



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 8, August 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Review Paper on Battery Management System for Electric Vehicle Application

Chandramani Madhav^{1*}, Mr. Manish Prajapati²

M. Tech. Scholar, Department of Electrical Engineering, Bhabha Engineering Research Institute, Bhopal, India¹

Assistant Professor, Department of Electrical Engineering, Bhabha Engineering Research Institute, Bhopal, India²

ABSTRACT:- 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. Electrical Vehicles (EVs) emit no greenhouse gas, and hence they are a potential alternative to internal combustion engine (ICEs) automobiles. However, the automobile industry had been limited to EVs with short range because of less 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 BEVs. These batteries have superior performance concerning specific energy, energy density, cycle lifespan, low self-discharge, and are environment-friendly. However, these batteries can be dangerous if they are not operated within their safety operation window. Therefore, an effective battery management system is indispensable for ensuring the safety of passengers.

KEYWORDS: Electrical Vehicles, Battery Management System, Battery Model

I. INTRODUCTION

The present world energy economy is at serious risk with the substantial depletion of fossil fuels, rapid increase in the energy prices, effect on the environment with the emission of Green House Gases (GHG) and the dependency on politically unstable fuel producing countries [1]. Therefore, investments in the development of the exploitation of clean energy resources are increasing worldwide. As per the report of the International Energy Agency (IEA), approximately 14% of total energy-related CO₂ emission (the primary cause of the greenhouse effect) occurs from automobile industry [2]. The urgency for clean energy has raised concern among government, automobile manufacturers and researchers. To promote electrification of transportation, Electric Vehicles (EVs) are a potential alternative to the internal combustion engine (ICEs) automobiles. In 2013, Indian government released National Electric Mobility Mission Plan (NEMMP) 2020, to set guidelines for deploying EVs in the country. According to the NEMMP, India aims to deploy 400,000 passenger EVs by 2020 [3]. Effectively accomplishing this target can abstain India from bringing in 120 million barrels of oil and prevent 4 million tons of CO₂ outflows by 2020 [4]. Moreover, EVs will be a boon to plan a modern transport foundation in India for meeting the needs of the nation's tremendous and diversified population. EVs, as the name suggest, are propelled by electric motor powered by electrical energy source such as rechargeable batteries. Historically, the first EV came in the automobile market in the mid-19th century. However, EVs witnessed declining popularity in the automobile market during the first half of the 20th century due to technical limitations of battery, lack of proper charging infrastructure and transistor-based electric technology [5].

In the last decade, with the advancement of technology and policy support, EVs have gained renewed attention in the automobile market. Table 1.1 shows the number of EVs in 14 different countries in 2015 and targets committed to be achieved by 2020 [6]. The number of EVs on the road in 2015 was extremely low (0.1%) compared with existing passengers vehicle around the world [6]. Even achieving the committed target would lead to EVs share increased to 3% only by 2020.

The technological readiness of energy storage system, i.e., batteries, was the crucial problem in mass production and penetration of EVs in the automobile market [7]. Thus, to realize an EVs paradigm shift, it is necessary to investigate the improvement and development of the battery technologies. The popular battery technologies used in EVs till dates are lead-acid, nickel-cadmium, nickel metal hydride, and Lithium-ion (Li-ion) battery [8].



Table 1: EVs in 2015 and targets committed to achieve by 2020

Countries	EVs in 2015 (thousand)	EVs target by 2020 (million)	EV share by 2020 in the market
Austria	5.3	0.2	4%
China	312.3	4.6	3%
Denmark	8.1	0.2	9%
France	54.3	2.0	6%
Germany	49.2	1.0	2%
India	6.0	0.3	1%
Ireland	2.0	0.1	3%
Japan	126.4	1.0	2%
Netherlands	87.5	0.3	4%
Portugal	2.0	0.2	5%
South Korea	4.3	0.2	1%
Spain	6.0	0.2	1%
United Kingdom	49.7	1.6	5%
United States	101.0	1.2	2%
Total	814.1	12.9	3%

