Smart Battery Management System for Lithium Ion Battery

Anto Arnold S [1], Udhaya Praveen S [1], Rahul B [1], Anushree G [2]

[1] *Students of B.E, Dept. of Electrical Engineering, Kumaraguru college of Technology, Tamil Nadu, India*
[2] *Assistant Professor, Dept. of Electrical Engineering, Kumaraguru college of Technology, Tamil Nadu, India*

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Abstract

The battery is a critical component of electric vehicles, which offer a significant step toward achieving sustainable mobility. A vital component of electric and hybrid vehicles is the battery management system. The BMS's job is to ensure that the battery operates safely and reliably. State monitoring and evaluation, charge regulation, and cell balancing are functionalities that have been incorporated in BMS to ensure battery safety. Battery behaves differently under various operational and environmental situations as an electrochemical product. The implementation of these functions is difficult due to the uncertainty of a battery's performance. The evaluation of a battery's state, including its charge, health, and life, is a key responsibility for a BMS. The future problems for BMSs are outlined by analysing the most recent approaches for battery status evaluation.

Key Words: Battery Management System, Lithium - ion Battery, State of Charge, State of Health, State of Life, Electric Vehicles.

1. INTRODUCTION

Due to their wide range of applications in different segments of automobiles, battery-pack technology in an automobile has maintained its place in the literature in recent decades. Cathodes, anodes, and electrolytes are commonly used in the construction of batteries. Each battery combination has different properties; some are better at storing capacity or density, while others are better at reducing heat generation. Lithium-ion batteries are the most advanced batteries developed in recent decades. They've seen exponential growth in their use across various industries and markets, particularly in the automotive industry. This is because they are now the most energy-dense, efficient, long-lasting, and lightweight materials available. When compared to other batteries such as lead-acid and nickel-cadmium, this is the preferable option. As a result, lithium-ion batteries are used in a variety of applications, including laptops, smartphones, automobiles, power banks, cordless power tools, and so on. The only disadvantage of lithium-ion batteries is that they must be constantly monitored and kept within a certain temperature range in order to function properly. Lithium-ion battery packs have Battery Management Systems (BMS) and Thermal Management Systems built in (TMS). TMS monitors the battery pack's temperature and prevents heat generation. It prevents thermal runaway by keeping the cells within a specific temperature range. This research focuses on various ways to assemble a lithium-ion battery pack, with a particular emphasis on battery chemistry and thermal management systems.

2. BATTERY CHEMISTRYs

Electricity is usually generated from traditional sources (fossil fuel, nuclear energy etc.) However, as we all know, conventional sources are limited and environmentally harmful. As a result, renewable energy sources are a great way to generate electricity. It can be stored and used in automobiles, with electrochemical batteries being the best option. Electrodes and electrolytes make up batteries. The electrolyte serves as a conduit for ions to pass through and produce electricity. Different types of batteries are available depending on the characteristics, functions, and requirements. As shown in Table, lithium-ion cells can be divided into three types. Lithium-Ion batteries are the most common type of battery. Compared to any other battery technology, Li-ion batteries have a higher power density and specific energy. Portable electronics, power tools, and mild hybrids or fully electric vehicles all use this material. The lithium-ion battery's main disadvantages are its high cost and short lifespan. Manufacturing and raw cobalt costs are also important considerations.

Table -1: Comparisons of different cell

	Cylindrical cell	Prismatic cell	Pouch cell
Strength	Very High	High	Low
Energy capacity	Medium	Very High	High
Heat dissipation	Low	High	Very high

2.1. LITHIUM ION BATTERIES FORMATION

Li-ion batteries can be constructed and packed in two major formations, which are metal cans either in cylindrical or prismatic shapes or laminate films that are familiarized as Li-ion polymer batteries. The cylindrical structure of rolled and plastered layers in metal cans with electrolytes can be used to make Li-ion batteries. The three layers are confined in laminate film and their edges are heat-sealed aluminized plastic in the stacked form. To keep the electrolyte from leaking out of this package, a gel or polymer is frequently used. To meet the precise energy demands of EVs, Li-ion cells must be assembled into modules and then further composed into battery packs of series-parallel connected cells.

