iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** I **Month of publication:** January 2024

DOI: https://doi.org/10.22214/ijraset.2024.58156

Design and Analysis of Battery Management System for Electric Vehicles

Ms. Aishwarya Devendra Gondane[1], Mr. Mahesh Bhimrao Thakare[2]
[1]*Department of Electrical Engineering, Govindrao Wanjari College Of Engineering And Technology Polytechnic, Nagpur*
[2]*Department of Electrical Engineering, Priyadarshani Polytechnic, Nagpur*

Abstract: This article presents a design for both the hardware and software components of the BMS, enabling battery monitoring and management. The Battery Management System (BMS) is a fundamental component of electric vehicles, primarily utilized to ensure battery safety and enhance battery lifespan. The hardware component encompasses the design of voltage acquisition circuitry, second-order filtering circuitry, sampling and holding circuitry, CAN bus communication circuitry, and other relevant features. The software section comprises subroutines for battery information collection, equalization circuitry, SOC estimation, and other relevant features. The BMS developed in this study successfully collects voltage, temperature, current, and other relevant information, and accurately estimates SOC and other crucial parameters. Testing confirmed that the battery management system precisely collects battery voltage, current, and temperature information, while the SOC estimation achieves a relatively high degree of accuracy.
Keywords: Battery management system, state of charge, state of life etc.

I. INTRODUCTION

The primary responsibility of the Battery Management System (BMS) in electric vehicles is to gather real-time information on the voltage, charging and discharging current, and temperature of the power battery pack. The BMS facilitates charge and discharge protection based on current levels, conducts balanced management based on voltage levels, and determines the current operational status of the battery pack based on temperature readings [1]. Additionally, the BMS estimates the SOC (state of charge) of the battery using data such as voltage, current, and temperature and predicts the driving range of the electric vehicle. To prevent battery damage and ensure safe use, the BMS can also safeguard batteries in abnormal states (such as over voltage, under voltage, over current, etc.) from power outages [2].

The estimation of SOC is central to the various functions of the BMS. SOC is the ratio of the current remaining capacity of the battery to its rated capacity, representing a critical parameter for characterizing battery status [3]. Accurately estimating SOC is advantageous for the rational use of power batteries, as it helps prevent overcharging and discharging, optimize energy storage capacity, and ultimately extend the service life of the power battery pack.

II. PROPOSED METHODOLOGY

Energy and environmental problems are the most dangerous problems faced by the world automotive industry.to overcome these problems world has accelerated to the new energy development.

III. BATTERY MANAGEMENT SYSTEM (BMS)

Battery management system (BMS) is the crucial system in electric vehicle because batteries used in electric vehicle should not be get overcharged or over discharged. If that happens, it leads to the damage of the battery, rise in temperature, reducing the life span of the battery, and sometimes also to the persons using it. It is also used to maximize the range of vehicle by properly using the amount of energy stored in it.

Battery management system is essential for following reasons:

1) Maintain the safety and the reliability of the battery
2) Battery sate monitoring and evaluation
3) To control the state of charge
4) For balancing cells and controlling the operating temperature
5) Management of regenerative energy.

IV. BMS BLOCK DIAGRAM

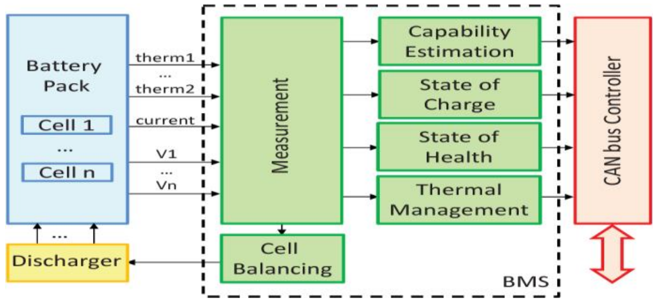


Figure 1. BMS block diagram

V. SOFTWARE DESIGN OF BMS

For the BMS, the software must fulfill the following requirements:

1) Real-time collection of battery voltage, current, temperature, and other relevant data.
2) Identification of the cause and location of battery failures and implementation of appropriate protective measures. The safety of the BMS relies heavily on this capability.
3) Calculation of SOC based on the collected battery data. This subroutine is the crux of software design, running throughout the entire program and closely intertwined with data collection, storage, and CAN communication.
4) CAN communication function.
5) Battery balancing function.

