Battery Management System for Electric Vehicle by using Charge and Mode Control Algorithm

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Abstract:- A battery management system has been developed for EVs to ensure reliable, efficient and consistent operation of batteries under different environmental and driving conditions. Firstly, for the development of battery management system a high fidelity battery model dependent on different operating conditions is developed. Then battery model parameters are identified using manufacturer data sheet without conducting expensive and time-consuming experiments. Secondly, this research work focuses on the estimation of internal states of batteries such as the State of Charge, State of Health and Remaining Useful Life. Determination of internal states of batteries helps in maintaining battery operation in safe operating window. Automobile industry presently designs and produces single large pack EVs which offers an extended range on the cost of a heavyweight vehicle with a high price. The researchers have suggested EV having two different size batteries. The overall weight of the vehicle is decreased for short-range travel by using smaller size fixed battery. The larger size battery is swappable and is used for longer distances. As it is seldom used, it has longer lifetime and its cost is distributed over the lifetime of the vehicle.

Keywords: Battery Management, Electric Vehicle, Charge, Control Algorithm

I. INTRODUCTION

Battery management system is a monitoring and control framework that maintains the operation of the battery in the specified constraints, as well as performs the appropriate safety steps in case of hazardous situations [1]. It utilizes a suitable battery model to describe the dynamic behavior of the battery under different operating conditions. This battery model also helps in the investigation of battery performance, lifetime and driving range of the vehicle. Consequently, the derived model for battery management system should be sufficiently simple but still capable of capturing the critical characteristics of the battery. Moreover, if any abnormal situation such as over-voltage, over-current, and overcharging/over-discharging are detected during the operation of EVs, battery management system should notify to execute preset correction procedure [2]. For these safety issues, battery management system requires accurate determination of various internal states of the battery (such as State-of-Charge (SOC) and State-of-Health (SOH)) and its Remaining Useful Life (RUL). Accurate estimation of internal states is also utilized as the key decision factor for power distribution and energy management system of the EVs. Development of effective battery management system requires a suitable battery model and accurate estimation of internal battery states. This leads to the growing interest of researchers to develop advanced battery management system with accurate battery model and precise online estimation of internal battery states for the application in EVs. Nowadays, automobile industries design and produce EVs with a single large-size battery pack which offer extended range and high performance. However, these EVs are still in the luxury segment with cost (> 40kUS $) out of which price of the battery represents a significant share.

In [3], the authors suggested the concept of dual-battery powered EVs having two different size batteries. Small size battery pack was fixed, and big size battery pack can be swapped according to the requirement. For short range, fixed small size battery has been used which will reduce the mass of the EV and improve the energy consumption per unit distance. For more extended range, both small and large size battery packs are utilized simultaneously to power the drivetrain in the EV. The authors have also analyzed the performance of the proposed dual-battery powered EV concept in comparison with single larger pack EVs and proved that there is a significant improvement in energy consumption (up to 17 %), and economic benefits are achievable by distributing the cost of the large battery pack over the lifetime of the vehicle. Benefits of using dual-battery powered EVs will encourage further studies in the field of power management strategies between different size batteries and development for battery swapping centers for the further popularization of EVs in the automobile market [4].

II. BATTERY MODELING

A high-fidelity battery model is a prerequisite for the development of efficient battery management system, to reflect and predict the performance of battery under varying load and environmental conditions. While operation of EVs, main purpose of the battery model is to reliably simulate the behaviour of the battery behaviour and estimate the internal states using battery management system. The main aspects is to be considered while choosing the appropriate battery model

is that it should be accurate and precisely reflect the characteristics and dynamic behavior of battery under different operation conditions [5, 6].
Another aspect is that it should be computationally easy and efficient to implement in battery management system for estimating internal states of the battery. Throughout the years, the researchers have numerous kinds of battery models consisting of different accuracy level and competition complexity for describing the behaviour of the battery [7]. These models have been primarily categorized as the electrochemical model, data-driven and equivalent circuit model. This section outlines the state-of-the-art of battery modeling and explains the advantages and disadvantages of different types of battery model.

