International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Battery Management System for Electric Vehicle

Pappu Yaswanth Ganesh[1], *Pilla Ramana*[2], *Ganteda Hinduja*[3]

[1,3]*B.Tech Student, Department of Electrical and Electronics Engineering, GMR Institute of Technology,Vizianagaram District, A.P, India*
[2] *Professor, Department of Electrical and Electronics Engineering, GMR Institute of Technology,Vizianagaram District, A.P, India.*

ABSTRACT

Nowadays, there are many different battery chemistries with various characteristics available for Electric Vehicles (EVs). For an EV to run smoothly and have a long lifespan, the battery management system (BMS) is a crucial component. This work discusses a practical battery-management system in this context. The phenomenon of heat generation and significant thermal problems with lithium-ion batteries are examined in this paper. As a result, all types of EVs require a common BMS. For four different batteries—Nickel Metal Hydride, Nickel Cadmium, Lithium-Ion, and Lead-Acid—this research suggests a simulation design of a typical BMS. Lithium-ion batteries are commonly used in electric cars due to their high energy density and extended cycle life. Maintaining the ideal temperature range is crucial since lithium-ion batteries performance and lifespan are highly sensitive to temperature. Following that, numerous studies on battery thermal management systems are in-depth reviewed and arranged into groups based on thermal cycle options. This paper has also covered the Electric vehicle's drive system and converters.

Keywords:— Battery Management System (BMS); Lithium-ion battery; Electrical Vehicles (EVs); Battery thermal management; On-board and wireless charger.

1. Introduction

EVs, smart grids, and renewable energy sources are just a few of the areas where batteries are one of the most often used energy storage technologies. Due to a number of variables, including vehicle speed, the state of the road, traffic, and varying load conditions, EVs are frequently subjected to drastically fluctuating loads. The battery's capacity is severely reduced as a result. It's important to keep an eye on the battery's performance in every region while it's under a load that changes often [1]. EVs are extremely eco-friendly and have cheap operating costs since they consume little fossil fuel (petrol or diesel) due to the smaller number of parts they have to maintain [2]. Examine Figure 1. It is a straightforward block diagram of an electric car with a battery control system.

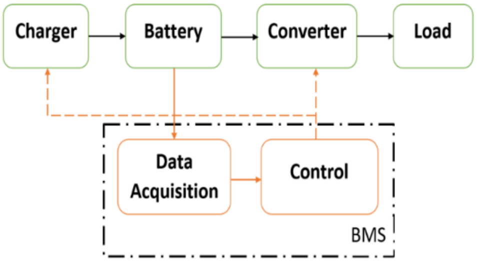


Fig 1: Block diagram of Battery management system in EV

* *Corresponding author.* Tel.: +0-000-000-0000 ; fax: +0-000-000-0000.
E-mail address: author@institute.xxx

Lithium-ion batteries have significant energy density and power density in comparison to other commonly used batteries. Consequently, they have gained wide acceptance and use in consumer electronics because to their long lifespan and environmental friendliness. Automobile lithium-ion batteries, however, have a high capacity and a large serial-parallel number, which when paired with problems like safety, renders them inappropriate. Durability, reliability, and price are factors that limit the wide choice of goods. Utilization of lithium-ion batteries in automobiles [3].

Diagnostics and prognosis have become an important and promising technique that has researchers' interest since it improves the robustness and safety of systems while also cutting maintenance costs. The major purpose of the diagnostic is to estimate the failure parameters in order to ascertain the system's End-of-Life (EOL) once the issue mode has been detected [4]. The lithium-ion battery (LIB) pack for electric vehicles (EVs) has a large capacity, several series-parallel topologies, and a constrained operational range. In order to ensure the battery pack's safe operation (safety), as well as to fully use the energy already there (power), extend the service life, and reduce the total cost of cars (durability), it must be efficiently monitored and managed by BMS [5].

2. Battery types

According to their capacity for recharge, batteries can be divided into two general categories: first and second grades battery. The primary battery is only capable of being used once. The primary battery is totally depleted and the secondary battery is after the process of discharging, capable of being recharged. Having a long cycle life, low energy loss, a high power density, and an acceptable safety level are certainly crucial for the auxiliary battery's functions in EVs and HEVs. EVs usually use a certain type of lithium-ion battery. Nickel-metal hydride (NiMH), lead acid, lithium-ion, nickel-cadmium (NiCd), etc**.**

Table1: Types of battery used in electric vehicle

Battery name	Voltage	Energy density	Power density
Li-ion battery	3.2–3.7	3.2–3.7	25.-680
Lead acid battery	2.0	30-50	180
NiCd battery	1.2	50-80	150
NiMH	1.2	60-120	150

3. Battery models

The foundation for battery status estimations and management, as well as behavioural description and analysis of the battery, are laid out by a precise battery model. The poly system that makes up lithium-ion batteries is complex and has many parts.

