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Implementation of Battery Management Systems Using Adaptive Modeling for Electric Vehicles Applications

R.Sundaramoorthi[1*] , Dr.P.Ramesh[2]

[1*]Assistant Professor, Department of Electrical and Electronics Engineering, Kings College of Engineering, Thanjavur, Tamilnadu, India
[2]Assistant Professor (Sr.Gr), Department of Electrical and Electronics Engineering, Anna University, University college of Engineering Ramanathapuram Campus, Tamilnadu, India, Emailid: ramesh2905@gmail.com

Abstract:
This paper proposes and implements a new method for the estimation of the state of charge (soc) and state of health for the electric vehicles (EVs). The key of the proposed method is to model the EV battery by using the neuro-fuzzy inference system. This paper describes about different Adaptive system for SOC estimation in Electric vehicle applications. Due to the increasing concern of fossil fuels and toxic gases, Environmental conditions and higher capacity accumulators transformation method has been changing day by day. In order to get safe and reliable operation, the battery should be protected. Battery properties such as state of charge and state of Health have been analyzed by using different algorithms. As batteries have been affected by many chemical factors and have non-linear state of charge (SOC) Adaptive systems offer good solution for SOC estimation. In recent years with the development Artificial Intelligence various new adaptive systems for SOC estimation have been developed. Among all the methods, neural network, radial basis function (RBF) neural network, Fuzzy logic methods, support vector machine, Fuzzy neural network and kalman filter are produced good results. In this work comparative solution is implemented using neural network method. Finally, the investigations of selected drive performances such as Battery voltage, current, ultra capacitor voltage evaluation parameters are presented. Matlab coding using simulation results is analyzed here.

Keywords—BatteryManagementSystems,Digitalcontroller;Electricvehicle;Ultra capacitor

I. INTRODUCTION

In Today's technological field, transportation system has been increased. Because of this pollution and toxic gases are produced around the world. This will create problems and the environment severely which affects. Battery operated vehicles are most popular in recent years. Due to the increased population many Vehicles play an important role. Because of increasing fuel cost, Electric vehicle has been increasing in recent years. Electric vehicles are under constant research area and researchers keep working on it for reduced fuel usage and to reduce CO2 emission. EVs are classified as hybrid electric vehicles and battery electric vehicles. Batteries play a major role in smooth running of EVs. Due to the lack of fossil fuels, environmental pollution, and the other reasons, the conventional internal combustion engine (ICE) powered vehicles faced with limitations. On the other hand, the electric vehicles (EVs), hybrid EVs (HEVs), have been growing steadily with the development of the vehicular battery over the last few years. Especially, HEVs can be a compromise of ICE powered vehicles and EVs, considering low exhaust emission and high driving efficiency (Moreno et al., 2006; Jeong and Lee, 2013; Bak et al., 2015 Air pollution is currently one of the main causes of premature death in the world, particularly on urban population1. Air pollutants are responsible for the increment in cardiovascular and respiratory diseases that affect the human health and contributing to climate change by affecting the amount of sunlight that is reflected by the atmosphere. Most of these pollutants are produced by the burning of fossil fuels in the transportation sector. For this reason, many governments are promoting the electrification of this sector, banning diesel and petrol cars in the city centers and providing financial incentives to boost the transition from conventional internal combustion engines (ICE) vehicles to electric ones2-3. One of the main challenges for the adoption of electric vehicles (EVs) is their limited range due to the lower energy density of batteries compared to fossil fuels4. A good and accurate estimation of the battery SOC is needed for an appropriate analysis and simulation of EVs behavior. It is also critical for current EV drivers and those fleet managers that are evaluating the possibility of changing their conventional ICE vehicles by EVs. SOC provides information regarding the remaining useful energy within the battery and its reliability and, therefore, for potential charging and discharging strategies. Battery SOC estimation is a very difficult task because it has non-linear time-varying characteristic and it cannot be directly measured5. There are different SOC estimation methods such as equivalent circuit-based models, empirical models and electrochemical models. Circuit-based models are founded upon the electrical behavior of the battery, while electrochemical models are founded upon the equations of the battery chemistry, that have been used mainly for battery SOC estimation techniques6 With increasing concerns about global warming and fossil fuel depletion, the automobile industry is facing a transition from internal combustion engines (ICEs) to electric vehicles (EVs). The major industrialized nations have outlined their plans for EV development and production. For example, the US government set a goal of having one million EVs on the road by 2015 [1], and the Chinese government plans to have five million EVs on the road by 2020 [2].Although EVs will inevitably permeate the market, challenges still exist. One challenge is the ''range anxiety'' problem, which refers to the driver's fear of running out of battery power on the road [3]. As of 2011, the driving range of an EV was only 40–100 miles, which is 3–4 times less than ICE vehicles. Adding to the problem is the current lack of battery charging infrastructure. Therefore, to prevent EVs from running out of charge on the road and leaving passengers stranded, the ability to predict their residual range is needed. The first step in residual range prediction is to know how much capacity remains in the battery, also known as its state of charge (SOC).The most common method for SOC estimation is Coulomb counting [4,5], in which the remaining charge is calculated by integrating the current entering or leaving the battery over time. Coulomb counting is simple and easy to implement in on-board applications. However, it requires knowledge of the starting SOC.

In addition, Coulomb counting is an open-loop method, and measurement noise and battery aging can cause drift. Generally, HEVs consist of numerous components for the use of both mechanical and electrical power. Moreover, HEVs contain starter generator system composed of the generator and its drive inverter to increase the driving efficiency. The role of the system can be summarized in two ways: i) the starter generator system converts the kinetic energy of the vehicle into electric energy to charge the vehicular battery. ii) the starter generator system eliminates exhaust gas emission when HEV is temporarily stopped during driving in the downtown. Battery charging method for the HEVs were proposed in many of studies. Due to the increasing concern over global warming and fossil fuel depletion, it is expected that electric vehicles powered by lithium batteries will become more common over the next decade. However, there are still some unresolved challenges, the most notable being state of charge estimation, which alerts drivers of their vehicle's range capability. We developed a model to simulate battery terminal voltage as a function of state of charge under dynamic loading conditions. The parameters of the model were tailoredon-line in order to estimate uncertainty arising from unit-to-unit variations and loading condition changes. We used an unscented Kalman filtering-based method to self-adjust the model parameter sand provide state of charge estimation. The performance of the method was demonstrated using data collected from LiFePO4 batteries cycled according to the federal driving schedule and dynamic stress testing.

