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Review on Design and Analysis of Battery Management System for Electric Vehicles

Ms. Rupal Kapse[1], Dr. Pratik Ghutke[2]
[1]PG Scholar, Departnment of Eletrical Engineering, Tulsiraimji Patil Caollage of Engineering, Nagpur, India
[2]Associate Porfesso, Departnment of Eletrical Engineering, Tulsiraimji Patil Caollage of Engineering, Nagpur, India

Abstract: In order to ensure effective functioning, the Batteries Management System (BMS) plays a crucial role in supervising and controlling the charging and discharge procedures of rechargeable battery packs within electric cars. Protection of the battery, preserving its dependability, and increasing its whole life are its fundamental goals. A range of monitoring methods, including as ambient temperature, voltage, and current monitoring, are used to maintain ideal battery conditions in order to do this. The use of microcontrollers in combination with analogue and digital sensors allows for efficient monitoring. In addition, this study investigates variables including battery maximum capacity, health condition, and charge state in an effort to offer thorough understandings of BMS features. Through the examination of these techniques, the research aims to anticipate and prepare for future difficulties related to BMS, while also addressing current concerns. An essential component of BMS functioning is evaluating the battery's state, involving factors like charge status, condition, and overall life status. The study provides a comprehensive analysis of state-of-the-art battery condition evaluation approaches, highlighting impending issues for BMS and offering workable solutions.

Keywords: Battery management system, state of charge, state of health, state of life , Electric vehicles etc.

I. INTRODUCTION

Power designers are faced with the task of creating flexible systems to suit a wide range of packs and cars with varying performance needs as the popularity of battery-powered cars (EVs) throughout different kinds of cars increases. In order to address battery performance, lifetime, and safety while creating smart battery management & charging systems, this paper goes into great detail. Multiple cell modules placed in parallel and sequence make up EV battery packs. The BMS is made up of a number of parts, such as monitoring devices placed close to the battery cells, energy-conversion stages customized for the vehicle, and sophisticated controllers placed in key locations throughout the design to monitor different aspects of the electrical system.

The usual job of a battery monitoring circuit (BMIC) or cells-balancer device is to keep an eye on several parameters, including the temperature and voltage of each battery cell in a module. A cell management control (CMC) receives this data, and based on the complexity of the system, higher-order processing units such as one or more batteries management controllers (BMC) may also receive it. To identify such problems early and take corrective action, BMICs and CMCs must communicate accurately and in a timely manner. For example, the BMC can modify power use or charging to keep each cell temperature within acceptable limits, or it can use dashboard indications to warn the driver. Because of the electrical noise that exists in the environment, EVs require effective communication networks. This poses a challenges in designing robust systems. Aircraft, electric vehicles (EVs), portable electronics, and other equipment needing dependable, high-energy-density power sources frequently employ lithium-ion battery packs. Under a variety of circumstances, a battery management platform (BMS) is essential to guaranteeing the longevity, performance, and safety of batteries. Before moving on to hardware testing, engineers may use Simulink to evaluate the battery management technique in a variety of operating and failure situations. Simulink makes it easier to convert models into C code, which speeds up the process of quickly developing control algorithms for microcontrollers or systems. Testing the BMS in real time using Simulink-generated code enables BMS validation prior to deployment.

II. OBJECTIVE

The following summarises the primary objectives of this study:

1) Building battery pack models with electrical networks that scale properly with the amount of cells and are organised like the real system.
2) Using experimental data to parameterize analogous circuit components to guarantee accurate cell chemistry depiction.
3) Creating the power circuits circuit that connects the controls and pack.

4) Creating closed-loop control methods to put fault detection logic and supervisory functions into practice.
5) Creating state observers to make it easier to estimate the status of charge and health online.