Its characteristics exhibit substantial nonlinearity and temporal variation are more vulnerable to the external environment, which raises the complexity of modelling.

3.1 Thermal modeling

The amount of heat produced and the use of cooling methods affect a LIB's temperature under various conditions.

When studying the temperature distributions of battery cells, modules, and stacks in the time and space domains, the thermal model incorporates the battery's phases of heat generation, heat transfer, and heat dissipation to improve the design and safety of the battery thermal management system (BTMS***)***.

$Q1=RI^2$

$Q2=I (V-OCV)$

$Q3=I (V-OCV) + IT (dOCV/dt)$

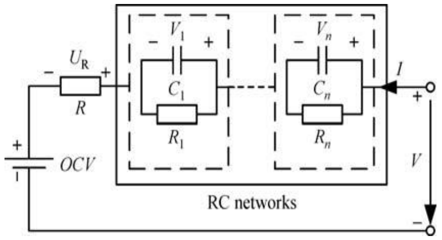


Fig 2: Thermal modeling

Where Q1 is the amount of battery heat generated as a result of a large current crossing the battery internal resistance, Q2 is the amount of battery heat generated as a result of over potentials across the RC network, and Q3 is the amount of battery heat generated as a result of both entropy change and Joule's heat. R stands for the battery internal resistance, I and V are the battery current and voltage, respectively, and OCV is the battery open circuit voltage

3.2 Electrical modeling

In order to study battery performance for different levels of management system requirements while reducing test time and costs, the electrical property model can either respond to the macroscopic electrical characteristics of batteries or characterize the particle domain parameters in the microstructure. There are two categories for existing EV models: models of electrochemistry and related circuit models.

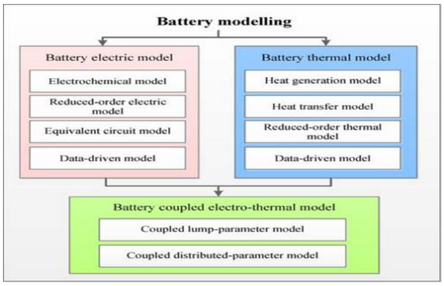


Fig 3: Electrical modeling

3.3 Electrical coupled electro-thermal model

Based on nonlinear electrochemical reactions, the electrochemical models depict the centers of batteries at a small size. Such models provide the most precise information regarding batteries, however they have two major challenges:

Global optimization is required to solve many non-analytical equations, because boundary conditions and control equations are closely related

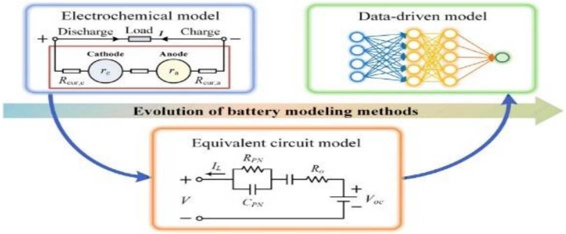


Fig 4: Electrochemical modeling

4. Methodology and Challenges

4.1 Batteries

When it comes to vehicle propulsion, high-energy batteries have three key problems to deal with: energy density, quick charging, and safety. The most promising batteries of the future will be made from regimes of LIBs, LMBs, and other technologies than lithium in order to address the challenges.

4.2 state of charge Estimation

A nonlinear filtering strategy (such as an extended Kalman filter) is used by the fusion method to SOC estimation (or, more precisely, SOC tracking), which models the problem as a recursive Bayesian estimation problem.

4.3 Real-Time State of Health Estimation

There are two options: replace the battery before it experiences an explicit failure event, or use the BMS technology available today, which is insufficient to predict a battery's state of health (SOH). Waiting it out will have a negative impact on the end user's safety and level of enjoyment, while early replacement will result in higher expenditures for the end user and excessive waste for the environment.