Due to urban pollution, transport electrification is being currently promoted in different countries. Electric Vehicles (EVs) sales are growing all over the world, but there are still some challenges to be solved before a mass adoption of this type of vehicles occurs. One of the main drawbacks of EVs are their limited range, for that reason an accurate estimation of the state-of-charge (SOC) is required. The main contribution of this work is the design of a Nonlinear Autoregressive with External Input (NARX) artificial neural network to estimate the SOC of an EV using real data extracted from the car during its daily trips. The network is trained using voltage, current and four different battery pack temperatures as input and SOC as output. This network has been tested using 54 different real driving cycles, obtaining highly accurate results, with a mean squared error lower than 1e-6 in all situations.

High power batteries require proper care and they should be sensed for their voltage, current and power. Improper operation of batteries like over charge, over discharge, over current, short circuit and extreme temperature might throw problems to the user. Hence proper BMS helps in overcoming these issues and provides a safety drive for electric vehicles. Key technologies in the BMS of EV include battery modelling, state estimation, charging and discharging. A good BMS should safely protect the driver/operator by detecting unsafe operating conditions, protecting the cells from damage in failure cases, prolongs the life of battery in normal operating region and should inform the user about the battery details and its status of operation.[3] This paper also explains about the different batteries and their electrochemistry. A battery has to be charged, discharged and its parameters are to be estimated well for its good maintenance. The measurable variables such as voltage, current, temperature that varies with state of charge are required for accurate and robust SOC estimation. This paper explains the variation of OCV and internal resistance of the battery at different SOC of Lithium ion battery and NiMH battery. Variation of its internal resistance curve at room temperature gives us the need for modelling a battery based on thermal behavior. In order to avoid the pollution, Battery operated vehicle is the right choice. 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. 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.

However, the application technologyof EV batteries, namely, the driving range indicator, cannot keep pace with the development of other EV technologies. At present and in the near future, batteries have been identified to be the major energy source for EVs because of their technological maturity and reasonable cost. Therefore, the key to the development of the driving range indicator for EVs is to accurately estimate the battery residual capacity (BRC) [3]. Different from the aforementioned methods, the applicationof the artificial neural network (ANN) to the estimation of the BRC under variable current discharge [14], [15] and constant current discharge [16], [17] provides a tool to deal with the above difficulties. This is due to two key features of the ANN.First, the ANN does not rely on the explicitly expressed relation- ship between input variables and the BRC. When using the ANN for the BRC estimation, one needs to only consider the selection of variables as the ANN inputs. The relationship between the input variables and the BRC is formulated by a training process, avoiding those difficulties in the modeling process. Second, theadaptive algorithm is another attractive feature of the ANN. Anupdated training data set can be used to retrain the ANN so thatthe ANN can adapt the change of the BRC in the most recent conditions. On the other hand, the fuzzy logic is also explored in the estimation of the BRC [18]. This is due to the fact that thefuzzy logic can handle uncertainties and imprecision in the realbattery system. Moreover, the parameters of the fuzzy system have clear physical meanings so that rule-based and linguistic information can be incorporated into the fuzzy system.

To enlarge the market share of EVs and HEVs, safety and reliability are the top concerns of users. However, both of them are subject to not only the battery technology but also the management system for the battery. Therefore, a battery management system (BMS), as the connector between the battery and the vehicle, plays a vital role in improving battery performance and optimizing vehicle operation in a safe and reliable manner. In view of the rapid growth of the EV and HEV market, it is urgent to develop a comprehensive and mature BMS The ANN for the estimation of the BRC cannot provide heuristic knowledge of the battery on the BRC estimationprocess because of its black-box approach. On the other hand, fuzzy logic is a tool that can easily implement and utilize heuristic reasoning, but it is generally difficult to provide exactsolutions. With the integrated synergy of the ANN and the fuzzylogic, the estimation of the BRC using adaptive neuro-fuzzy inference system (ANFIS) can function to provide more accurate solutions under different operating conditions and alsoa better understanding of the estimation process. Therefore, thepurpose of this paper is to develop a new estimation approach of the BRC by using the ANFIS. The idea behind the fusionof the ANN and fuzzy logic is to use the learning ability of the ANN to implement and automate the fuzzy system which utilizes the high-level human-like reasoning capability. Tofacilitate the application to EVs, the estimation of the BRC.

II. DC/DC INTERLEAVED CONVERTER

Converter is one of the important parts in Battery operated vehicles. The Conventional Converters such as Buck and Boost converters produced non inverted output and current ripples. To overcome the concerns of conventional converters a 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 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. Due to battery current ripple which creates problem in Electric vehicle, designing part of converter is essential .In order to control the Current ripple and voltage ripple SEPIC would be better choice for the Battery drive systems.

III.Adaptive Modelling

The Adaptive is a fuzzy Sugeno model put in the framework of adaptive systems to facilitate learning and adaptation [19]. Such a framework makes the ANFIS modeling more systematic and less reliant on expert knowledge. To present the ANFIS architecture, the following two fuzzy if–then rules based on a first-order Sugeno model are considered:

Rule:1:If (x is M1)and (y is N1) then (z1 – A1x+B1y+c1)

Rule:2:If (x is M2)and (y is N2) then (z2 – A2x+B2y+c2)

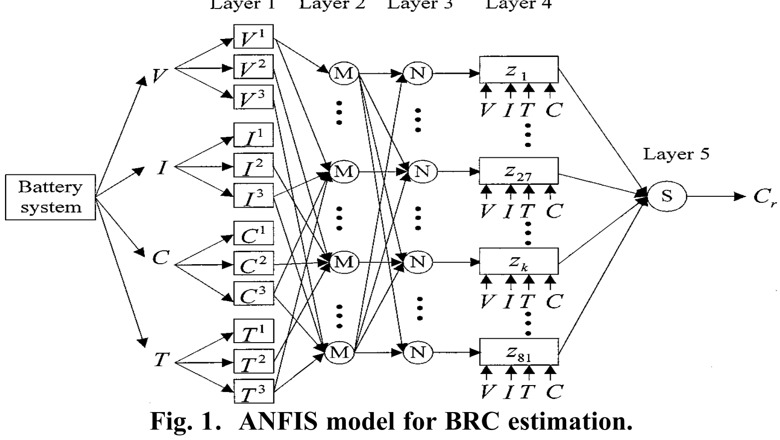

Fig. 1. ANFIS model for BRC estimation.

