Electric Vehicle Drive System Drive System Performance Enhancement Using Ultra Capacitor

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Abstract - *In the strive to improve the lifetime and performance of a hybrid vehicle drive, one of the Most challenging task is to improve the performance of the electrical Energy Storage Unit regarding the electrical power and energy capacity. The process of storing electric energy chemically in batteries is afflicted both with losses, power limitations and limited usage. By introducing a Ultra capacitor as aid to increase system power and mitigate the battery from stresses, the performance of the combined energy storage unit is improved. Moreover, this dissertation contributes to the problem description of managing power and energy of multiple energy sources & load for electric vehicle power system architectures. . In this work, an attempt has been made to provide a new perspective to the problem description of electric vehicle power and Energy management with the help of Battery-Ultra capacitor combinations. It is also observed in the four different mode of The HEV that the energy regeneration and its storage have increased the overall efficiency of Electrical Vehicle.*

Key Words: ***Electric vehicle, buck boost convertor, dc pmmc motor, batteries, ultra-capacitor.***

1. INTRODUCTION

Petroleum resources across the world is depleting at a high rate due to the large dependency of the transportation sector on petroleum as the primary fuel. Also due to this, there is a vast greenhouse gas emission that is degrading the quality of air and causing injury to life and environment. Electric vehicles attract more and more consideration because of its clean and eco friendly features. In electric vehicle one of the big issues is the life time of battery and other one is charging time, but new materials are utilized to extend the battery life and also increase the storage density to save weight and space. Besides the new materials, there are still some researches. However, the use of batteries as energy buffer is somehow problematic and difficult, it reducing the battery's lifetime. Electrical Double Layer Capacitor (EDLC) or (Super capacitor) has extremely low internal resistance and high power density so it is help to improve efficiency of Hybrid Electrical Vehicle (HEV). The primary design problems in electrical vehicle having multiple energy storage system in systematic arrangement focus on how to form hybrid energy storage system to improve the battery operation condition. This problem solved using buck boost convertor.

1.1 Electric Vehicle Drive System

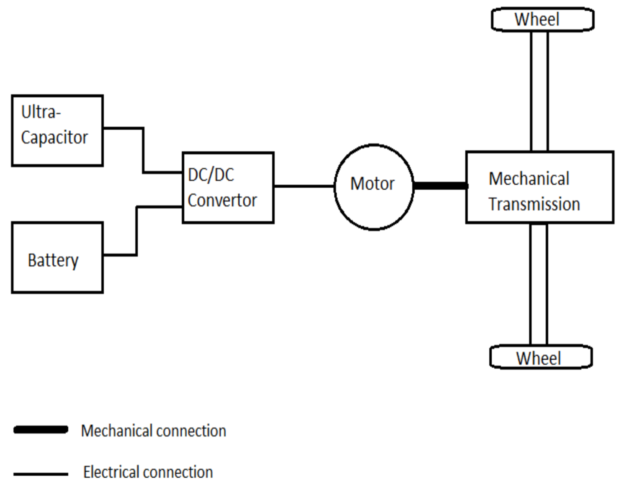

Fig-1.1: block diagram

Explanation of each block from the given block diagram in fig.1.1 The battery is used as source supply for Electric Vehicle which supplies 12 Volt to the Bi Directional Converter (BDC), the converter is bidirectional only to fulfil the need of recharging the battery during the deceleration and supplying the voltage which is due to 50% duty cycle gives boast operation and produces 24 volts across 24-volt capacity Ultra capacitor. While direct connection of the ultra-capacitor across the battery terminals does reduce transient currents in an out of the battery, the best way to utilize the ultra-capacitor bank is to be able control its energy content through a power converter. The direct ultra-capacitor-battery shunt connection, after a short section addressing component modelling issues. The desired connection is then addressed by using a DC/DC converter in the boost mode when discharging at >=50% duty cycle. And in the buck mode when charging the ultra-capacitor bank at <50% duty cycle. The ultra-capacitor gets charged up and in parallel provides the voltage to the Motor. During the downhill, breaking or travelling the motor works in mode of generator motion. The Control Block provides the gating signals to drive the IGBT in the converter. And further the control can enhance the working by different control techniques. Here PWM technique is used for controlling system. The main power system components in an electric vehicle namely the battery, the ultra-capacitor and DC-DC Converter and Motor.

