Novel Pulse Power Estimation Technique for Li – Ion Battery using DCIR and SOC Relationship

Ujjwal Sharma, Shaphali Jain, Shashwat Tripathi and
Vishal Sharma

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Ujjwal Sharma[1]
Jaipur Engineering College and Research Center, Jaipur, India
ujjwalsharma0198@gmail.com

Shaiphali Jain[2]
Jaipur Engineering College and Research Center, Jaipur, India
shaiphalijainjain@gmail.com

Shashwat Tripathi[3]
Jaipur Engineering College and Research Center, Jaipur, India
shashwatt14@gmail.com

Vishal Sharma[4]
Jaipur Engineering College and Research Center, Jaipur, India
vishalsharma.ee@jecrc.ac.in

Abstract:- The Li-ion battery has the most inclusive features of all types of the batteries due to unlimited voltage, light mass, low self-discharge, more cycle life and other benefits. The Li-ion battery has therefore been developed and is extensively used in several fields for energy saving systems and for protecting the global situation. Recently, electric vehicle (EV) and hybrid electric vehicle (HEV) applications mostly practice the Li-ion battery due to are the utmost used for weight reduction, downsizing, development of input and output presentation as well as the discharging and charging effectiveness. To determine the presentation of EV and HEV applications, certain factors should be well measured. Amongst these, the power is an important than other factors. Therefore, it is compulsory to obtain precise battery power evidence. The power is defined as 10 seconds pulse power competency.

i. Introduction

a. Progresses till date-

Present Algorithms of State of Charge (SOC) Approximations In Battery Management Systems (BMS). The most direct algorithm to estimate SOC exists coulomb counting. It is an exposed loop method that brings an accumulated error given disorders, such as a poor initial deduction of SOC or a biased current measurement. To confirm a more robust SOC estimation, numerous trainings have established that model-based closed loop algorithms are greater to open loop methods. Above certain disturbances, closed loop algorithms can catch the error of terminal voltage designed from the model by equating it to the measured terminal voltage. Subsequently applying certain filters, the error is used to reward the model for a better SOC approximation. Therefore, the accuracy of closed loop SOC valuation heavily relies on the precision of the battery model. Maximum battery models incorporated in closed loop algorithms are comparable circuit models (ECM) that use resistance-capacitance (RC) net as basic mechanisms to represent the voltage response beneath the current inputs. The models comprise first order RC [15–17], second order RC [18–23], and third order RC [24]. Though, none of them have implemented current reliant on parameters, according to a recent comprehensive analysis of ECM [25]. While existed electrochemical models are extra sophisticated than ECMs, current dependence is static not considered in most of the work due to traditions.

a. What further is being done-?

I. Improvements of Current Work Considering the rising prospect of MHEV and the occurred technical gap-

This work has advanced a Li-ion battery model bearing in mind both the current and SOC dependences of DCR and combined it into EKF for accurate SOC assessment at large current applications. For the first time, together simulation and testing have enclosed a many wide ranging currents, from one C to twenty five C, which has not been mentioned in the literature [5,6,9–12] as the highest current ever achieved is 4 C [6]. Here, the dependency of current is considered for both charge transfer [6] and for solid phase diffusion, which should not be avoided [8]. These results shows that more accurate terminal voltages under the dynamic stress test (DST) Energies 2017, 10, 1486 3 of 17 profile is predicted by the model with current dependent parameters. When the current dependent model is integrated to EKF the mathematical derivation is provided. As a result, based on the simulation of DST profile, more accurate SOC estimation is achieved which is validated by experimental data. The Overall Scheme, the Li-ion battery which we have studied in this work is A123® pouch type high power cell having 14 Ah capacity. Graphite and LFP are the active material of anode and cathode respectively. Its electrochemical property is shown by using an equivalent electrical circuit, as in Figure 1a. The battery terminal voltage, VT, is equal to open circuit voltage (OCV, or Voc) in a steady state.

Open circuit voltage (Voc) is a function of SOC and hysteresis voltage, which will be described in Section 2.2. (a) (b) .The Overall Scheme of equivalent circuit model and (b) open circuit voltage , versus state of charge. A resistor (R0) and two RC circuits consisting of resistors and capacitors (R1, R2, C1, and C2) is used to model the internal resistance of a battery, or DCR. The ohmic resistance of the electrolyte, separator and electrode of the battery is described by using RO. The fast dynamic response is modeled by using R1 and C1,that is dominated by charge transfer processes. The slow dynamic process is modeled by using R2 and C2, which is governed by the diffusion of lithium ions in electrodes. The voltage drops on these components when the battery is charged or discharged by a current I.

