Research Article

NMC Lithium Ion Battery Management with Distributed Monitoring Topology

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Abstract: Lithium-ion battery management often called BMS (Battery Management System) is a system that controls all operations between the battery and the required load. The advantages of lithium-ion batteries, such as high energy density and long service life, make them highly desirable. Along with the increase in demand, the use of lithium-ion batteries is also increasingly complex, such as in the use of electric vehicles and smart grids. The battery must have the same voltage as the battery when connected directly. Safety and battery life are at stake if this condition is not met. BMS is a solution to this problem. The purpose of this research is to create a BMS that has three main features: monitoring, balancing, and protection. The Nano Microcontroller can be used to build the BMS. For nickel-based battery types, namely NMC (Nickel Manganese Cobalt) batteries, the design of a battery management system with a distributed monitoring and protection architecture can help battery packs be used for various applications and reduce battery pack production costs.

Keywords: Battery Management System; Nano Microcontroller Lithium; Nickel Manganese Cobalt; Battery Protection Management

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1. Introduction

an important component in electric vehicles and new renewable energy is the battery pack. There are several problems related to the battery pack for both implementations. The battery pack is still classified as the most expensive component in both implementations, this is due to battery cells that are still imported, battery management systems have specific functions for certain applications as a result the battery pack becomes less flexible to be recycled for other applications. For example, an electric vehicle battery pack when its condition is not good does not need to be directly disposed of but can still be used for new renewable energy applications by adjusting the working voltage of the battery pack, so that the battery pack utilization rate will be more optimal, this will make the battery pack have a higher economic value. In other words, the expensive battery pack price will be balanced with a high level of utilization. Another impact is that it can reduce the growth rate of battery waste itself. Currently, the government is promoting a local nickel-based battery cell industry to reduce the price of battery cells that are still imported [1].

This research will develop a Battery Management System [2,3,4,5,6,7,8] design for nickel-based battery types, namely for NMC (Nickel Manganese Cobalt) battery types with distributed monitoring and protection architecture that can support the implementation of battery packs for several applications flexibly, while also reducing the cost of the battery pack production process. Battery Management in IoT (Internet of Things) systems and Electric Vehicles (EV) is used for energy efficiency, safety, durability of batteries, performance improvement, monitoring and diagnostics, and cost optimization. [9,10,11,12,13,14,15]

2. Method

The method used in this research is to make direct observations and calculate the measurement results of the test experiments. Where testing is carried out using a battery simulator to shorten the battery discharge and charging time. Testing includes protection features on the BMS itself, namely over-current protection, overcharging protection, and over-discharge protection, then measuring the cut-off voltage on each feature using a multimeter at each measurement point [16,17,18,19,20]. Figures 1 and 2 show the wiring diagram of the overall research conducted and Figure 3 shows the flowchart of the research stages carried out.