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In this stage, the gradient descent is used to optimally adjust the premise parameters corresponding to the fuzzy sets in the input domain. The output of the ANFIS is calculated by fixing the consequent parameters to the values found in the forward pass. By comparing the estimated output with the actual output, the output error of the ANFIS is then propagated from the output to the input to adapt the premise parameters using thestandard back propagation algorithm. It has been proven that theANFIS can be used as a universal approximated [20] and the hybrid learning algorithm is highly efficient in training this ANFIS [21].

Block diagram:

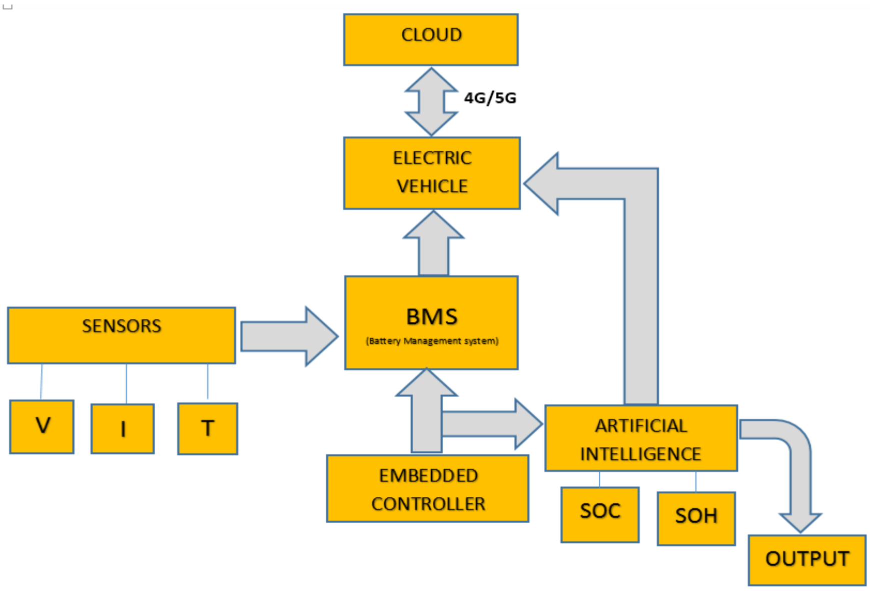

Fig 2.Experimental setup

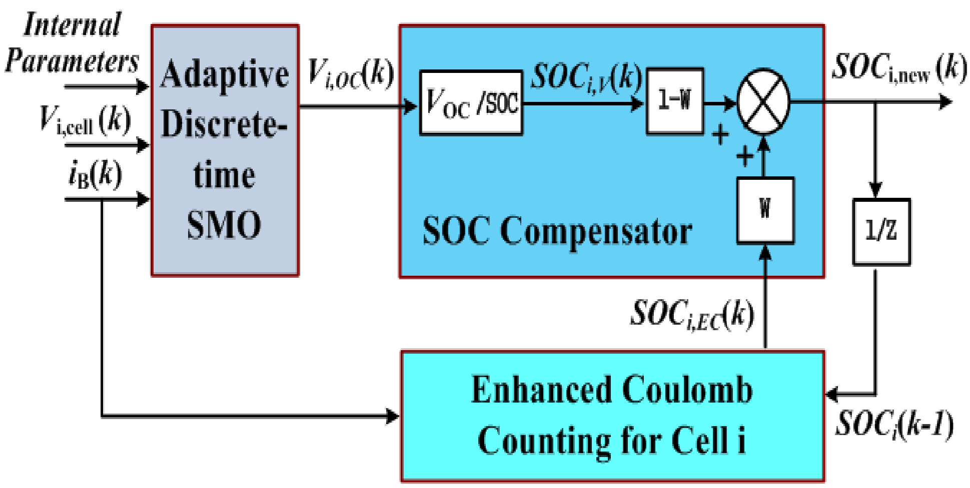

Fig 3. State of Charge and Current BMSs

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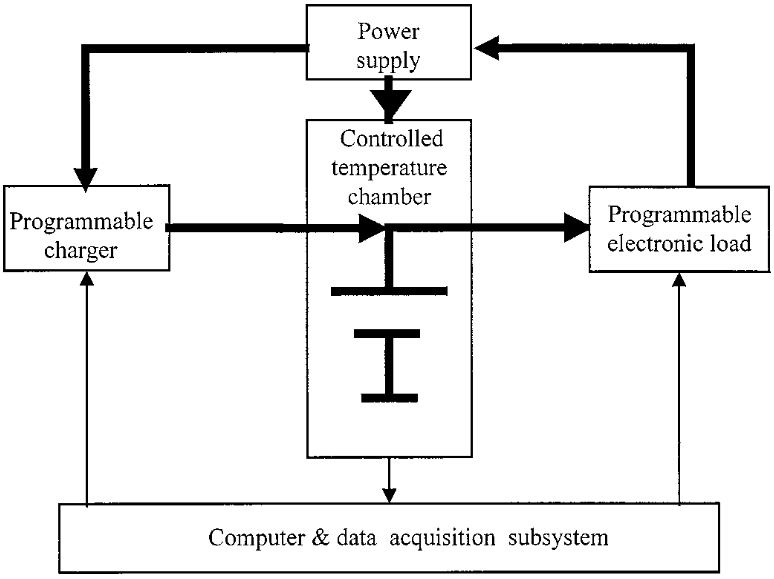