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They are vehicle low and high constant speed operating modes; acceleration mode, and deceleration (regenerative braking) mode. The four operating modes will be discussed below in detail.

Mode I: Vehicle Low Constant Speed Operation:The constant speed operation of the vehicle was separated into two depending on if the power of the DC/DC converter (conv P) can cover the power demand (dmd P). If dmd P is equal to or smaller than conv P, we call this operating condition the low constant speed mode. If the vehicle is running at a higher speed and in which dmd P is higher than conv P, we call it the high constant speed mode. Both the low and high constant speed operating modes are ideal modes, since in practical vehicle driving; the power demand is always changing. They are defined here in order to explain the operation of the proposed HESS.

Mode II: In high consant speed operating mode in the high constant speed operatig mode dmd P.conv P, ULtracapacitor voltage can no longer maintained higher than .Therefore,the main power diode is forward biased. The battery is providing energy directly to the motor. In this mode, the DC/DC converter will be turned off. Figure shows the energy flow of the high constant speedoperatingmode. battrey voltage .

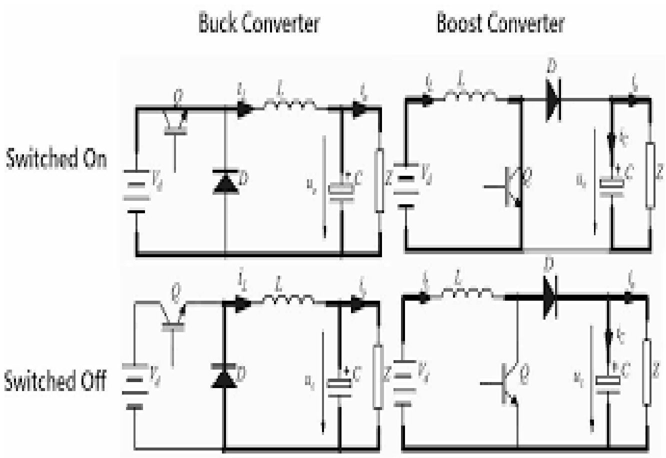

Fig-1.2:mode of buck boost convertor

Mode III: Acceleration At the beginning of the acceleration mode, assume SC V >Batt V. Since conv P <dmd P, SC V will keep decreasing. Energy from the SC and the DC/DC converter are bothsupportingthevehicleacceleration. Illustratestheenergyflowoftheaccelerationmodephase.

Mode IV: Deceleration (Regenerative Braking)in the deceleration mode, there are two phases. In phase I, the regenerative power will be injected into the SC only. In phase I, the DC/DC converter might be in boost operation or no operation depending on if S C V is less than the target Ultra capacitor voltage S C tgt V . The energy flow diagrams for the two conditions are shown inFigures.

2.CALCULATION OF BUCK BOOST CONVERTOR

The following four parameters are needed to calculate the power stage:

1. Input voltage range: Vinmin and Vinmax
2. Nominal output voltage: Vout
3. Maximum output current: Iout
4. Integrated circuit used to build the buck-boost converter.

This is necessary because some parameters for the calculations must be derived from the data sheet. If these parameters are known, the power stage can be calculating.

Calculating the Duty Cycle

The first step after selecting the operating parameters of the converter is to calculate the minimum duty cycle for buck mode and maximum duty cycle for boost mode. These duty cycles are important because at these duty cycles the converter is operating at the extremes of its operating range. The duty cycle is always positive and less.

$$D\ buck = \frac{Vout * \eta}{Vinmax}$$

$$D\ boost = 1 - \frac{Vinmin * \eta}{Vout}$$

Where:

Vinmax = maximum input voltage

Vinmin = minimum input voltage

Vout = desired output voltage

Dbuck = minimum duty cycle for buck mode

Dboost = maximum duty cycle for boost mode

η = estimated efficiency at calculated Vin, Vout, and Iout

Buck Mode

For buck mode the following equation is a good estimate for the right inductance:

$$L > \frac{Vout * (Vinmax - Vout)}{Kind * Fsw * Iout * Vinmax}$$

Where:

Vinmax = maximum input voltage

Vout = desired output voltage

Iout = desired maximum output current

Fsw = switching frequency of the converter

Kind = estimated coefficient that represents the amount of inductor ripple current relative to the maximum output current.