III. LITERATURE SURVEY

Xu wang et. al. 2019, An essential part of the battery infrastructure of new energy vehicles, the system for managing batteries (BMS) is the subject of this paper's investigation. The complexity of these batteries' control algorithms rises along with their energy density, putting more strain on the BMS. The ARIX multi-core processor is used in the development of the BMS's hardware, software, and management strategy paradigm in order to solve this. The AURIX265 + LTE35584 chip allows for the creation of a simple BMS system that satisfies functional safety standards. This configuration increases processing efficiency by allowing dual-core processing for individual information gathering and control approach. Furthermore, the BMS's three-tier software architecture is created using the concepts of software hierarchical architecture. MATLAB/Simulink makes it easier to create the BMS strategy concept graphically. The developed BMS demonstrates that it satisfies business application requirements and accomplishes batch matching in car enterprises through bench testing and actual vehicle trials.

Yang Xu et. al. 2020, This article presents the lithium-ion battery management framework particularly made for e-bikes, which are becoming more and more popular among manufacturers because of their great efficiency and energy density. Real-time monitoring of rental battery life operation is the goal of the system when it comes to charging and discharging. It can monitor a number of characteristics, including voltage, current, temperature, storage of energy, and battery pack position, and it can send this data to a cloud-based management system. A leasing company has effectively integrated this method into its battery leasing offerings.

Fawad Ali Shah et. al. 2021, This research explores how batteries are widely used in electric cars (EVs), hybrid electric cars (HEVs), and other high-power applications. It highlights how important battery modelling is to maintaining efficiency, safety, and dependability. First, it examines the wide range of batteries used in EVs and HEVs, paying particular attention to the most recent developments in battery management techniques (BMS). Li-Ion batteries are a popular option for EVs and HEVs because of their favourable charging and discharging characteristics, high energy/power weight, and long lifespan. However, there are still issues, including as complex electrochemistry, worries about deterioration, and the requirement for precise battery health evaluation. The study looks at current methods for evaluating the State of Health (SOH) of batteries and provides a comparison analysis to assess different methods based on models/algorithms, estimate accuracy, benefits/drawbacks, and related costs. Additionally, it investigates the worldwide phenomena of vehicle electrification and examines the implications for regional economies, the environment, and energy efficiency.

Federico Martin Ibanez et. al. 2022, This research suggests an impedance-based alternative circuit modelling (ECM) method for EVs in order to prevent system failure and predict the ageing of a battery made of lithium-ion (LIB) ($LiFePO_4$). It is crucial to model the behaviour of LIBs under different circumstances, including as temperature, current at load, and state of charge. With the use of an appropriate model, LIB characteristics like capacity, voltage in the open circuit, and impedance may be described. An actual electric motorbike load profile was used to age LIB experimentally. The results of the impedance tests for aged LIB at various cycles have been installed and examined using an ECM of choice. The ageing of the same battery type was analysed and compared using the same ECM, with a profile made possible by a hybrid energy storage system (HESS) that combines supercapacitors and LIB. It was confirmed that HESS has a greater cycle life than a system that stores energy from batteries when the ECM for the HESS profile showed less impedance change and capacity decline with ageing compared to the ECM for the battery's profile.

Chong Zhu et. al. 2019, The goal of this research is to mitigate the severe capacity and power deterioration that car lithium-ion batteries encounter at subzero temperatures by introducing a unique interleaved resonant board battery self-heater. The heater seeks to allay worries about "range anxiety," a problem that is frequently connected to electric cars (EVs). In order to provide EVs operating in cold areas with the flexibility to prepare batteries at different parking places without relying on outside power sources, onboard battery preheating technology is very important. The self-heater accomplishes zero-current-switching (ZCS), which eliminates voltage spikes during turn-off and improves energy consumption efficiency, by carefully controlling the switching frequency. Additionally, by reducing circulating current, the study provides a thorough set of guidelines for optimizing resonant tank characteristics to further improve the efficiency of the self-heater. The effectiveness of the suggested heater is demonstrated by experimental validation carried out on 18650 batteries, which shows that it can raise the battery's temperature between -20°C to 0°C in just 3.5 minutes while using just 5% of the cell's energy.