Aligned with the previously designed hardware circuit, the BMS main program flowchart is depicted in the following figure.

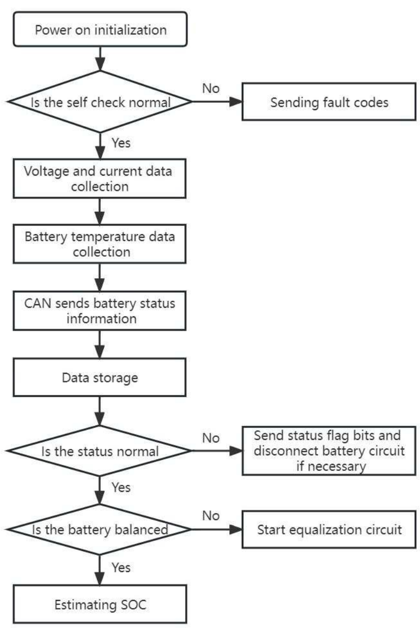


Figure 2. Main routine flow chart

VI. STATE OF CHARGE ESTIMATION

State of charge is defined as the available amount of battery as the percentage of rated capacity of the battery. State of charge gives a crucial support to battery management system to assess the state of the battery which helps the battery to operate within the safe operating range by controlling charging and discharging. It also increases the life span of the battery. State of charge cannot be estimated directly. It is calculated by using the equation

$$SOC = 1 - \frac{\int idt}{C_n}$$

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue I Jan 2024- Available at www.ijraset.com

Where I =current and
Cn= maximum capacity that the battery can hold

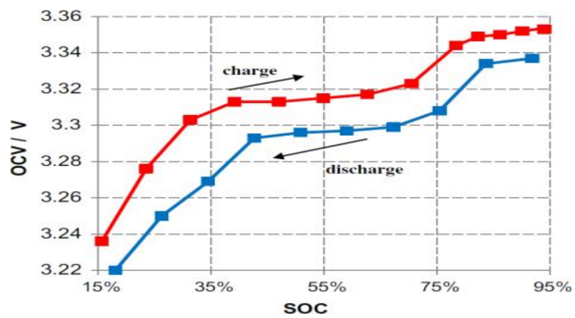


Figure 3. SOC during charging and discharging

There are various methods to estimate the state of charge.

Following are the list of state of charge estimation method:
1) Coulomb counting SOC estimation method
2) Fuzzy logic SOC estimation method
3) Impedance spectroscopy SOC estimation method
4) Kalman filtering SOC estimation method
5) Open circuit voltage SOC estimation method.

Among all these various methods Kalman filtering method has been successful for the estimation of SOC for EV'S.

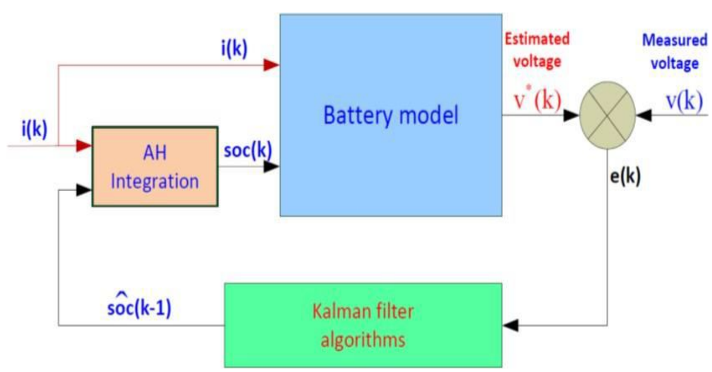


Figure.4. Kalman filtering SOC estimation model

VII. BATTERY CAPACITY ESTIMATION USING VARYING LOADS AND ENVIRONMENTAL TEMPERATURES

Degradation of a battery depends upon charge and discharge
cycle, environmental conditions and specific materials. The status of the battery is predicted when discharging at constant current and constant temperature. Here are few experimental factors of a lithium ion battery at different discharge rates and temperatures.