A good estimation for the inductor ripple current is 20% to 40% of the output current, or

0.2 < Kind < 0.4.

Boost Mode

For boost mode the following equation is a good estimate for the right inductance:

$$L > \frac{Vinmin^{\wedge}2 * (Vout - Vinmin)}{Kind * Fsw * Iout * Vout^{\wedge}2}$$

Where:

Vinmin = minimum input voltage

Vout = desired output voltage

Iout = desired maximum output current

Fsw = switching frequency of the converter

Kind = estimated coefficient that represents the amount of inductor ripple current relative to the maximum output current.

A good estimation for the inductor ripple current is 20% to 40% of the output current, or 0.2 < Kind < 0.4.

2.1.PWM technique

It is use for the controlling the gate pulse of the IGBT. The advantages possessed by PWM techniques are Lower power dissipation, Easy to implement and control, No temperature variation and aging-caused drifting or degradation in linearity, Compatible with today's digital micro-processors, the output voltage control can be obtained without any additional components and with the method, lower order harmonics can be eliminated or minimized along with its output voltage control. As higher order harmonics can be filtered easily, the filtering requirements are minimized. The most efficient method of controlling the output voltage is to incorporate pulse-width modulation (PWM) control within the inverters. The commonly used techniques are:

1. Single pulse-width modulation

2. Multi-pulse width modulation

From this we use the single pulse width modulation because we need variable input. The frequency of the reference signal sets the output frequency and carrier frequency determine the number of pulses per half cycle, P

