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Performance Analysis of Electric Bike using Battery and Supercapacitor

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Abstract - *The market for electric bikes, scooters and bicycles is growing. There are numerous brands of E-bikes emerging locally. All most all incorporate a rear wheel BLDC (Brushless DC) hub motor; lead acid battery pack, a light weight chassis, and a controller. The Vehicle achieves average speed of 30-50km/hr, range of 70km/charge. The other drawback is the long charging time of 6-8 hrs and short lifespan of battery pack i.e. around 2 years. Considering these limitations modifications in the existing design of an electric bike which will give a better performance with the use of a hybrid system of battery and super capacitor are made. The drawbacks observed in e-bike operations has considered and experimental results are presented. Super-capacitor modules are used to provide the high current required during starting and acceleration, and eventfully will help increasing lifespan of battery. A secondary source, like regenerative braking or a small solar panel module could be availed onboard so as to charge battery/ super capacitor.*

Key Words*: *BLDC, Buck-Boost Converter, E-bike, Hall Sensor Feedback, PWM, Super-Capacitor, Throttle.

1. INTRODUCTION

Electric vehicles have their history since early 20thcentury even before the IC engines came along. Even though the IC engines have dominated for most of the 20thcentury, electric vehicles have emerged again quite firmly, mainly due to the environmental concerns related with fossil fuels. But there are similar environmental concerns with electric vehicles too if we consider lead acid batteries whose decomposition is not eco-friendly. The electric bikes which are available and are affordable incorporates a rear wheel BLDC (Brushless Direct Current) motor which is suitable and compact. The battery pack is a series combination of cells, a controller which controls the power transaction. Traction battery is generally lead acid which are cheaper compared with other types. A potentiometer box is present which acts as accelerator along with other minor circuitry and accessories. With these specifications, E-bikes attend 25-40km/hr speed and 50-70km/charge range.

This describes a solution that was developed and studied to be applied in electric vehicles of individual use as bicycles. The solution proposes the combination of two sources of energy, batteries and super capacitors, and two DC-DC converters. On board, batteries and super capacitors store the energy.

As it is well known, in the typical electric traction systems the batteries drive the high currents and in the worst situation drive the current peaks demanded by the load. In this situation, a solution to improve the battery behavior and its time life is to replace temporarily the battery by another power source or, as in the developed solution, to supply the system using other power source when undesired and transient situations occur. In this case, the load is supplied by the complementary energy source avoiding, at least, deep discharges of the battery. The adopted solution uses super capacitors, which drive the peaks of power required by the load.

For much of the world; especially places like China, India, and Sweden etc. bicycles have been a transportation mainstay because the work place and housing areas in most of these densely populated cities are within walking or cycling distance. This reliable yet overlooked form of transportation has evolved over the years from simple utility bicycles to powerful geared mountain bikes and now electric assisted bicycles or pedicels. Environmental concerns in terms of emissions and depleting fuel reserves has revived the electric vehicle industry and research community. China has produced 21 million of bicycles within nine years. In 2005 itself, China has produced 10 million of bicycles. Electric assisted bicycles still retain the characteristics of a conventional bicycle with an added advantage of extra power, say when riding up a hill. This enables the elderly or not so physically fit people to still enjoy riding a bicycle up a slope.

2. AN ELECTRIC BICYCLE

Electric bicycles were lead to more popular in used on present-day. At the present moment, the energy price from oils was more expensive. The used of motor type in this paper was in wheel of Electric bicycle type. The useful of this motor type is use to perform an original model in the studying and designing inspection and regenerative power control circuit. Electric-motor-powered bicycles are required to operate with 50% human pedal power, and an even higher percentage of human power is required above that speed. Such bicycles are commonly known as "peddles"(pedal electric cycle). In this article, the term

"electric Bicycle" is used to describe "electric-motor-powered Bicycles," including both fully and partially motor-powered Bicycles.

Super-capacitor modules are used to provide the high current required during starting and acceleration, and eventfully will help increasing lifespan of battery. A secondary source, like regenerative braking or a small solar panel module could be availed onboard so as to charge battery/ super capacitor.

A small onboard solar panel could charge the super capacitor through an auxiliary battery. The solar panel will also help extending the range of the bike in addition to the regenerative braking system. So even if the bike is parked somewhere where there is no charging facility, a sheer standing bike is getting charged up for the solar panel.

2.1: Block Diagram Description

Based upon a detailed analysis we have proposed a modified design of E-bikes as shown in Fig. 1. The bike will have 2kw 48V geared BLDC rear Wheel hub motor, driven by a 48V 40Ah battery pack and the super capacitor bank consisting of 16V, 58F to be connected in parallel with the battery pack via a buck boost Converter which is designed to harvest the maximum energy from it. Microcontroller circuitry senses various parameters and performs switching and controlling action. The Controller is the heart of E-Bike which regulates controlling Actions and power through each subsystem. Throttle is a Potentiometer box which acts as an accelerator.