Table1: Experiment factors—different discharge rates and temperatures

Discharge Rate	Temperature
0.5C (350 mA)	25 °C
0.5C (350 mA)	50 °C
1C (700 mA)	25 °C
1C (700 mA)	50 °C

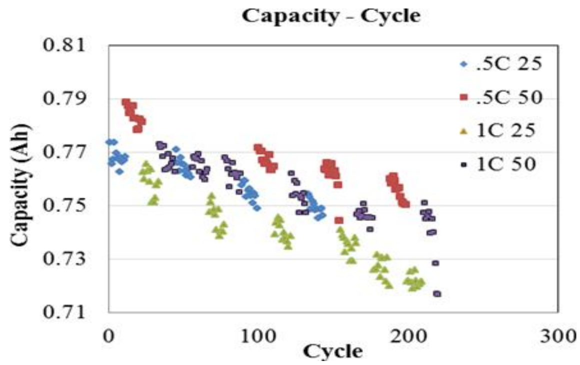


Figure 5. Discharging capability alternating at different discharge rates and at different temperatures.

VIII. CHARGING AND DISCHARGING OF LI-ION CELL USING BMS

Lithium-ion batteries are highly reactive, smaller in weight and has the highest energy. Charging and discharging of lithium-ion batteries are very faster than the other batteries. Lithium-ion cells should be operated beyond its safe operating voltage range to avoid combination of many chemical reactions, rise in temperature which leads to cell venting and generation of fire. Hence, Battery management system (BMS) is used which allows the battery to operate with in their safety zone.

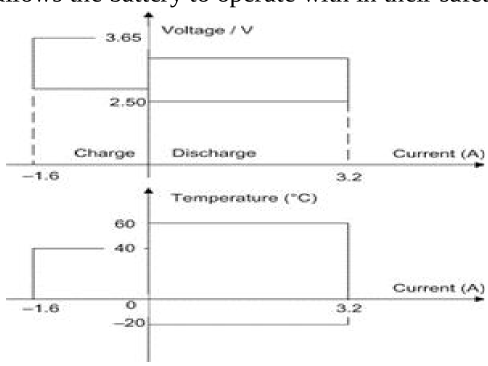


Figure 6. Safe operating area charging and discharging

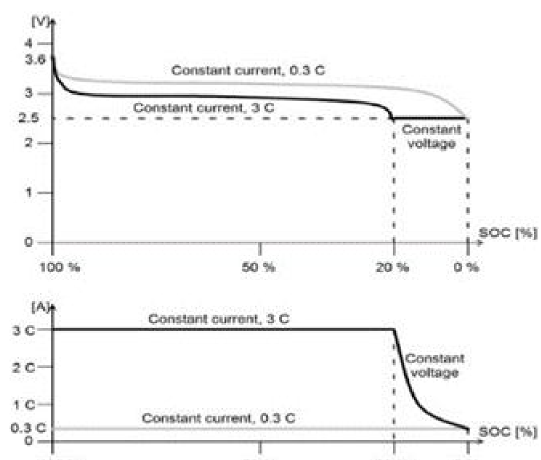


Figure 7. Charging and discharging of lithium-ion batteries

IX. ADVANTAGES

1) It improves the battery performance
2) It enhances the life span of battery
3) It controls the charging, discharging and temperature ranges and keeps them with in their range.
4) It predicts the batteries capabilities in near future.

X. FUNCTIONAL TESTING OF BMS

The BMS collects voltage, current, and operating temperature information of the power battery pack in electric vehicles running in INDIA_URBAN cycle condition. As SOC cannot be directly measured, a BP neural network is employed to predict it. The BP neural network takes voltage, current, and operating temperature information as input and predicts SOC as output [12].

To overcome the issues of local minima, slow convergence, and reduced generalization ability of the BP neural network, the initial weights and thresholds of the network are optimized using genetic algorithms [13]. This optimization results in a neural network that predicts the output more accurately [14]. Figure 5 displays the voltage, current, temperature, and SOC data collected by BMS.