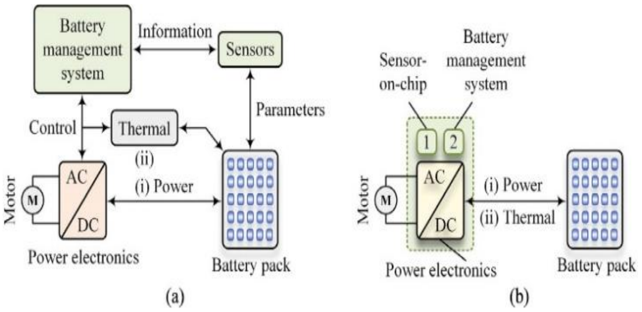


Fig5: Power electronics system in EVs modelling

4.4 Smart Power Electronics

Physical separation exists between the BMS and the power electronics. Power converters receive control signals from the BMS for battery management, which makes use of standard power electronics. Charge of motor drives and charge/discharge management Due to the rapid development of wide bandgap semiconductors, microcontrollers, battery management, and power conversion in power electronics, this sector will aggressively adopt communication technologies. Future power electronics will be able to control battery management without the need for a separate BMS, allowing the integration of the hardware and software. Normally, it is possible to balance battery cells and regulate heat.

4.5 Move-and-charge

One possibility for reducing the requirement for a large energy capacity is to use wireless charging options. WPT, which is both static and dynamic. Every EV is allowed to have a tiny battery pack installed so that it may collect wireless power from the charging lane while it is moving along the road. The charging flexibility and convenience offered by this "charge and move" technology

In situations like this, wireless energy on-demand and wireless energy encryption may be utilized to ensure energy safety for wireless charging systems with several pick-ups, much like information encryption. A second strategy for lowering the demands on high-energy batteries for EV charging is to use renewable energy sources.

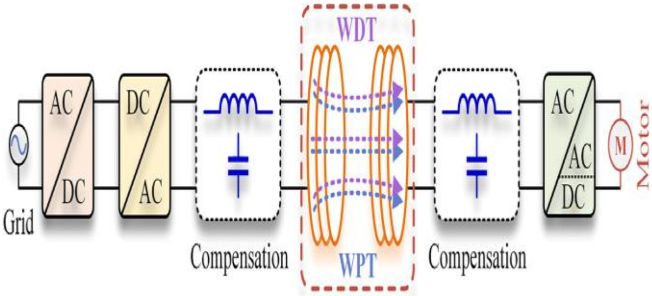


Fig6: Wireless power driver system

4.6 Wireless power driver

The wireless charging architecture shown in Figure 6 involves charging the battery using the WPT system and then discharging it to power the EV's motor. EV battery packs, on the other hand, often achieve a round-trip efficiency of 70% to 80% for each charge-and-discharge cycle. Such a low efficiency is inappropriate for the use of high-efficiency energy. One of the better options for deploying the future generation of EVs, especially in challenging driving conditions, was identified as a viable wireless motor technology to remedy this deficiency.

4.7 Battery Reuse

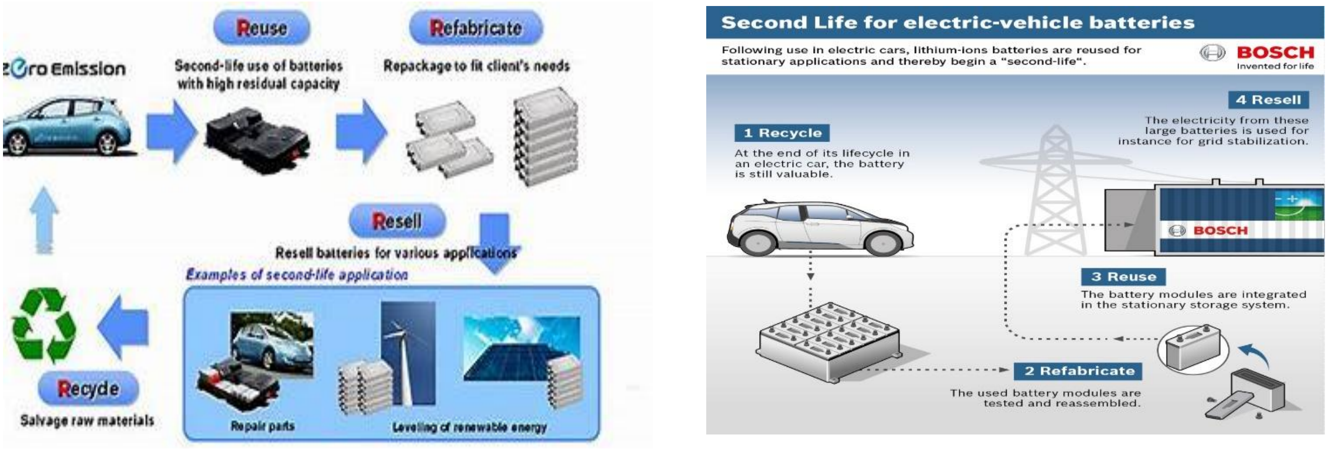
The public is being encouraged to adopt EVs through a range of incentives as counties fight to lower their greenhouse gas emissions. Due to its projected use in electric automobiles, lithium-ion battery output is therefore expected to soar in the next decades. Battery packs for electric vehicles should be replaced when they are about 80% full of their capacity.