II. RELATED WORK

Smaranika Mishra et al. [1], presently electric vehicles (EVs) are considered as most propitious solution for the replacement of internal combustion (IC) engine-based vehicle. The development of EV technologies is growing rapidly and the battery technology is an important concept for development of the electric vehicles. The EV performance mainly relies on the battery performance and battery management system (BMS). Recently, the Lithium-ion (Li-ion) battery is mainly used as a battery in EVs due to smaller weight, high energy density and capability of fast charging and discharging. Considering the dynamic performance, economy, safety friendliness to the environment of the EVs, the BMS is designed such a way to meet the challenges like the energy management of battery, reduction of heating-time at low temperature and enhancing remaining useful life (RUL) with accuracy of prediction. The battery is managed and controlled by BMS and it is mainly focused to maintain the reliability and safety. The state estimation of the battery is essential for vehicle control and management of energy. The paper gives review on the strategies like battery modeling, state estimation and prediction. The state estimation for State of charge (SOC), State of power (SOP), State of health (SOH) and prediction of RUL are overviewed.

X. Lu et al. [2], in battery/ultracapacitor (UC) crossover energy capacity frameworks (HESS), measuring and energy the executives techniques are critical, which decide the framework cost and execution. Nonetheless, research on these two issues in a coupled way for module electric vehicles is as yet juvenile. Both assembling cost and framework end-of-life timing are consolidated. A quantitative battery corruption model is utilized to assess the battery dynamic limit misfortune and cycle life. Dynamic programming calculation is then conveyed to accomplish ideal power appropriation among battery and UC. Besides, the power the board and HESS ideal estimating methodologies are bound together into a solitary expense minimization issue. Joining those endeavors, the ideal size of the HESS with limited normal working expense is settled by reenacted toughening technique. Improvement results show that a base expense of 15.52 USD is accomplished with 72 UC cells and 7100 battery cells. An enormous arrangement of recreation information has demonstrated the optimality of the enhancement results. Contrasted and the battery-just arrangement, the proposed arrangement shows 11.9% expense decrease and 21.7% battery cycle life expansion under the Urban Dynamometer Driving Schedule. Besides, the temperature climb of the battery is decreased by 31.1%. At last, in light of the ideal outcomes, the energy the board procedure is stretched out to fit constant applications by using Markov chain and stochastic unique programming.

N. Noura et al. [3], to adapt to the new transportation challenges and to guarantee the security and solidness of electric vehicles and cross breed electric vehicles, superior execution and dependable battery wellbeing the executives frameworks are required. The Battery State of Health (SOH) gives basic data about its exhibitions, its lifetime and permits a superior energy the executives in cross breed frameworks. A few examination studies have given various techniques that gauge the battery SOH. However, not these large numbers of strategies meet the necessity of auto ongoing applications. The continuous assessment of battery SOH is significant in regards to battery shortcoming finding. Besides, having the option to assess the SOH progressively guarantee a precise State of Charge and State of

Power assessment for the battery, which are basic states in half and half applications. This study gives a survey of the fundamental battery SOH assessment strategies, illuminating their primary benefits and bringing up their constraints with regards to continuous car similarity and particularly crossover electric applications. Exploratory approval of an on the web and on-board fit SOH assessment strategy utilizing model-based versatile separating is led to exhibit its constant achievability and precision.

M. Zhang et al. [4], battery innovation has been one of the bottlenecks in electric vehicles. Whether it is in principle or practically speaking, the exploration on battery the board is critical, particularly for battery condition of-charge assessment. Truth be told, the battery makes areas of strength for some shifting and non-straight properties, which are incredibly mind boggling. Thusly, precisely assessing the condition of charge is a difficult errand. This paper surveys different delegate licenses and papers connected with the condition of charge assessment techniques for an electric vehicle battery. As per their hypothetical and trial attributes, the assessment strategies were ordered into three gatherings: the conventional techniques in view of the battery analyzes, the cutting edge techniques in light of control hypothesis, and different strategies in light of the creative thoughts, particularly zeroing in on the calculations in view of control hypothesis. The outcomes suggest that the calculations in view of control hypothesis, particularly shrewd calculations, are the focal point of exploration in this field. The future advancement course is to lay out a rich data set, further develop equipment innovation, think of a vastly improved battery model, and give full play to the benefits of every calculation.