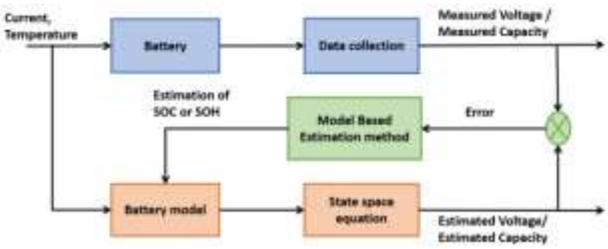

Figure 1: Model based internal states estimation

In the case of SOC estimation, inaccurate estimation of battery SOC using ampere hour methods develop error in the battery OCV measurement and then OCV error increases the battery terminal voltage prediction error. Therefore, accurate estimation of battery SOC minimizes prediction error of the battery terminal voltage. The feedback compensation for estimation of SOC is the battery terminal voltage prediction error. Hence, the method is required to obtain the value of the feedback gain for compensating the uncertainty in battery SOC estimation. Similarly in case of capacity degradation estimation feedback gain is obtained through comparison of measured and estimated battery capacity.

III. SIMULATION MODEL AND RESULTS

The use of clean energy in the transportation industry has gained substantial attention in the last two decades with the increase in fuel price and harmful gases emitted by burning fossil fuels in conventional vehicles. EVs emit no greenhouse gas, and hence they are a potential alternative to the internal combustion engine (ICEs) automobiles. However, the automobile industry had been limited to EVs with short range because of small battery capacity, long charging time, and lack of charging infrastructure. Nowadays, the advent of Li-ion batteries has reinforced the automobile sector to develop long-range EVs. Brands such as Mercedes Benz, Nissan, Tesla, Toyota, and others are developing EVs with the single sizeable Li-ion battery which leads to an oversizing of the battery and high initial cost. However, in [14] author suggested the concept of EV having two different size battery sources. Small size battery pack is fixed, and big size battery pack can be swape according to requirement. For short range, fixed small size battery is used which will reduce the mass of the EV and improve the energy consumption per unit distance. For more extended range, small size battery with swappable large size battery pack is utilized to power the drive train in the EV. The author has analyzed and evaluated the performance of proposed EV concept in comparison with single larger pack EVs and proved that there is a significant improvement in energy consumption (up to 17 %), and economic benefits are achievable by distributing the cost of the large battery pack over the lifetime of the vehicle. Benefits of using different size batteries encourage further studies in the development of power management systems for the dual battery-powered EVs. The core concerns of power management systems are to effectively provide energy from each battery source to match the power demanded and stored energy in the battery sources during regenerative braking.

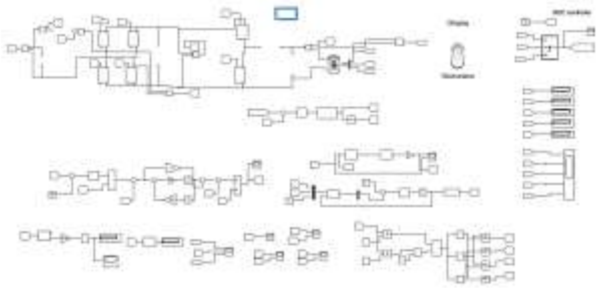

Figure 2: Simulation Model

Figure 3: Algorithm Coding

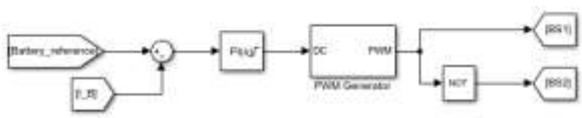

Figure 4: Battery Charge Control

The number of PV installations has an exponential growth, mainly due to the governments and utility companies that support programs that focus on grid-connected PV systems.
In a general structure distributed system, the input power is transformed into electricity by means of a power

conversion unit whose configuration is closely related to the input power nature. The electricity produced can be delivered to the local loads or to the utility network, depending where the generation system is connected.
One important part of the distributed system is its control. The control tasks can be divided into two major parts:

(1) Input-side controller: Its main property is that it can extract the maximum power from the input source. Naturally, protection of the input-side converter is also important to be considered.
(2) Grid – side controller: It performs the following:
   (a) It controls the active power generated
   (b) It controls the reactive power transfer between the PV and the grid
   (c) Control of the dc-link voltage is done by the grid-side controller
   (d) It ensures high quality of the injected power

The items listed above for the grid-side controller are the basic features this controller should have. In addition to the above, auxiliary services like voltage harmonic compensation, active filtering or local voltage and frequency regulation might be requested by the grid operator.
The necessity of voltage feed forward and cross-coupling term is the major drawback of the control structure implemented in synchronous reference frame. In addition to that the phase angle of the grid voltage is a must in this implementation. In the case of control structure implemented in a stationary reference frame, if PR controllers are used for current regulation, the complexity of the control becomes lower compared to the structure implemented in dq frame. In addition to that, the phase angle information is not a necessity, and filtered grid voltages can be used as templates for the reference current waveform.

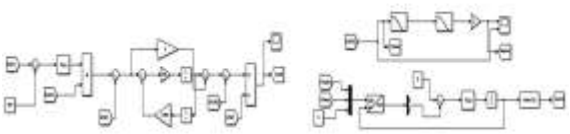

Figure 5: Grid Controller for battery management

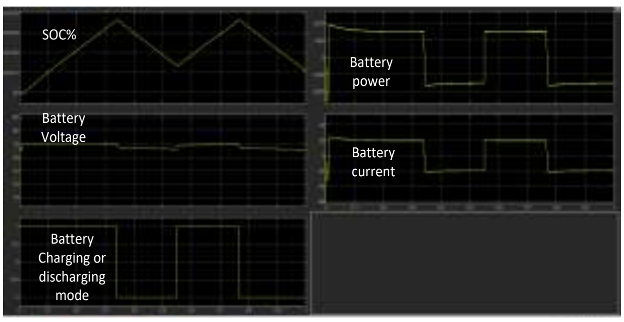

Figure 6: Battery state of charge, battery voltage, battery current, battery power, battery charging or discharging mode

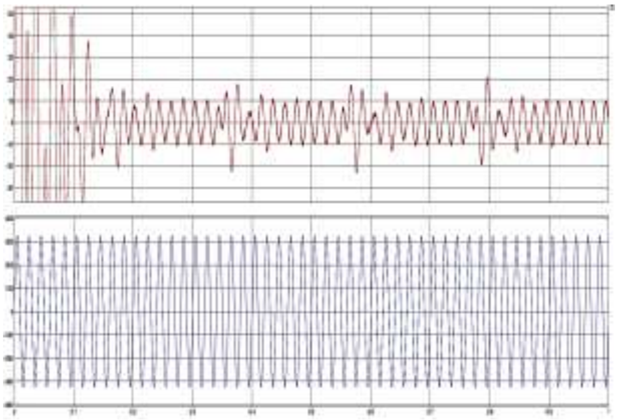

Figure 7: I_grid and V_grid

Accurate estimation of the State-of-Charge (SOC) and State-of-Health (SOH) are of great significance in battery management system due to the requirement of ensuring safe and reliable operation of a Li-ion battery in EVs. For driving purpose, it is essential for the driver to have information about how long the driver can still drive with the present charge in the battery. If the driver does not have the precise information, it will create a lot of inconvenient if the charge gets finished before completion of the ride. Conventional internal combustion engine automobile has a dashboard for fuel gauge that shows the absolute level of fuel remaining in the tank. Similarly, battery SOC corresponds to the amount of energy left inside a battery to power the EVs. For EVs customers it is essential to determine the current remaining available capacity so that driver can recharge or change the battery for traveling. Moreover, another inevitable problem with the battery is that their performance (health) deteriorate gradually with cycling (usage) and calendar life (aging) due to irreversible chemical changes with load variations.

IV. CONCLUSION

The power management system avoid the burden on single battery for long distance, it share load among both the batteries with equal charging and discharging rates. Low charging rate and discharge rate compared to single battery will increase the life of batteries. Development of effective power management system help in increasing range of batteries for extended range and increase the probability of using dual battery powered EVs. Since Dual battery powered is EVs have less weight for short range which will also increase their battery life and long range covered compared to single large size battery.

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