(i)Reycling Initiatives

By 2025, Nissan predicts that the batteries in tens of thousands of electric vehicles will be obsolete. Effective recycling is critical to reducing ongoing raw material shortages and the industry's dependence on naturally risky mining for the production of batteries. In addition, new technologies enable the quick removal of important components from present battery boxes and the modification of their chemistries to ensure efficient reusing for the production of new electric cars.

(ii)Reuse Initiatives

Even when they are no longer functional, EV batteries retain at least 70% of their initial capacity, allowing for "second life" energy storage. Electrical grids, communication towers, and energy storage for solar farmhouses, wind farms, and other renewable sources are examples of applications. To achieve standardization across all worldwide manufacturers, however, in order to support repurposing programmers, is one of the industry's major hurdles given that manufacturers build battery packs with varied mechanical and chemical complexity.



(a) (b)

Fig7: (a) & (b) Recycling and Reuse Initiatives

5. Battery Charging Approach

The discharging process must be stopped and the battery replenished when a battery's energy supply runs out, its terminal voltage falls below the cut-off voltage, or its SOC decreases to 20% or lower.

5.1 Traditional Charging Approach

To solve the problem of battery charging, there are a number of conventional yet well-liked charging strategies with various goals and termination conditions. There are four conventional charging methods that are often used to recharge EV batteries.

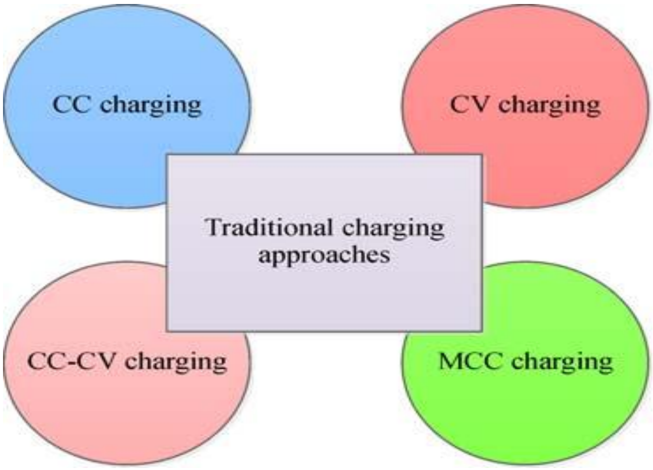
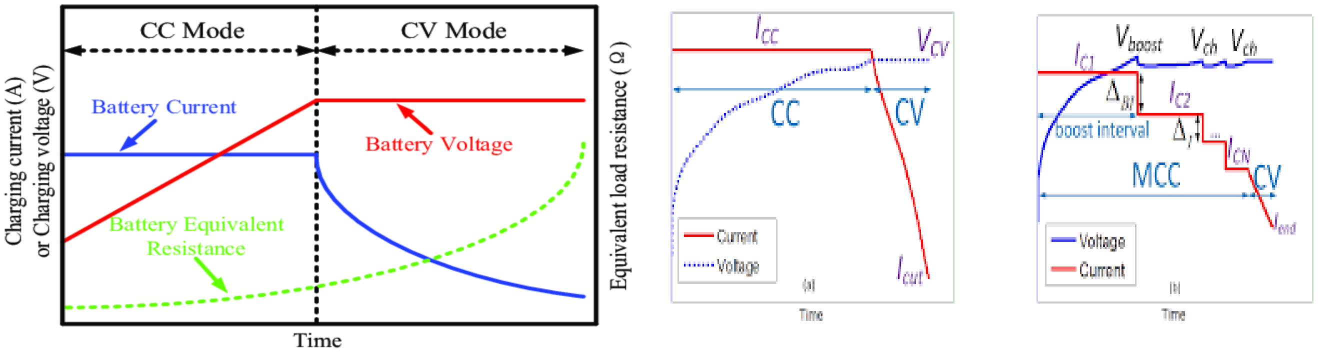