Angela C. Caliwag et. al. 2021, Because they use less petrol and need less oil, electric cars (EVs) are becoming more and more popular. One important EV component that is frequently seen as a major limiting element is the battery. Electric vehicles are frequently powered by lithium-ion batteries. Ensuring safe functioning of these batteries requires effective monitoring and management, which is frequently accomplished by state estimation. State-of-charge (SoC), state-of-health (SoH), state-of-power (SoP), and state-of-life (SoL) are some of the characteristics that make up battery status. The remaining useable capacity percentage, or SoC, is determined by the operating circumstances of the electric vehicle. It is usually set by the output voltage of the battery, which drops to zero SoC when the voltage reaches a particular cutoff point. This study suggests a hybrid strategy that combines long short-term memory (LSTM) and vector an autoregressive average moving average (VARMA) models to forecast SoC and output voltage. Estimating and forecasting SoC and voltage outputs when an EV is operating under the CVS-40 driving cycle is the goal. When predicting using the hybrid VARMA and LSTM technique, the root-mean-square error (RMSE) is lower than when using VARMA or LSTM alone.

Juan D. Valladolid et. al. 2021, In many types of cars, such as electric vehicles (EV), plug-in hybrid electric cars (PHEV), hybrid electric vehicles (HEV), and smart grids, batteries are a crucial component of the energy storage systems. Operating temperature has a big impact on a battery's state of charge (SOC), which affects its capacity and ability to store energy. The creation of a mathematical model that utilises experimental data from electric car route tests is therefore essential. This work presents a metaheuristic optimisation strategy to maximise state-of-charge (SOC) in lithium-ion (Li-ion) batteries throughout both the charge and discharge phases using accelerated particle swarm optimisation (APSO). The optimisation model's goal is to minimise SOC decrease while ensuring that the battery supplies the required energy while maintaining system-specific restrictions. It does this by balancing current, temperature, and time factors. The results of the simulation show an improvement in SOC without affecting the energy output of the battery, highlighting the possible effectiveness of the optimisation method in electric cars.

IV. EXISTING CONFIGURATION

Ninety percent of common batteries are composed of metal-ion batteries, which have the potential to explode from overheating or overcurrent problems. Because of the serious risks these occurrences represent to public safety, a Battery System for Management (BMS) must be installed for both monitoring and protection. A BMS's main purpose is to increase the lifespan of batteries or cells and to guarantee safe charging, releasing, and overcharging avoidance. A battery bank consists of many cells linked in series or parallel, each with its own charging and discharge characteristics. As a result, controlling the battery's total power or voltage requires controlling each cell separately. A BMS is necessary for all lithium-ion, or Li-ion, batteries in order to prevent failures brought on by full discharge, overcharging, or use of the batteries over their acceptable temperature range. Because Li-ion cells have distinct safe operating limits, BMS programming must be customised for each kind of cell. To guarantee battery life and safety, the BMS continuously checks important parameters including state of charging (SOC), state of departure, and condition of health (capacity). When it detects irregularities like cell imbalance, action, or excessive temperature, it sends out warnings and service notifications. Furthermore, the BMS sends out alarms when the capacity of the battery drops below the user-specified threshold, signifying the end of its usable life.

1) However, current battery technologies have a number of drawbacks restricted functionality for data logging.
2) Lack of estimates for the status of health (SOH) and life (SOL)
3) Inadequate safety precautions against short circuit, overcurrent, and overvoltage events short lifespan of cells
4) Ineffectiveness while using hybrid vehicles.
5) The device may be susceptible to a number of problems, including excessive or low voltage, overheating, overpressure, leaking current or voltage, short circuits, overcharging or discharging, associated device malfunctions, and ground faults.