Fig 4. Computer &data acquisition subsystem

In order to ensure optimal performance, availability, and reliability of a battery system, it is crucial to precisely estimate the cell-level state of charge (SOC) and state of health (SOH) of the multi cell batteries. Therefore, SOC and SOH are the main parameters of a battery management system (BMS) during battery operation .State of charge (SOC) is a relative measure of the amount of energy stored in a battery, defined as the ratio between the amount of charge extractable from the cell at a specific point in time and the total capacity. Accurate state-of-charge estimation is important because battery management systems (BMSs) use the SOC estimate to inform the user of the expected usage until the next recharge, keep the battery within the safe operating window, implement control strategies, and ultimately improve battery life. Traditional approaches to state-of-charge estimation, such as open-circuit voltage (OCV) measurement and current integration (coulomb counting), can be reasonably accurate for cell chemistries with a significant OCV variation throughout the SOC range, as long as the current measurement is accurate. However, estimating the state of charge for battery chemistries that exhibit a flat OCV-SOC discharge signature, such as lithium iron phosphate (LFP), is challenging. Kalman filtering is a promising alternative approach that circumvents these challenges with a slightly higher computational effort. Such observers typically include a nonlinear battery model, which uses the current and voltage measured from the cell as inputs, as well as a recursive algorithm that calculates the internal states of the system, including state of charge Comprehensive and mature BMSs are currently found in portable electronics, such as laptop, computers and cellular phones, but they have not been fully deployed in EVs and HEVs.

This is because the number of cells in a vehicle's battery is hundreds of times greater than that in portable electronics. Moreover, a vehicle's battery is designed not only to be a long-lasting energy system, but also to be a high power system. In other words, batteries for EVs and HEVs have to provide high voltage and high current. These make BMSs for EVs much more complicated than those for portable electronics. From a hardware structure perspective, three kinds of topologies have been implemented in BMSs, including centralized, distributed and modular structures [6]. However, the functions of the BMSs in each case are similar. Meissner and Richter [7] proposed a layer structure for battery monitoring, battery state, and battery management. Gold [8] categorized the different functions in a BMS. These concepts can be combined into a generic BMS structure with the basic functions as shown in Figure 1.Various sensors are installed in the battery pack for data acquisition at the monitoring layer. The real-time collected data is used to maintain the system's safety and determine the battery state. The battery state determines the charge time, discharge strategy, cell equalization, and thermal management among the cells, while the state will be passed to the user interface as well.

IV. PROPOSED PROTOTYPE DESIGN

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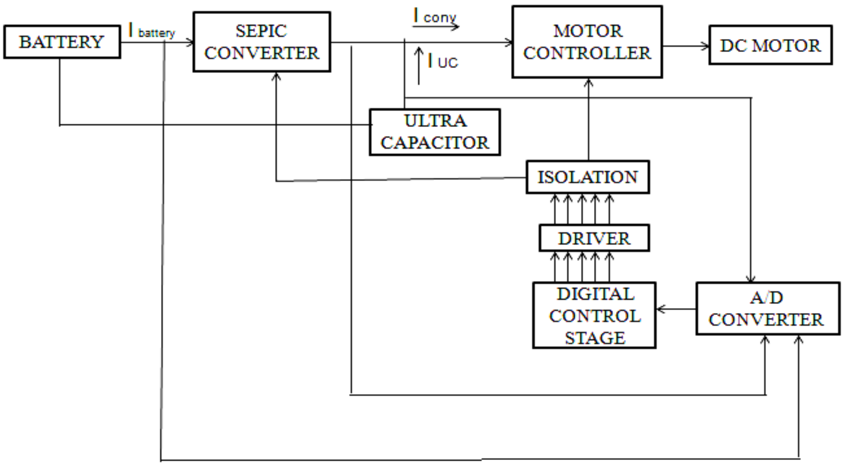

Fig.5 .Operational circuit diagram

V. SIMULATION CIRCUIT DIAGRAM

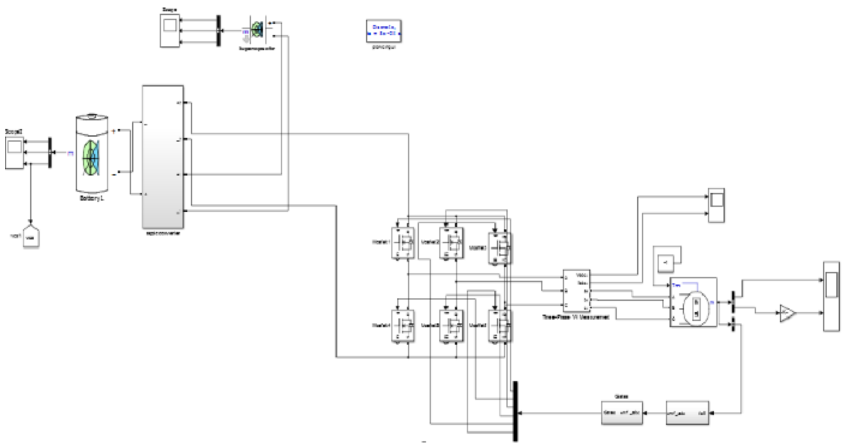

Fig.6. Proposed simulation circuit diagram

The Proposed simulation circuit diagram for the SEPIC converter is as shown in fig.6.The schematic circuit is similar to that of conventional DC-DC converter. In order to overcome the disadvantages of conventional Buck-Boost converter has been used in the Electric drive applications. SEPIC Converter has been implanted in this research survey. In the extended version of DC-DC Converter such as SEPIC Converter has non-inverted output voltage and current is similar to an established buck-boost converter, but in the case of buck-boost converter is the output voltage has opposite polarity with respect to the input voltage. An unwanted noise is available in the conventional converter and that can be avoided by using SEPIC Converter. While in case of buck-boost the output voltage is of opposite polarity with respect to the input voltage. The single-ended primary inductor converter (SEPIC) is a type of DC-DC voltage converter and it act as voltage regulator which means that it can able to step up and step down the voltage. It has some useful characteristics to obtain a maximum capacity depends upon the requirement

VI. ULTRA CAPACITOR

Ultra Capacitors are same as super capacitors which are used for the Battery operated vehicles and Hybrid Electric drive systems. These are used to improve the acceleration of vehicle, enhance the driving range of vehicle, extend the life time of the storage device as Battery and also reduce the battery size. In general Ultra capacitors are used to provide high peak current and also keeping constant power. Hybrid combinations can be used that is the combination of battery and Ultra capacitors for the improvement of energy density. There are different kinds of batteries are used in Battery operated and Hybrid Electric vehicles. The batteries which are used in electric vehicle such as lithium-ion battery, lead-acid battery, sodium nickel chloride, battery and nickel zinc battery and zebra battery. Mostly, lithium ion batteries are used in electric vehicle compared to other types of batteries. The combination of battery and ultra-capacitor act as hybrid system for the purpose of improving the energy in electric vehicle.