Fig8: Traditionalcharging Approaches

Constant-current (CC), constant-voltage (CV), constant-current-constant-voltage (CC-CV), and other common techniques can be used to charge batteries.
The CC charging method is a straightforward but simple one that uses a modest constant current rate to charge the battery throughout the charging procedure.
Another straightforward traditional charging method is called CV charging, which uses a constant voltage that has been predetermined to fully charge batteries. Utilizing CV charging has several advantages, including preventing overvoltage and other potentially harmful side effects during the charging process, as well as extending battery cycle life.



(a) (b)

Fig 9: (a) & (b) Current and Voltage curves in CC and CV modes

5.2 Optimization of charging approach

Recently, a number of improved charging techniques have been advanced to enhance the charging appearance of batteries in EVs. These techniques are based on the conventional traditional charging. These billing method improvements fall into four categories.

The first area is CV charging optimization. To improve the charging efficiency of normal CV charging, certain strategies have been used. These methods take into account goals like temperature change and charging speed.

The current rate in the CC phase and the constant voltage value in the CV phase are the two primary ideal components for CC-CV charging optimization. Recently, a lot of studies to enhance the CC-CV charging strategy have been established. A cycle control technique linked to the zero computational to improve the CC-CV profile of Li-ion batteries. This upgraded battery charger has been demonstrated to correctly and efficiently determination the CC-CV process.

6. Solutions Through Model Based Alogirthms

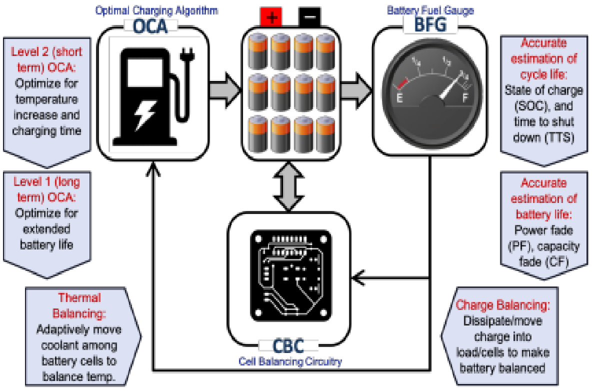


Fig10: Block Diagram of a Battery Management System

Fig shows the diagram of a BMS, which is made up of three crucial parts: the BFG, the OCA, and the cell-balancing circuitry. at the BFG output is needed for same the OCA and CBC, the BFG is regarded as the main part of a BMS. The SOC and BFG estimate Voltage, current, and temperature readings are used to determine the battery pack's SOH.

6.1 Normalized Open Circuit Voltage Characterization

One of any BMS's most crucial components is open circuit voltage characterization, which enables one to calculate the SOC from a given OCV. Different OCV-SOC characteristics were to be stored at various temperatures, according to earlier approaches to OCV modelling. A single set of parameters is produced for all temperatures using the normalized method to OCV characterization.Different OCV characterization models were also measured.