X. Liu et al. [5], a better technique for assessing the condition of charge (SOC) of lithium-particle batteries is proposed, which is created from the molecule channel (PF). A superior hereditary molecule channel (GPF), inferable from the upsides of the PF and hereditary calculation, is proposed to defeat the drawback of the customary molecule channel: coming up short on the variety of particles. First and foremost, the relationship among SOC and open-circuit voltage (OCV) is distinguished on the low-current OCV test. Besides, a first-request resistor and capacitance (RC) model is laid out, then, at that point, the least-squares calculation is utilized to distinguish the model boundaries by means of the steady current test. Thirdly, GPF and the gotten to the next level GPF (IGPF) are proposed to take care of the issues of the PF. The technique in light of the IGPF is proposed to gauge the condition of force (SOP). At last, IGPF, GPF, and PF are utilized to appraise the SOC on the government metropolitan driving timetable (FUDDS). The outcomes show that contrasted and conventional PF, the blunders of the IGPF are 20% lower, and contrasted and GPF, the greatest mistake of the IGPF has declined 1.6% SOC. The SOC that is assessed by the IGPF is applied to gauge the SOP for battery, taking into account the limitations from the pinnacle SOC, the voltage, and the guidance manual. The outcome shows that the strategy in view of the IGPF can effectively appraise SOP.

J. Tian et al. [6], condition of charge (SOC) assessment for lithium particle batteries assumes a basic part in battery the board frameworks for electric vehicles. Battery fragmentary request models (FOMs) which come from recurrence space demonstrating have given an unmistakable knowledge into SOC assessment. In this article, we look at five cutting edge FOMs with regards to SOC assessment. To this end characterisation, right off the bat, tests on lithium particle batteries are led, and the exploratory outcomes are utilized to recognize FOM boundaries. Boundary recognizable proof outcomes demonstrate the way that rising the intricacy of FOMs can't necessarily in every case further develop precision. The model R(RQ)W shows unrivaled recognizable proof precision than the other four FOMs. Furthermore, the SOC assessment in view of a partial request unscented Kalman channel is led to look at model precision and computational weight under various profiles, memory lengths, encompassing temperatures, cells and voltage/current floats.

H. Ben Sassi et al. [7], vehicle to network innovation is presently not a fiction yet rather a reality. Because of late mechanical advances in bidirectional power move, EVs could serve as transportation devices as well as electric stockpiling units for the framework. Subsequently, battery the board is presently more pivotal than any time in recent memory to control the energy move to and from the battery pack, while keeping all battery boundaries inside a protected and ideal locale. To do as such, exact information on SOC is of critical significance, since it mirrors the inward condition of the battery. This paper proposes, a multi-development hypothesis to upgrade the assessment exactness of the unscented Kalman channel. By growing a solitary development voltage worth to multi-developments comprising of the past and current upsides of the battery's result, the exactness of the UKF is definitely gotten to the next level.

V. Vaideeswaran et al. [8], electric Vehicle innovation assumes a significant part in ozone depleting substance restriction and carbon contaminations. Battery-powered batteries are utilized to convey capacity to the assistant frameworks and engine in the electric vehicle applications. Different characterizations of battery-powered batteries are accessible these days, for electric vehicle applications. Among every single battery-powered battery, Lithium Ion Batteries will give high productivity for electric versatility since Li-Ion batteries have low self-release rate, wide working reach, greatest energy thickness and lap of luxury cycle. To work on the nature of battery and safe activity, battery the board framework is utilized and it assumes an essential part in utilization of Electric Mobility. This paper audits the properties of battery the executives framework and its innovation with benefits and burdens for electric vehicle application. This audit incorporates the battery cell checking, state assessment, charging and releasing control, temperature control, shortcoming examination, information securing and assurance plans to work on the exhibition of battery for EV applications.

III. BATTERY MANAGEMENT SYSTEM

For electrification of the automobile, battery refers to core component for energy supply which requires real-time supervisory monitoring and control system for reliable and safe operations [9]. Battery management systems is an electronic device that monitors and controls the operation of the battery in the specified constraints as well as perform the appropriate safety steps in case of catastrophic hazardous situations [10]. The battery management system is the brain of the EVs which takes information from the various sensors within the battery as well as external sensors available in the automobile [11]. And then transmit this information to the controllers for issuing control commands as well as decision factors for the power management system. The main function performed by the battery management system is [12]:

- Data acquisition: To measure operation parameters such as battery voltage, current, and temperature, etc.
- State estimation: Monitoring the amount of charge stored (SOC), health condition (SOH) and power capability.
- Safety Protection: Protection of the battery from out-of-tolerance conditions such as overcharging over-discharging, thermal stress and thermal runaway, i.e., Maintain battery operation within their operational limits to prolong its service life.
- Cell balancing: Using passive and active balancing techniques
- Control charge/discharge: Ability to control the charging/discharging conditions of the battery.