VII. EVALUATION OF BATTERY MANAGEMENT SYSTEMS

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State of charge (SOC) is a relative measure of the amount of energy stored in a battery, defined as the ratio between the amount of charge extractable from the cell at a specific point in time and the total capacity. Accurate state-of-charge estimation is important because battery management systems (BMSs) use the SOC estimate to inform the user of the expected usage until the next recharge, keep the battery within the safe operating window, implement control strategies, and ultimately improve battery life. Traditional approaches to state-of-charge estimation, such as open-circuit voltage (OCV) measurement and current integration (coulomb counting), can be reasonably accurate for cell chemistries with a significant OCV variation throughout the SOC range, as long as the current measurement is accurate. However, estimating the state of charge for battery chemistries that exhibit a flat OCV-SOC discharge signature, such as lithium iron phosphate (LFP), is challenging. Kalman filtering is a promising alternative approach that circumvents these challenges with a slightly higher computational effort. Such observers typically include a nonlinear battery model, which uses the current and voltage measured from the cell as inputs, as well as a recursive algorithm that calculates the internal states of the system, including state of charge.

State of charge estimation is the task of the battery management system, or BMS. An accurate determination of the State of Charge (SOC) in a battery indicates to the user how long they can continue to use the battery-powered device before a recharge is needed. In a car, for example, an accurate knowledge of the time to recharge reduces anxiety and allows for appropriate trip planning. Discover how Simulink and Model-Based Design help engineers develop battery management system algorithms and software that:

1. Monitor cell voltage and temperature
2. Estimate battery state-of-charge (SOC) and state-of-health (SOH)
3. Limit power input and output for thermal and overcharge protection
4. Control the battery charging profile
5. Balance the state-of-charge of individual cells
6. Isolate the battery pack from source and load when necessary
7. Simulating battery management systems using Simulink enables you to gain insight into the dynamic behaviour of the battery pack, explore more software architectures, test more operational cases, and begin hardware testing earlier with fewer design errors.
8. Battery management systems (BMS) ensure safe and efficient operation of battery packs in electric vehicles, grid power storage systems, and other battery-driven equipment. One major task of the BMS is estimating state of charge (SoC). Traditional methods for SoC estimation require accurate battery models that are difficult to characterize. An alternative to this is to create data driven models of the cell using AI methods such as neural networks.

The residual capacity of batteries in commercial products is usually indicated by the state of charge (SOC) of the battery set, in terms of the measurement of amp-hours, or roughly an instant voltage. The Equivalent Circuit Battery block implements a resistor-capacitor (RC) circuit battery that you can parameterize using equivalent circuit modeling (ECM). To simulate the state-of-charge (SOC) and terminal voltage, the block uses load current and internal core temperature. The Equivalent Circuit Battery block calculates the combined voltage of the network battery using parameter lookup tables. The tables are functions of the SOC and battery temperature. You can use the Estimation Equivalent Circuit Battery block to help create the lookup tables. Specifically, the Equivalent Circuit Battery block implements these parameters as lookup tables that are functions of the SOC and battery temperature:

1. Series resistance, $R_o=f(SOC,T)$
2. Battery open-circuit voltage, $E_m=f(SOC,T)$
3. Battery capacity, $C_{batt}=f(T)$
4. Network resistance, $R_n=f(SOC,T)$
5. Network capacitance, $C_n=f(SOC,T)$

The Equivalent Circuit Battery block calculates the combined voltage of the network battery using parameter lookup tables. The tables are functions of the SOC and battery temperature. You can use the Estimation Equivalent Circuit Battery block to help create the lookup tables. Specifically, the Equivalent Circuit Battery block implements these parameters as lookup tables that are functions of the SOC and battery temperature:

1. Series resistance, Ro=f(SOC,T)
2. Battery open-circuit voltage, Em=f(SOC,T)
3. Battery capacity, Cbatt=f(T)
4. Network resistance, Rn=f(SOC,T)
5. Network capacitance, Cn=f(SOC,T)

Drawbacks of the mentioned BMUs include the following:
(1) Limited data logging function. The data logging function plays an important role in database establishment, which stores the driving pattern. This profile can help to build up and update the state of charge (SOC) model.
(2) Lack of state of health (SOH) and state of life (SOL) estimations. SOH and SOL are used to characterize the current health status and the remaining performance of the battery that will guarantee the reliable operation of the vehicle and scheduled maintenance of the battery replacement.
(3) Non-interchangeable among current BMSs. As each BMU has its own cell balancing scheme and communication mechanism, it is impossible to utilize the existing components to form a new BMS.

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In order to maximizing the battery capacity ,the drive line efficiency should improve in the case of energy sources other than In order to improve driveline efficiency and/or to provide for the use of energy sources other than engine powered hybrid-electric and fuel cell powered vehicles petroleum for road transportation, are being developed by auto companies around the world. The energy storage technologies being utilized are rechargeable batteries and ultra capacitors (electrochemical capacitors). The energy storage units can be recharged from the engine or fuel cell or from the electric grid much like an electric vehicle. In the later cases (often referred to as plug-in hybrids), the vehicles can use both liquid or gaseous fuels and grid electricity. One of the attractive features of the plug-in hybrid vehicle is that it permits the use of grid electricity generated using energy sources other than petroleum. As a battery discharges its output voltage diminishes. For example, a single lithium-ion (LI-ion) battery supplies 4.2 V when fully charged, dropping to 3 V at the end of discharge point. Figure 7 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).

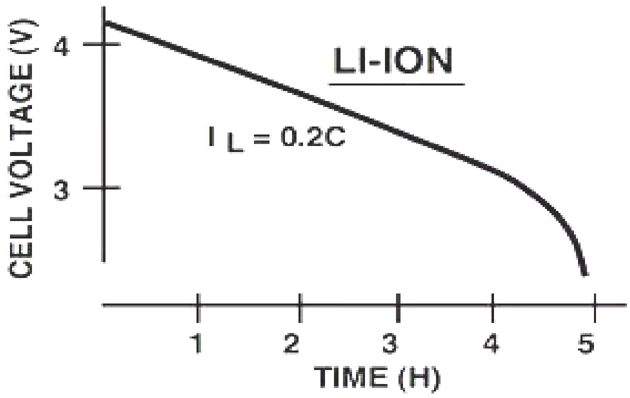

Fig.7 Discharge curve for Li-ion battery.