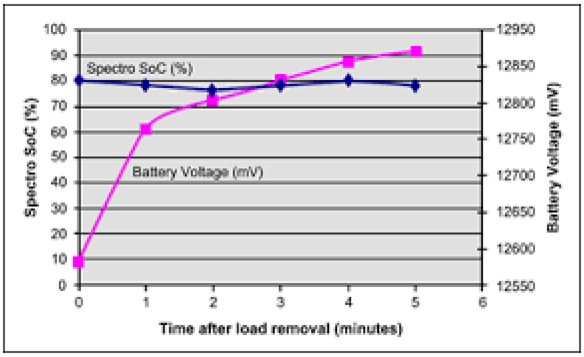


Fig11: Normalized open model identification

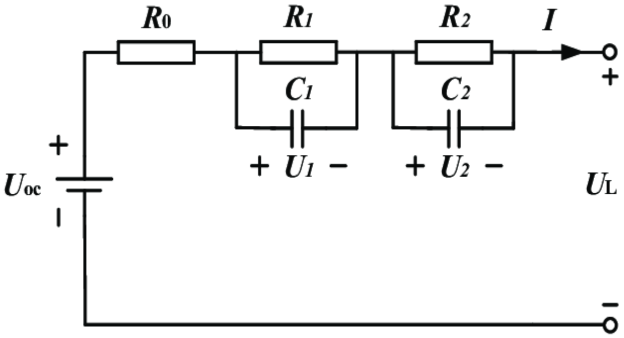


Fig12: Equivalent circuit model of a battery

6.2 Equivalent Circuit Model Identification

Chemical processes are used to power Li-ion batteries. It is difficult to solve the models created by simulating such chemical reactions using physics and chemistry. ECM, on the other hand, gave a straightforward, if accurate enough, representation of batteries and battery packs. Utilizing the time, and complexity.

7. Discussion and recommendation

Worldwide chemists will actively promote battery technologies such LIBs, SSBs, and alternative-ion batteries with an emphasis on improving energy density, rapid charging, and safety harms in order to happen the ever growing demands of battery chemistry. The performance of EVs will improve because to these battery developments. The detection and processing of energy and data inputs will depend heavily on sensor-on-chip technology and smart power electronics. By merging cutting-edge computer, server, and AI technologies, the vehicular information and energy internet will coordinate the power flows and information flows among several EVs. Finally, there are potential alternatives to using high-energy batteries, including wireless power transfer technologies like wireless power drive and move-and-charge. Future electric cars will be fuel cell and BEVs.

8. Conclusion

The suggested BMS's functioning with several battery types, such as Lead-Acid, Lithium-Ion, Ni-Cadmium, and Ni-MH batteries, is simulated.. To compare how the proposed Battery Management System operates, the simulation is run with initial values of the identical RL load and SoC. Because battery prices are falling quickly, EVs have a promising future. Coming soon are EVs with a 300-mile range that are both long-range and reasonably priced. The RUL forecast is therefore realized. Through a series of tests using two different battery types—lithium iron phosphate and lithium titanium oxide—aged under various calendar ageing circumstances, the efficiency of the suggested prediction model is demonstrated. The procedures for battery modelling from a Multiphysics standpoint have been outlined in this study first and foremost. When modelling one of them, the electro thermal model is frequently combined with the electrical model. It is frequently used in the management system for electric vehicles when combined with the equivalent circuit model, however when coupled with the electrochemical model, it is frequently utilized in studies on the interior features of batteries.

References

1. Sreedhar, R., & Karunanithi, K. (2021). Design, simulation analysis of universal battery management system for EV applications. *Materials Today: Proceedings*.

2.Kim, J., Oh, J., & Lee, H. (2019). Review on battery thermal management system for electric vehicles. *Applied thermal engineering*, *149*, 192-212

3. Ranawat, D., & Prasad, M. P. R. (2018, December). A review on electric vehicles with perspective of battery management system. In *2018 International Conference on Electrical, Electronics, Communication, Computer, and Optimization Techniques (ICEECCOT)* (pp. 1539-1544). IEEE.

4. Carkhuff, B. G., Demirev, P. A., & Srinivasan, R. (2018). Impedance-based battery management system for safety monitoring of lithium-ion batteries. *IEEE Transactions on Industrial Electronics*, *65*(8), 6497-6504.

5. Shen, M., & Gao, Q. (2019). A review on battery management system from the modeling efforts to its multiapplication and integration. *International Journal of Energy Research*, *43*(10), 5042-5075.

6. Liu, K., Li, K., Peng, Q., & Zhang, C. (2019). A brief review on key technologies in the battery management system of electric vehicles. *Frontiers of mechanical*

engineering, *14*(1),

7. Liu, W., Placke, T., & Chau, K. T. (2022). Overview of batteries and battery management for electric vehicles. *Energy Reports*, *8*, 4058-4084.

8. Xing, Y., Ma, E. W., Tsui, K. L., & Pecht, M. (2019). Battery management systems in electric and hybrid vehicles. *Energies*, *4*(11), 1840-1857.

9. Ramkumar, M. S., Reddy, C., Ramakrishnan, A., Raja, K., Pushpa, S., Jose, S., & Jayakumar, M. (2022). Review on Li-Ion Battery with Battery Management System in Electrical Vehicle. *Advances in Materials Science and Engineering*, *2022*.

10. Singh, M., & Kamboj, R. K. (2022). Development of Passive Battery Management System at TRL 4. *Teknomekanik*, *5*(1), 48-56.