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Implementation of Embedded Controller based Energy Storage & Management system for EV applications

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Abstract— The energy sector has grown extensively in recent years, encouraging a move towards Electric Vehicles (EVs) as environmental friendly modes of transportation. Due to their dependence on a single resource of charging, many current approaches have grater rates of utilization and require more computation time before being applied. Energy management issues related with EVs are power grid issues, charging infrastructure battery loss, and vehicle features. The improvement of standard EVs through enhanced energy storage system and the various uses is main goals of this research work. By employing a Single Ended Primary Inductor Convertor (SEPIC) to raise voltage levels and optimizing power extraction through a Maximum Power Point Tracker (MPPT) algorithm to increase efficiency of energy transformed storage in EVs. Due to the non linear characteristics of litium ion batteries, accurate estimation of balancing techniques is stills a challenge and many have been adopted to address this issues. When applied to practice, the current estimation methods face significant challenges and yield large errors in the battery models and measurement system. On the other hand, the significant progress is still required to improve estimation accuracy and computation efficiency. All of the highlighted insights in this paper will hopefully lead to increased efforts towards improving litium ion battery management parameters and energy management system for EV Applications.

Keywords— Digital controller;Electricvehicle;Ultra capacitor

I. INTRODUCTION

Due to the demand of fossil fuels, our world moved to Electric vehicles. In order to protect and safe the environment conditions, Electric vehicles are the alternative choice. In Today's modern world, Battery operated vehicles are most popular in recent years. In order to avoid the pollution, Battery operated vehicle is the right choice.[2] There are many types of Batteries are used in Electric Vehicles for the solution of dynamic performance of the vehicles. Multiple researches are in progress in the area of Battery operated vehicles. In the Energy Scenario technologies, primarily batteries are the precarious for the advancement of Hybrid Electric vehicles and Plug in Hybrid Electric vehicles. Research is under way to reduce the cost of electrochemical energy storage by developing technologies that afford higher energy and power densities without sacrificing safety or performance [6]. Because of the higher cost, limited capacity and long recharge time of batteries impose a number of obstacles for the widespread implementation of electric vehicles. Multi-battery systems that combine a standard battery with super capacitors are currently one of the most promising ways to increase battery lifespan and reduce operating costs [1]. However, their routine is not still crucial depends on many issues due to the designing methodologies.

II. SEPIC CONVERTER

In Electric Vehicle, Converter plays an important role which is used to control the transportation wheels. Battery operated vehicle system, the important part of the system is Converter. The Conventional Converters such as Buck and Boost converters produced non inverted output and current ripples. To overcome the concerns of conventional converters an Improved SEPIC Converter is used to perform the advantageous functions. The single- ended primary-inductor converter (SEPIC) is a type of DC/DC converter which allows potential (voltage) at its output to be greater than or less than, or equal to that at its input. The SEPIC converter is accomplished by including of the diode and the capacitor. Here voltage multiplication technique is used in order to increase the gain of boost dc to dc converter. The operational characteristics of the basic SEPIC converter are changed with the conventional buck

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boost converter. In accordance with the PWM pulse technique a pulse is generated and increases the static gain. Single Ended Primary Converter has produced non-inverted output and responds short circuit output. The output voltage and current ripple has been reduced when the circuit is operating condition. This converter is capable of producing reasonable output voltage depends upon the operating condition. In the proposed method system a SEPIC Converter topology is designed with systematic power electronics components. By eliminating the output ripple and current ripple a regulated output voltage signal can be developed across the load side. For example, a single lithium ion battery typically discharges from 5.2 volts to 4 volts; if other components require 4.3 volts. Because of this reason SEPIC would be better choice for the Battery drive systems.

III. PID CONTROLLER

In Industrial based control systems, proportional–integral–derivative controller (PID controller) is commonly used in order to provide control loop feedback mechanism (controller). Based on the process variable and using proportional, integral, and derivative terms, (sometimes denoted P, I, and D respectively) determines error value e(t) as the difference between a process variable.