2.2. BATTERY MANAGEMENT SYSTEM

A battery-management system predicts the health and capacity of a battery, with an overall goal of accurately indicating the remaining time available for use. It often also monitors the charging and discharging of a battery. Typically, a BMS receives input from the battery its monitoring, processes it in an algorithm, and then generates the output

2.3. NEED FOR BMS

A battery management system allows users to monitor individual cells within a battery pack. As cells work together to release energy to the load, it is crucial to maintain stability throughout the whole pack. This is where a battery management system (BMS) comes into play.

2.4. CELL BALANCING

Cell balancing is a technique in which voltage levels of every individual cell connected in series to form a battery pack is maintained to be equal to achieve the maximum efficiency of the battery pack. When different cells are combined together to form a battery pack it is always made sure that they are of the same chemistry and voltage value.

2.4.1. ACTIVE CELL BALANCING

In an active cell balancer, energy transfers from a higher voltage to a lower voltage cell within the battery. In other words, the cell with higher SoC transfers energy to a lower SoC cell. Thus, the active cell balancing technique avoids dissipating heat energy and rather uses shuttling or converters to balance out the energy levels of the highest voltage cell and the lowest. The charge shuttling method transfers charges to reach an equal cell voltage.

2.4.2. PASSIVE CELL BALANCING

In the Passive Cell Balancing technique, there is a burn-off of excess energy from the higher energy cells till it matches or equals the lower voltage cell. There can be either fixed shunting or switching shunting resistor method for passive cell balancers.

2.5. BATTERY CELL MONITORING SYSTEM

A pack of Li-ion battery cells is used in electric vehicles. During the run-time, the battery cell may behave differently. As a result, continuous battery cell monitoring is required to investigate the condition of the cells. The results of the battery cell monitoring could help the system perform better by managing, protecting, equalizing, and controlling operations. It

Emphasizes, the importance of charge and discharge control, protection against overcharged and undercharged cell conditions, temperature and heat control, data acquisition communication and interface, and fault diagnosis and assessment.

3. METHODOLOGY

3.1. STATE OF CHARGE

State of charge is the level of charge of an electric battery relative to its capacity. The units of SoC are percentage points.

The method **Coulomb counting**. It is dependent on the recording of current noise. A high-pass filter with a cut-off frequency of 0.01 Hz is used to filter the signal. Either analogue or digital filters can be used. The absolute value of the current samples that have been measured is then added up over time. Although it is impossible to calibrate this in terms of an estimated corrosion rate, a steep slope is taken as an indication of rapid corrosion. This method can be shown to be similar to integrating the current standard deviation over time[19]. The use of an integrating plot provides a type of low pass filtering that may make it easier to spot trends, but digital filtering can also be used. The technique's value is limited by the fact that it does not allow for the estimation of noise resistance, and it's difficult to see what real advantages it has over the traditional three-electrode method, though the use of integrating plots may be useful.

3.2. STATE OF HEALTH

The state of health of a battery is a metric that compares its current state to its ideal state. SOH is measured in percent points. The SOH of a battery is usually 100 percent when it is manufactured and gradually decreases with time and use.

DC discharge internal resistance measurement method. According to the physical formula R=U/I, the test equipment forces the battery to pass a large constant DC current in a short period of time (usually 2 to 3 seconds) (currently a large current of 40A to 80A is generally used), and the battery is measured at this time The voltage at both ends and the current internal resistance of the battery are calculated according to the formula. The accuracy of this measurement

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method is relatively high. With proper control, the measurement accuracy error can be controlled within 0.1%. But this method has obvious shortcomings:

(1) Only large-capacity batteries or accumulators can be measured, and small-capacity batteries cannot load a large current of 40A-80A within 2 to 3 seconds;

(2) When the battery passes a large current, the electrodes inside the battery will be polarized and polarized internal resistance will appear. Therefore, the measurement time must be very short, otherwise the measured internal resistance value will have a large error;

(3) The large current flowing through the battery will damage the internal electrodes of the battery to a certain extent.