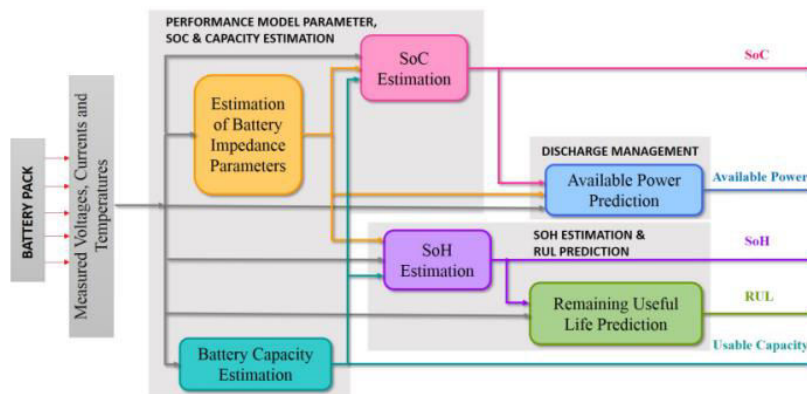


Figure 1: A typical information flow within battery monitoring System

Developing an effective battery management system has always been a big concern for all the battery drive automobile manufacturers. Battery management system is responsible for accurately monitoring of parameters and internal states of the battery for safe and reliable operation of EVs. Battery parameters term refers to the system characteristics quantities including electric quantities (resistance, capacitance) and chemical quantities (diffusion coefficients, solid phase conductivity, etc.) while the states of the battery are the variables related to system evolution (such as SOC, SOH, RUL, and available power) [12].

IV. BATTERY MODEL

Simple battery models are composed of the ideal voltage source (open circuit voltage (OCV)) V_{oc} connected in series with the constant internal resistance R_0 as shown in Figure 2. Simple battery model parameters are constant and do not depend on the SOC [13]. This model is not capable of describing the voltage profile for the charging and discharging process [14]. Hence, this model work appropriate when the dependency on SOC is not essential energy released from the battery is supposed to be infinite [15]. In practical conditions, internal resistance changes concerning the change in load. The advanced simple battery model is obtained by adding dependency of internal resistance on the SOC and temperature [16]. These models represent the static behavior of the battery. Many researchers have utilized this model for monitoring of battery, but this model did not explain the capacitance effect for representing transient current conditions. Modeling of the lead-acid battery used in various application such as uninterpretable power supply is performed by using this battery model [17].

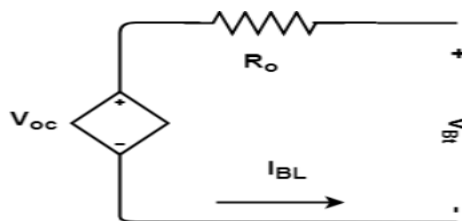


Figure 2: Simple battery model

V. CONCLUSION

The primary function of the battery management system is to monitor and regulate the internal battery states for developing power management system of the dual battery-powered EVs. From the review of related research work, it could be concluded that the prerequisite for estimation of internal battery states is to build a battery model that could reflect the dynamic behavior of the battery. Throughout the years, the researchers have developed numerous types of battery models with different level of accuracy and complexity to predict the behavior of the Li-ion battery. Electrochemical battery models were based on electrochemical methodologies involving current densities at the electrodes, electrolyte concentration parameters and many other electro-chemistry parameters implementation for battery modeling.