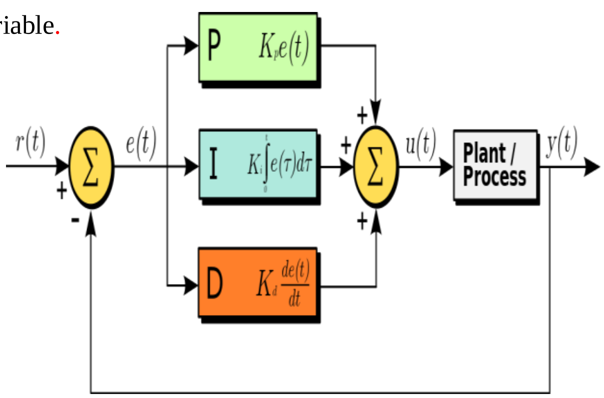

Figure.*1*. PID Controller design

The Conventional controllers such as P,PI and PID which is used to control dynamic performance of the Electric vehicles. When compared with PI and PID, feedback gain has been varied to get the optimum solution. P stands for Proportional controller, which does nothing more than detect current error values. If the error is large and positive, the control output will be large and positive as well. I represents the error's previous values. If the current output, for example, is insufficiently strong, the integral of the error will accumulate over time, and the controller will respond by taking a stronger action. D takes into account the error's potential future trends based on its current rate of change. Hence PID Controllers are used in Industrial applications and suitable for electric drive applications. Since it produces optimum solution, it has been implemented in all types of vehicle applications. The error is also reduced based on the selection parameters such as Kp,Ki,and Kd.