3.3. TEMPERATURE

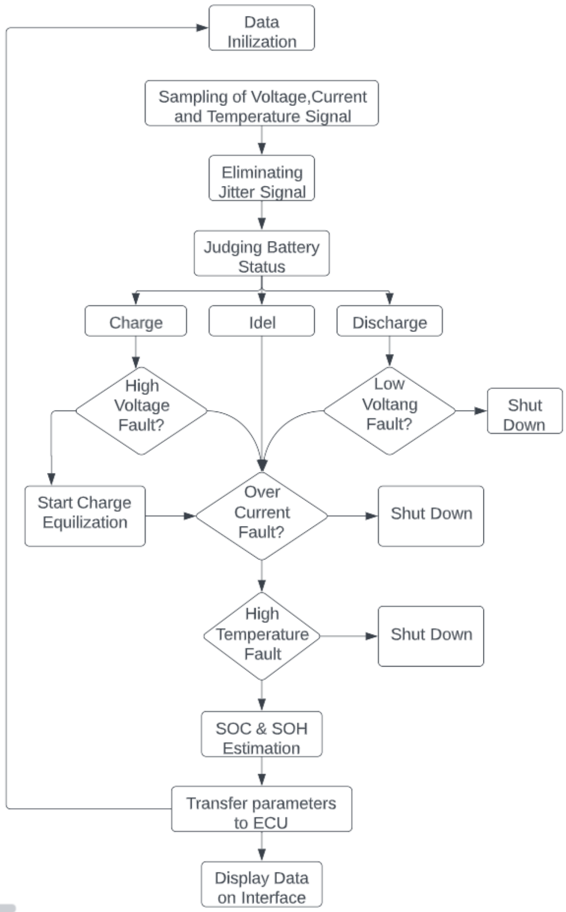
To ensure optimal battery performance, it monitors the temperatures throughout the pack and opens and closes various valves to keep the overall battery temperature within a narrow temperature range. Management of capacity. One of the most important battery performance features provided by a BMS is the ability to maximize the capacity of a battery pack.

3.4. USER INTERFACE

Providing the user with interactive real-time feedback. The output is displayed using the Node MCU through a LCD display and a mobile application.

4. BALANCING CIRCUIT

Due to various differences in technology, parameters, chemical composition, manufacturing procedures, self-discharge, and ageing curve inconsistency, not all batteries get fully charged at the same time during charging or discharge. The performances of the cells differ. Because of their high charge density and light weight, Lithium-ion batteries have proven to be the battery of choice for electric vehicle manufacturers. Even though these batteries have a lot of power for their size, they are extremely unstable. It is critical that these batteries are never overcharged or discharged under any circumstances, necessitating the use of voltage and current meter. This process becomes more difficult because an electric vehicle's battery pack is made up of many cells, and each cell must be individually monitored for safety and efficiency, necessitating the use of a dedicated system known as the Battery Management System. In order to get the most out of a battery pack, we must fully charge and discharge all of the cells at the same voltage, which necessitates the use of a BMS. During charging and discharging, the SoC of different cells in the series may differ. One cell might be fully charged during charging while the other was not. If you keep charging, the fully charged battery will be overcharged, which could result in fatal damage to the cell, greatly reducing the cell's life cycle, or even a catastrophic failure of the entire battery pack. Stopping charging when a cell is not fully charged reduces the number of charge-discharge cycles (CDCs) before the available capacity in [Ah] fails to meet specific performance criteria, which is an important parameter for a cell. Likewise, vice versa. As a result, a dependable and efficient BMS design is required.



5. RESULTS

This review provides an overview of lithium-ion battery pack technology used in electric vehicles. Different battery components, such as the anode, cathode, and electrolyte, have different characteristics.