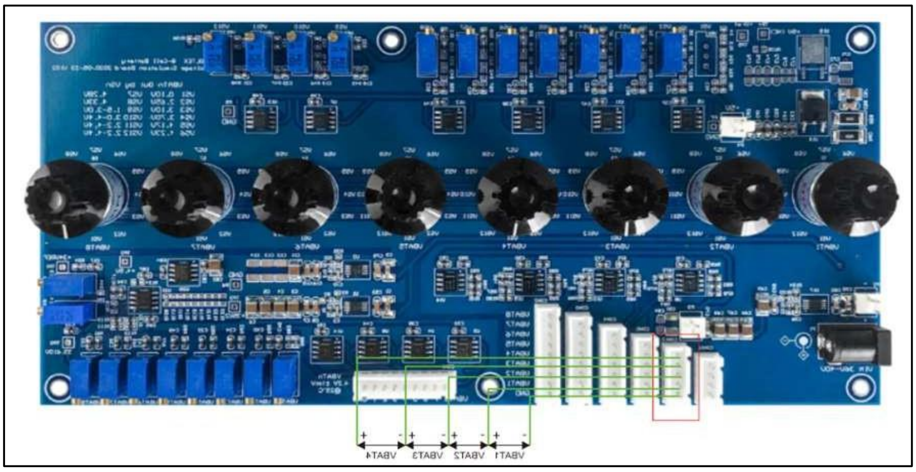

Figure 1. Test Point Measurement of BMS Simulator

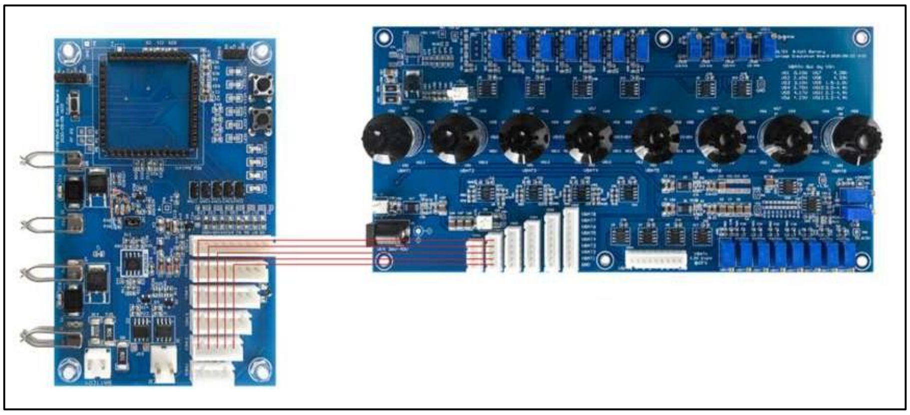

Figure 2. Wiring BMS Simulator and BMS Board

Moreover, Research is shown in the following steps:

1. Literature Study, at this stage the process of studying references related to the topic raised is carried out. Such as battery characteristics, SOC calculation methods, battery management system planning, and so on.
2. Collection of Tools and Materials This test is intended to ensure that the tools used in the research are following the desired characteristics [21,22,23,24,25].
3. System design is designed based on some existing literature, such as journals and books. This is done to be able to do the design process well when designing the BMS Including making prototypes for testing.
4. Prototype testing is done by simulating the BMS on a battery simulator to be used as data for analyzing whether the prototype that has been designed functions as expected.

5. Drawing Conclusions After seeing some existing conditions, several conclusions are drawn. This conclusion also ends with providing suggestions and recommendations for further research.

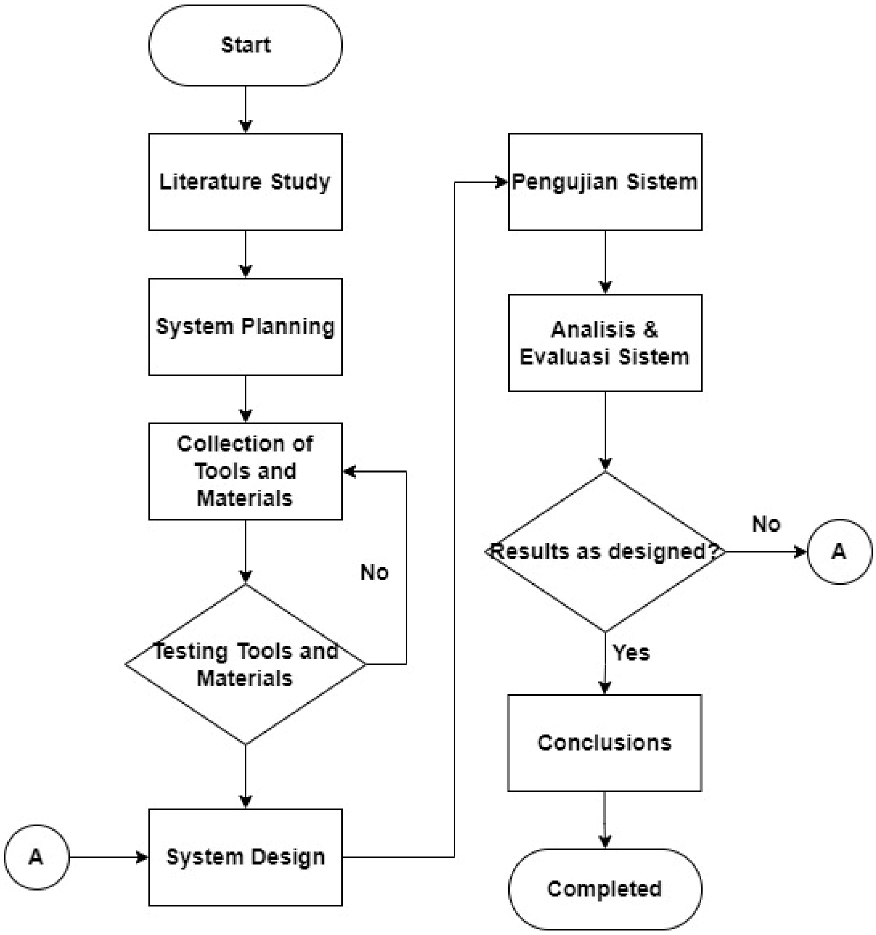

Figure 3. Research Flowchart

3. Result and Discussion

Furthermore, Table 1 is a testing the output voltage from the battery simulation board on each cell. In the current test, researchers used the 4S configuration according to the BMS configuration that has been designed.