Battery State Evaluation

Knowledge of the battery state not only helps to determine whether the operational environment is safe and reliable, but also provides information about the charge-discharge operation, which is especially important for cell balancing. Usually, the battery state includes SOC and SOH determination. SOC is similar to the fuel usage indication in gasoline cars, but the battery is inaccessible for measuring and experiences aging, varying environmental conditions, and charge-discharge cycles, which will makes it difficult for a BMS to provide an accurate SOC estimation. According to [12],SOH describes the percentage of battery life remaining. However, there is no consensus on the definition of SOH because it does not correspond to the measurement of a specific physical quality. Although the ratio of the current capacity to the maximum capacity that the battery can hold is usually viewed as a health indicator, more parameters referring to the field performance must be considered during SOH evaluation. The actual formula of the SOH for a specific application is often a trade secret. SOL is referred to in the literature as the time when the battery must be replaced [12]. It is similar to SOH, but quantifies the remaining time until the battery will be unable to perform. Prediction of battery performance helps the engineer to plan maintenance strategies, and handle disposal and replacement issues.

VIII.METHODOLOGIES FOR BATTERY EVALUATION IN BMSS

Based on the analysis above, it can be seen that the evaluation of battery status is one of the weakest links in BMS and yet it has a large impact on BMS performance. The top concern for EV users is the safety and reliability of the power system in a vehicle. The most important question is whether they will run out of battery power on the road. These issues refer to the estimation and prediction of SOC,SOH, and SOL of the EV battery. Thus, an accurate quantification of the battery status has become one of the most critical tasks for BMSs. In this section, the latest methodologies for battery state estimation and prediction are reviewed.

State of Charge (SOC):

SOC is critical, but it is not measurable given the current onboard sensing technologies. The ratio of the currently available capacity to the maximum capacity can be expressed as SOC [25], which is calculated by Equation (1),where i is the current, and n C is the maximum capacity that the battery can hold. SOC reflects the amount of remaining charge that is available to the battery. It is used to determine the driving distance remaining in EVs, while it indicates when the internal combustion engine should be switched on or off in HEVs [26]. Due to the inherent chemical reactions of the battery and different external loads, the maximum capacity of the battery gradually decreases over time. Uncertainty regarding these factors will lead to non-linear, non-stationary battery degradation characteristics. The most straightforward approach for SOC estimation is Coulomb counting, which characterizes the energy in a battery in Coulombs. This method calculates the capacity of a battery by integrating the current flowing in and out of the battery over time. SOC can be obtained by

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referring to the calibration point at full charge. However, this reference point (i.e., the initial point) will change due to battery aging and coulombic efficiency. Thus, the reference point must be compensated when operating at practice conditions, and the SOC estimation should be updated under different measured voltage. Building an accurate table between the discharge capacity and open circuit voltage (OCV) isnecessary for achieving SOC. An Algorithm of SOC is used to identify the charging current and discharging current can be calculated. Here the duty cycle is calculated to check it should be operate on constant current control mode 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.

State of Health (SOH):

SOH describes the physical condition of a battery, ranging from internal behavior, such as loss ofrated capacity, to external behavior, such as severe conditions [12]. Unlike SOC, there is no clear-cut definition of SOH. A general definition of SOH is that it reflects the health condition of a battery and its ability to deliver specified performance compared to a fresh battery [26,31]. The SOH in EV applications is used to characterize the ability to drive a specific distance or range. SOH in HEV applications is a characteristic of the specified power, such as the cranking power from regenerative braking. Scholars and manufacturers use the percentage of nominal capacity as the health threshold of the battery [17]. When the capacity reduces to 80% of the beginning of life capacity after charge-discharge cycling, it is defined as battery failure. However, studies have defined different rules or indicators to quantify the SOH in terms of battery characteristics, test equipment, and different applications. Pattipati et al. [31] combined capacity fade and power fade as health characteristics. Capacity fade indicates the decrease in the driving range with a fully charged battery pack, and power fade indicates the reduced acceleration capability. Both of these features were input into an auto-regressive Support Vector Regression (SVR) model to estimate SOH. Here, the power fade was due to an increase in cell impedance during aging. The total resistance HF tc R was obtained from EIS data using nonlinear least squares. Figure 2 shows a Randles circuit model of a battery, where HF R and tc R are the high frequency resistance and the transfer resistance. By using Mat lab software, the design of Single Ended Primary Inductor Converter is analyzed here. This Converter composed of Inductor and one of the Inductor is made as coupled inductor. With the help of PID Controller the Power factor is calculated. The characteristics curve of Li- ion battery is as shown in Fig.7.The actual Output voltage and gate pulses are also shown in fig: 9 to 11. The simulation parameters are given in table: 1.

TABLE 1 SIMULATION COMPONENTS AND VALUES.

Simulation Components	Ratings
Primary Inductor,(L_1, L_2)	5mH , 600µH
Value of Capacitor (C_1, C_2)	760nF
Output Capacitor	500µF
Switching frequency	50Hz
Input voltage	110V
Nominal Output voltage	300V
Nominal Output Current	0.46A

One key characteristic of the basic buck/boost topology is that the voltage at the load is inverted compared to that delivered by the battery.[4] This voltage inversion can add complexity to a design, particularly when supplying analog components. In comparison, the SEPIC regulator is based on the buck/boost design but with the addition of an extra inductor and capacitor. Moreover, one end of the primary inductor is connected to the battery-positive terminal (hence SEPIC's name.) The capacitor blocks any DC component between the input and output. The addition of this capacitor means that a second inductor must be added so that the diode's anode can connect to a known potential. This is accomplished by connecting the diode to ground through a second inductor. Since the same voltage is applied to the inductors throughout the switching cycle, some designs see both inductors wound onto the same core with the advantages of reduced component count and a more compact design.