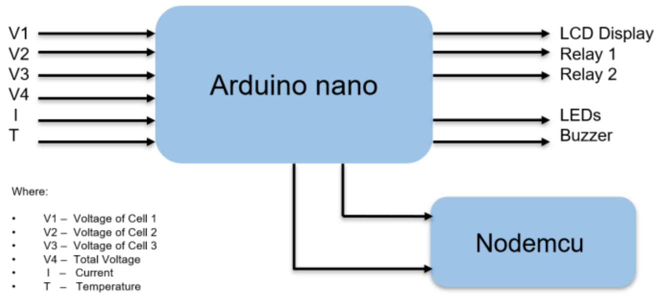
Different types of battery chemistries are described.

Currently available on the market are contrasted based on various variables We can state that the features of

Li-ion batteries are currently available in a variety of sizes. chemistries. Some chemistries have a higher storage density than others.

However, because they contain rarer elements, they are more expensive. Some chemistries are safer than others. Chemicals such as in electric vehicles, NMC, NCA, and LFP are commonly used. Depending on the situation the application's requirements with the battery selection

The next step is to choose and integrate a cooling system. A battery cooling system is chosen based on the working conditions. The battery pack's operating conditions and environment Some cooling systems are more efficient than others, but they all require maintenance. Due to their complexity, they aren't widely used. expense. When choosing a cooling system, consider the following factors. must consider factors such as the contact surface area of the battery with the cooling medium, medium flow rates the types of heat exchangers and coolants used, as well as whether they are the system will work in tandem with the battery. range of temperatures According to the findings, air, fluid, and the most common cooling method is refrigerant cooling. EVs, which require more research and development.



6. FUTURE SCOPE

I. 1.The BMS optimization algorithm could be further improved by considering the cost of each charge of each cell as a techno economical and discharge cycle of battery to prevent excessive activities that could shorten the battery life.

II. Algorithms can be developed to predict power usage and generation in the microgrid, such algorithms can be integrated with optimization-based power flow control method for real time energy management in the microgrid.

III. New transmission capacity and better operating practices, such as greater automation controller, forecasting, renewable energy visibility, and transmission planning methods, market integration and implementation of smart energy systems can resolve the problems and challenges for grid operators, often circumventing the need for curtailment

6. CONCLUSION

Since batteries are the primary source of power in electric vehicles, their performance has a significant impact on their power. Therefore, in both fields, manufacturers are looking for breakthroughs. BMS and battery technology. in chemical reactions Operating conditions affect batteries, and as a result, battery degradation may vary. environments. Creating a thorough and mature plan for manufacturers who want to be more efficient, BMS is critical. increase their product's market share the main This report addressed BMS's concerns. They evaluation, modelling, and cell balancing, in which methods for assessing the state of the batteries was regarded as critical. Thus, the SOC, SOH, and SOL batteries have similar functions. To overcome the shortcomings of current BMS in both research and commercial products, a BMS framework was proposed.

The specific challenges facing BMS and their potential solutions were presented as a strong foundation for future research based on previous work. A standard solution was not required due to changing circumstances in real-world applications. Different strategies must be implemented depending on the specific situation in order to improve and optimize BMS performance in the future.

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REFERENCES

[1] .W. He, N. Williard, M. Osterman and M. Pecht, "Prognostics of lithium-ion batteries based on Dempster–Shafer theory and the Bayesian Monte Carlo method", *J. Power Sour.*, vol. 196, pp. 10314-10321, 2011.

[2] L. Chen, Z. Lü, W. Lin, J. Li and H. Pan, "A new state-of-health estimation method for lithium-ion batteries through the intrinsic relationship between ohmic internal resistance and capacity", *Measurement*, vol. 116, pp. 586-595, Feb. 2018.

[3] Vikas Gupta, Aamani Ravada , 2015 "Model Based Battery Management System for Electric Vehicles",Indo American Instituions Technical Campus, Visakhapatnam, India