V. PROPOSED CONFIGURATION WORK

It is vital to control every single cell in a battery in order to regulate its total power or voltage. Each cell in a battery bank has unique charging and discharging properties, even whether they are linked in series or parallel. There could be situations when cells are wired in series, yet they have different charging properties. In places without access to the grid, energy availability is essential. Energy storage systems must be safe, user-friendly, and under constant observation. The tasks carried out by a Battery System for Management (BMS) include monitoring energy storage, safeguarding against overload and heating up, and making charging and discharging simple. It is simple to move stored energy across locations when it is in the shape of battery packs, cells, and any other energy storage system.

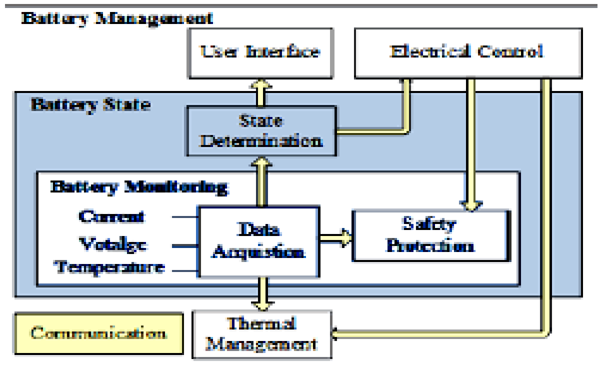

Fig 1 Proposed System diagram

State of charge (SOC) is a term used to describe the amount of charge that is contained in a battery or cell; it is usually expressed in percentage or capacities units. Keeping the SOC low allows for quicker charging times.

The term "state of health" (SOH) refers to the general health or state of a battery or cell. It represents the differences in capacity amongst cells made by the same manufacturer and rated similarly, with capacity decreasing with time.

State of power describes a cell's or battery's instantaneous power characteristics. Differential power readings across cells are caused by differences in internal resistance, which can be attributed to several factors including use, temperature, and chemical characteristics.

To measure available power and guarantee optimal performance, it is essential to keep an eye on the real-time electrical condition of batteries or cells.

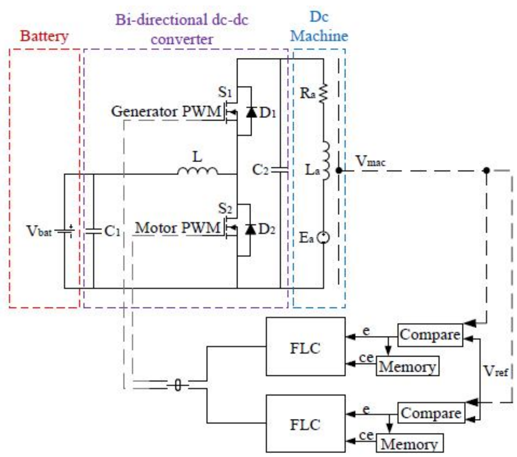

Fig. 4. Circuit diagram of EV machine driver With battery management

Motor mode simulations with different torque values are run to track battery characteristics including voltage, current, and state of state (SoC), as well as the DC machine's voltage. Under the supervision of the FLC, the simultaneous DC-DC converter regulates the DC machine's voltage to 500 V. The DC machine charges the battery while operating in generator mode. To make the battery's charging and discharge procedures easier, the FLC decides what S1 and S2's duty cycles are. The brushes, commutator, field core and windings, and armature core & windings are all part of the DC machine. The resistance, counter-electromotive source, and inductor make up the series arrangement of the armature circuit.

VI. CONCLUSION

The research of battery management techniques (BMS) and enhancing electric vehicle power performance are the main topics of this work. Critical variables like voltage, current, state of charge, health, life, and temperature are managed by the BMS system model in electric cars. It is important to guarantee the dependability and security of the BMS. The implementation of a system to manage batteries has a major impact on cutting greenhouse gas emissions.

