction of energy circulation is

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determined by the alteration of the circuit.

In future employment roles related to electric bikes, the focus will be on enhancing the efficiency of the system to minimize travel time. However, it is necessary to address the size of the DC to DC converter compared to the SC option in order to minimize the cost of the total system while still retaining the benefits of a smaller bike.

The MATLAB model shows the power curve of an electric car, along with voltage parameters produced from the model. The model includes a parallel connection of an ultracapacitor and a battery, as well as a DC-DC power converter.

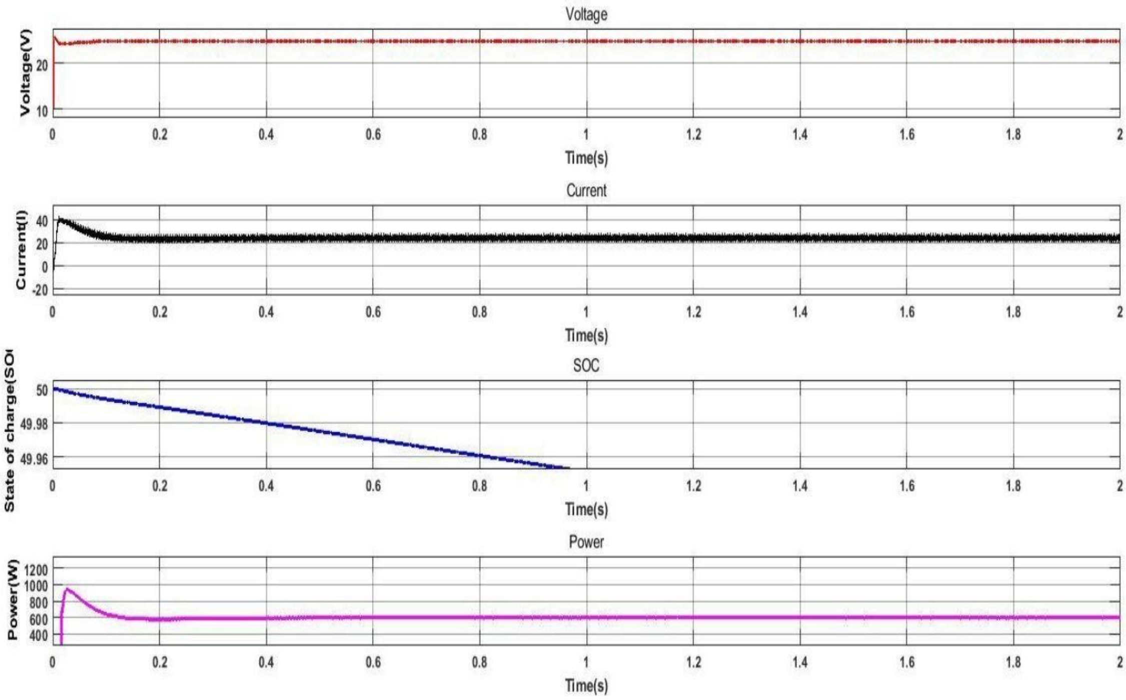

Fig.6-Batterycharacteristicsofelectricalvehicle

The battery has a voltage of 24V. Assuming the battery is set to the running mode, the state of charge (SOC) of the battery will definitely decrease, as shown in Number 8. In the absence of using an ultra-capacitor in an electric vehicle propulsion system alongside a battery. In the absence of the maximum output from the highly capacitive bank, the battery requires a peak power of 800W, as shown in Number.

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CONCLUSION

This research proposes a bi-directional DC-DC converter for the power regeneration of electric cars using super-capacitors. The suggested voltage control approach enables the selection of the operational mode to optimize the use of the capacitor voltage. The link between the capacitor usage ratio and the result voltage is an indicator of the efficiency of the recommended circuit. Finally, the experiment validates the efficiency of the suggested circuit.

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