IV. PROPOSED PROTOTYPE DESIGN

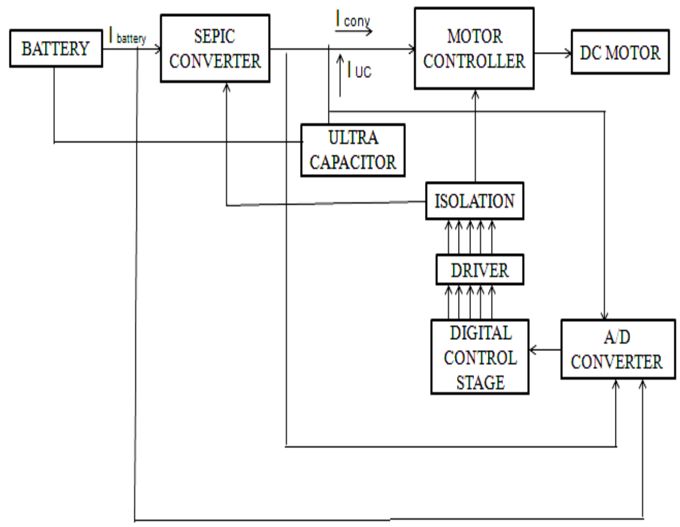

Figure.*2* .operational circuit diagram

V. SIMULATION CIRCUIT DIAGRAM

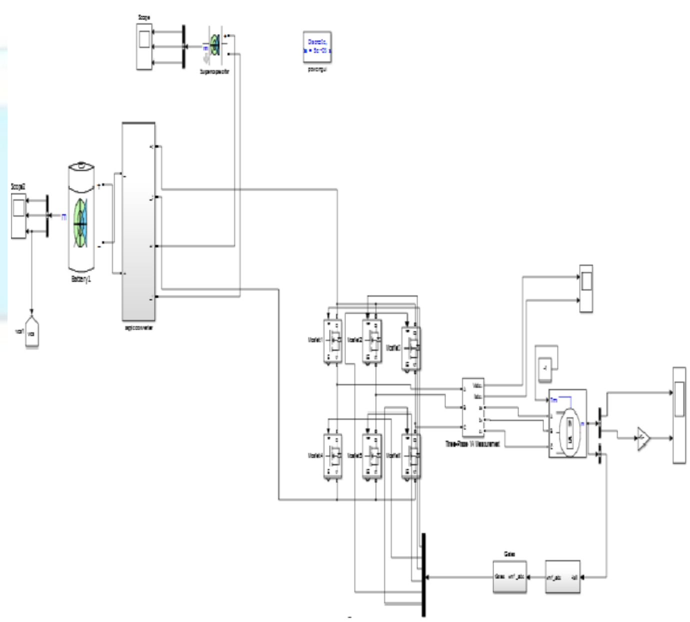

Figure.*3*. Proposed simulation circuit diagram

Figure 3 depicts the proposed simulation circuit diagram for the SEPIC converter. The schematic circuit is similar to a standard DC-DC converter. To overcome the drawbacks of conventional Buck-Boost converters, they have been used in electric drive applications. This research survey contains a SEPIC Converter. The extended version of a DC-DC converter, such as the SEPIC Converter, has non-inverted output voltage and current, which is similar to an established buck-boost converter, but the output voltage has opposite polarity with respect to the input voltage. The conventional converter contains unwanted noise, which can be avoided by using the SEPIC Converter.

In the case of buck-boost, the output voltage has the opposite polarity as the input voltage. The single-ended primary inductor converter (SEPIC) is a type of DC-DC voltage converter that functions as a voltage regulator, allowing it to step up and step down the voltage. It has some useful properties for obtaining a maximum capacity depending on the requirement.

VI. DRIVE CHARACTERISTICS

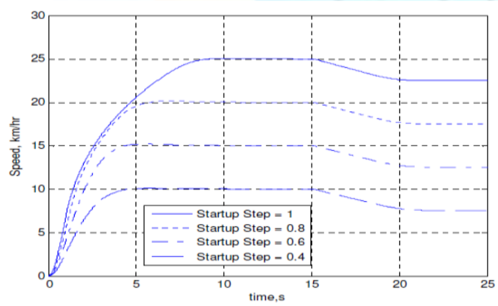

Figure.*4*. Drive characteristics

(a)Maximizing battery capacity

In order to maximise battery capacity, drive line efficiency should be improved when using alternative energy sources. Automakers around the world are developing hybrid-electric and fuel cell powered vehicles to improve driveline efficiency and/or to provide for the use of energy sources other than engine powered vehicles. Rechargeable batteries and ultra capacitors are used as energy storage technologies (electrochemical capacitors). The energy storage units, like an electric vehicle, can be recharged by the engine or fuel cell or by the electric grid. Later models (often referred to as plug-in hybrids) can run on both liquid or gaseous fuels and grid electricity. One of the appealing features of the plug-in hybrid vehicle is the ability to use grid electricity generated by sources other than petroleum. The output voltage of a battery decreases as it discharges. When fully charged, a single lithium-ion (LI-ion) battery provides 4.2 V, dropping to 3 V at the end of the discharge point. Figure 5 shows a Li-ion discharge curve under a load of 0.2 C (where C is the battery's rated capacity in ampere-hours. The battery would therefore be expected to last five hours under this load).

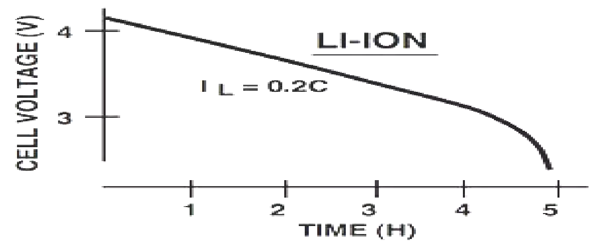

Figure.5. Discharge curve for Li-ion battery.

VII. HARDWARE DESIGN

Figure 2 depicts the proposed operational circuit diagram for a single-ended primary inductor converter. The output voltage is the product of the pulse-width-modulation train's duty cycle and the input voltage. The battery is connected to a SEPIC Converter, which is a DC-DC converter. The motor controller's output is sent to the DC motor. The controller circuit compares the ultra capacitor current and the converter current. All other components are provided with an isolation circuit. The digital control stage serves as an FPGA controller, supplying pulse signals to converter circuits. The driver sits between the isolation circuit and the digital control stage. The Ultra capacitor current signal is converted to a digital signal using an Analog to Digital Converter. The Single Ended Primary Inductor Converter is used to obtain a ripple-free output signal. Because of its high efficiency, the proposed system design will be implemented in a hardware circuit, which is popular in battery-powered applications.