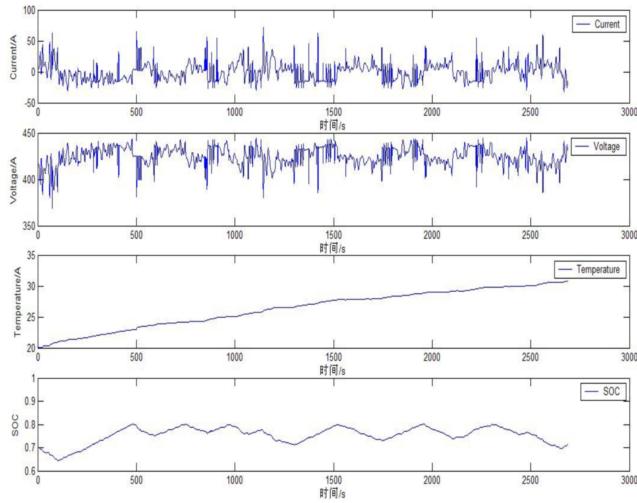


Figure 5. Main routine flow chart

XI. CONCLUSION

The Battery Management System (BMS) is a crucial component of electric vehicles. Its primary role is to collect real-time data on the power battery pack, including information on voltage, charging and discharging current, and temperature. BMS monitors and safeguards the battery, while also estimating the State of Charge (SOC) of the battery pack, which in turn predicts the range of electric vehicles.

This article presents the design of hardware circuits, such as the voltage acquisition circuit, second order filtering and sampling hold circuit, and CAN bus communication circuit, in the hardware design section. Additionally, subroutines for collecting battery temperature, voltage, and current, balancing circuit subroutines, and SOC estimation subroutines are designed in the software design section.

This article employs a BP neural network to estimate the battery's real-time SOC value, utilizing the battery's working voltage, current, temperature, and internal resistance as the input layers of the neural network. In order to enhance the estimation accuracy, genetic algorithms were implemented to optimize the neural network's weights and thresholds.

The findings indicate that utilizing neural networks for SOC prediction can eliminate the need for modeling the intricate electrochemical reactions occurring within the battery and result in relatively precise estimations. The use of a genetic algorithm to optimize the neural network considerably reduced the prediction error.

REFERENCES

[1] Wang Y & Wang H (2019). Battery System Modeling and System Management - Review of "Battery Modeling and Battery Management System Design" Battery (05), 451-452. doi: 10.19535/j.1001-1579.2019.05.023

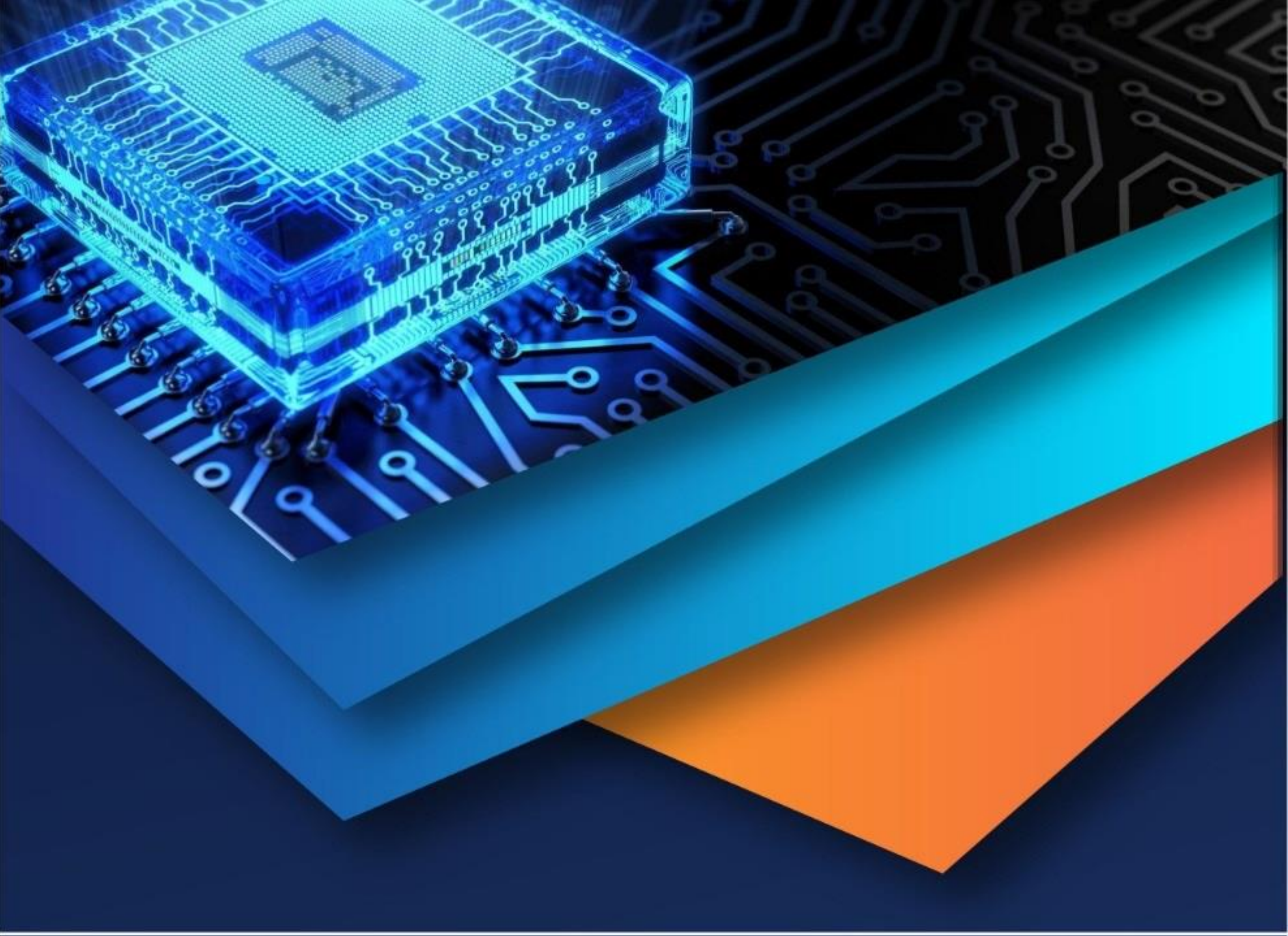
[2] Verani A, Di R R, Nicodemo N, Baronti F, Roncella R & Saletti R. (2023). Modular Battery Emulator for Development and Functional Testing of Battery Management Systems: Hardware Design and Characterization. Electronics (5). doi: 10.3390/ ELECTRONICS12051232.