II. Energy Storage Systems for EVs

EVs consist of four main parts: an energy storage system (battery), mechanical transmission system, motor, and power converter. Many energy storage systems are there, such as lead acid, NaS, NaNiCl, NiCd, VRFB, ZBFB, and Li-ion. For safe and reliable operation only ambient temperature batteries have been considered in EVs. As compared to the others the Li-ion battery has the highest energy and power densities. In addition to it, the cost, life cycle, and nominal voltage of the battery are also important factors. The nominal voltage of a cell decides the quantity of single cells required in a battery pack for safe and reliable operation so it's a critical point. The Li-ion battery seems to be a better option because of its good energy density, power density, lifespan, nominal voltage, and cost. For a better understanding and comparison Figure 2 shows a spider chart of the various cell chemistries. Lithium Ion Battery Figure 3 represents the working diagram of a Li-ion battery in a simplified manner. The Li-ion cell is made up of a separator, two current collectors a positive electrode (anode) and a negative electrode (cathode).To complete the discharging cycle Li+ is transferred from the anode to the cathode through an electrolytic separator. The anode generally contains one of the following materials: Li-iron-phosphate (LFP), Li-ion manganese oxide (LMO), and Li-nickel-manganese-cobalt-oxide (LNMC) and the negative electrode is generally formulated from graphite. For electrolyte Diethyl carbonate or ethylene carbonate are used. For positive and negative current collectors Aluminum and copper are used respectively. As an example of both charging discharging the chemical reactions of LMO/graphite are reported. Energies 2019, 12, 446 4 of 35

For charging:

$\mathrm{LiMnO} \rightarrow \mathrm{LiMnO} + \mathrm{aLi} + \mathrm{ae}\ \mathrm{LiC} + \mathrm{aLi} + \mathrm{ae} \rightarrow \mathrm{LiC}$

For discharging:

$\mathrm{LiMnO} + \mathrm{a\ Li} + \mathrm{a\ e}^{-} \rightarrow \mathrm{LiMnOLiC} \rightarrow \mathrm{LiC} + \mathrm{a\ Li} + \mathrm{a\ e}^{-}$.

During the charging and discharging condition Schematic diagram of the Li-ion battery. In the literature different chemistries of Li-ion battery have been reported. Good R&D stage Although Li-ion battery is the superior choice for EVs; it still needs a decline in its capital cost along with refining performance and high life cycle. By using manufacturing and technology perspectives capital cost reduction can be achieved. To improve the round-trip efficiency and depth of discharge of Li-ion battery a lot of efforts have been made.

As per the report, the decrement in the capital cost of Lithium-ion battery will be 77–574 USD/kWh from 200–1260 USD/kWh, the enhancement in the energy density will be from 200 to 735Wh/L, and the round-trip efficiency will rise 2% till 2030 [20]. 3. Battery management system (BMS) for EVs After substantial progress in ESS, BMS is needed which is an effective and reliable.

A BMS is a system that is capable of managing a battery according to the most accepted definitions. *Different types of sensors, actuators, and controllers are consisted by the BMS in EVs.* The following main tasks are performed by an efficient BMS: i) It protects the battery; ii) It operates the battery having a current with safe limit. iii) The battery states are measured and estimated by it precisely.

The measurement unit of the voltage and current is installed to measure the currents and potential of entire string and that of the single cell. The control of temperature unit is added for measuring the temperature of inserted battery and the coolant. The cooling as well as the heating systems can be controlled with the help of this unit. This system contains few analog and digital inputs, such as the, braking pedal sensor, accelerating pedal sensor charging control, and engine switch on/off. The balancing control circuit consisting of power dissipation R and C. This is used for equalizing the State Of Charge of the cells for battery packs. The safety units are used in avoiding physical damages to the battery. The system not only protects the battery packs from overcharge but also from over-discharge and similar conditions. The output in digital form of BMS contains the SOH, failure alarm balancing work indicator, SOC.

ii. Conclusion-

In a nutshell it can be well expressed that a li-ion battery is of best use in all devices of present needs. All what is required is to device proper and economical means and ways to extract out the best utilization out of them .Energy storage systems and their charging and discharging relationships have come a long way in improving their longevity and utility.

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