$$P = \frac{f_c}{2 f_o}$$

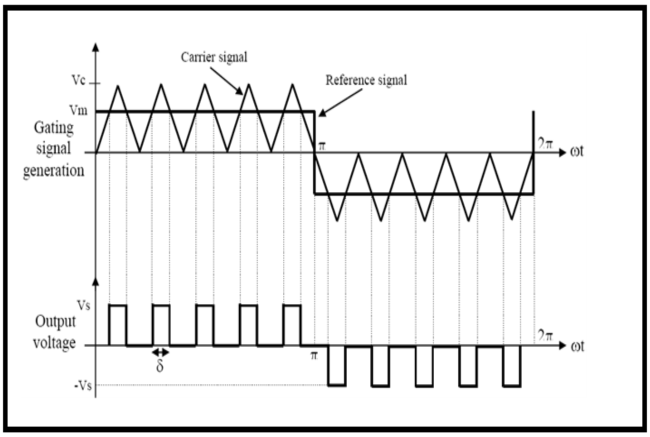

Fig -2.1: pulse width modulation

3. SIMULATIONS

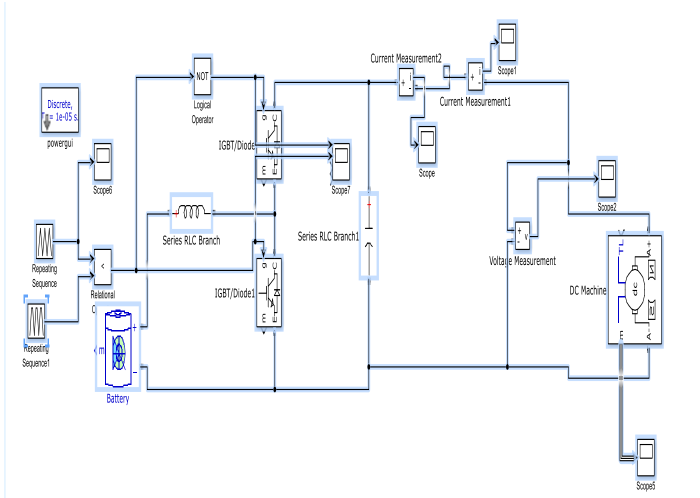

Fig-3.1: simulation of buck boost convertor

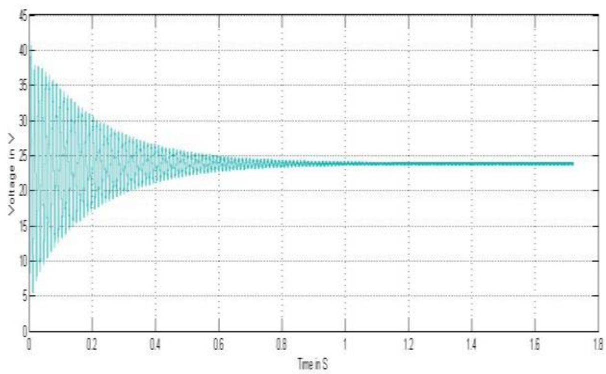

Fig -3.2: output voltage of boost convertor

Fig 3.8 shows the voltage with respect to time the output of the simple buck boost convertor. When the buck boost convertor work in the boost mode then the we get the voltage at the output is step up 12V to 24V.which we required for the driving the dc motor for the driving electric vehicle.

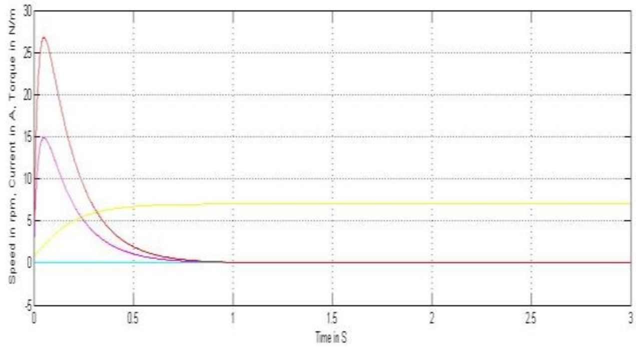

Fig-3.3: acceleration

In the acceleration mode at the starting the speed gradually increases and the starting current gradually decreases. After this it reach the maximum value of speed and minimum value, Current and then it is constant.

Yellow line represent speed.

Red line represents current.

Purple line represent torque.

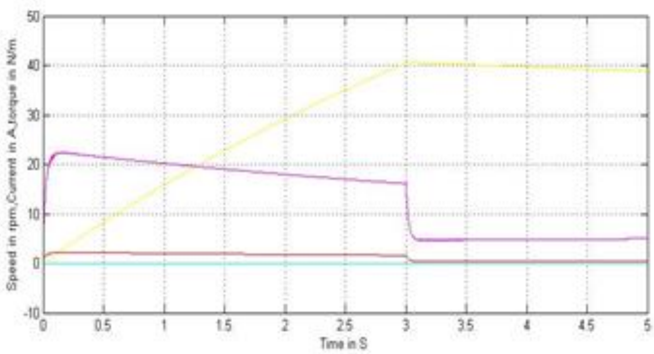

Fig-3.4: acceleration and constant run

The graph is shown the in fig which give the different output of the motor with respect to time.in this we are run the motor in acceleration mode up to the 3 Second for this we give gate pulse to the igbt 1.we get the speed in the 3 sec is about 40 Km/h and the current is very from 23A to 13A.after the 3 second the gate supply is constant, so the constant speed we get.

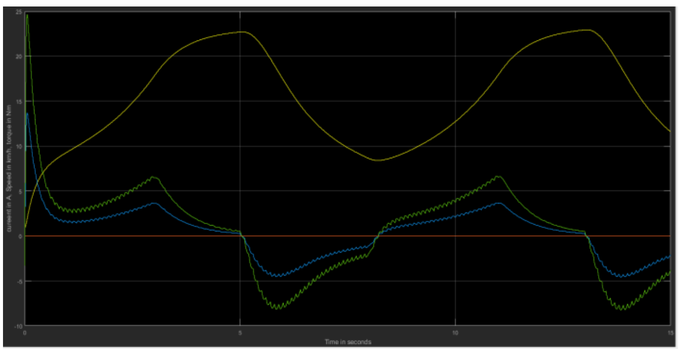

Fig-3.5: all mode operation

In this we can show that the up to the 4s the speed increase then the after 5s this speed is decreases which is regenerative breaking.

Name	Branch Type	Capacitance	Measurements
C	C	0.166F	None
Series RLC Branch	L	0.3e-3H	None

4. HARDWARE IMPLEMENTATION

Buck boost convertor

As per the simulation we are selecting the values of all the components but in simulation we are considering the ideal situation so we select some more rating than the ideal value like our maximum current is 14A so we select the value of IGBT is 2time higher than it. We are using IGBT 25N120, 5ultra-capacitors 5.5V 1F,0.3mH inductor and 10A10 diode for making the circuit of buck boost converter.