[3] Xu S (2021). Application of Huada MCU in the Design of Lithium Battery Management System. Electronic World (21), 186-187. doi: 10.19353/j.cnki.dzsj.2021.21.080.

[4] Raoofi T & Yildiz M. (2023). Comprehensive review of battery state estimation strategies using machine learning for battery Management Systems of Aircraft Propulsion Batteries. Journal of Energy Storage. doi: 10.1016/J.EST.2022.106486.

[5] Xu B & Ning J (2021). Design of Battery Management System for Electric Vehicles. Internal Combustion Engines and Accessories (19), 214-215. doi: 10.19475/j.cnki.issn1674- 957x.2021.19.101.

[6] Meng X, Zhao H, and Jiang C (2021). Design and Research of New Energy Vehicle Battery Management System. Electronic Components and Information Technology (06), 117- 118+123. doi: 10.19772/j.cnki.2096-4455.2021.6.052.
[7] Zhang P (2020). Analysis of the Design of a New Energy Vehicle Power Battery Management System. Electronic World (20), 184-185. doi: 10.19353/j.cnki.dzsj.2020.20.084.
[8] Zhang L (2018). Key technologies and optimization methods for pure electric vehicle battery packs Shandong Industrial Technology (22), 66. doi: 10.16640/j.cnki.37-1222/t. 2018.22.057
[9] Surya S, Samanta A, Marcis V & Williamson S. (2022).Smart Core and Surface Temperature Estimation Techniques for Health-Conscious Lithium-Ion Battery Management Systems: A Model-to-Model Comparison. Energies (2). doi: 10.3390/EN15020623.
[10] Trogrlić T & Beus M. (2022).Development of a battery management system for centralized control of a battery cluster. Journal of Energy: Energija (2). doi: 10.37798/2022712415.
[11] Issa F. (2021).Battery Management System for an Electric Vehicle. The Scientific Bulletin of Electrical Engineering Faculty (2). doi: 10.2478/SBEEF-2021-0019.
[12] Samanta A & Williamson S S. (2021).A Comprehensive Review of Lithium-Ion Cell Temperature Estimation Techniques Applicable to Health-Conscious Fast Charging and Smart Battery Management Systems. Energies (18). doi: 10.3390/EN14185960.
[13] Andrea T. (2020).Battery management system for industrial-scale vanadium redox flow batteries: Features and operation. Journal of Power Sources (C). doi: 10.1016/j.jpowsour.2020.228229.
[14] Duraisamy T. & Kaliyaperumal D. (2020).Active cell balancing for electric vehicle battery management system. International Journal of Power Electronics and Drive Systems (2). doi: 10.11591/ijpeds.v11.i2.pp571-579.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)