Table 1. BMS Simulator Voltage Output Test Results

Selector	VBA T 1	VBA T 2	VBA T 3	VBA T 4
VS1	0,100	0,100	0,099	0,101
VS2	2,649	2,649	2,649	2,650
VS3	3,098	3,098	3,099	3,100
VS4	3,698	3,698	3,699	3,699
VS5	4,168	4,169	4,169	4,170
VS6	4,228	4,228	4,229	4,230
VS7	4,279	4,279	4,279	4,280
VS8	4,329	4,329	4,329	4,330
VS9	2,556	2,556	2,556	2,557
VS10	3,997	3,996	3,997	3,998
VS11	3,866	3,866	3,867	3,867
VS12	3,796	3,796	3,796	3,797

In the Table 1, it can represent the battery voltage at each knob step. This makes BMS testing more time effective without having to wait for the battery when charging or discharging the battery. Testing the BMS board consists of several stages including the Cut-Off or protection system. The Cut-Off or Protection System consists of several types, including: Over current protection (Charging) over current protection when Charging aims to protect the battery from overcurrent. Overcurrent Protection Test Results (Charging) are shown in Table 2.

Table 2. Overcurrent Protection Test Results (Charging)

Voltage	Current	BMS Mosfet Status
18V	1 A	ON
18V	2 A	ON
18V	3 A	Cut Off

In Table 2, the BMS can be said to be functioning properly according to the threshold limits set in the firmware. BMS. The maximum threshold value of current when charging is 3A. Moreover, Table 3 shows the test results using a dummy load with different current values.

Table 3. Overcurrent (Discharge) Protection Test Results

Voltage	Current	BMS Mosfet Status
16,69V	1 A	ON
16,69V	2 A	ON
16,69V	3 A	ON
16,69V	4 A	ON
16,69V	5 A	ON
16,69V	6 A	ON
16,69V	7 A	ON
16,69V	8 A	ON
16,69V	9 A	ON
16,69V	10 A	Cut Off

In Table 3, the BMS can be said to be functioning properly according to the threshold limits that have been determined in the BMS firmware. The maximum threshold value of the current when discharging is 10A. Moreover, Table 4 shows the test results using the BMS simulator board with different voltage settings.

Table 4. Overcharge Protection Test Results

Battery Voltage	BMS Mosfet Status
14,8 V	ON
15,3V	ON
15,75V	ON
16,22V	ON
16,69V	ON
16,75V	ON
16,81V	ON
16,85V	ON
16,93V	ON
16,98V	ON
17,03V	Cut Off
17,08V	Cut Off
17,13V	Cut Off

In Table 4, the BMS cut-off functions properly according to the threshold limit that has been determined in the BMS software. The maximum threshold value of voltage when full charge is 17V. Moreover, Table 5 shows the test results using the BMS simulator board with different voltage settings.

Table 5. Over-discharge Protection Test Results

Battery Voltage	VBat 1	VBat 2	VBat 3	VBat 4	Status Mosfet BMS
14,81V	VS4	VS4	VS4	VS4	ON
14,21V	VS3	VS4	VS4	VS4	ON
13,61V	VS3	VS3	VS4	VS4	ON
13,01V	VS3	VS3	VS3	VS4	ON
12,40V	VS3	VS3	VS3	VS3	ON
11,97V	VS2	VS3	VS3	VS3	Cut Off
11,51V	VS2	VS2	VS3	VS3	Cut Off
11,07V	VS2	VS2	VS2	VS3	Cut Off
10,62V	VS2	VS2	VS2	VS2	Cut Off

In Table 5, the BMS cut-off functions properly according to the threshold limit that has been determined in the BMS software. The minimum threshold value of each cell voltage when loading is 2.7V. Table 5 represents the voltage of each battery cell according to the Table 4.

4. Conclusions

Based on the results of the research that has been carried out, the following conclusions are obtained, [1] The designed BMS has the main features of balancing, and distributed protection. In the balancing feature, it is possible to balance the capacity of the battery cells to reduce the possibility of failure in one of the battery cells. The circuit breaker protection feature using Mosfet, this protection can protect the battery pack from unsafe battery operations such as over temperature, overcurrent, overcharge, and over-discharge. [2] The BMS has been implemented and tested under conditions corresponding to safe battery pack operation, taking into account variations in voltage and current. [3] The BMS can be set up flexibly to be able to adjust to the needs and type of battery used. [4] Each battery has different characteristics depending on the type each battery and the condition of the battery itself. [5] The test results show that the BMS performance for voltage protection and current sensors has high accuracy. In the balancing feature, the length of time for balancing is influenced by the amount of voltage difference between batteries and the number of batteries that have varying voltages. In the protection feature, it can work well when there is an overcharge or over-discharge with a predetermined voltage value limit.

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Author contributions: All authors are responsible for building Conceptualization, Methodology, analysis, investigation, data curation, writing—original draft preparation, writing—review and editing, visualization, supervision of project administration, funding acquisition, and have read and agreed to the published version of the manuscript.

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