The SEPIC configuration (Fig 6) retains the benefits of the buck/boost topology for battery-powered designs but with the key advantage that the SEPIC's output voltage is the same polarity as the input. The SEPIC design boasts a number of other benefits. First, the capacitor coupling energy from input to output allows the device to deal with short circuits in a more controlled manner than the traditional buck/boost design. Second, when the switch is turned off the output of the SEPIC regulator, unlike a buck/boost configuration, drops to 0 V. The most notable downside of the SEPIC topology is a reduction in efficiency due to the small additional parasitic capacitances and impedances associated with the extra capacitor and inductor. The magnitude of the effect varies according to the application, but whereas a typical buck/boost device might boast an efficiency of up to 92 percent, an equivalent SEPIC will exhibit a peak efficiency of around 90 percent.

IX. CHARGING METHODS OF LI-ION BATTERY

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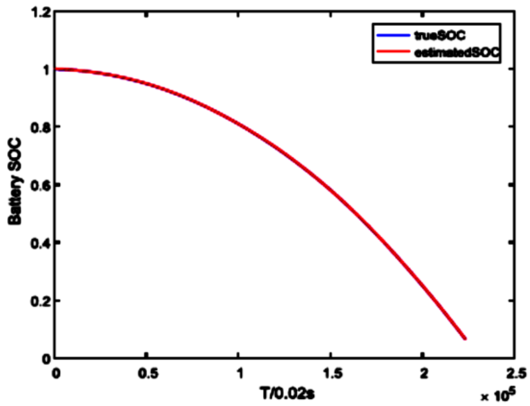
There are different compounds materials are incorporated with a multilayered crystalline structure in order to allowing charging levels. Li-ions have the characteristics during discharge of a Li-ion battery, ions move from the negative electrode through an electrolyte to the positive electrode, causing electrons to move in the opposite direction around the circuit to power the load. The mode of operation can be performed in the battery operated vehicle is constant current mode (CCM) and constant voltage mode (CVM). These modes are requires multiple control loop which is used to control the required output parameters through feedback mechanism such as Inner and outer loop mechanism. A Comparative analysis can be done using different mode for the operation of smooth charging. The schematic characteristics of Li-ion battery are as shown in figure. The statistical data of Battery voltage can be analyzed through simulation .The discharge voltage may reach 4V and after reaching the full capacity of 5V.In the Initial period the battery is checked by two modes. If the battery voltage reaches the maximum capacity, after that it will be performed by Constant Voltage Mode. The charger current may decrease, drastically but the voltage remains constant.

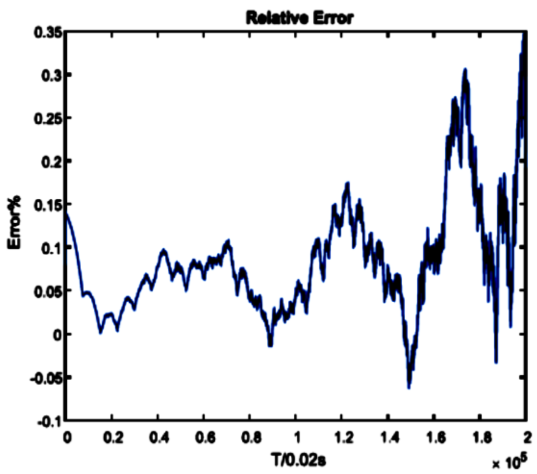
TABLE 2 COMPARISON RESULTS

Concluding Discharge Voltage [V/cell]	**Voltage [V/cell]**	**Limit Voltage at Full Charge[V/cell]**	**Method**
4.5	2.8	5.2~5.4	Continuous Conduction

X. Simulation Results



Training sets-1



Error Analysis

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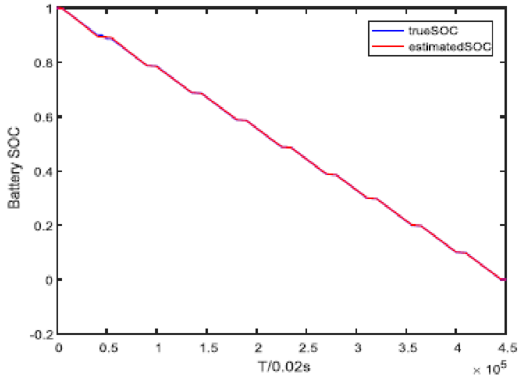
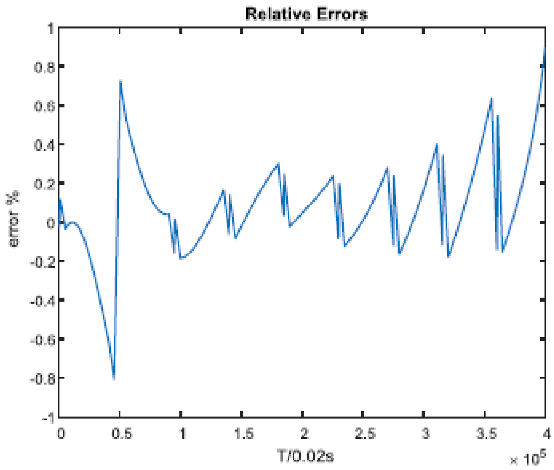


Training sets-2



Error Analysis-2

XI. SYNTHESIS REPORT OF HIGH FREQUENCY COUNTER BASED PWM GENERATOR

In order to perform the synthesis report for the PWM generating signal Xilinx XST of Xilinx ISE 10.2 software can be used.

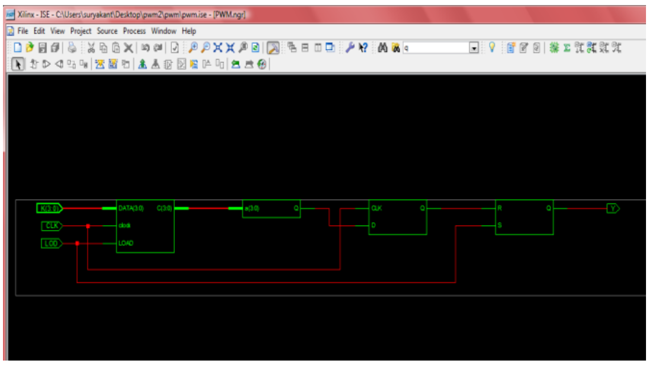


Fig.8. FPGA Signal generation

XII. SIMULATION RESULTS

The State of charge algorithm is provided for analyzing the Parameters such as Voltage and Current.(I_{ref} or V_{ref}) The actual value is compared with the reference value for the specified duty ratio [6]. Depending upon the value of duty ratio a PWM pulse is generated and compared with constant voltage and the actual output voltage. Because of this battery life time has been increased when comparing with conventional battery plug in systems used in electric drive mechanism.