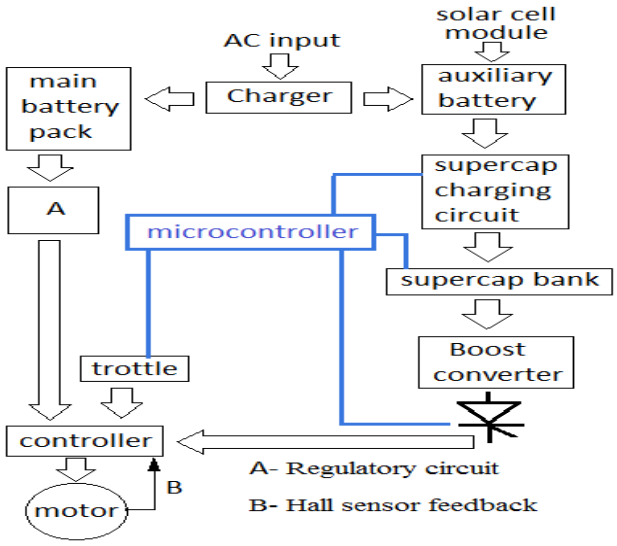


Fig. 1: Block Diagram of Proposed Design of E-Bike

The solution proposes the combination of two sources of energy, batteries and super capacitors, and two DC-DC converters. On board, batteries and super capacitors store the energy. Anyway, the proposed topology considers that fuel cells should be used in two ways: replacing the set of batteries or to charge the batteries and the super capacitors. As it is well known, in the typical electric traction systems the batteries drive the high currents and in the worst situation drive the current peaks demanded by the load. As it is well known, this type of operation decreases strongly the autonomy of the vehicles for individual use. The continuous and random operation of electrical vehicles requires and claims for systems improving the autonomy and the performance of the available ones. In this situation, a solution to improve the battery behavior and its time life is to replace temporarily the battery by another power source or, as in the developed solution, to supply the system using other power source when undesired and transient situations occur. In this case, the load is supplied by the complementary energy source avoiding, at least, deep discharges of the battery. The adopted solution uses super capacitors, which drive the peaks of power required by the load.

2.2: Objectives

Increased Speed

The prime demerit of electric bikes available is their low speed which falls in the range of 25km/hr to 50km/hr. Experimentation platform vehicle has achieved a top speed of 65km/hr with a load of one person due to the extra instantaneous current provided by ultra capacitor and highly efficient controller.

Increased Range per Charge

The second drawback of e-bikes available locally is their lower range per charge typically 50 to 70km/charge. Since our design involves regenerative braking with 2 modes. We have achieved maximum range of 90 km / charge.

Improved Battery Life

Another major drawback of E-bikes is 6-8 hrs of long charging time. As super capacitor relieves the heavy usage of battery current, we could expect an extension in battery Life of above 2 years.

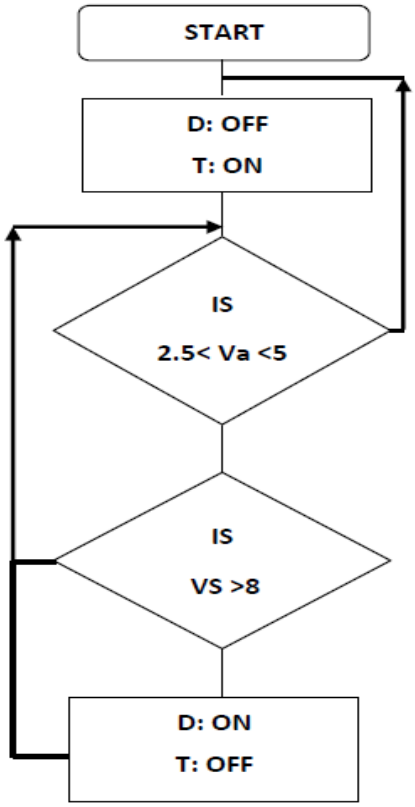
Reduction in Charging Time

If we apply the parallel charging technique in the proposed model in addition with onboard solar panel, the battery charging time has been reduced to a nearly 60 percent.

3. CIRCUIT DESCRIBTION

3.1 Algorithm for Battery Power Management

Algorithm for Battery Power Management with specifications is as follows:



Va = Throttle (pot) position (0-5 V)

Vs = Super capacitor (SOC)

T = Thyristor across super capacitor Bank

D = Diode across Super Capacitor Charging Circuit

3.2: Electric Bicycle

This work implements a smart boost converter to enable an electric bicycle to be powered by a battery/super capacitor hybrid combination. A 36V, 250W front hub motor was retrofitted onto a normal geared bike powered by a 36V; 12Ah lithium ion phosphate battery pack. A 16.2V, 58F super capacitor module was connected in parallel to the battery pack via a custom made microcontroller-based boost converter which arbitrates power between the battery and super capacitor. The control algorithm for the boost converter was developed using a practical approach by using various sensor inputs (battery/super capacitor current and voltage, bike speed) and comparing the robustness of control scheme. Also energy efficient components were used in designing the boost converter to ensure maximum power transfer efficiency.

3.3: Hybrid Energy Storage System

A parallel combination of battery and super capacitor is involved. As the name implies, a super capacitor is a capacitor with capacitance of very high value. Super capacitors do not have a traditional dielectric material like ceramic, polymer films or aluminum oxide to separate the electrodes instead a physical barrier made of activated carbon. A double electric field which is generated when charged, acts a dielectric. The surface area of the activated carbon is large thus allowing for the absorption of large amount of ions.

4. CONCLUSION

IC engines had dominated and revolutionized the last century and have been through a significant transformation from their earlier less efficient designs. Comparatively, E bikes are newer in market and have started to gain attention of innovators and engineers since a decade. With more and more advancement in battery technology, electric vehicles offer a prominent future in transportation. With modification of design using advanced controller, better motor, other subsequent improvements implemented in the design, the speed of vehicle is increased considerably. A small onboard solar panel could charge the super capacitor through an auxiliary battery. The solar panel will also help extending the range of the bike in addition to their generative braking system. So even if the bike is parked somewhere where there is no charging facility, a sheer standing bike is getting charged up for the solar panel. With incorporation of super capacitors the life of battery has been increased.

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