Now first we test the circuit on the no load only forgetting 24V at the output. And after that show signal on the CRO. we observe that more distortion occur.it reduce by the using ultra capacitor.

Gate supply

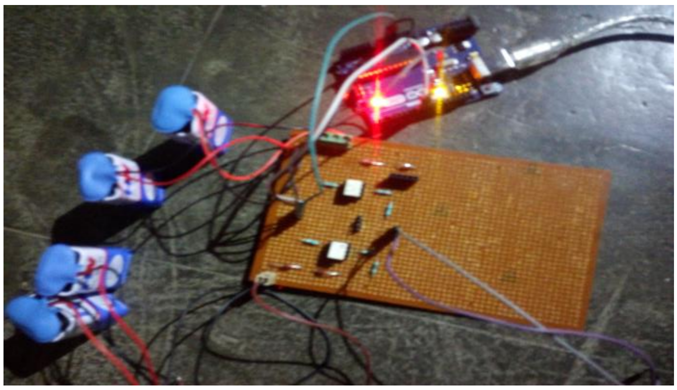

Fig-4.1: gate supply

For applying gate supply we are using the opto-coupler which is driven by the Arduino UNO. The Arduino is used to convert the input analog signal in to the digital signal with the pulse width modulation. The analog signal come from the accelerator at the analog pin A0 that signal is converted in to the digital signal PWM. According the movement of the accelerator.it comes at the pin no. 13. Pin 13 is connected to the second pin of the opto-coupler with the 220Ω resistance. The output is taken between the pin 7 and ground.

The opto-coupler takes supply from pin 8 as shown. The supply is provided by the two 9V batteries and using the zener diode we can give the 12V supply to the opto-coupler.

The opto-coupler is use to provide the different ground to the control circuit and the buck boost convertor.

The TOSHIBA TLP250 consists of a GaAlAs light emitting diode and a integrated photodetector. This unit is 8–lead DIP package. TLP250 is suitable for gate driving circuit of IGBT or power MOS FET.

Final working

Fig-4.2: mechanical structure

We are implementing this driver circuit on the bicycle for that we need some changes in the bicycle. we remove the chain connected to the pedal and then weld one plate nearer to the pedal on which the motor(24V,350W) is mount on it and make one box on the carrier in this we are putting the driver circuit and inductor on it.

Finally, all these are assembling on the bicycle. Now, start the testing on a no load. When the start button then the control circuit and the main buck boost convector are get the supply now when the accretion increase then the voltage between the variable and ground pin is decrees so the input of the Arduino at pin A0 decreases according the programing pwm generate at the output pin 13 and 2 for the both the IGBT .now the IGBT1 have the sufficient gate voltage than the it conducted and work as the boost convertor and give the 24V supply to the motor and the motor start the rotating so the wheel rotate.at this time we measure the speed of the wheel and measure the current at the input of motor.

Now the reduce the acceleration so the input to the Arduino is increase then the width of pulse is change at one point the duty cycle is <50% than the IGBT 1 has not sufficient gate signal so the it can not conduct. But IGBT2 have the sufficient voltage at the gate so it conducts and convertor work on the buck mode and regenerative breaking start at the motor. When the acceleration decreases continually than the at the one-point motor stop.

5. CONCLUSION

This work indicates that it is possible to integrate a ultra-capacitor in parallel with the battery in a HEV application. The work has also showed that when installing the ultra-capacitor, it is preferable to have power control. This power control is applied through a DC/DC converter. Moreover, it was also manifested that the strategy that has the highest potential to mitigate the battery of stress is the strategy that controls the power drawn from battery in peak demand condition. With this strategy and a suitable ultra-capacitor. it is possible to relieve the battery from stress and lower the RMS current considerably. This thesis work has also showed that the Bidirectional DC/DC converter, combined with ultra-capacitor and battery, functioned well. The converter is used for discharging (boost mode) voltage 50% of step up to source voltage. While recharging (buck mode) the power forward breaking and reverse braking modes voltage step down 50%, because of ultra-capacitor charging very low voltage. Thus power regeneration while braking and cruising is buck boost operation of convertor and power management strategy in MATLAB simulations using variable load condition

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