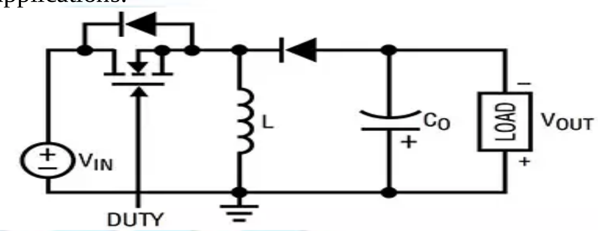

Figure.6.Non-isolatedbuck/boost-switching-voltage-regulator topology

The design of a Single Ended Primary Inductor Converter is analyzed here using Mat lab software. This converter is made up of inductors, one of which is a coupled inductor. The power factor is calculated using a PID controller. Figure 5 depicts the characteristics curve of a Li-ion battery. Figures 6–8 show the actual output voltage and gate pulses. The following are the simulation parameters:

TABLE1
SIMULATION COMPONENTS AND VALUES.

Simulation Components	Ratings
Primary Inductor,(L_1, L_2)	10mH , 500µH
Value of Capacitor (C_1, C_2)	860nF
Output Capacitor	600µF
Switching frequency	50Hz
Input voltage	120V
Nominal Output voltage	48V
Nominal Output Current	0.7A

One distinguishing feature of the basic buck/boost topology is that the voltage at the load is inverted when compared to the voltage delivered by the battery. [4] This voltage inversion can complicate a design, especially when powering analogue components. The SEPIC regulator, on the other hand, is based on the buck/boost design but with an additional inductor and capacitor. Furthermore, one end of the primary inductor is connected to the battery's positive terminal (hence the name SEPIC). Any DC component between the input and output is blocked by the capacitor. The addition of this capacitor necessitates the addition of a second inductor so that the diode's anode can connect to a known potential. This is done by connecting the diode to ground via a second inductor. Because the same voltage is applied to the inductors throughout the switching cycle, some designs incorporate both inductors onto the same core, resulting in a lower component count and a more compact design. The SEPIC configuration (Fig 3) retains the benefits of the buck/boost topology for battery-powered designs, but with the added benefit that the output voltage of the SEPIC is the same polarity as the input. Other advantages of the SEPIC design include. First, the capacitor coupling energy from input to output allows the device to deal with short circuits more effectively than the traditional buck/boost design. Second, unlike a buck/boost configuration, when the switch is turned off, the output of the SEPIC regulator drops to 0 V. Third, the SEPIC design uses few active components and is controlled by a simple controller, which saves money and board space. Finally, because the SEPIC regulator employs a "clamped" switching waveform, the noise from its high-frequency switching operation is reduced, easing electromagnetic interference concerns. The main disadvantage of the SEPIC topology is a loss of efficiency due to the small additional parasitic capacitances and impedances associated with the extra capacitor and inductor. The magnitude of the effect varies depending on the application, but while a typical buck/boost device may have an efficiency of up to 92 percent, an equivalent SEPIC will have a peak efficiency of around 90 percent.