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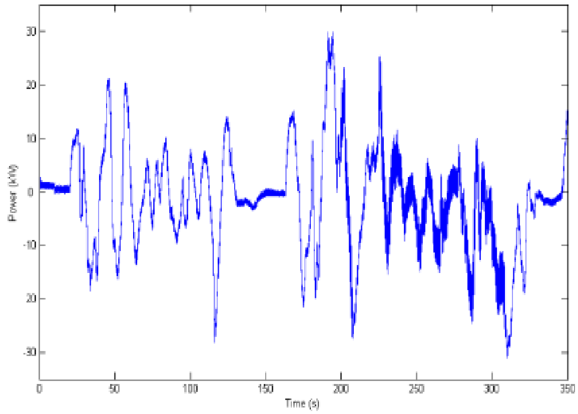

Fig.9 Charging Condition of the Ultra capacitor

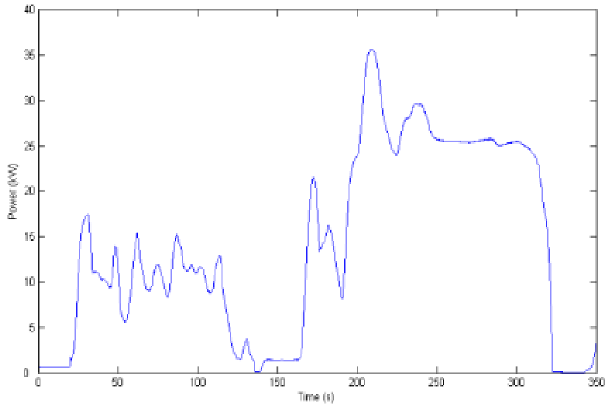

Fig.10 Battery power state

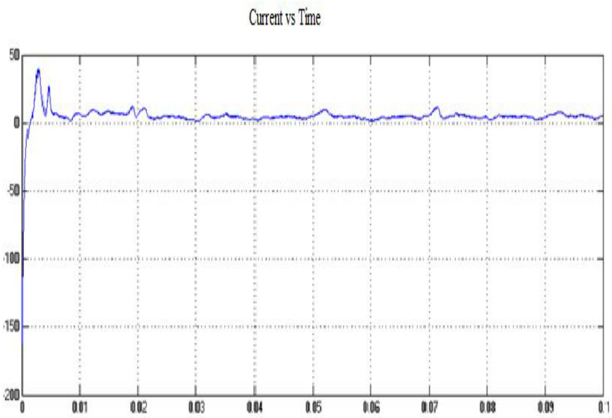

Fig 11. Status of the condition of Battery.

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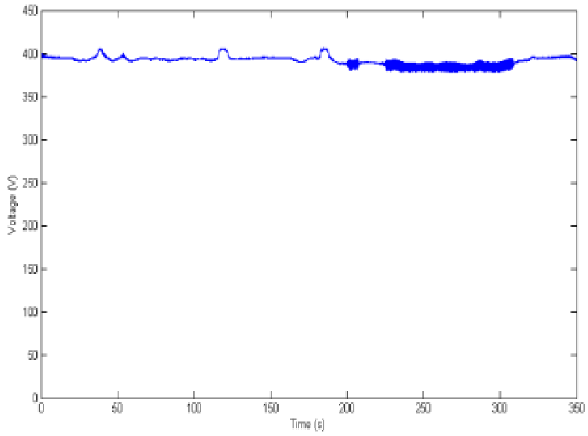

Fig.12. Ultra capacitor power

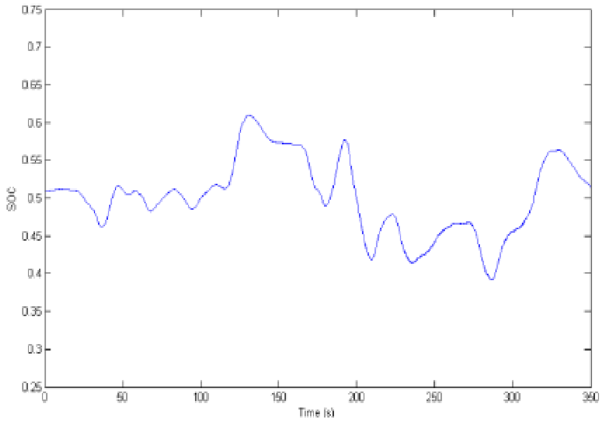

Fig.13. Battery power

XIII. CONCLUSION

In this paper, it concluded that, as batteries are the core energy sources in EVs and HEVs, their performance greatly impacts the salability of EVs. Therefore, manufacturers are seeking for breakthroughs in both battery technology and BMSs. Chemical reactions in the battery are subject to operating conditions, and hence, the Degradation of a battery may vary in different environments. Developing a comprehensive and mature. BMS is critical for manufacturers who would like to increase the market share of their products. The major concerns of BMSs were discussed in this paper. They include battery state evaluation, modeling, and cell balancing, wherein the evaluation methodologies of battery status were viewed as the crucial issue. Thus, related work on the SOC, SOH, and SOL of batteries were reviewed with comparisons. ABMS framework was proposed to deal with the deficiencies of current BMSs in both research and commercial products. Based on previous work, specific challenges facing BMSs and their possible solutions were presented as a solid foundation for future research. Due to varying situations inreal-world applications, a standard solution was not wanted. Based on the specific situation, differentstrategies should be applied to improve and optimize the performance of BMSs in future EVs and HEVs. Two drawbacks have been identified in the conventional methods such as converter losses and incremental feedback gain. In order to eliminate the drawbacks a SEPIC Converter and FPGA Controller has been used here. The Performance of the system has risen to certain level from 80% to 85%.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 system is simulated by using the MATLAB Simulink tool and their performance is shown. Adaptive system is the good choice for SOC and SOH.

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