REFERENCES

- [1] Smaranika Mishra, Sarat Chandra Swain and Rajat Kumar Samantaray, "A Review on Battery Management system and its Application in Electric vehicle", pp. 01-06, 10th International Conference on Advances in Computing and Communications (ICACC), IEEE 2021.
- [2] X. Lu and H. Wang, 'Optimal Sizing and Energy Management for Cost- Effective PEV Hybrid Energy Storage Systems', *IEEE Trans. Ind. Informatics*, vol. 16, no. 5, pp. 3407–3416, 2020.
- [3] N. Noura, L. Boulon, and S. Jemeï, 'A review of battery state of health estimation methods: Hybrid electric vehicle challenges', *World Electr. Veh. J.*, vol. 11, no. 4, pp. 1–20, 2020.
- [4] M. Zhang and X. Fan, 'Review on the state of charge estimation methods for electric vehicle battery', *World Electr. Veh. J.*, vol. 11, no. 1, pp. 1–17, 2020.
- [5] X. Liu, C. Zheng, J. Wu, J. Meng, D. I. Stroe, and J. Chen, 'An improved state of charge and state of power estimation method based on genetic particle filter for lithium-ion batteries', *Energies*, vol. 13, no. 2, 2020.
- [6] J. Tian, R. Xiong, W. Shen, and J. Wang, 'A Comparative Study of Fractional Order Models on State of Charge Estimation for Lithium Ion Batteries', *Chinese J. Mech. Eng.*, 2020.
- [7] H. Ben Sassi, F. ERRAHIMI, and N. ES-Sbai, 'State of charge estimation by multi-innovation unscented Kalman filter for vehicular applications', *J. Energy Storage*, vol. 32, no. November, p. 101978, 2020.
- [8] V. Vaideeswaran, S. Bhuvanesh, and M. Devasena, 'Battery Management Systems for Electric Vehicles using Lithium Ion Batteries', *2019 Innov. Power Adv. Comput. Technol. i-PACT 2019*, no. 1, pp. 1–9, 2019.
- [9] J. Tian, R. Xiong, W. Shen, and J. Wang, 'A Comparative Study of Fractional Order Models on State of Charge Estimation for Lithium Ion Batteries', *Chinese J. Mech. Eng.*, 2020.
- [10] Y.-J. Zhang, H.-R. Peng, Z. Liu, and W. Tan, "Direct energy rebound effect for road passenger transport in china: a dynamic panel quantile regression approach," *Energy Policy*, vol. 87, pp. 303–313, 2015.



- [11] W. Li, R. Long, H. Chen, and J. Geng, "A review of factors influencing consumer intentions to adopt battery electric vehicles," *Renewable and Sustainable Energy Reviews*, vol. 78, pp. 318–328, 2017.
- [12] A. M. Andwari, A. Pesiridis, S. Rajoo, R. Martinez-Botas, and V. Esfahanian, "A review of battery electric vehicle technology and readiness levels," *Renewable and Sustainable Energy Reviews*, vol. 78, pp. 414–430, 2017.
- [13] S. Abada, G. Marlair, A. Lecocq, M. Petit, V. Sauvart-Moynot, and F. Huet, "Safety focused modeling of lithium-ion batteries: A review," *Journal of Power Sources*, vol. 306, pp. 178–192, 2016.
- [14] L. Lu, X. Han, J. Li, J. Hua, and M. Ouyang, "A review on the key issues for lithium-ion battery management in electric vehicles," *Journal of power sources*, vol. 226, pp. 272–288, 2013.
- [15] X. Hu, C. Zou, C. Zhang, and Y. Li, "Technological developments in batteries: a survey of principal roles, types, and management needs," *IEEE Power and Energy Magazine*, vol. 15, no. 5, pp. 20–31, 2017.
- [16] K. Liu, K. Li, Q. Peng, and C. Zhang, "A brief review on key technologies in the battery management system of electric vehicles," *Frontiers of Mechanical Engineering*, pp. 1–18, 2018.
- [17] Z. Yang, J. Zhang, M. C. Kintner-Meyer, X. Lu, D. Choi, J. P. Lemmon, and J. Liu, "Electrochemical energy storage for green grid," *Chemical reviews*, vol. 111, no. 5, pp. 3577–3613, 2011.
- [18] W. Lu, C. M. L'opez, N. Liu, J. T. Vaughney, A. Jansen et al., "Overcharge effect on morphology and structure of carbon electrodes for lithium-ion batteries," *Journal of The Electrochemical Society*, vol. 159, no. 5, pp. A566–A570, 2012.



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.118



ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 **9940 572 462**  **6381 907 438**  **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details