VIII. CHARGING METHODS OF LI-ION BATTERY

In order to allow charging levels, various compounds materials are incorporated with a multilayered crystalline structure. During the discharge of a Li-ion battery, ions move from the negative electrode to the positive electrode via an electrolyte, causing electrons to move in the opposite direction around the circuit to power the load. The charging current and discharging current can be calculated using the SOC Algorithm. The duty cycle is calculated here to determine whether it should operate in constant current or constant voltage control mode. It will produce reference current and regulate the current Simulation results for the state of charge of the capacitor, Battery voltage and current is represented here. Constant current mode (CCM) and constant voltage mode (CVM) are two modes of operation that can be used in a battery-powered vehicle (CVM). These modes necessitate the use of multiple control loops to control the required output parameters via feedback mechanisms such as the inner and outer loop mechanisms. A comparative analysis can be performed using different modes for smooth charging operation. Figure depicts the schematic characteristics of a Li-ion battery. Battery voltage statistical data can be analyzed using simulation. After reaching full capacity of 5V, the discharge voltage may reach 4V. During the initial period, the battery is tested using two modes. If the battery voltage reaches its maximum capacity, Constant will take over.

TABLE 2
COMPARISON RESULTS

Method	Voltage [V/cell]	Limit Voltage at Full Charge[V/cell]	Discharge Voltage [V/cell]	Efficiency
Buck-Boost	2.8	5.2~5.4	4.8	91%
SEPIC	3.8	6.2-6.6	4.6	96%

IX. FPGA CONTROLLER

The proposed design for the dynamic performance of the electric vehicle makes use of a digital controller. In a typical Buck boost converter, incremental converter losses can occur. The proposed circuit employs Field Programmable Gate Array (FPGA) controllers to avoid converter losses. This controller is ideal for improving the charging and discharging mechanisms in battery-powered vehicles. It has logic block interconnection characteristics. The proposed circuit employs an FPGA to generate pulses for the converter circuit. It has the ability to reprogramme the structure and provides a digital PWM signal.

X.SYNTHESIS REPORT OF HIGH FREQUENCY COUNTER BASED PWM GENERATOR

The synthesis report for the PWM generating signal can be performed using the Xilinx XST of the Xilinx ISE 10.2 software.Figure.8. FPGA Signal generation

XI. SIMULATION RESULTS

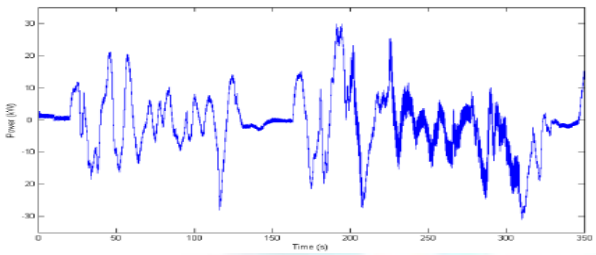

Figure.7. Charging Condition of the Ultra capacitor.

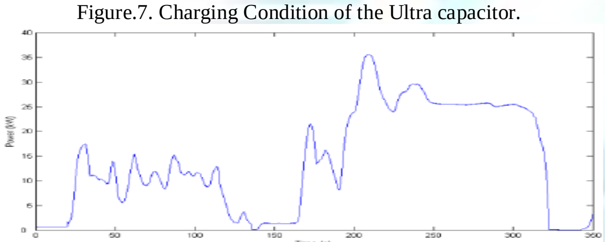

Figure.8 Battery power state

XII. CONCLUSION

In this research article, it concluded that an electric vehicle performance, based on the improved SEPIC Converter and digital controllers are discussed and analyzed. A Conventional controller such as PID controller has compared with Digital controller. Two drawbacks have been identified in the conventional methods such as converter losses and incremental feedback gain. In order to eliminate the drawbacks of conventional buck boost converter design, here an improved SEPIC Converter and FPGA Controller has been used here. The Performance of the system has risen to certain level from 90% to 95%.This system introduces to track the dynamics analysis of Battery operated systems. A Comprehensive analysis has been done in order to improve the performance of the battery. The Battery voltage is tracked between (12-38V).In this approach a considerable losses and cost of the system has reduced. The proposed prototype design is simulated using simulation software. The system is simulated using the MATLAB Simulink tool, and its performance is demonstrated. For non-isolated battery-powered systems, the SEPIC-voltage regulator is an excellent choice. The topology shown here uses buck and boost voltages to provide non-inverted and zero-volt output, unlike a conventional buck/boost regulator.

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