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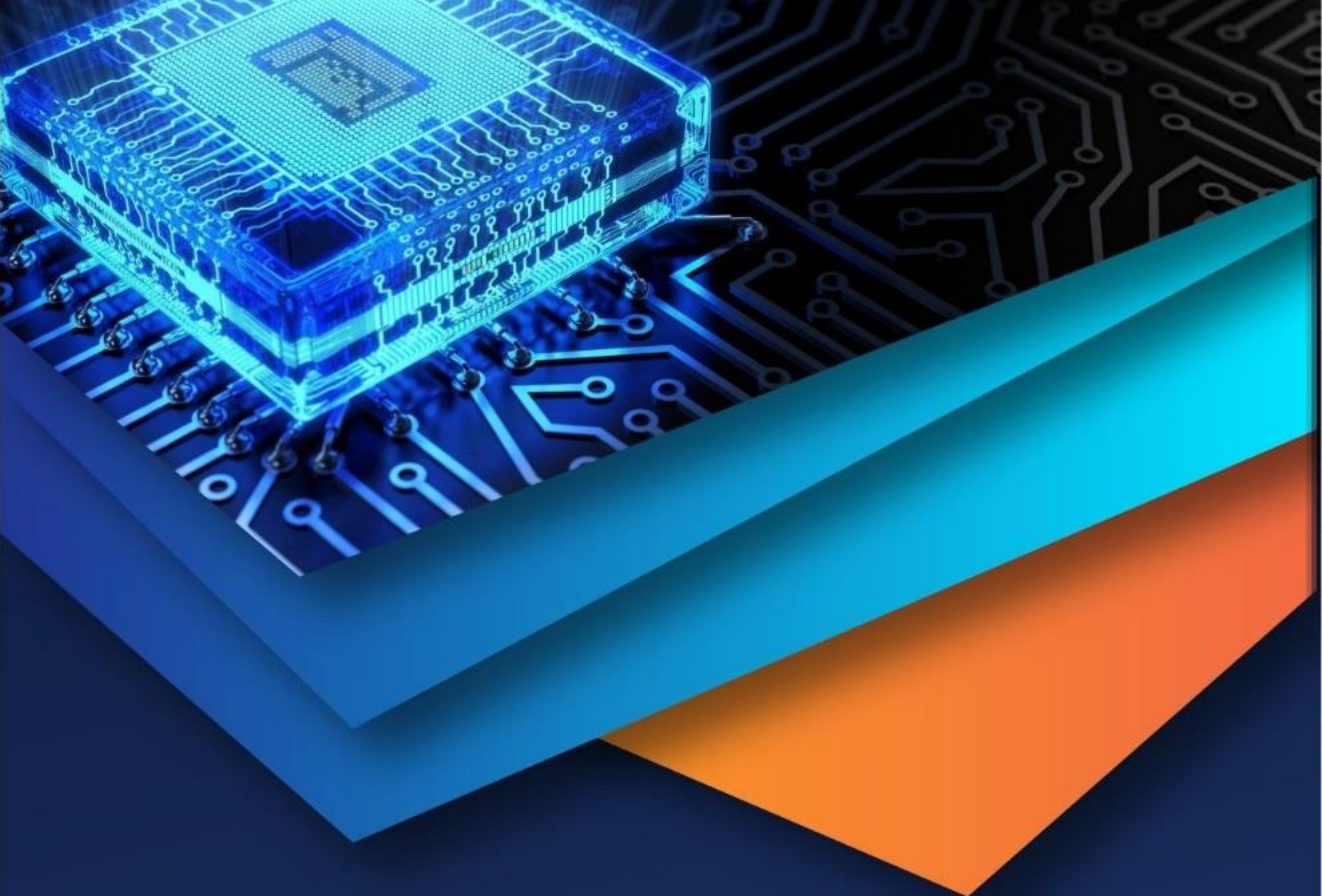

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